ENERGYAUSTRALIA NSW
Water Access Licence and Approval

ANNUAL COMPLIANCE REPORT

July 2023 – June 2024

26 November 2024

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Cover photography: 'Lake Lyell Spillway', *EnergyAustralia NSW 2024*

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EnergyAustralia NSW (EA NSW) use of water from the Coxs River is regulated by Water Access Licence 27428 (WAL) and Water Supply Work and Water Use Approval 10CA117220 (the Approval) issued under section 66 (1) (a) of the Water Management Act 2000. The WAL and Approval Annual Compliance Report has been prepared pursuant to Condition DK5863-00039 of the Approval and addresses compliance with the conditions of both the WAL and the Approval for the twelve-month period from July 2023 to June 2024.

The total annualised rainfall for Lithgow of 917.6 mm was 15.8% above the long-term average (BOM, 2024a). Significant rainfall events (above 50% monthly average) were observed at Lithgow for 4 months of the reporting period which included January, April 2024 and November and December 2023 and April. The reporting period started and ended with drier than average months occurring for July to October 2023 and May to June 2024. NSW experienced warmer than average seasonal temperatures over Spring, Summer and Autumn. July and August 2023 were also above their respective monthly averages however June 2024 was 0.14°C below its monthly average. (BOM, 2024b). Monthly rainfall across the state was below average for July, August and Spring 2023 however, rain increased during summer 2023-24 where 15.0% above average rainfall was received in NSW. The above average rainfall continued into Autumn and July 2024 where 1.3% for the season and 8.5% for July above average rainfall was received. (BOM, 2024b)

EA NSW's Total Active Storage (TAS) had a net increase of 287 ML for the 12 months ending 30 June 2024. The Total Active Storage remained above the drought trigger level throughout the 2023-24 reporting period. Daily dam release requirements at Lake Lyell have therefore remained at fully variable translucent flows, with the exception of planned outages and during periods when the dam spilled. Lake Lyell spilled for just under half of the 2023–24 reporting period, only releasing water intermittently for dam safety works and environmental requirements. Lake Wallace spilled continuously. On 8 September 2023, the TAS reached its highest capacity, Lake Lyell was at 96.7% capacity, Thompsons Creek Reservoir (TCR) 94.24% capacity and Lake Wallace was above full capacity, i.e. spilling.

EA NSW's water allocation from the Fish River Water Supply Scheme (FRWSS) was 100% allocation during the 2023-24 reporting period, with Oberon Dam starting the reporting period at 100% capacity. EA NSW's actual consumption of water from the FRWSS was 930 ML, which equates to approximately 8.8% of the full annual allocation. 2.61 ML was sourced from the Duckmaloi Transfer Scheme.

The calculated water balance suggests an evaporative and system loss (including spill) of 23,664 ML for the year, using the calculation procedure provided in Section 5.5. This is a substantial volume of water and approximately 32,156 ML may be attributed to Lake Lyell spilling and ungauged inflows from Jocks Creek recorded at Lithgow Gauge following significant rainfall events as mentioned above.

Routine water quality and River Health monitoring results are presented in Section 10 of this report. The ongoing event-based Geomorphology Study was not performed in the reporting period as the Annual Channel Maintenance Flow (ACMF) was not required as flows of greater than 800 megalitres per day (ML/day) were recorded at Lithgow Gauge (212011) on four separate occasions during the 2023-24 reporting period.

In summary, EA NSW has complied with the requirements of the WAL and the Approval for the 2023-24 water year.

1. Introduction and Background

EnergyAustralia NSW (EA NSW) owns one coal-fired power station providing a reliable supply of 24-hour base-load, peak demand and flexible electricity generation. The power station is located in the Western Region of the Hawkesbury-Nepean Catchment (**Figure 1-1**) Mt Piper Power Station (MPPS), located 25 km west of Lithgow and 5 km east of Portland, operates two units with a generating capacity of 700 and 730 megawatts.

The MPPS produces electricity using coal-fired steam turbine generators. Water is pumped into boilers and heated using coal-fire to produce steam. The steam, under high pressure, flows into a turbine, which spins a generator to produce electricity. The exhausted steam is then cooled and condensed back into water and returned to the boiler. A significant amount of water is evaporated in this cooling process. The water required for the operation of MPPS is supplied from the Coxs River Water Supply Scheme (CRWSS), the Fish River Water Supply Scheme (FRWSS) and the Springvale Mine Water Treatment Plant (SMWTP).

EA NSW use of water from the Coxs River is regulated by two regulatory instruments: a Water Access Licence (WAL) and a Water Supply Work and Water Use Approval (the Approval) issued under section 66 (1) (a) of the Water Management Act 2000. The water is allocated to EA NSW in accordance with the Greater Metropolitan Water Sharing Plan for Unregulated River Water Sources 2023 (the WSP).

The third and fourth five-year term review of the licence (from July 2010 to June 2015 and from July 2015 to June 2020, respectively) have been finalised between EA NSW and Natural Resource Access Regulator (NRAR), formerly known as NSW DPI Water as acknowledged by receipt of the updated WAL and Approval dated 24 March 2022. These reviews led to the reconsideration of EA NSW's Water Management scenarios, including the review of Operational and Monitoring requirements and the associated update of the Operations and Monitoring Manuals.

Figure 1-1 Western Region of the Hawkesbury Nepean Catchment (HNCMA, 2011)

This Annual Compliance Report has been prepared to address the requirements of condition DK5863-00039 of the Approval and relevant conditions of the WAL. It reports compliance against the conditions for the 12-month period of July 2023 to June 2024.

The required Water Quality and River Health monitoring reports are summarised within Section 10 of this report and are provided within Appendices C, F and G.

1.1 Coxs River Water Supply Scheme

The CRWSS was developed for the upper Coxs River catchment (**Figure 1-2**) to ensure an adequate supply of water for the operation MPPS and former Wallerawang Power Station (WPS). The location and various elements of MPPS, WPS and the CRWSS is shown in **Figure 1-3, Figure 1-4** and **Figure 1-5, Figure 1-6** depict the location of the flow measuring devices used at Mt Piper Power Station.

The CRWSS comprises Lake Lyell and Lake Wallace on the Coxs River and Thompsons Creek Reservoir (TCR) on a tributary of the Coxs River. A pipeline enables the transfer of water from Lake Lyell to MPPS via TCR.

The combined active storage volume across the three reservoirs (Lake Lyell, Lake Wallace and TCR) peaked in June 2012 when the Total Active Storage (TAS) reached 100%. The TAS exceeded 50,000 megalitres (ML) in October 2011, which deactivated the drought trigger, and has remained above drought trigger level since November 2011 (Appendix A2). It is noted that the maximum TAS levels reached in previous years were 25,573 ML in 2009/10, 49,080 ML in 2010/11, 61,580 ML in 2011/2012, 61,580 ML in 2012/2013,61,211 ML in 2013/14, 61,345 ML in 2014/15, 61,742 ML in 2015/16, 61,898 ML in 2016/17, 57,178 ML in 2017/18, 55,715 ML in 2018/19, 59,665 ML in 2019/20, 59,665 ML in 2020/2021, 61,079 in 2021/22 and 61.879 ML in 2022/23. The maximum TAS reached in the 2023/24 water year was 59,921 ML on the 8th September 2023.

1.1.1 **Lake Lyell**

Figure 1-2 Upper Coxs River Sub-Catchment (HNCMA, 2011)

Lake Lyell has a TAS of 32,109 ML and a total capacity of 34,192 ML. Water from Lake Lyell is transferred using up to three (3) pumps with a combined design flow of 95 ML per day through a 750 mm rising main to a surge tank and valve house. From the surge tank water is pumped to TCR via a 1,200 mm diameter pipe and diversion valve house. From there it is gravity-fed through two 750 mm diameter pipes, and down to two 600 mm diameter pipes directly to MPPS.

The main tributaries upstream of Lake Lyell are:

- Farmers Creek
- Marrangaroo Creek
- Pipers Flat Creek (influenced by Wallerawang Sewage Treatment Plant), and
- Thompsons Creek.

Lake Lyell is downstream of the other two reservoirs in the water supply scheme, having a catchment area of 380km^2 which is a multi-use catchment including widespread grazing, forestry, coal mining and urban and industrial use. It is also used for trout fishing and water skiing but is prone to blue-green algae (BGA) blooms which may limit the public amenity of the Lake.

Water levels in Lake Lyell remained above 771m Relative Level (RL) throughout 2023-24, which is the level determined safe for public amenity and recreation. There were no occasions of red alert at Lake Lyell for BGA during the reporting period. All BGA alerts for Lake Lyell for the reporting period are outlined in **Table 1-1**

Table 1-1 Blue-green Algae Alerts- Lake Lyell 2023 - 2024

Date	BGA Alert Type - Lake Lyell			
	Red	Amber	Green	None
	≥50,000 cells/mL *M aeruginosa* or ≥ 10 mm³/L	≥ 0.4 - < 4.0 mm³/L	>0.04 - <0.4 mm³/L	0 - 0.04 mm³/L
1 Jul – 4 Jul 2023				
5 Jul – 25 Jul 2023				
26 Jul – 6 Dec 2023				
7 Dec 2023 – 10 Jan 2024				
11 Jan – 14 Feb 2024				
15 Feb – 6 Mar 2024				
7 Mar – 2 Apr 2024				
3 Apr – 15 Apr 2024				
16 Apr – 4 Jun 2024				
5 Jun – 27 Jun 2024				
27 Jun – 30 Jun 2024				

* mm^3/L refers to cubic millimetres of biovolume equivalent (all present cyanobacteria) per litre

The drought trigger was deactivated in October 2011 which has continued as the TAS has exceeded 50,000 ML. This resulted in the requirement for variable translucent environmental flows from Lake Lyell which continued throughout 2023-24 water year, except for periods when the dam was spilling or the release valves were closed due to planned maintenance. Refer to Section 2.1 for additional information.

1.1.2 **Lake Wallace**

Lake Wallace was constructed on the Coxs River to supply water to WPS and has an operating capacity of 2,206 ML and a total capacity of 4,004 ML. Water was historically extracted from Lake Wallace using up to three (3) pumps with a total capacity of 40 ML per day, before the gravity assisted transport of water to WPS. When extraction from Lake Wallace exceeded inflows, water could be pumped from Lake Lyell to retain the water level above the minimum operating level of 870.42 mASL.

WPS was sold by EA NSW on 15th September 2020 but was not removed from EA NSW's Approval until 23 March 2022. No water was extracted (gross) from Lake Wallace by the power station with zero net extraction from the CRWSS for use in WPS due to the non-operational status of the power station.

The Lake is used by the local community for non-motorised boating and other recreational activities. Lake Wallace had one (1) period of an Amber Alert level for BGA during the reporting period. All BGA alerts for Lake Wallace for the reporting period are outlined in **Table 1-2** below.

Table 1-2 Blue-green Algae Alerts- Lake Wallace 2023 – 2024

Date	BGA Alert Type - Lake Wallace			
	Red	Amber	Green	None
	≥50,000 cells/mL *M aeruginosa* or ≥ 10 mm^3/L	≥ 0.4 - < 4.0 mm^3/L	>0.04 - <0.4 mm^3/L	0 - 0.04 mm^3/L
1 Jul 2023 – 13 Feb 2024				
14 Feb – 6 Mar 2024				
7 Mar – 2 Apr 2024				
3 Apr – 30 Apr 2024				
1 May – 4 June 2024				
5 June – 30 June 2024				

* mm^3/L refers to cubic millimetres of biovolume equivalent (all present cyanobacteria) per litre

1.1.3 **Thompsons Creek Reservoir**

TCR has a capacity of 27,245 ML and supplies MPPS via gravity-feed. This reservoir is considered off-stream storage as it has a minor catchment of less than 10km^2. EA NSW's general strategy is to maintain the level of TCR close to its Low Operating Level (1031.61 mAHD) to maintain sufficient capacity to store periodic transfers and any elevated rainfall events. The TAS volume increased from 25,029 ML (91.9%) at the beginning of the 2023-24 water year to its highest of 26,331 ML or 96.6% in October 2023. Riparian releases from TCR were adjusted throughout the reporting period to maintain a safe operating level while meeting environmental flow requirements. The yearly average TAS of TCR was 92.2% or 25,127 ML. Limited trout fishing is the only recreational activity permitted, with the dam classified as a Trophy Trout Dam (DPI, 2011). No boats are permitted on the reservoir, nor is there public vehicle access to the reservoir. An emergency discharge occurred from TCR Pipers Flat Creek outlet valve during the reporting period and is discussed in more detail in section 3.1.2.

1.1.4 **Sawyers Swamp Creek Ash Dam**

SSCAD was previously owned and operated by EA NSW which was sold to Generator Property Management (GPM) in September 2019 and removed from EA NSW's Approval on 23 March 2022. Incidental water take from SSCAD from the catchment area in its immediate vicinity has historically been accounted for as part of EA NSW WAL10AL116411. Following the sale of the SSCAD for closure and rehabilitation purposes, EA NSW acknowledge that up to 300ML incidental water take should still apply to SSCAD until the site is fully rehabilitated and free draining.

For the purpose of preparing this report and EA NSW annual water entitlements, EA NSW still considers the incidental take of up to 300ML associated with SSCAD as applying to is annual water allocation. EA NSW will continue to deduct this annual water take at SSCAD from its allocation while additional administrative arrangements are implemented with GPM.

1.2 Other Water Supplies

1.2.1 Fish River Water Supply

EA NSW is a major customer of the FRWSS and has an annual allocation of 8,184 ML. The FRWSS is comprised of a 45 GL storage dam at Oberon and a 20 ML weir on the Duckmaloi River. Both the Dam and weir are connected to the Stage 2 system, supplying EA NSW via a 370 ML reservoir at Rydal.

Due to the high quality of water from the FRWSS, this water is more suitable than alternate water supplies for domestic, fire services and boiler feedwater, and at this time is critical to EA NSW's operations. The dependence of other consumers on the FRWSS is acknowledged, and hence use of this water source is minimised wherever possible during low rainfall years, and EA NSW's allocation is restricted according to the level at Oberon Dam.

The water year started with EA NSW's FRWSS allocation remaining at 100% from the 2022-23 water year and only dropped slightly below this to a low of 96.1% but returned to 100% capacity before the end of the reporting period. EA NSW's actual consumption of water from the FRWSS was 930 ML, which equates to approximately 8.8% of the full annual allocation. 2.61 ML was sourced from the Duckmaloi Transfer Scheme.

1.2.2 **Springvale/Angus Place Mine Water**

On 19 June 2017, Springvale Coal Pty Ltd was granted State Significant Development Approval SSD7592 for the development of the SMWTP. The SWMTP has since been constructed and supplies treated mine water to MPPS. It is designed to treat raw mine water transferred from the Springvale Mine and provide an additional source of fresh water to MPPS, for use in the station's cooling water system. The SMWTP is approved to process up to 15,330 ML/yr (42 ML/day) and, with a recovery rate of 94%, produce a maximum of 14,410 ML of treated water per year. Operations at the SMWTP commenced in December 2019, with a total of 5,958.9 ML of treated water used at MPPS during the 2023-24 reporting year.

Angus Place Mine Water (AP800) transfer pipeline finished construction in 2021 and is approved to transfer up to 2.6ML/Day of mine water to MPPS under Development Consent 06_0021. During the 2023-24 reporting period 882.8 ML was transferred to MPPS.

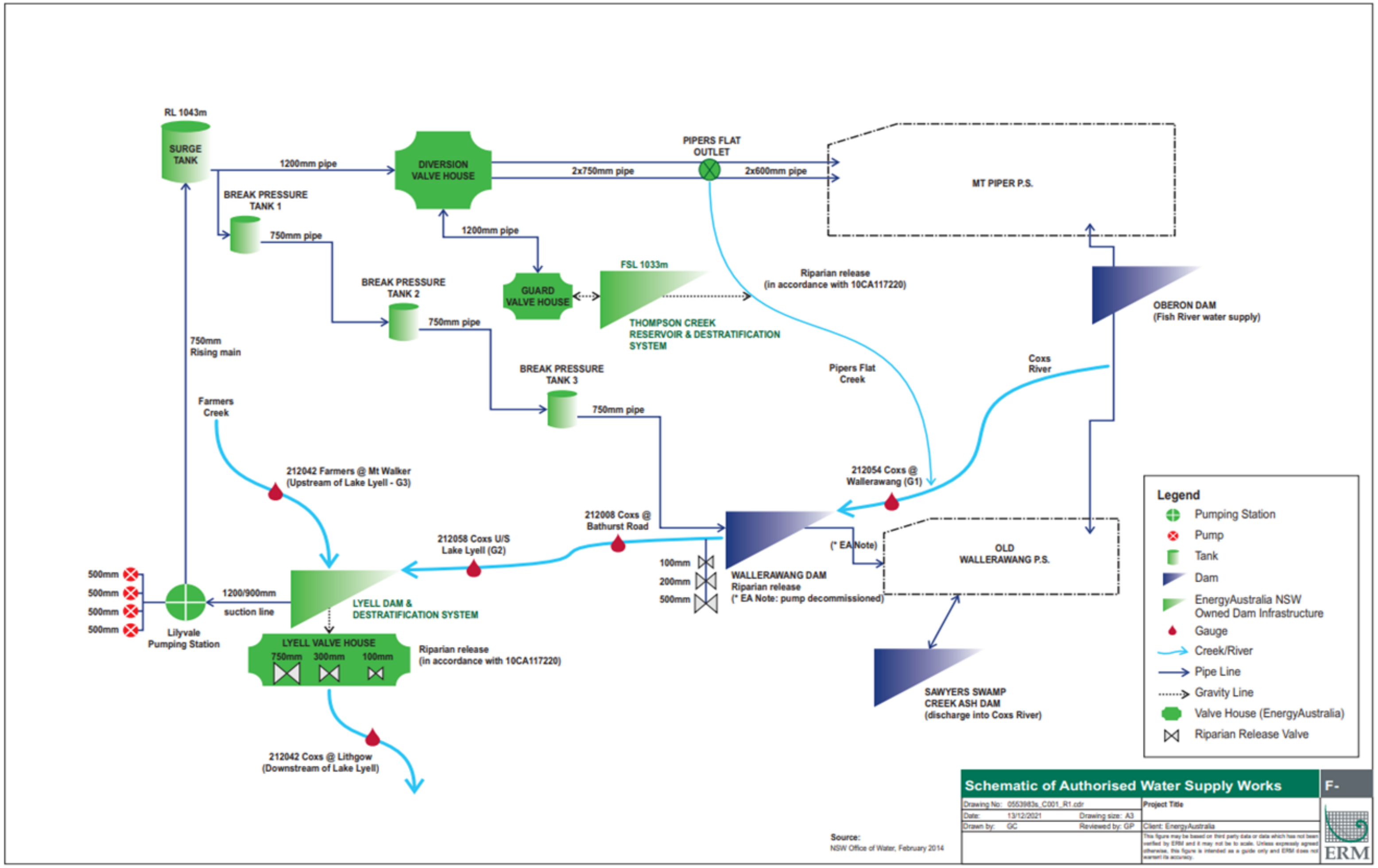

Figure 1-3 Locality Schematic, including Coxs River Water Supply Scheme

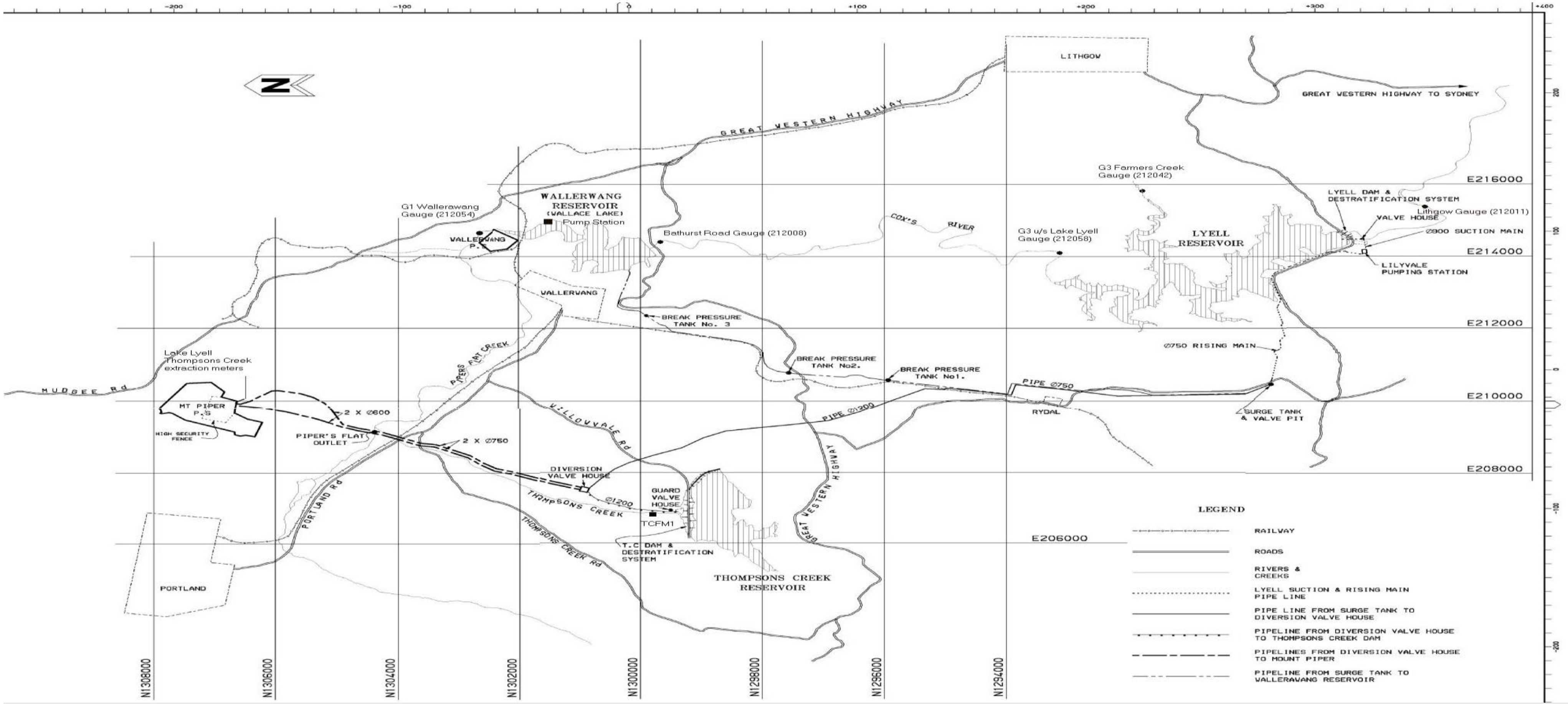

Figure 1-4 Coxs River Water Supply Scheme Schematic including stream gauging stations and extraction meters. Refer Figure 1-5 for detailed flow diagram.

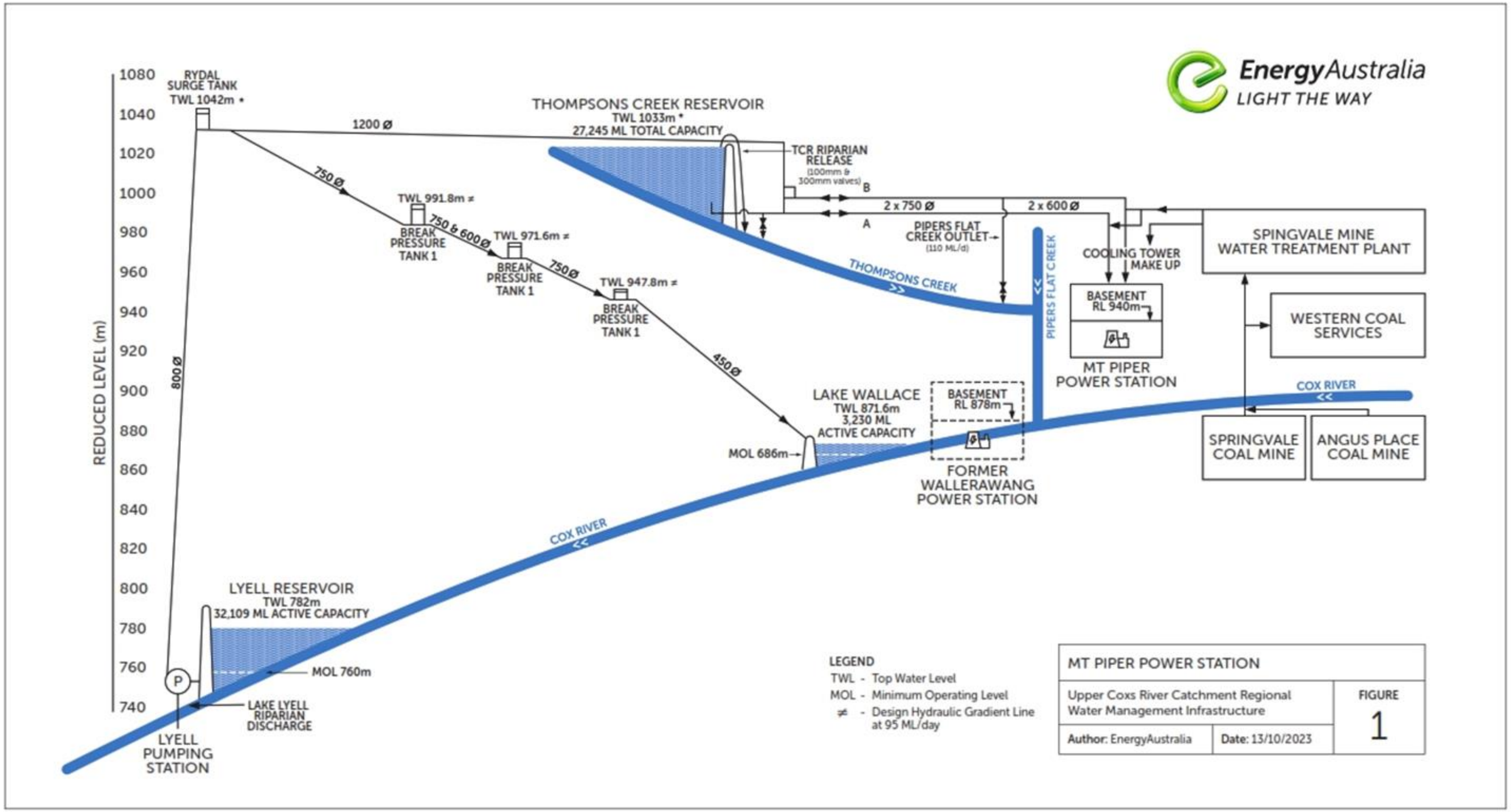

Figure 1-5 Coxs River Water Supply Scheme flow diagram.

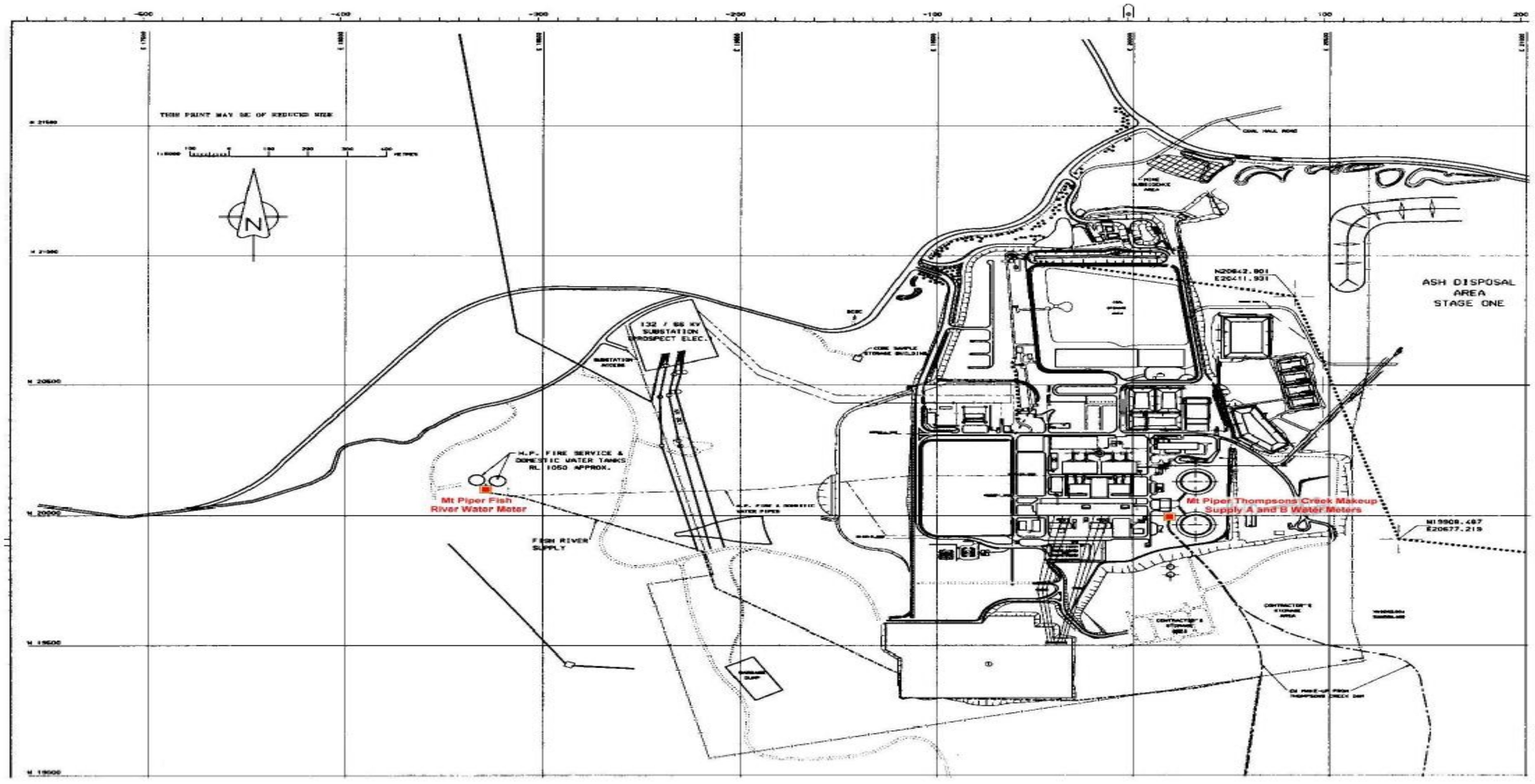

Figure 1-6 Flow measuring devices at Mt Piper Power Station

2. Dam Flow Releases

2.1 Dam Flow Data 2023-24

The requirements for dam flow releases from Lake Lyell under Section 57H of the WSP, contain provisions for:

- Translucent flows – When the daily volume of natural inflows into Lake Lyell is greater than 13.6 ML/day, the volume of water that is released from Lake Lyell is 13.6 ML/day plus 25 per cent of the natural inflow volume above 13.6 ML/day.
- Transparent flows – When the daily volume of natural inflows into Lake Lyell is less than or equal to 13.6 ML/day, the volume of water released from Lake Lyell is equivalent to the natural inflow volume.
- Drought triggers – When the TAS in Lake Lyell, Lake Wallace and TCR is less than 50,000 ML, the volume of water released from Lake Lyell is equivalent to the natural inflow volume up to a maximum of 9.0 ML/day. If this situation has existed for a continuous six-month period, the volume of water released from Lake Lyell is equivalent to the natural inflow volume up to a maximum of 5.0 ML/day.
- Annual Channel Maintenance Flow (ACMF) – Ensures that within any continuous 12-month period there is at least one flow event of at least 800 ML/day (for a minimum period of one hour) at the Lithgow Gauge when not in drought trigger.

The conditions for the delivery of dam flows (transparent flow, translucent flow, ACMF, and drought triggers) are included in the EA NSW Operating Protocol Manual. These conditions have been incorporated into the spreadsheets EA NSW uses to record weekly data on Environmental Flows.

The ‘As Released’ spreadsheet (Appendix A1) is used for the daily calculation of release requirements from Lake Lyell, while the ‘Corrected and Verified’ spreadsheet (Appendix A2) is updated to include final and corrected data for the stream gauging stations and EA NSW’s flow meters at the end of the reporting period.

From the Corrected and Verified data, it is noted that:

- The calculated natural inflow to Lake Lyell for 2023-24 was 37,811 ML, with a total flow of 39,263 ML recorded for the period downstream at Lithgow Gauge.
- The dam release requirement for the 12-month period according to the ‘As Released’ spreadsheet was 5,334 ML, with 7,107 ML actively released via the environmental flow valves. This discrepancy is mainly due to over releasing to lower the water level below the spillway. Between 4 September and 21 November 2023 4,143.6 ML was actively released through the riparian valves, 1,605.1 ML additional to the 2,563 ML that was required. This was due to the lowering of the dam level for concrete spillway maintenance works and high inflows. In addition, limitations in the operation of the 100mm, 300mm and 750mm valves resulted in occasions when a release in excess of what was required occurred.
- There were several occasions when the dam commenced spilling and the required flows were achieved the following day with spill volume rather than environmental flow. The volumes observed at Lithgow Gauge during these events are detailed in (**Figure 2-3**). During periods where Lake Lyell was spilling, all release valves were closed. The following spill volumes have been recorded at Lithgow Gauge and include inflows from the ungauged Jocks Creek tributary:
    - 2,194.7 ML from 15 August to 2 September 2023;
    - 598.1 ML from 3 December to 7 December 2023;
    - 7,452.3 ML from 20 December to 29 January 2024;
    - 38.4 ML and 37.8 ML on 31 January and 3 February 2024 respectively;
    - 1,951.2 ML from 6 February to 20 February 2024;
    - 41.5 ML on 24 February and 128.0 ML from 26 to 27 February 2024;
    - 14,253.8 ML from 5 April to 30 June 2024

Section 57H sub-clause 3 of the WSP provide the definition for the ACMF. The ACMF is considered to be an event in which at least one flow of 800 ML/day or greater is recorded in the Coxs River, at the Lithgow Gauge (212011), for a minimum period of one hour within any continuous 12-month period. If this level of flow does not occur in any given period, EA NSW is required to produce an artificial ACMF by creating the lesser of a flow of 800 ML/day, or the maximum rate obtainable from the Lake Lyell outlet valves when fully open, for a minimum continuous period of 2 hours as soon as practicable, in accordance with relevant protocols.

As detailed within Section 3.2.1 of the Operating Protocol Manual, the basic triggers for an artificial ACMF release are based on hourly total flows recorded at two gauging stations upstream of Lake Lyell during the last 24 hours at the time of polling. The following states the triggers adopted:

- A flow greater than 600 ML/day recorded at G3 – Farmers Creek at Mt Walker gauge (212042) for 2 consecutive hours; and
- A flow above 300 ML/day recorded at G1 – Coxs River at WPS gauge (212054) for 2 consecutive hours.

Despite high inflows at Stream Gauges G1 and G3 which were sufficient to trigger an ACMF release during the 2023-24 water year, the ACMF was not required due to significant spill volumes released from Lake Lyell with the following observed at Lithgow Gauge:

- Maximum flow rates exceeded 800 ML/day continuously from 21 to 22 December 2023, 5 January 2024, 18 to 20 January 2024, 6 to 8 April 2024
- The maximum flow rate recorded during these periods were respectively 2,282 ML/day on 21 December 2023, 919.9 ML/day on 5 January 2024, 1,161 ML/day on 19 January 2024, 4,272 ML/day on 7 April 2024

The above spills were again contributed to by the ungauged tributary, Jocks Creek and adequately cover the rate of flow required for ACMF under the WAL. According to Section 57H sub-clause 3 of the WSP, the next ACMF will be due during the 2024-25 water year unless the flow rate at Lithgow Gauge exceeds 800 ML/day.

The drought trigger, which had been active since 11 March 2002, was deactivated briefly on 10 October 2011. The TAS then dropped back below 50,000 ML reactivating the drought trigger. On the 20 November 2011, the drought trigger was deactivated and has remained deactivated throughout the 2023-24 reporting period **Figure 2-1.**

Overall compliance with the WAL Conditions and the Approval can be found in Section 11.

2.1.1 **Dam Levels**

The TAS level in the combined reservoirs showed a net increase of 288 ML from 1 July 2023 to 30 June 2024, a percentage increase of approximately 0.5%. A maximum level of 59,921 ML was reached in September 2023 with Lake Wallace spilling and TCR and Lake Lyell at approximately 99.7% and 99.6% capacity respectively. The reporting year ended with Lake Wallace and Lake Lyell spilling and TCR at approximately 93.9% capacity. The system was at 97.3% TAS at the end of the 2023-24 water year.

2.1.2 **Compliance**

The dam flows released from Lake Lyell during July 2023 to June 2024 essentially complied with the requirements of the Approval, and while the following issues were observed, 23,664 ML of excess water was released from Lake Lyell:

- On the 2 July 2023, a cumulative under-release of 1.4 ML was accrued as a result of the required adjustment to the environmental flow not being made. The banked releases were recouped as part of the regular adjustment of the 300mm valve in accordance with normal protocol until the banked release had been returned to zero on 3 July 2023.
- On the 11 July 2023, a cumulative under-release of 1.7 ML was accrued as a result of the required adjustment to the environmental flow not being made. The banked releases were recouped as part of the regular adjustment of the 300mm valve in accordance with normal protocol until the banked release had been returned to zero on 18 July 2023.
- On the 21 July 2023, a cumulative under-release of 3.9 ML was accrued as a result of the required adjustment to the environmental flow not being made. The banked releases were recouped as part of the regular adjustment of the 300mm valve in accordance with normal protocol until the banked release had been returned to zero on 23 July 2023.
- On the 28 July 2023, a cumulative under-release of 2.8 ML was accrued as a result of the required adjustment to the environmental flow not being made. The banked releases were recouped as part

of the regular adjustment of the 300mm valve in accordance with normal protocol until the banked release had been returned to zero on 29 July 2023.

- On the 13 August 2023, a cumulative under-release of 8.7 ML was accrued as a result of real-time (instantaneous) water data being used for some inflow gauges at the time of environmental flow calculation, instead of polling (Hydstra) data. The under-release was noted upon update of the calculations with the polled data. The banked releases were recouped as part of the regular adjustment of the 300mm valve in accordance with normal protocol until the banked release had been returned to zero on 15 August 2023.
- On the 4 September 2023, a cumulative under-release of 2.2 ML was accrued as a result of the required adjustment to the environmental flow not being made. The banked releases were recouped as part of the regular adjustment of the 300mm valve in accordance with normal protocol until the banked release had been returned to zero on 5 September 2023.
- On the 30 September 2023, a cumulative under-release of 3.0 ML was accrued as a result of real-time (instantaneous) water data being used for some inflow gauges at the time of environmental flow calculation, instead of polling (Hydstra) data. The under-release was noted upon update of the calculations with the polled data. The banked releases were recouped as part of the regular adjustment of the 300mm valve in accordance with normal protocol until the banked release had been returned to zero on 1 October 2023.
- On the 5 October 2023, a cumulative under-release of 13.9 ML was accrued as a result of real-time (instantaneous) water data being used for some inflow gauges at the time of environmental flow calculation, instead of polling (Hydstra) data. The under-release was noted upon update of the calculations with the polled data. The banked releases were recouped as part of the regular adjustment of the 300mm valve in accordance with normal protocol until the banked release had been returned to zero on 7 October 2023.
- On the 14 October 2023, a cumulative under-release of 16.2 ML was accrued as a result of real-time (instantaneous) water data being used for some inflow gauges at the time of environmental flow calculation, instead of polling (Hydstra) data. The under-release was noted upon update of the calculations with the polled data. The banked releases were recouped as part of the regular adjustment of the 300mm valve in accordance with normal protocol until the banked release had been returned to zero on 19 October 2023.
- On the 5 November 2023, a cumulative under-release of 7.4 ML was accrued as a result of the required adjustment to the environmental flow not being made. The banked releases were recouped as part of the regular adjustment of the 300mm valve in accordance with normal protocol until the banked release had been returned to zero on 6 November 2023.
- On the 9 December 2023, a cumulative under-release of 17.4 ML was accrued as a result of communications issues with the 300mm riparian valve remote connection. The banked releases were recouped as part of the regular adjustment of the 300mm valve in accordance with normal protocol until the banked release had been returned to zero on 14 December 2023.
- On the 16 December 2023, a cumulative under-release of 2.9 ML was accrued as a result of the required adjustment to the environmental flow not being made. The banked releases were recouped as part of the regular adjustment of the 300mm valve in accordance with normal protocol until the banked release had been returned to zero on 17 December 2023.
- During March 2024 there were intermittent missing values from the polling (Hydstra) water data used to calculate the releases. The under releases were 9 ML on 3 March, 4.9 ML on 6 March, 9.8 ML on 9 March and 2 ML on the 11 March. The banked releases mentioned were recouped the following day they occurred as part of the regular adjustment of the 300mm valve in accordance with normal protocol.

2.2 Comparison of 2023-24 with 2000-20

2.2.1 Background

There is a requirement to compare the releases in 2023-24 with those releases since the issue of the licence on 1 July 2000 (refer to **Table 2-1**). During the 12-month period, July 2000 to June 2001, the following provisions applied under the historic Water Management Licence (WML) for the release of dam flows from Lake Lyell:

- 1 July 2000 to 31 December 2000, the 100mm valve was to be fully open which corresponds to a release of approximately 6.5 ML/day.

It should be noted that there was no measurement of dam flow releases from Lake Lyell in 2000-2001 due to the lack of suitable instrumentation. This was the case up until an in-line flow meter was trialled in December 2001 and agreed to by the (then) Department of Land and Water Conservation (DLWC) on 10 January 2002.

As river flows are determined by inflows from surface runoff and groundwater seepage, rainfall should be considered when comparing flows from different years. The rainfall at Lithgow (BOM Site No. 063226 from 2006) for these years is provided within **Table 2-2**

The total rainfall for the 2023-24 period of 917.6 mm was above the long-term average for Lithgow of 792.2 mm/yr (BOM, 2024a) and above the short-term average rainfall of 765mm for the Lithgow area over the 2000 – 2015 period (**Figure 2-1** and **Figure 2-4**).

The total annualised rainfall for Lithgow of 917.6 mm was 15.8% above the long-term average (BOM, 2024a). Above average rainfall events were observed for 6 of the 12 months of the 2023-24 water year, July, August, September, October 2023, February and March 2024 were months where below average rainfall was received. Monthly rainfall across the state was below average for July, August and Spring 2023 however rain increased during summer 2023-24 where 15.0% above average rainfall was received in NSW. The above average rainfall continued into Autumn and July 2024 where 1.3% for the season and 8.5% for July above average rainfall was received. The reporting period started off with below average rainfall across the state for July to October the November to February portion of the reporting period had increase rainfall with NSW receiving above average rainfall during those 4 months. March was drier with below average rainfall but the remainder of the reporting period (April to June) had above average rainfall (BOM, 2024b)

Table 2-1 Annual Flow data Since July 2000

Period	Actual Release (ML)	Maximum Instantaneous Flow at Lithgow Gauge (ML/day)	Total Flow at Lithgow Gauge (ML)
2000 – 2001	2,373*	134**	3,571**
2001 – 2002	6,422	74	6838
2002 – 2003	2,120	39	2,414
2003 – 2004	1,830	51	1,966
2004 – 2005	2,075	1,799	4,323
2005 – 2006	1,991	3,466	4,432
2006 – 2007	1,786	2,819	11,422
2007 – 2008	1,889	708†	8,436
2008 – 2009	1,990	270	3,238
2009 – 2010	1,963	335	3,021
2010 – 2011	5,641	7,113	22,119
2011 – 2012	8,668	16,552	71,790
2012 – 2013	6,054	4,234	27,831
2013 – 2014	9,235	699	13,716
2014 – 2015	8,414	2,304	17,367
2015 – 2016	9,788	717	17,979
2016 – 2017	6,447	2,188	43,028
2017 – 2018	11,087	869	9,818
2018 – 2019	10,218	718	8,675
2019 – 2020	10,862	781	11,633
2020 – 2021	7,589	5,523	60,454
2021 – 2022	6,314	7,817	116,893
2022 – 2023	23,683.7	11,512	125,271
2023 – 2024	7,107.1	4,271.5	39,263

* Estimated release as described earlier in this section.
** Data available from 1 January 2001 only.
† Value erroneously reported as 706 ML/day in 2007-08 report

Table 2-2 Annual rainfall at Lithgow since July 2000

12 Month period	Rainfall at Lithgow (mm)
Jul 2000 – Jun 2001	792.6
Jul 2001 – Jun 2002	780.4
Jul 2002 – Jun 2003	446.2
Jul 2003 – Jun 2004	636.6
Jul 2004 – Jun 2005	859.8
Jul 2005 – Jun 2006	703.7
Jul 2006 – Jun 2007	863.8
Jul 2007 – Jun 2008	721.7
Jul 2008 – Jun 2009	849.3
Jul 2009 – Jun 2010	733.3
Jul 2010 – Jun 2011	970.9
Jul 2011 – Jun 2012	1025.4
Jul 2012–Jun 2013	766.1
Jul 2013–Jun 2014	558.0
Jul 2014-Jun 2015	818.0
Jul 2015-Jun 2016	697.8
Jul 2016-Jun 2017	816.4
Jul 2017-Jun 2018	492.8
Jul 2018 – Jun 2019	787.0
Jul 2019 – Jun 2020	652.4
Jul 2020 – Jun 2021	973.5
Jul 2021 – June 2022	1,272.4
Jul 2022 – June 2023	1,081.4
July 2023 – June 2024	917.6

2.2.2 Comparison

The following is evident when evaluating the information provided in section 2.2.1

- Translucent dam releases were required for the first time since 2000-02, in 2011-12 continuing through the 2023-2024 period resulting in greater flow variability downstream of Lake Lyell than has been experienced throughout the previous 10 years.
- Lake Lyell spilled for just under half of the 2023-2024 water year. The TAS remained above 90% during the 2023-24 water year but varied between 92% capacity to 97% storage capacity. As such the variable flows recorded at the Lithgow Gauge were influenced only by translucent dam releases, with approximately 23,664 ML of excess water being released via environmental flows or spill volume.
- Above average total rainfall was observed for the 2023-24 water year comparable to both the short-term and long-term averages (**Figure 2-4**). Rainfall generally remained below average for first quarter of the 2023-24 water year and increased in the middle to second half of the reporting period. Rainfall varied greatly throughout the reporting period with rainfall being 82.0% below average in July 2023 and 101.52% above average in November 2023.
- The total flow observed at the Lithgow Gauge during the 2022-23 water year was the sixth highest on record since July 2000, with maximum flow rates the sixth highest on record since July 2000.

Figure 2-2 indicates the degree of variability of flows at the Lithgow gauge site for 2023-24; whilst **Figure 2-3** shows the degree of variability of in-flows into Lake Lyell from the three gauges upstream of Lake Lyell, i.e. upstream of Lake Wallace (G1), Farmers Creek at Mt Walker (G3) and Upstream of Lake Lyell (G2).

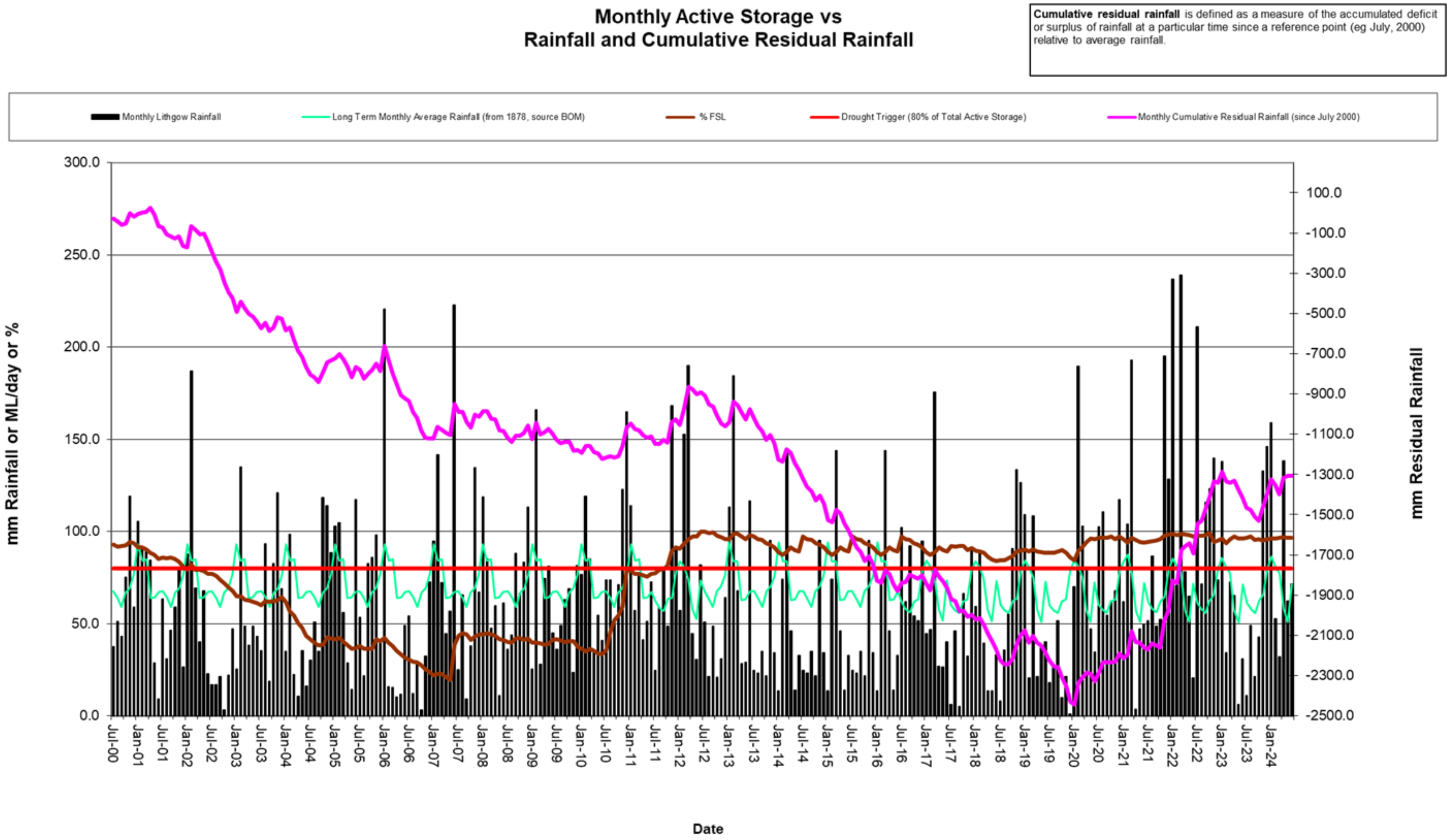

Figure 2-1 Monthly Active Storage Level, Rainfall and Cumulative Residual Rainfall July 2000 to June 2024

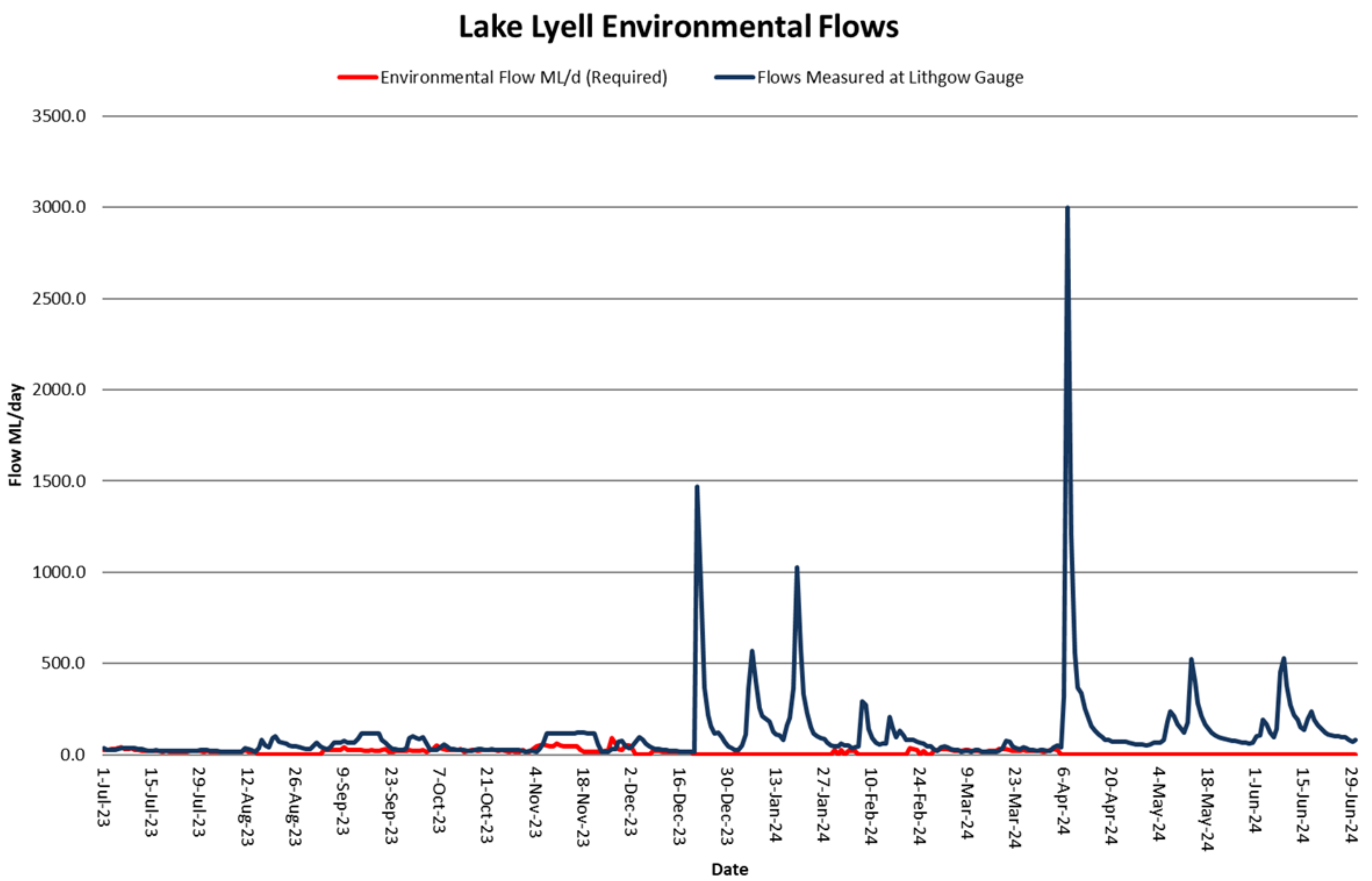

Figure 2-2 Required dam releases and corrected and verified flows at Lithgow Gauge 2023-24

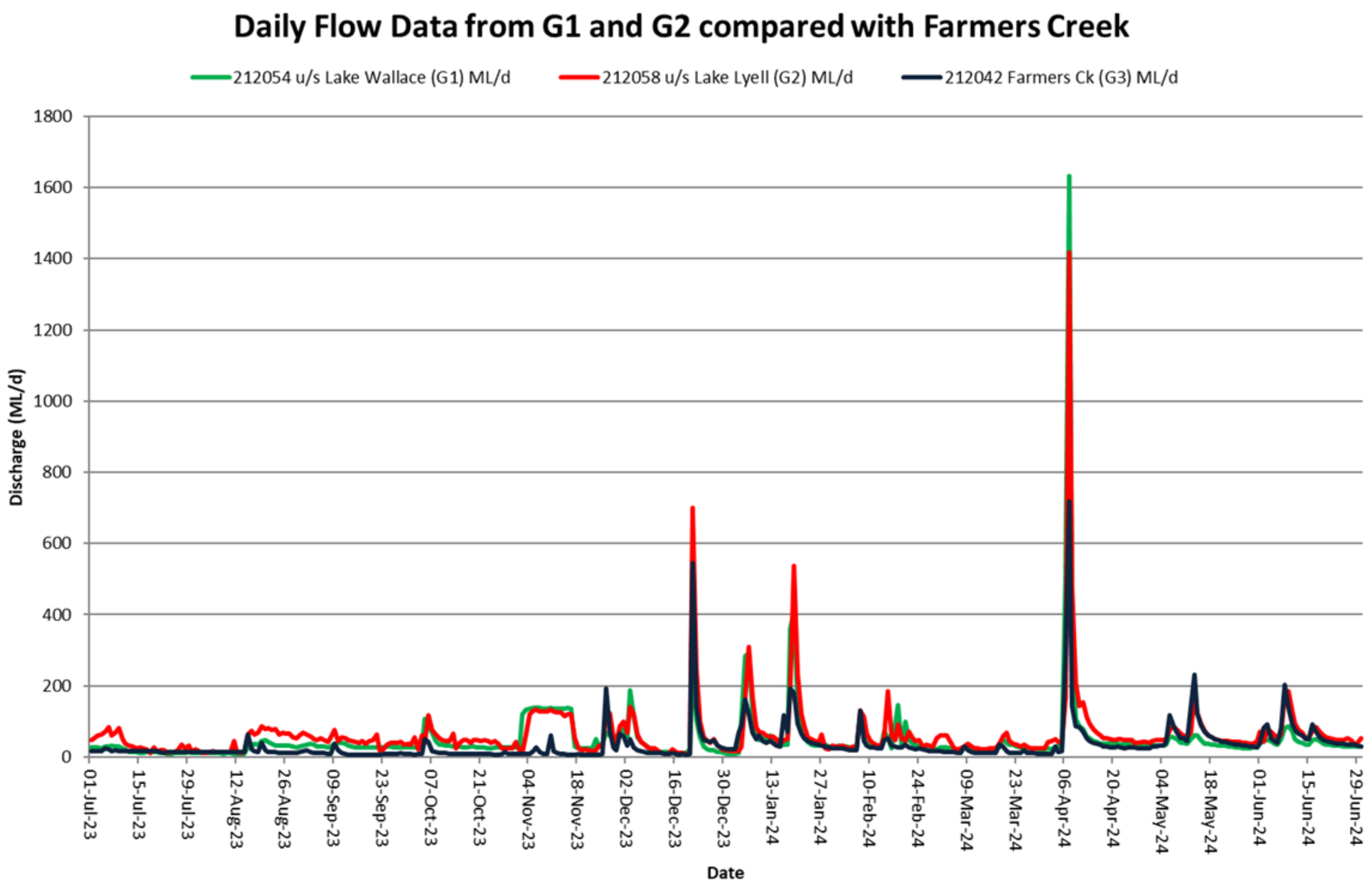

Figure 2-3 Daily Flow Data from Gauges Located at Wallerawang (Lake Wallace) and Upstream of Lake Lyell Compared to Farmers Creek during 2023-2024.

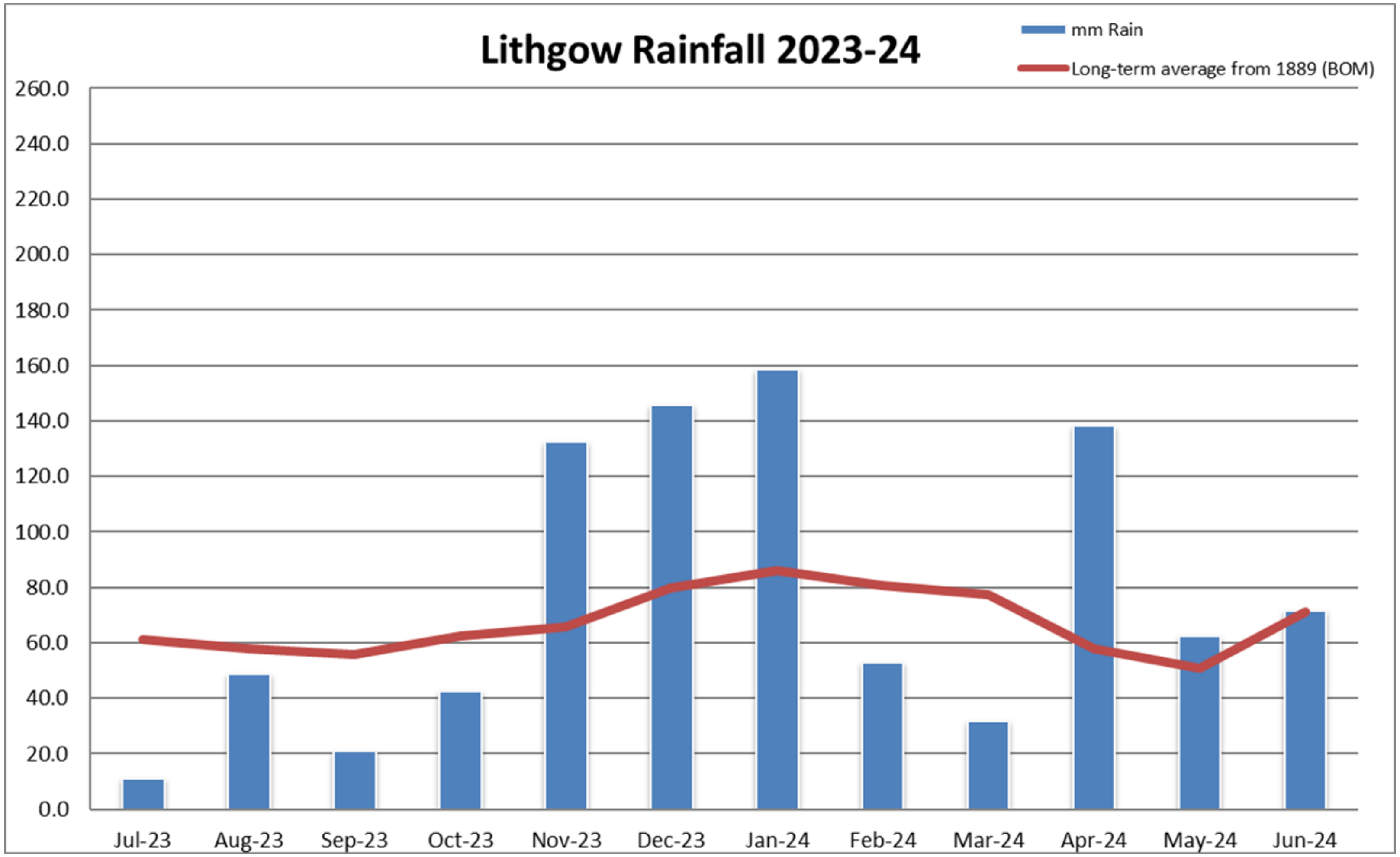

Figure 2-4 Rainfall distribution for Lithgow 2023-24

2.3 Comparison of 2023-24 with 1982-2000

It is a requirement of the WAL to compare the dam releases from Lake Lyell in 2023-24 with flows recorded at the Lithgow gauge during the period between completion of construction of Lilyvale Dam and commencement of the dam flow regime (i.e. from May 1982 to 30 June 2000).

Actual dam releases during the 1982-2000 periods were between 0.9 ML/day and 2.6 ML/day. The original surface water licence required a minimum 0.9 ML/day environmental flow and an irrigation allocation of 2.8 ML/day if required. There was a continuous release from Lake Lyell of 0.9 ML/day until 29 November 1995. After this date a simulated flood of 400 ML over three days was released followed by a baseline release of 2.6 ML/day.

The flows at the Lithgow gauge during the 2023-24 reporting period are shown with the required release from Lake Lyell in **Figure 2-2** above. Compared with historic flows and rainfall at the Lithgow gauge in **Table 2-3**, the following is evident:

- Peak flows at the Lithgow gauge for 2023-24 (4,271.5 ML/day) were below the average (7,607 ML/day) and below the median (4,388 ML/day) for the July 1982 – June 2000 maximum annual flows.
- The 2023-24 rainfall (917.6mm) was slightly higher than the average annual rainfall recorded for the 1982-2000 (910.4mm) period.
- The peak flows for 2022-23 were associated with periods when the dam was spilling and above average rainfall recorded in November 2023, December 2023, January 2024 and April 2024, as indicated in **Figure 2-2** and **Figure 2-3**.
- The highest annual flow in the 12-month periods that recorded rainfall within 20% of that observed in 2023-24 was the previous reporting period 2022-2023 with an annual flow of 125,271 ML (1,081.4 mm rainfall) compared with 39,263 ML (917.6 mm rainfall) in 2023-2024.

The average flow recorded for the 1982 – 2000 was 43,353 ML, with a median flow of 33,291 ML. Compared with the measured value of 39,263 ML for 2023-24, it is evident that flows in the current reporting period were approximately 9.4% lower than the average and approximately 17.9% higher than the median flow recorded in 1982 – 2000.

Table 2-3 Rainfall data at Lithgow compared to Lithgow Stream Gauge for 1982 -2000 & 2011–2024

Period	Rainfall at Lithgow (mm)	Flow at Lithgow Gauge	
		Total (ML)	Maximum (ML/day)
1982 – 1983	704.2	2,729	241
1983 – 1984*	1,005.9	29,876	1,848
1984 – 1985*	895	36,705	6,896
1985 – 1986	675.4	23,517	1,689
1986 – 1987	1,234.2	106,392	38,188
1987 – 1988	1,132.4	38,955	4,603
1988 – 1989	1,261.6	143,613	10,082
1989 – 1990*	1,033.4	106,709	12,163
1990 – 1991*	916.7	113,921	24,967
1991 – 1992*	935.4	39,448	5,414
1992 – 1993*	787.4	5,158	673
1993 – 1994	701.2	4,514	541
1994 – 1995	725.6	3,553	548
1995 – 1996*	803.2	7,124	813
1996 – 1997*	806	25,377	4,173
1997 – 1998*	780	2,795	124
1998 – 1999*	898.5	43,811	18,491
1999 – 2000*	1,091.8	46,156	5,471
2011 – 2012*	1,025.4	71,790	16,552
2012 – 2013*	766.1	27,832	4,235
2013 – 2014	558.0	13,716	699
2014 – 2015*	818.0	17,367	2,304
2015 – 2016	687.8	17,979	717
2016 – 2017*	816.4	43,028	2,188
2017 – 2018	492.8	9,818	869
2018 – 2019*	787.0	8,675	718
2019 – 2020	652.4	11,633	781
2020 – 2021*	973.5	60,454	5,523
2021 – 2022	1,272.4	116,893	7,817
2022 – 2023*	1,081.4	125,271	11,512
2023 – 2024	917.6	39,263	4,272

*Rainfall within these periods is within 20% of the 2023-24 year; i.e. 734.08mm – 1,101.12mm.

2.4 Comparison of 2023-24 with 1960-1979

It is a requirement of the WAL to compare the dam releases from Lake Lyell in 2023-24 with flows recorded at the Lithgow gauge (Gauge Site Number 212011) prior to the construction of Lilyvale Dam (i.e. from June 1960 to May 1979).

Prior to the construction of the Lilyvale Dam, flows in Farmers Creek and Coxs River below Lake Wallace were recorded at the Lithgow gauge with no impediment to alter the flow in the river.

Detailed analysis of flows during this period have been undertaken previously, and evidence used in calculating natural flows, flow duration curves and flow variability. These analyses have found that flow data for 1960-79 had higher base flows and higher and more frequent medium range (>100 ML/day) flows than since July 2000.

The reasons for the high base flows and higher medium flows are:

- The period 1960 to 1979 is recognised as part of a flood dominated period with above average rainfall of 913mm/year
- The flow records are not corrected for unnatural inflows from the FRWSS via cooling tower blowdown and ash dam discharges to the Coxs River from WPS, STPs and Coal Mine groundwater discharges
- The CRWSS did not exist to provide water to WPS and MPPS
- There was no dam at Lilyvale, and as such the flows at the Lithgow gauge were affected by extractions by the WPS and the presence of a dam at Lake Wallace. Otherwise, the flows varied in concert with rainfall and other unnatural inflows
- The hydrographic response recorded at the Lithgow gauge was primarily due to the influence of flows from Jocks Creek

Notable rainfall events throughout the 2023-24 water year resulted in Lake Lyell spilling on several occasions. The following observations and results were recorded (**Figure 2-4** & Appendix A2):

- The 2023-24 period had a total rainfall of 917.6 mm.
- The minimum flow recorded at the Lithgow Gauge for the year was 14.5 ML/day (coinciding with low in-flows experienced in December 2023).
- The mean flow rate for the period was 107.3 ML/day, which is slightly higher than the long-term average of >100 ML/day recorded from 1960 – 1979 at the Lithgow gauge

3. Other Releases

3.1 Environmental Flows

The requirements for environmental flows for Lake Wallace and TCR are listed in Part 8A Section 57J sub-clauses 1 and 2 of the WSP respectively. The actual environmental flows for 2023-24 are summarised in **Table 3-1** below. The TCR V-notch environmental flows are represented graphically in **Figure 3-1** below.

Table 3-1 Environmental flow from Thompsons Creek Reservoir and Lake Wallace

Environmental Flow (ML/day)			
Dam	**Period**	**WAL Requirement**	**Average Actual release**
Thompsons Creek Reservoir	01 July 2023 to 31 August 2023	At least 0.3 ML/day	7.45 ML/day
	01 September 2023 to 30 April 2024	At least 0.8 ML/day	12.75 ML/day*
	01 May 2024 to 30 June 2024	At least 0.3 ML/day	10.27 ML/day
Lake Wallace	01 July 2020 to 15 September 2020	At least 0.7ML/day	Spilling for the entire water year
*Emergency release from Pipers Flat Creek outlet occurred from 1 November – 15 November 2023. The average release was 104.71 ML/day during this period from the Pipers Flat Creek outlet.			

3.1.1 **Thompsons Creek Reservoir Riparian Release**

Environmental flows from TCR are comprised of seepages from toe drains, releases from the environmental flow valves and surface runoff from the southern face of the dam wall, i.e. a total of seven v-notches measure flow. The combined “seepages” of the dam’s toe drains resulted in an average discharge of 0.73ML/day. When combined with the controlled releases from the environmental flow valve, 0.8 ML/day release can be achieved.

Environmental flows at Thompsons Creek Reservoir were implemented as required throughout the reporting period and assisted to maintain a safe operating level and provide enough capacity to hold excess water.

3.1.2 **Thompsons Creek Reservoir Emergency Discharge**

Following consistent high flows from the SMWTP to TCR during the 23-24 reporting period, the water level in TCR continued to approach the High Operating Level (1032.61 mAHD). Despite attempts by EnergyAustralia to reduce the water level through the riparian discharge valve, the inflow of water into TCR from the continuous volumes transferred from the SMWTP were greater than what could be released to the catchment. An emergency water release was implemented and coordinated by EnergyAustralia to release water from TCR via a known purpose build water discharge valve. The emergency water release involved discharging 1,549.8 ML of water which occurred over 15 consecutive days between Wednesday 1 November and Wednesday 15 November 2023. A letter report providing a summary of the emergency release of water from TCR was prepared and submitted to the EPA to satisfy the requirements of Condition E8.2 under EPL13007.

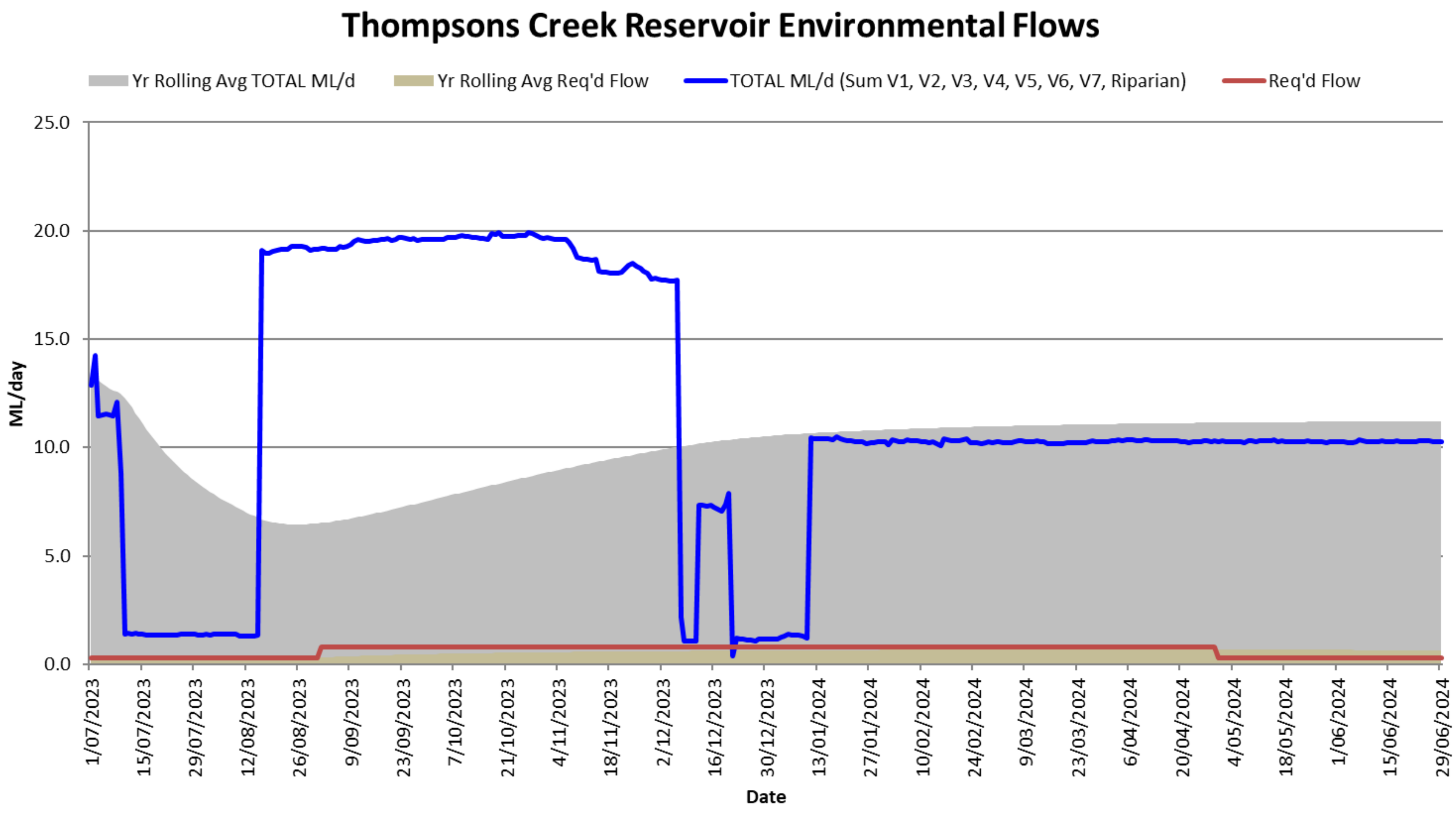

Figure 3-1 Thompsons Creek Reservoir Environmental Flows for 2023-24

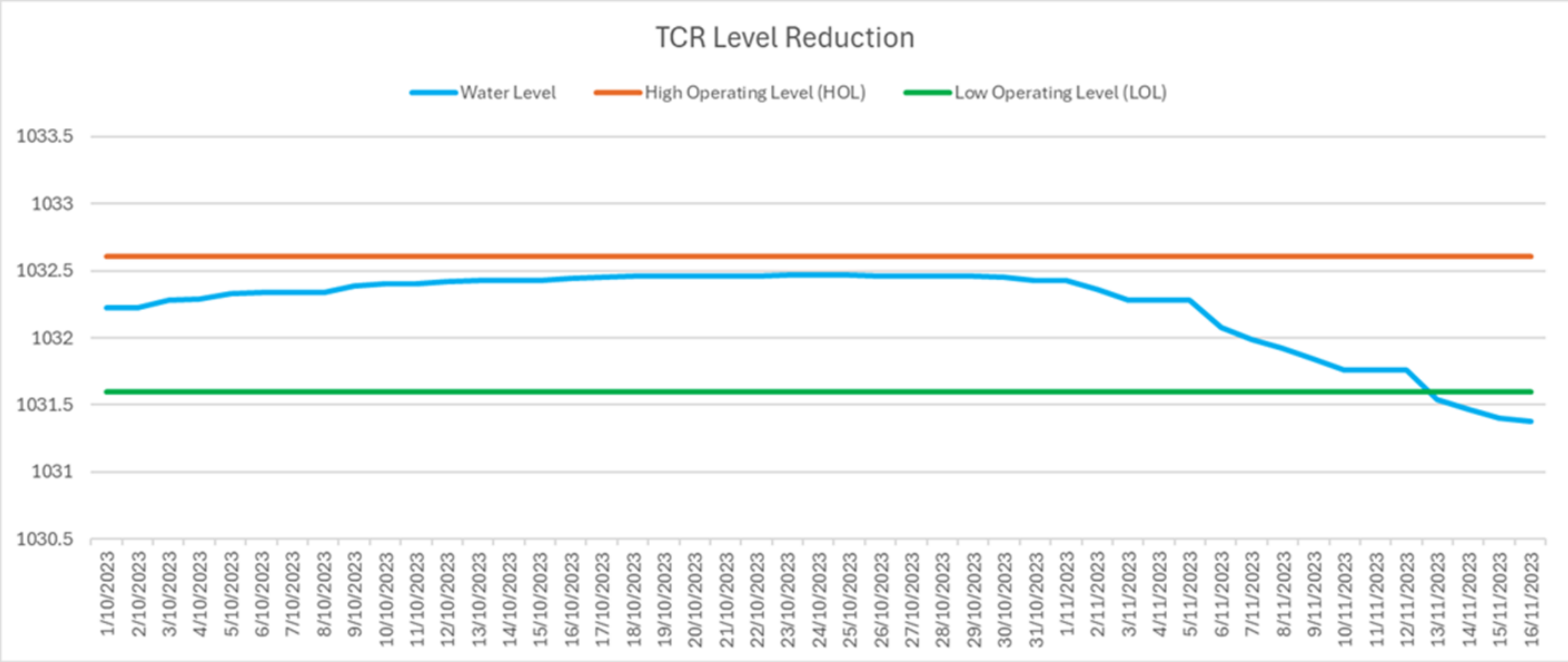

Figure 3-2 Thompsons Creek Reservoir Emergency Release Level Reduction

3.1.3 **Lake Wallace Riparian Release**

Lake Wallace was sold in September 2020 along with WPS and is now owned and operated by GPM, EA continue to monitor the flows in and out of Lake Wallace as it influences the greater CRWSS.

Lake Wallace "spilled" for the majority of the water year as detailed in **Table 3-2** below. A spill has been defined as Lake Wallace water level exceeding 871.42m AHD

Table 3-2 Lake Wallace spills during 2023-2024

Period lake spilled	Bathurst Rd Gauge Flow (ML)	LDP4 blowdown and environmental flow component of flow (ML)
1/07/2023 –30/06/2024	15,597	0

3.2 Water Releases for Firefighting

There were no releases for firefighting purposes during the 2023-2024 reporting period.

4. Demand Management Strategy

4.1 Water Saving and Efficiency Gains

The accepted design efficiency of water usage at Mt Piper Power Station is 1.65 ML/GWh.

During the year 2023-24, the water use at Mount Piper was **9,316.8 ML**.

The overall usage of water for EA NSW operations was **1.25 ML/GWh** by calculation. The Independent Assessment of EA NSW's (then Delta Electricity) Demand for Water (SMEC, 2003) established the above typical accepted annual water use. The accepted net thermal efficiency is 36% for MPPS.

- Sent out generation thermal efficiency was **35.29%** for MPPS
- Output factor was **56.54%** for MPPS
- Mt Piper Power Station operated close to the design thermal efficiency in spite of overall low generation profile when compared to base-load operation. The Output factor, though lower than previous years, is in line with expectations due to the increase in the renewable energy capacity in the National Electricity Market. This financial year 2023-24 saw a few planned and unplanned outages & reserve shutdowns which also contributed to the overall low output of Mt. Piper.
  - Unit 1 Integrity Outage – May 24
  - Unit 1 Forced Outage Reheater Tube Leak- June 24
  - Unit 1 Weekend Two Shifting – Oct 23
  - Unit 2 Summer Readiness Outage – Nov 23
  - Unit 2 Forced Outage Secondary Superheater Leak – Dec-Jan 24

Efficiency losses include those typically associated with mature subcritical boilers and original turbines;

- Unit 1 & 2
  - Gas Air Heaters, Steam Coil Air Heaters & Mills performance affecting boiler efficiency
  - High ash and moisture coal impacting thermal heat transfer in the boiler
- Unit 2 Turbine performance degradation since commissioning in 1992-93.

Unit 2 Major Outage scheduled in September 2027 will see a Turbine Upgrade which will increase the unit's maximum capacity to 730MW and restore lost turbine efficiency, this will be in conjunction with several other major works on boiler critical components.

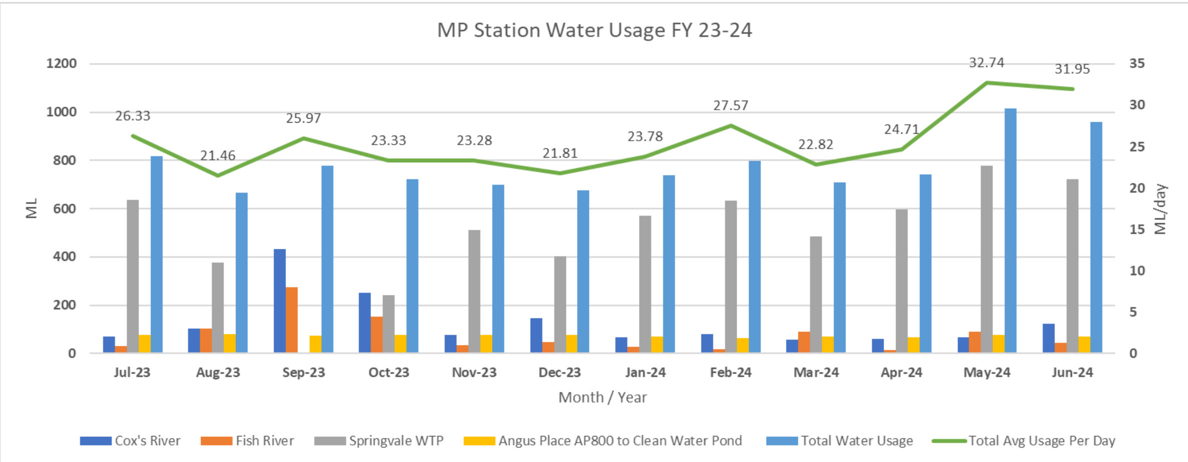

Figure 4-1 Mt Piper Power Station Make-up Water Use for 2023-2024 Reporting Period

5. Water Extraction, Transfers and Water Consumption

5.1 Site Map

The locations of extraction points and other measurement devices are shown in **Figure 1-3, Figure 1-4**, **Figure 1-5** and **Figure 1-6.**

5.2 Water Measurement Devices

The following devices are used to measure water transfers and extractions by EA NSW.

Table 5-1 Water measurement devices

Water transfer, extraction or measurement	**Measurement device**
Coxs River extraction	Inline flow meter and electronic accumulators (IWAS registered extraction site 257127)
TCR Riparian	100mm & 300mm pipe outlets with inline flow meters & V notch weirs
Lake Wallace Riparian	Downstream flow meter
Lake Lyell releases	300mm & 750mm FDCV, 100mm gate valve and inline flow meters
Lake Lyell transfers	Inline flow meter
Coxs River stream gauging network	WaterNSW supplied staff gauges and various rating tables
FRWSS	Inline flowmeters and manual accumulators (measured by WaterNSW)
SMWTP	Inline flowmeter
AP800	Inline flowmeter

The flow measuring devices were maintained in good working order by routine inspection and maintenance of flow meters and electronic accumulators, V notch weirs (refer Section 4 for description of potential capacity issue) and valves. This includes (Appendix B):

- Calibrations of all pressure sensors at the Coxs River gauging stations by WaterNSW;
- Routine inspection, calibration and maintenance of flow meters and electronic accumulators, V notch weirs and valves at the power stations; and
- Calibration certificates of in-line flow meters from FRWSS.

5.3 Daily Water Extraction and Transfers

5.3.1 **Lake Lyell, Thompsons Creek Reservoir and Lake Wallace**

For daily water extractions and transfer for Lake Lyell, TCR and Lake Wallace, please refer to Section 5.4.5

5.3.2 **Sawyers Swamp Creek Ash Dam**

EA NSW acknowledge that up to 300 ML of its current water allocation is associated with the incidental water take from the catchment area associated with SSCAD.

5.4 Daily Water Consumption

5.4.1 **Coxs River Consumption**

CRWSS water can be transferred from Lake Lyell to TCR and Lake Wallace. TCR is maintained between its low operating level and its high operating level and is on a tributary of the Coxs River.

The monthly and daily consumption of CRWSS water at MPPS is provided within **Table 5-2**. It comprises a total of 3,114.2 ML for the 12-month period July 2023 to June 2024.

Appendix A4 (MP Coxs Ext tabs) includes the calculations used to obtain these figures.

Table 5-2 Monthly and daily average Coxs River water consumption 2023-24

Month	Gross Ext ML/mth	ML/Day average
Jul-23	726.7	23.4
Aug-23	1124.5	36.3
Sep-23	913.1	30.4
Oct-23	0.0	0.0
Nov-23	0.3	0.0
Dec-23	1.0	0.0
Jan-24	86.2	2.8
Feb-24	262.3	9.0
Mar-24	0.1	0.0
Apr-24	0.0	0.0
May-24	0.0	0.0
Jun-24	0.0	0.0
2023 – 24	**3,414***	**8.5**
*Incidental 300 ML water usage at SSCAD		

5.4.2 **Fish River Consumption**

Oberon Dam was at 100% storage capacity at the beginning of 2023-24 water year resulting in EA NSW's water allocation for the FRWSS being 100%. FRWSS water is used at the MPPS as both cooling water make-up and fire and domestic water.

EA NSW's actual consumption of water from the FRWSS was 930 ML, which equates to 11.4% of the annual allocation. 2.61 ML was sourced from the Duckmaloi Transfer Scheme.

The monthly and daily consumption of FRWSS at MPPS is given below **Table 5-3.** It should be noted that while ML/day consumption figures are provided, these are by average calculation only as readings are collected weekly. Weekly data is available in Appendix A4 (Fish River Summary).

Table 5-3 Monthly Fish River water consumption 2023-24

Month	ML/Month	ML/Day (average)
July 2023	31	1.0
August 2023	104	3.3
September 2023	273	9.1
October 2023	152	4.9
November 2023	35	1.2
December 2023	49	1.6
January 2024	27	0.9
February 2024	19	0.6
March 2024	91	3.0
April 2024	15	0.5
May 2024	91	2.9
June 2024	43	1.4
2023 – 24	**930**	**2.5**

N.B: The Fish River – Mt Piper – Thompsons Creek interconnector pipeline was not utilised during 2023-24, i.e. All FRWSS water delivered to MPPS was consumed at the Station.

A review of the Water Sharing Arrangements for the FRWSS as finalised in February 2012 indicates that major changes with the potential to affect EA NSW are not implemented until the highest restriction levels, so under normal climatic conditions there should be minimal impact.

Under the FRWSS, extractions from Oberon Dam affect the carry-over provisions. As the actual consumption of water from the FRWSS was 930 ML for the 2023-24 water year, EA NSW's carry-over balance at 1 July 2024 was 20% of unused water entitlement for the 2023-24 water year i.e. 8,184 – 930 = 7,254 x 20% = 1,450.8 ML. As a consequence of this, EA's full allocation from the FRWSS for 2024-25 is 8,184 + 1,450.8 = 9,634.8 ML.

5.4.3 **Springvale Mine Water Consumption**

The SMWTP commenced supplying treated mine water to MPPS in December 2019, with a total of 5,958.9 ML of treated mine water used at MPPS during the 2023-24 reporting year.

Table 5-4 Monthly Springvale Mine Water consumption 2023-24

	MPPS	
Month	**ML/Month**	**ML/Day (average)**
July 2023	637.3	20.6
August 2023	376.2	12.1
September 2023	0.0	0.0
October 2023	241.7	7.8
November 2023	511.3	17.0
December 2023	402.1	13.0
January 2024	572.7	18.5
February 2024	634.4	21.9
March 2024	485.3	15.7
April 2024	595.2	19.8
May 2024	779.2	25.1
June 2024	723.5	24.1
2023 – 24	**5,958.9**	**16.3**

5.4.4 **Total Consumption at Mount Piper Power Station**

The following table (**Table 5-5**) summarises the water sources and use at Mt Piper Power Station. Note that the daily data provided is an average value only, as data is received weekly.

Table 5-5 Make-up Water at Mount Piper Power Station

Month	Coxs River# (ML/ month)	Fish River (ML/ month)	Springvale Mine (ML/ month)	Angus Place (ML/month)	Monthly Make-up Water (ML/ month)	Daily Average Make-up Water Use (ML/day)
Jul 2023	726.7	31	637.3	76.6	1471.8	47.5
Aug 2023	1124.5	104	376.2	81.2	1685.6	54.4
Sept 2023	913.1	273	0.0	72.4	1258.6	42.0
Oct 2023	0.0	152	241.7	77.8	471.6	15.2
Nov 2023	0.3	35	511.3	76.6	622.8	20.8
Dec 2023	1.0	49	402.1	76.4	528.7	17.1
Jan 2024	86.2	27	572.7	70.2	756.3	24.4
Feb 2024	262.3	19	634.4	64.8	980.1	33.8
Mar 2024	0.1	91	485.3	72.1	649.0	20.9
Apr 2024	0.0	15	595.2	68.6	679.0	22.6
May 2024	0.0	91	779.2	76.5	946.2	30.5
Jun 2024	0.0	43	723.5	69.7	836.2	27.9
Total 2023-24	**3,414.2***	**930.0**	**5,958.9**	**882.8**	**10,885.9**	**29.7**

#Coxs River figure is the sum of MPPS gross extraction figures

*Incidental 300 ML water usage at SSCAD

5.4.5 **Transfer from Lake Lyell to Lake Wallace**

Excess water pumped to MPPS from Lake Lyell was directed to TCR via the Rydal surge tank which is an existing pipeline designed for this purpose. Excess water pumped to Mt Piper Power Station from Lake Lyell was also transferred to Lake Wallace during the 2023-24 water year.

5.5 Total Active Storage Water Balance

Water balance investigations in previous years have revealed evaporation and loss figures of several thousand ML per year. Due to periods of high rainfall and the resulting large unquantifiable spill volumes from Lake Lyell during the 2023-24 water year, it is very difficult to use previous methodology for calculating evaporation and losses. The volume spilling from Lake Lyell is not accurately measured at the Lithgow Gauge due to inputs from the downstream catchment as well as the ungauged Jocks Creek.

For this reason, the 2023-24 calculations have been based on corrected and verified stream gauge data with the addition of the previously accepted total system loss figure of 5,000 ML/year (SMEC, 1998). This has allowed an approximation of the volume of excess water released from Lake Lyell as 23,664 ML for 2023-24.

To give an indication of the overall performance of the system in 2023-24, the annual water balance was estimated by:

Evaporation & losses = (Change in volume + Natural inflows + STPs + GW) – (Net extraction + Lyell releases)

	30/06/2023	-	30/06/2024		
Change in storage volume =	59,107	-	59,395	=	**-287.3 ML**

	(Change in Storage	**+**	**Nat Inflow**	**+**	**STPs**	**+**	**GW)**	**-**	**(Net Xtract WW**	**+**	**Net Xtract MP**	**+**	**Lyell out)**
Unaccounted Water =	-287	+	37,811	+	558	+	804	-	0	+	3,114	+	7,107

Unaccounted Water	**-**	**Estimated Evaporation and Losses**	**=**	**2023-24 Spill from Lake Lyell**	
28,664	**-**	**5,000***	=	**23,664**	**ML**

*5,000 ML/year taken from DLWC Coxs River System Analysis Detailed Results (SMEC, 1998)

For the above equations, STP and GW are defined as:

- STP: refers to the average discharge of the inter-valley transfer water component (i.e. Fish River and Clarence Colliery water) that is reticulated through the Lithgow and Wallerawang townships and discharged into the Coxs River Catchment from Wallerawang and Lithgow Sewage Treatment Plants.
- GW: refers to incidental groundwater extracted from various coal mines and discharged into the Coxs River upstream of Lake Lyell.

Both components are considered unnatural flows in the Coxs River Catchment.

Evaporation and losses refers to the evaporative and seepage losses from the dam storages, plus any transmission losses from cooling tower blowdown and environmental flows from Lake Wallace and TCR, as no allowances for these discharges are made.

6. Groundwater Investigation and Monitoring

6.1 Background

There were no additional groundwater investigations undertaken during the reporting period as described under Condition 33 of the Approval.

7. Non-compliance

EA NSW complied with the Approval requirements for environmental flows during the 12-month period of 1 July 2023 to 30 June 2024

8. Significant Events 2023-24

- TAS in the Coxs River exceeded 50,000ML throughout the 2023-24 reporting period, remaining above the drought trigger and continuing variable translucent environmental flow requirements from Lake Lyell. The drought trigger was initially deactivated in October 2011 and then continually from November 2011 to the end of the 2023-24 reporting period
- In 2023-24, notable rainfall events occurred for the majority of the first half of the reporting period
- Lake Lyell spilled for just over half of the 2023-24 water year. A total flow of 40,683 ML was reported to the Lithgow Gauge
- No Red alerts for BGA were recorded at Lake Lyell. Amber alerts were recorded on 5 July – 25 July, 7 March – 2 April and 5 June – 27 June
- The TAS of TCR remained above 80% capacity for the entirety of the 2023-24 water year. On 1 November 2023, an emergency release was required to lower the water level in TCR to a safe operating level following high rainfall and high inflows from the SMWTP
- The ACMF was not activated during the 2023-24 reporting period as flows above 800 ML/day were recorded at Lithgow gauge between 21 to 22 December 2023, 5 January 2024, 18 to 20 January 2024, 6 to 8 April 2024
- A total of 5,958.9 ML and 882.8 ML of treated mine water from SMWTP and Angus Place AP800 operations, respectively, has been used at MPPS during the 2023-24 reporting period

9. Recommendations

Table 9-1 Recommendations

Item	Recommendation	EnergyAustralia Comments
2023 – 2024 Report Recommendations		
1	*Finalise the review of the Operating Protocol Manual and Monitoring Manual associated with the EA NSW's WAL and Approval once the 2023 WSP is published.*	Complete.
2024 – 2025 Report Recommendations		
2	Finalise the Operating Protocol Manual and Monitoring Manual associated with the EA NSW's WAL and Approval in consultation with NRAR.	The draft documents have been submitted to NRAR on 6 September 2024 for their review and approval.
3	Continue to actively engage with the Departments on the Fish River Wywandy Catchment Management Strategy.	EA will attend workshops and consult with the department on this matter during the reporting period.
4	Consider installation of real-time water quality monitoring in TCR to support Modification 11 to the Springvale Water Treatment Plant development consent for the transfer of blended mine water to TCR.	Will investigate suitable monitoring equipment to comply with this requirement once approved.

10. Water Quality, River Health & Geomorphology Monitoring 2023-24

The water quality, river health and geomorphology report is prepared as part of the Annual Compliance Report, as detailed in EA NSW's Monitoring Manual and Condition DK5863-00039 of the Approval. It assesses the effects of the water storages within the CRWSS, on the water quality in the Coxs River. Compliance with the monitoring program is also reported against the WAL and the Approval conditions for 2023-24. The water quality monitoring includes:

- Stream inflow, outflow and downstream sites;
- In the water storages, including profiles for temperature, dissolved oxygen (DO), turbidity and pH; and
- Algae in the water storages and at outflow sites.

The WML was revised on 30 November 2001 to include a Monitoring Manual covering the requirements of a fully integrated river health monitoring program. The monitoring program was modified after consideration of the recommendations from the 5-year licence review and was re-evaluated again as part of the 2010 Licence Review process. The monitoring regime was altered so that only one sampling event is required per annum, in place of the original bi-annual sampling program. Further review of the monitoring program, as part of the 2023 update to the Monitoring Manual, saw the focus of fish studies change from introduced fish communities to native fish species.

The monitoring program includes:

- the current water quality at the water storages.
- effects of the Lake Lyell dam flow strategy on:
    - Water quality;
    - Occurrence of planktonic algal blooms in pools below Lake Lyell;

- Benthic macroinvertebrate communities in the Coxs River below Lake Lyell;
- Periphyton communities in the Coxs River below Lake Lyell;
- Recruitment of native fish species in the Coxs River below Lake Lyell; and
- Geomorphic monitoring on riparian plant communities and sand content of the Coxs River below Lake Lyell.

The water quality and river health monitoring components of this annual compliance report aim to assess the effects of the water storages, which comprise the CRWSS, on the water quality in the Coxs River.

10.1 Water Quality

10.1.1 **Sample Collection**

The following water quality sampling information is provided in Appendix D (**Figure 1-1**) for an overview of the Coxs River Catchment):

- Appendix D1 – Site monitoring requirements.
- Appendix D2 – Water quality site descriptions.
- Appendix D3 – Map of water quality site locations

10.1.2 **Quality Assurance and Quality Control**

Under the direction of EA NSW, the water quality samples were collected and analysed by Ecolab/Nalco Australia P/L. The Laboratory is NATA accredited for water quality sampling and all required analyses.

Excerpts from the Laboratory's QA and QC procedures and NATA scopes of accreditation are provided in Appendix E. Appendix E also provides information on sampling and analytical methods used.

10.1.3 **Water Quality Results**

The upstream, within and downstream water quality data (raw) for each characteristic – including presence of algal species – at each sampling site is given in Appendix F. This data has been collated and depicted graphically for comparison with historical results in Appendix C.

A summary of the water quality data (average values for 2023-24) compared with ANZECC guidelines is given in **Table 10-1** below. Refer to Section 10.1.4 for a written summary of significant results.

10.1.4 **Water Quality Data Review**

The water quality data and graphs have been reviewed, with several trends and results emerging.

Nalco perform chemical characteristic analyses, including depth profile results for Lake Lyell, Lake Wallace and TCR for turbidity, conductivity, dissolved oxygen and pH **Table 10-1** as part of routine monthly water sampling undertaken on behalf of EA NSW. The following observations were made from the data collected:

- Generally, water quality results were within the historical range, with a few exceptions as detailed below.
- Temperature results for majority of the monitoring sites had increased by an average of 1.7°C compared to the results for the previous water year, with increases occurring at Lake Lyell (COX8A), COX3, upstream of Lake Wallace (WX9), COX6, below Lake Lyell (COX9), downstream of Lake Lyell (COX10) and TCR TC1 and decreased at COX5 as shown in Appendix C1. The temperature recorded at the TCFM1 and WX13 which were aligned with the median value. COX3, Lake Lyell (COX8A), TCR (TC1) and COX6 were all above the 95^{th} Percentile, COX9 and COX10 which were close to 75^{th} percentile and Upstream of Lake Wallace (WX9) and COX5 which were between 5^{th} and 25^{th} percentile and below 5^{th} percentile respectively.
- Turbidity for all the monitoring site had decreased from the previous year's result (Appendix C2a) remaining below the ANZECC Guidelines (**Table 10-1**) for majority of the sites. Turbidity remained above the ANZECC Guidelines at COX3 however decreased by 395.5NTU. Turbidity at TCR (TC1) continued its decreasing trend from the previous year dropping from 40.5 to 12.45 NTU (Appendix C2a). Majority of the sites were aligned with the median except for Lake Lyell (COX8A) and TCR (TC1) which were at the 25th percentile and COX3 was just above the 25th percentile (Appendix C2b).

- Suspended solid levels showed mixed trends across the monitoring sites. A decrease occurred for majority of the monitoring sites while increases were observed on Upstream of Lake Lyell (COX5) and upstream of Lake Wallace (WX9) during the 2023/2024 reporting period. All suspended solid results were below the ANZECC Guidelines (**Table 10-1**). Majority of the sites are below or aligned with the median except for the WX9 and COX6 which were close to 75th percentile and upstream of Lake Lyell (COX5) which was between 75th and 95th percentile (Appendix C3b).
- As shown in Appendix C4a, conductivity increased at all sites except TCFM1 and TCR (TC1) which remained close to the median value. During the 2023-2024 water year, half of the monitoring site recorded conductivity levels below the ANZECC guidance while other half remained above (**Table 10-1**). Conductivity at majority of the sites were close to the 25th percentile except for below TCR (TCFM1) which aligned with their median values and Lake Lyell (COX8A), below Lake Lyell (COX9) and downstream of Lake Lyell (COX10) which were between 5th and 25th percentile (Appendix C4b).
- PH measurements were generally above the ANZECC guidelines at all sites, except for below TCR (TCFM1) (**Table 10-1**). PH measurements for all of the monitoring site increased during the 2023/2024 reporting year with the exception of below TCR (TCFM1) and TC1 which had pH measurements remained constant in the reporting period (Appendix C5a). Most sites were within 25th percentiles, except for TC1 (close to 75th percentile) and TCFM1 aligned with the median and Farmer Creek (COX6) which displayed increases above their historic 95th percentile refer to Appendix C5b.
- DO concentrations increased at all sites since last year (Appendix C6a). Nine out of ten sites were above 95th Percentile levels except for Lake Wallace (COX3) was between 75th and 95th Percentiles (Appendix C6b). The destratification systems at Lake Lyell and TCR were generally in service throughout the warmer months, with the system at Lake Lyell being placed in operation for an extended period during the 2023-2024 water year in an attempt to minimise BGA outbreaks. The operation of the artificial destratification systems has been known to directly impact on the dissolved oxygen of reservoir sites (Schladow & Fisher, 1995).
- Total phosphorous decreased for all of the monitoring sites since the previous reporting period (Appendices C7a). All of the sites recorded total phosphorous concentrations above the ANZECC guidelines (**Table 10-1**) except for the downstream of Lake Lyell (COX10) which is slightly below the ANZECC guidelines. Total phosphorous levels for Lake Lyell (COX8A), Farmers Creek (COX6) and WX13 were close to 25th percentile, COX3, upstream of Lake Lyell (COX5) and COX10 had values close to 5th percentile and TCR (TC1), upstream of Lake Wallace (WX9) and below TCR (TCFM1) were just at the 75th percentile (Appendix C7b). The Total Phosphorous for below Lake Lyell (COX9) which was aligned closely with the median values.
- Filtered phosphorous decreased for all sites, except upstream of Lake Wallace (WX9) and below Lake Lyell (COX9) had no change from the previous reporting year (Appendix C8a). All seven stream monitoring sites were below the ANZECC guidelines with Farmers Creek (COX6) dropping below the ANZECC guideline for this reporting period after being slightly higher in the 22-23 reporting year. The storage sites (COXA8, COX3 and TC1) all decreased from the previous year but COX8A and COX3 remained slightly above the ANZECC guideline, levels at TC1 were in line with the guidelines (**Table 10-1**). All results were on or below their respective median values except WX9 which was slightly above the median (Appendix C8b).
- Total Nitrogen decreased at seven of the sites from last year's results, Farmers creek (COX6), upstream of Lake Wallace (WX9), and TC1 recorded increases in Total Nitrogen (Appendix C9a). All sites, except for TCR (TC1), recorded Total Nitrogen concentrations above the ANZECC Guidelines (**Table 10-1**). All the monitoring sites were close to their respective historical median values except for the below TCR (TCFM1) which was above the 25th percentile and Lake Wallace (COX3), WX13 and upstream of Lake Lyell (COX5) which were aligned with 25th percentile and 5th percentile respectively. (Appendix C9b).
- Nitrate and Nitrite concentrations decreased at all but one of the monitoring sites, with increases in concentration at Farmers Creek (COX6) as shown in Appendix C10a. The nitrate and nitrite concentrations for all sites were above the ANZECC Guidelines (**Table 10-1**). The recent nitrate and nitrite results were within the range of historical data and close to median values, except for upstream of Lake Wallace (WX9) results close to the 5th percentile, Farmers Creek (COX6) close to 25th percentile and Downstream TCR (TCFM1) values close to 75th percentile.

- Ammonical Nitrogen (NH_4) concentrations were above ANZECC Guidelines for all sites, except for TCR (TC1) and below TCR (TCFM1), as detailed in (**Table 10-1**). Increases in Ammonical Nitrogen concentrations were recorded at COX3, downstream of Lake Lyell (COX10), upstream of Lake Wallace (WX9), and TCR (TC1) from the previous year. The results for Ammonical Nitrogen were generally close to median values except for WX9, WX13 and COX9 which were close to 25th percentile. (Appendix C11b).
- Aluminium decreased for all the monitoring site since last reporting period (Appendix 12a). Aluminium concentrations were below ANZECC Guidelines for all sites except Farmers Creek (COX6) and upstream of Lake Wallace (WX9) which were above the guidelines this reporting year. All of the sites recorded Aluminium concentrations generally above or aligned with their historical median values except for the downstream of Lake Wallace (WX13), below Lake Lyell (COX9) and downstream of Lake Lyell (COX10) which were at the 5th percentile (Appendix C12b).
- Decreases in filtered Iron were observed compared to last reporting period for all of the monitoring sites. Below Lake Lyell (COX9), downstream of Lake Lyell (COX10) and downstream of Lake Wallace (WX13) had the greatest reductions in concentrations from the previous year's results (Appendix C13a). All sites had filtered Iron results aligned with their historical median values, except for WX13 and Farmers Creek (COX6) which had a concentration closely aligned with 25th percentile and upstream of Lake Wallace (WX9) and below TCR (TCFM1) which had a result below or aligned with its 75th percentile respectively (Appendix C13b).
- Slight increases in filtered Manganese were observed for all of the monitoring sites except for Farmers creek (COX6), below Lake Lyell (COX9) and downstream of Like Lyell (COX10) which had a slight decrease from the last year as shown in Appendix C14a. All filtered manganese results were below the ANZECC Guidelines (**Table 10-1**), and the majority of the results were close or aligned with their median values, with WX9 recording filtered manganese results between 75th and 95th percentile and WX13 displayed increases above their historic 95th percentiles (Appendix C14b).

As detailed in Sections 1.1.1 and 1.1.2, Cyanobacteria species (BGA) were again present in EA NSW's water storages and tributaries to the Coxs River Catchment throughout the 2023-24 reporting period. The results within Sections 1.1.1 and 1.1.2 are based on the biovolume equivalent of all cyanobacteria present in samples taken (mm3/L) and the presence of potentially toxic BGA species. As a comparison to previous years, the following findings have been made:

- BGA biovolume levels decreased at the majority of sites in comparison to the previous year's results (Appendix C15a) but increased from 0.018 to 0.065 at Farmers Creek (COX6), from 0.004 to 0.138 at Lake Wallace (COX3), from 0.003 to 0.155 at downstream of Lake Wallace (WX13) and slight increase from 0.00 to 0.01 at below TCR (TCFM1). Biovolume concentrations were aligned or below median values for the majority of site, with the result for Lake Wallace (COX3) was between 25th percentile and median values (Appendix C15b).

Increase in the total BGA concentrations(cells/mL) were recorded at most of the sites besides below TCR (TCFM1) which decreased by 49.4%% & Farmers Creek (COX6) which decreased by 39.6% (Appendix F). All results for total BGA were inline or below median values except for COX3 and downstream of Lake Wallace (WX13) which were at the 25th percentile and Lake Lyell (COX8A) and below Lake Lyell (COX9) were at the 75th and 95th percentile respectively (Appendix C16).

Table 10-1 Summary of water quality characteristics for the Coxs River water supply scheme (inflow, outflow and storage sites) from July 2023- June 2024

Characterisitics (average values)		Sampling Sites										ANZECC (2000)	
	Units	COX5	COX6	COX8A	COX9	COX10	WX9	COX3	WX13	TC1	TCFM1	River	Storage
Biological characterisitics													
Chlorophyll 'a'	µg/L	-	-	-	-	-	-	-	-	-	-	-	5.0
Total blue green algae	cells/mL	-	414	15,370	9,327	13,441	-	6,018	4,488	4,339	85	50000**	50000**
Biovolume*	mm3/L	-	0.011	0.065	0.014	0.017	-	0.138	0.155	0.003	0.001	4.0**	4.0**
Physical Characterisitics													
Temperature	˚C	18.3	15.4	16.2	16.7	16.6	13.8	16.5	16.6	15.0	14.9		
Turbidity	NTU	11.6	3.9	15.0	0.8	0.9	8.6	127.3	1.4	12.4	0.4	2.0-25.0	1.0-20.0
Suspended Solids	mg/L	14.6	5.7	2.5	2.5	2.5	6.2	2.5	3.0	2.7	2.5	2.0-25.0	1.0-20.0
Chemical Characteristics													
Conductivity	µS/cm	428	229	297	296	297	725	660	657	496	510	30-350	30-350
pH		7.9	8.0	7.6	7.9	7.9	7.7	8.2	8.3	8.5	6.8	6.5-7.5	6.5-8.0
Dissolved Oxygen	mg/L	10.5	11.9	9.7	11.1	11.1	10.2	9.9	10.5	10.7	9.6	-	-
Total Phosphorus	mg/L	0.027	0.038	0.018	0.028	0.019	0.027	0.018	0.025	0.015	0.028	0.020	0.010
Filtered Phosphorus	mg/L	0.016	0.027	0.010	0.014	0.013	0.021	0.013	0.018	0.018	0.024	0.015	0.005
Total Nitrogen	mg/L	0.483	1.183	0.442	0.567	0.517	0.508	0.392	0.483	0.317	0.417	0.250	0.350
Nitrate + Nitrite	mg/L	0.034	0.695	0.106	0.092	0.090	0.051	0.013	0.009	0.013	0.249	0.020	0.010
Ammonical Nitrogen NH4+	mg/L	0.018	0.023	0.015	0.016	0.018	0.024	0.023	0.021	0.010	0.008	0.013	0.010
Trace elements													
Aluminium	mg/L	-	0.107	0.020	0.010	0.012	0.140	0.013	0.010	0.016	0.014	0.055	0.055
Filtered Iron	mg/L	-	0.094	0.035	0.025	0.025	0.137	0.025	0.025	0.025	0.025		
Filtered Manganese	mg/L	-	0.018	0.004	0.007	0.005	0.226	0.067	0.109	0.004	0.002	1.900	1.900

10.2 River Health Monitoring

Stantec NSW/ACT (formerly Cardno Ecology Lab Pty Ltd) (Cardno) have historically been engaged by EA NSW to conduct specific biological monitoring to assess the response of relevant indicators of aquatic health to daily environmental flows from Lake Lyell into the Coxs River Catchment. Stantec has monitored the condition of the macroinvertebrate, periphyton and fish assemblages in the Coxs River on behalf of EA NSW in accordance with the WAL since 2002. The River Health Monitoring Program (RHMP) examines trends in macroinvertebrate periphyton and fish data and assesses if there is evidence of a change in abundance at the environmental flow locations (EFR2, EFR3 and EFR4) relative to the Control and Reference sites following the implementation of the environmental flow regime. The most recent survey was performed in Spring (October) 2023 (Stantec, 2024).

A summary of the monitoring findings including those from the survey performed prior to Spring 2023, is provided below and the full report is contained as Appendix G. It is noted that the 2021 survey was scheduled to for Spring 2021, though had to be postponed to June 2022 due to high flow in the Coxs River during the second half of 2021 preventing the survey from being performed. As was the case in the Autumn (March / April) 2020, all sites on the Coxs River and external reference rivers (Abercrombie, Turon and Fish rivers) were surveyed (Stantec, 2024).

The findings of the current survey, completed in in October 2023, were consistent with observations made previously in 2017, 2018, 2019, 2020 and 2022. The majority of the significant changes detected in some of the over 50 macroinvertebrate indicators (individual taxon abundances and total number of AUSRIVAS taxa) at EFR locations relative to temporal patterns at R5, up to and including the current survey, supported the hypothesis that macroinvertebrate communities just downstream of Lake Lyell are becoming more similar to that expected in association with natural flows. The most obvious indicator showing this was the increase in abundance of pollution-sensitive leptophlebiid mayflies at EFR2, EFR3 and EFR4 to a level comparable to that at R5 following implementation of the environmental flow regime in October 2011 (Stantec, 2024).

Changes in macroinvertebrate indicators at EFR2, EFR3 and EFR4 relative to those at the reference locations (FISH, ABE and TUR) on the Fish, Abercrombie and Turon rivers are also difficult to interpret. Given an absence of a gauging station and flow data for FISH it is also unclear if this location experiences flow characteristic of ‘controlled’ conditions or not. Both of the natural flow locations (ABE and TUR) appear to have experienced far greater flow variability and magnitude than in the Coxs River and as a result may support unique macroinvertebrate communities adapted to these conditions. These locations were not sampled in May 2018 or November 2019 due to no flow. Both of these rivers can cease to flow for periods of time and they also differ from the Coxs River in several other ways (i.e., morphology, geographic location etc.), hindering direct comparison (Stantec, 2024).

Changes in numbers of periphyton indicators (diatom, blue-green algae and green algae) among locations provided very little evidence of an influence of the environmental flow regime on these assemblages. Periphyton abundance appears naturally highly variable, and it may take further time before any change attributable to the flow regime can be detected (Stantec, 2024).

Fish data from 2023 also provided inconclusive evidence of changes related to implementation of the environmental flow regime. The relatively lower numbers of fish caught in 2023, 2022 and 2018 compared to 2017 was a pattern consistent across each survey site, with no indication of a decrease in the number of fish at any one location in particular. Rather, the low abundance of fish apparent after 2017 was likely due to higher flows in the Coxs River and its influence on the ability to view and capture fish. Flathead gudgeon caught in 2023 and 2022 were smaller in length than in earlier surveys, though the fewer numbers caught in 2018, 2022 and 2023 prevented thorough assessment of potential changes in flathead gudgeon recruitment attributable to implementation of the environmental flow regime. It is anticipated that with greater flow variability and the resulting changes in river geomorphology, there would be an increase in habitat heterogeneity, thus supporting a greater number and variety of existing and newly created habitat areas for native fish species to utilise (Stantec, 2024).

10.3 Geomorphology Monitoring

Geomorphology monitoring commenced in 1999 with surveys performed on an annual basis until 2008, when the requirement to perform the monitoring ceased as a result of drought. As such, Cardno NSW/ACT were engaged by EA NSW to conduct a new baseline and subsequent event-based geomorphology surveys to identify changes in geomorphic and vegetative conditions within the Coxs River downstream of Lake Lyell resulting from the new flow regime. Cardno performed the baseline geomorphology survey in July 2017 (Cardno NSW/ACT, 2017). The last event-based survey (Cardno NSW/ACT, 2020b) was performed during the 2020-21 water year following the ACMF release performed by EA NSW in June 2020 and was reported in the 2019-20 WAL & Approval Annual Compliance Report.

As the artificial release of an ACMF was not required during the 2023-24 reporting period due to flows of 800 ML/day being recorded at the Lithgow Gauge December 2023, January 2024 and April 2024, an event-based geomorphology survey was not performed.

11. Assessment of EnergyAUstralia NSW Compliance with WAL Conditions and Statement of Approval

The following assessment of compliance with the WAL and the Approval Conditions has been performed in accordance with the NSW Government's *Independent Audit Guideline*.

Condition No.	Licence and Approval Requirements	EA NSW Comment	Compliance Assessment
WATER ACCESS LICENCE CONDITIONS			
Take of water			
MW0603-00001	The total volume of water taken under this access licence in any water year must not exceed a volume equal to: A. the sum of water in the account from the available water determination for the current year, plus B. the net amount of water assigned to or from the account under a water allocation assignment, plus C. any water re-credited by the Minister to the account.	EA NSW has only taken water under this access licence in compliance with the conditions of water supply work and water use approval number 10CA117220. Total water use for 2023-24 water year was 3,114.2 ML, approximately 13.5% of the annual water allocation (23,000ML). Therefore, the amount of water taken did not exceed a volume equal to A, B or C.	COMPLIANT
MW0604-00001	Water allocations remaining in the account for this access licence must not be carried over from one water year to the next water year.	EA NSW has not carried unused water allocation to the following years.	COMPLIANT
MW0605-00001	Water must be taken in compliance with the conditions of the approval for the nominated work on this access licence through which water is to be taken.	EA NSW has taken water in compliance with the water access licence and for the nominated work described in the licence.	COMPLIANT
MW5870-00001	Water must not be taken from the Coxs River in the Wywandy Management Zone of the Upper Nepean and Upstream Warragamba Water Source unless all available mine water from its storages has first been used.	EA NSW prioritises using mine water treated at the SMWTP before extracting from Coxs River. The SMWTP commenced operations in December 2019, with a total of 5,958.9 ML of treated mine water from SMWTP and 882.8 ML from Angus Place used in the MPPS cooling water system during the 2023-24 water year. This water made up the majority of water used within the MPPS cooling water system, since operations of the SMWTP commenced operations, as detailed in Appendix A4.	COMPLIANT

Condition No.	Licence and Approval Requirements	EA NSW Comment	Compliance Assessment
MW5869-00001	The maximum volume of water taken in any water year must not exceed: A. 23,000 ML, or B. 25,000 ML, if the water available from the Fish River Water Supply Scheme is reduced by 30 % or more relative to the full entitlement.	EA NSW's water allocation from the FRWS Scheme remained at 100% of the full entitlement, i.e. 8,184 ML, due to Oberon Dam starting the year at 100% capacity. Total CRWSS water use for 2023-24 water year was 3,114.2 ML.	COMPLIANT
MW5155-00002	A. By 31 July each year, the licence holder must submit to Crown Lands and Water Division, Parramatta Office, a record of the volume of water taken under this water access licence for the previous water year. B. The record must be provided in an electronic format. C. The record must include volume of water taken for each month and in total for the previous water year.	EA NSW submitted a record of the volume of water taken under the water access licence during the 2023-24 water year to WaterNSW/Crown Lands and Water Division in the form of monthly meter readings from the registered Lake Lyell extraction site via the iWAS portal by 31 July 2024. EA NSW will report monthly water usage via the iWAS online reporting tool in accordance with the new recording and reporting requirements set out in clause 244 of the Water Management (General) Regulation 2018.	COMPLIANT
Use of Water			
MA2455-00009	Water must be used for the purpose of power generation.	EA NSW has only used the water extracted from Coxs River for power generation purposes.	COMPLIANT
Monitoring and recording			
MW2339-00001	A logbook must be kept, unless the work is metered and fitted with a data logger. The logbook must be produced for inspection when requested by the relevant licensor.	EA NSW Coxs River extraction site is fitted with flow meter and data logger. The spreadsheets used to capture EA NSW's Logbook requirements are provided within Appendix A1-A4 of this report and are available upon the licensor's request.	COMPLIANT
MW2338-00001	The completed logbook must be retained for five (5) years from the last date recorded in the logbook.	The spreadsheets used to capture EA NSW's Logbook requirements are retained within EA NSW's document storage system and have been allocated a disposal schedule of 5 years from the date to which the information relates.	COMPLIANT

Condition No.	Licence and Approval Requirements	EA NSW Comment	Compliance Assessment
MW2337-00001	The following information must be recorded in the logbook for each period of time that water is taken: A. date, volume of water, start and end time when water was taken as well as the pump capacity per unit of time, and B. the access licence number under which the water is taken, and C. the approval number under which the water is taken, and D. the volume of water taken for domestic consumption and/or stock watering. This condition ceases to apply to a work on the day that the recording and reporting requirements apply to that work under the Water Management (General) Regulation 2018.	Logbook requirements for the 2023-24 water year are captured within the spreadsheets provided within Appendix A1 – A4.	COMPLIANT
Reporting			
MW6037-00002	Once the water access licence holder becomes aware of a breach of any condition on this water access licence, the water access licence holder must notify the Minister as soon as practicable. The Minister must be notified by: A. email: nrar.enquiries@nrar.nsw.gov.au, or B. telephone: 1800 633 362. Any notification by telephone must also be confirmed in writing within seven (7) days of the telephone call.	EA NSW will notify the Minister of any breach as soon as they become aware by options A or B. Written notification of any breach will be provided in the form of an event notification emailed to the Minister via the email provided in option A.	COMPLIANT

Condition No.	Licence and Approval Requirements	EA NSW Comment	Compliance Assessment
COMBINED WATER SUPPLY WORK AND WATER USE APPROVAL CONDITIONS			
Take of water			
MW0655-00001	Any water supply work authorised by this approval must take water in compliance with the conditions of the access licence under which water is being taken.	As detailed within this report, EA NSW have complied with the access rules for the taking of water as specified in the relevant access licence conditions.	COMPLIANT
MW0911-00001	Before water is taken through the water supply work authorised by this approval, visible flow in the water source at the location at which water is proposed to be taken must be confirmed. If a logbook is required to be kept: A. confirmation that water may be taken, and B. the method of confirmation, such as visual inspection, internet search must be recorded in the logbook.	EA NSW's Dam Safety Contractor performs routine inspections of EA NSW's dams, pumps and other infrastructure to confirm that water may be taken prior to water being taken through the water supply works authorised by the Approval.	COMPLIANT
MW2452-00001	Water must be taken through metering equipment that meets the following requirements: A. the metering equipment must accurately measure and record the flow of all water taken through the water supply work authorised by this approval, B. the metering equipment must comply with the Australian Standard AS 4747: 'Meters for non-urban supply', as may be updated from time to time, C. the metering equipment must be sited and installed at a place in the pipe, channel or conduit between the water source and the first discharge outlet. There must be no flow of water into or out of the pipe, channel or conduit between the water source and the metering equipment, and D. the metering equipment must be operated and maintained in a proper and efficient manner at all times. This condition ceases to apply to a work on the day on which that work is required to comply with the mandatory metering equipment condition under the Water Management (General) Regulation 2018.	**Figure 1-6** within Section 1.1 of this report depict the location of the flow measuring devices used at MPPS and WPS. These flow measuring devices have been calibrated accordingly as detailed within Appendix B1. MPPS now has a registered extraction site in the IWAS reporting portal which is used to report on the gross Coxs River extraction.	COMPLIANT

Water management works

Condition No.	Licence and Approval Requirements	EA NSW Comment	Compliance Assessment
MR6932-00001	A. Under section 101A of the Water Management Act 2000, metering equipment must be installed, used and properly maintained in connection with all water supply works with surface pumps 500 mm and above from 1 December 2020. B. Metering equipment standards are set out in the Water Management (General) Regulation 2018. An approval holder must comply with the standards set out in the Regulation. Note. More information on how to comply with this condition is available on the Department's website.	EA NSW has received an exemption for the installation of metering equipment at Lake Lyell pumphouse due to telemetry network coverage issues.	COMPLIANT
MW5885-00001	Annual channel maintenance flow releases must be made in accordance with the Energy Australia Operating Manual, signed December 2007, or as amended or replaced from time to time. A copy of the protocol is held at Crown Lands and Water Division, Parramatta Office. Releases are not required when total active storage at Lilyvale Dam is less than 50,000 ML.	As detailed within Section 2.1, the ACMF was not required to be released during the 2023-24 water year.	COMPLIANT
MW4981-00001	Water credited to a Banked Environmental Flow (BEF) account in the Upper Nepean and Upstream Warragamba Water Source can be transferred to any BEF account in the Upper Nepean and Upstream Warragamba Water Source after being granted written approval from Crown Lands and Water Division.	No written approval from Crown Lands and Water Division has been required as no water credited to EA NSW's Banked Environmental Flow account has been transferred to another BEF account in the Upper Nepean and Upstream Warragamba Water Source.	NA
MW4982-00001	The volume of water credited to a Banked Environmental Flow (BEF) account must: A. Only be released with the written direction of Crown Lands and Water Division. B. Reset to zero if any water spills over the water supply work. C. Be reduced at a rate of 1% of the volume of water remaining in the BEF account per day. D. Releases must be managed so that the BEF account cannot have a negative balance.	As per Appendix A1 tab 'Bank Env flow acc.', EA NSW, in circumstances where a release was altered, the difference between the recorded release and required release has been credited to the BEF account and has been: A) released from Lilyvale Dam in accordance with any written direction from the Minister. B) reset to zero if any water is spilling from Lilyvale Dam. C) reduced at a rate of one percent of the volume of water remaining in the banked environmental flow account per day. D) managed so that the BEF account did not have a negative balance.	COMPLIANT
MW5884-00001	A. When the combined volume in Lake Lyell, Lake Wallace and Thompsons Creek Reservoir is: i. less than 50,000 ML, and has been for less than 6 months continuously, daily releases from Lake	Total dam storage volumes exceeded 50,000 ML for the entire reporting period. Natural inflows to Lake Lyell were above 13.6 ML/day throughout the 2023-24 water year. As detailed within Section 2.1 of this report and Appendix A1, translucent flows were met for the entire reporting	COMPLIANT

Condition No.	Licence and Approval Requirements	EA NSW Comment	Compliance Assessment
	Lyell must be either 9 ML/day or equal to the daily inflow to Lake Lyell, whichever is the lesser, ii. less than 50,000 ML, and has been 6 months continuously or more, daily releases from Lake Lyell must be either 5 ML/day or equal to the daily inflow to Lake Lyell, whichever is the lesser, iii. equal to or greater than 50,000 ML, and inflow to Lake Lyell is 13.6 ML/day or less, daily releases from Lake Lyell must be equal to the daily inflow, iv. equal to or greater than 50,000 ML, and inflow to Lake Lyell is greater than 13.6 ML/day, daily releases from Lake Lyell must be equal to 13.6 ML/day plus 25 % of the volume of the daily inflow above 13.6 ML.	year, except for the events detailed in Sections 2.1 and 2.1.2.	
MW5884-00001 (cte.)	B. Releases are not required when: i. an emergency situation arises and Crown Lands and Water Division, Parramatta Office, is notified in writing within seven days of becoming aware of the emergency, or ii. requirements cannot be met due to water supply work capacity constraints or necessary maintenance, refurbishment or modification work that has the potential to temporarily affect the flow rate or behaviour of water for a period of more than 24 hours. In this circumstance the approval holder must notify in writing Crown Lands and Water Division, Parramatta Office, and be granted permission not to release from Crown Lands and Water Division, or iii. Crown Lands and Water Division requires an alternate release due to an emergency situation or a maintenance activity, or iv. a channel maintenance flow release is being made v. the storage is spilling at a rate that equals or exceeds the respective release requirement specified in (A) above. C. If releases are not made under B(i), B(ii), B(iv) or an alternative release is made under B(iii) then the approval	Translucent flows were met for the entire reporting year, except for the events detailed in Sections 2.1 and 2.1.2. In circumstances where a release was altered, the shortfall has been credited to the banked environmental flow account	COMPLIANT

Condition No.	Licence and Approval Requirements	EA NSW Comment	Compliance Assessment
	holder must record the shortfall and credit the appropriate Banked Environmental Flow account.		
MW5878-00019	A. Daily releases of water must be made from Thompsons Creek Reservoir equal to: i. 0.8 ML/day between 1 September and 30 April, or ii. 0.3 ML/day between 1 May and 31 August. B. The volume of releases must be calculated in accordance with the Energy Australia Operating Manual, signed December 2007, or as amended or replaced from time to time. A copy of the protocol is held at the Natural Resources Access Regulator, Parramatta Office. C. Releases are not required when: i. an emergency situation arises and the Natural Resources Access Regulator, Parramatta Office, is notified in writing within seven days of becoming aware of the emergency, or ii. requirements cannot be met due to water supply work capacity constraints or necessary maintenance, refurbishment or modification work that has the potential to temporarily affect the flow rate or behaviour of water for a period of more than 24 hours. In this circumstance the approval holder must notify in writing the Natural Resources Access Regulator, Parramatta Office, and be granted permission by the Natural Resources Access Regulator not to release, or iii. the Natural Resources Access Regulator requires an alternate release due to an emergency situation or a maintenance activity, or iv. the storage is spilling at a rate that equal or exceeds the respective release requirement specified in (A)above.	As detailed within Sections 3.1.1 of this report, EA NSW has met the requirements of this condition.	COMPLIANT

Condition No.	Licence and Approval Requirements	EA NSW Comment	Compliance Assessment
MW5883-00001	A. An investigation on the feasibility, suitability and adequacy of environmental releases from Lilyvale Dam must be: i. conducted independently, and ii. peer-reviewed. B. A report must be submitted to the Natural Resources Access Regulator, Parramatta Office, by 1 July 2018 that addresses: i. transparent and translucent flow dam releases, ii. annual channel maintenance flow releases, iii. drought triggers, and iv. options and recommendations for release rules.	EA NSW engaged independent contractors GHD to investigate the feasibility, suitability and adequacy of environmental releases from Lilyvale Dam. The report was submitted to NRAR and addressed: i. transparent and translucent flow dam releases, ii. annual channel maintenance flow releases, iii. drought triggers, and iv. options and recommendations for release rules.	COMPLIANT
Monitoring and reporting			
MW0484-00001	Before water is taken through the water supply work authorised by this approval, confirmation must be recorded in the logbook that cease to take conditions do not apply and water may be taken. The method of confirming that water may be taken, such as visual inspection, internet search, must also be recorded in the logbook. If water may be taken, the: A. date, and B. time of the confirmation, and C. flow rate or water level at the reference point in the water source must be recorded in the logbook.	EA NSW's Dam Safety Contractor performs routine inspections of EA NSW's dams, pumps and other infrastructure to confirm that water may be taken prior to water being taken through the water supply works authorised by the Approval. Logbook requirements for the 2023-24 water year are captured within the spreadsheets provided within Appendix A1 – A4.	COMPLIANT
MW2339-00001	A logbook must be kept unless the work is metered and fitted with a data logger. The logbook must be produced for inspection when requested by the relevant licensor.	Logbook requirements for the 2023-24 water year are captured within the spreadsheets provided within Appendix A1 – A4.	COMPLIANT
MW2338-00001	The completed logbook must be retained for five (5) years from the last date recorded in the logbook.	EA NSW retains logbook copies for the previous 5 years.	COMPLIANT

Condition No.	Licence and Approval Requirements	EA NSW Comment	Compliance Assessment
MW2337-00001	The following information must be recorded in the logbook for each period of time that water is taken: A. date, volume of water, start and end time when water was taken as well as the pump capacity per unit of time, and B. the access licence number under which the water is taken, and C. the approval number under which the water is taken, and D. the volume of water taken for domestic consumption and/or stock watering. This condition ceases to apply to a work on the day that the recording and reporting requirements apply to that work under the Water Management (General) Regulation 2018.	The spreadsheets used to capture EA NSW's Logbook requirements are retained within EA NSW's document storage system and have been allocated a disposal schedule of 5 years from the date to which the information relates.	COMPLIANT
MR6933-00003	The approval holder must comply with the recording and reporting requirements set out in clause 244 of the Water Management (General) Regulation 2018 from 1 December 2023, and from 1 December 2020 for surface pumps 500 mm and above. Note. Information about this condition, including the approved form and manner for recording and reporting is available on the Department's website.	EA NSW has received an exemption for the installation of metering equipment at Lake Lyell pumphouse due to telemetry network coverage issues. EA NSW will report monthly water usage via the iWAS online reporting tool in accordance with the new recording and reporting requirements set out in clause 244 of the Water Management (General) Regulation 2018.	COMPLIANT
MW5882-00001	The volume of daily inflows recorded and water releases must be calculated in accordance with the EnergyAustralia Operating Manual, signed December 2007, or as amended or replaced from time to time. A copy of the protocol is held at the Natural Resources Access Regulator, Parramatta Office.	Excel files contained within Appendices A1 & A2 include all raw and adjusted data used for the calculation the volume of water to be released from Lake Lyell. These spreadsheets have been developed in accordance with the EA NSW Operating Manual.	COMPLIANT
Reporting			
MW6037-00001	Once the approval holder becomes aware of a breach of any condition on this approval, the approval holder must notify the Minister as soon as practicable. The Minister must be notified by: A. email: nrar.enquiries@nrar.nsw.gov.au, or B. telephone: 1800 633 362. Any notification by telephone must also be confirmed in writing within seven (7) days of the telephone call.	EA NSW will notify the Minister of any breach as soon as they become aware by options A or B. Written notification of any breach will be provided in the form of an event notification emailed to the Minister via the email provided in option A.	COMPLIANT

Condition No.	Licence and Approval Requirements	EA NSW Comment	Compliance Assessment
MW5876-00001	Data must be made available to the public at the earliest time that is practically possible and no later than 9.00 am regarding details of any releases from its storages for environmental and other purposes, and details of any run of river transfers, planned for the next twenty four hours.	EA NSW have made the details of daily releases publicly available through its reception at the MPPS. The availability of this information has been advertised on the EnergyAustralia website, which includes the appropriate contact number. The website is: https://www.energyaustralia.com.au/about-us/energy-generation/mt-piper-power-station/mt-piper-and-wallerawang-water-data When flow volumes are significantly increased over a short period of time, e.g. during the ACMF, additional measures including press releases and radio announcements, are taken to keep the community informed. A report containing the daily releases from EA NSW storage for environmental and other purposes is also uploaded onto the website on a weekly basis.	COMPLIANT
MW3860-00001	A. When a water supply work authorised by this approval is no longer to be used permanently, the approval holder must: i. notify the relevant licensor in writing of the intention to decommission the work at least 90 days before the start of decommissioning, and ii. decommission the work, unless the approval holder receives notice in writing from the Minister within 60 days of notifying DPI Water requiring that the work is not to be decommissioned or be decommissioned in accordance with specific requirements. B. Within 60 days of the work being decommissioned, the approval holder must notify the relevant licensor in writing that the work has been decommissioned.	The water supply works authorised by this approval are intended to continue to be used until further notice. This condition is not applicable.	NA

Condition No.	Licence and Approval Requirements	EA NSW Comment	Compliance Assessment
MR7736-00001	A. Under clause 238 of the Water Management (General) Regulation 2018, the approval holder must give a copy of a certificate provided under clause 237(1) and (2) to the Minister within 28 days of receiving the certificate. B. This condition does not apply to works to which an exemption from the mandatory metering equipment condition applies as described in clauses 230, 231, 232 or 233 of the Water Management (General) Regulation 2018. Note. More information on how to comply with this condition is available on the Department's website.	EA NSW has received an exemption for the installation of metering equipment at Lake Lyell pumphouse due to telemetry network coverage issues. This condition is not applicable.	NA
Other Conditions			
Take of water			
DK7830-00001	All instrumentation, monitoring, data management and reporting must be carried out in accordance with the quality assurance and quality control procedures listed in Energy Australia Operating Protocol, signed December 2007, or as amended or replaced from time to time. A copy of the protocol is held at the Natural Resources Access Regulator, Parramatta office.	All instrumentation, monitoring, data management and reporting has been carried out in accordance with the quality assurance and quality control procedures listed in EA NSW's Operating Protocol and Monitoring Manual.	COMPLIANT
Water management works			
DK7694-00034	The location and specifications of the water supply work(s) authorised by this approval, shown on the attached plan titled - '10CA117220 - Description of authorised works' stamped February 2022, must not be altered. A copy of the plan is held in the relevant licensor, Parramatta Office.	The location and specifications of the water supply work(s) authorised by this approval, shown on the attached plan titled - '10CA117220 - Description of authorised works' stamped February 2022, has not been altered.	COMPLIANT
Monitoring and recording			
DS4976-00002	All instrumentation, monitoring, data management and reporting must be carried out in accordance with the quality assurance and quality control procedures listed in EnergyAustralia Operating Protocol, signed December 2007, or as amended or replaced from time to time. A copy of the protocol is held at Crown Lands and Water Division, Parramatta office.	All instrumentation, monitoring, data management and reporting has been carried out in accordance with the quality assurance and quality control procedures listed in EA NSW's Operating Protocol and Monitoring Manual.	COMPLIANT
DK5860-00006	A. Within 3 months of the issue of this approval, a protocol for the operation of the water supply works including any associated monitoring must be submitted to Natural Resources Access Regulator, Parramatta Office. B. Once the protocol is approved by Natural Resources Access Regulator, monitoring of parameter(s), recording and reporting must be carried out in accordance with the protocol.	A copy of EA NSW's Operating Protocol signed December 2007 is held at Crown Lands and Water Division, Parramatta office. The Operating Protocol and Monitoring Manual have recently been updated to reference 2023 WSP clauses where possible. Copies of these documents are to be submitted to NRAR for approval within the 2024-25 reporting period.	COMPLIANT

Condition No.	Licence and Approval Requirements	EA NSW Comment	Compliance Assessment
Reporting			
DS7849-00001	A. Once the licensor approves the monitoring plan for measuring and recording the effectiveness of environmental releases, monitoring, recording and reporting of parameter(s) must be carried out in accordance with the plan. B. Records, as specified in the plan, must be kept for 10 years and made available to the licensor when requested.	Monitoring for the measurement and record of the effectiveness of environmental releases, monitoring, recording and reporting of parameter(s) is carried out in accordance with the current monitoring manual. Records of the monitoring performed are retained within EA NSW's document storage system with an allocated disposal schedule of 10 years from the date to which the information relates and are available to the licensor upon request.	COMPLIANT

Condition No.	Licence and Approval Requirements	EA NSW Comment	Compliance Assessment
DK5863-00039	A. By 30 November each year, an Annual Compliance Report for the preceding water year must be submitted to Natural Resources Access Regulator, Parramatta Office. B. The report must contain: i. compliance statement against each of the access licence and approval conditions; ii. an introduction, including an overview of the Approval Holders water management activities associated with this water source; iii. updated maps to scale, showing the location of this water source, the authorised water supply works and Lithgow Gauge [No. 212011], Farmers Creek at Mt Walker Gauge [No. 212042], Coxs River at Wallerawang Gauge [No. 212054], Coxs River Upstream of Lake Lyell Gauge [No. 212058]; iv. analysis of all data for flow releases and water extractions, including storage levels, banked environmental flows, comparisons with data from previous years and an interpretation of the results; v. a summary of water use under the Fish River Water Supply Scheme; vi. results and interpretation of the ecological and geomorphological monitoring program in accordance with the approved monitoring protocol; vii. evidence verifying that the devices used for measuring and recording extractions and releases were subject to appropriate quality assurance and control; viii. a list of notifiable events; and ix. an electronic appendix that includes all raw data used in the preparation of this report. C. The report must be provided in electronic form.	This report addresses the requirements of this condition.	COMPLIANT

12. References

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DPI. (2011). *Go Fishing - Thompsons Creek Dam*. Retrieved from Department of Primary Industries: https://www.dpi.nsw.gov.au/fishing/recreational/resources/info/fishing-locations/thompsons-creek-dam

HNCMA. (2011). *Upper Coxs River Subcatchment*. Retrieved 2011, from Hawkesbury Nepean Catchment Management Authority: www.hn.cma.nsw.gov.au

Schladow, S. G., & Fisher, I. H. (1995). The physical response of temperate lakes to artificial destratification. *Limnology & Oceanography Vol. 40 No. 2*, 359-373.

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Stantec. (2024). *Coxs River Biological Monitoring Program 2023.* NSW: Stantec.

13. Glossary of Terms

ACMF	Annual Channel Maintenance Flow
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environmental and Conservation Council
BEF	Banked Environmental Flow
BGA	Blue-Green Algae
BOM	Bureau of Meteorology
CRWSS	Coxs River Water Supply Scheme
DO	Dissolved Oxygen
DPI Water	Department of Primary Industries – Water
EA NSW	EnergyAustralia NSW
EPL	Environment Protection Licence
FRWSS	Fish River Water Supply Scheme
GL	Gigalitres
GPM	Generator Property Management
GW	incidental groundwater extracted from various coal mines and discharged into the Coxs River upstream of Lake Lyell
HNCMA	Hawkesbury Nepean Catchment Management Authority
iWAS	WaterNSW's internet Water Accounting System
L	Litre
LCC	Lithgow City Council
LDP	Licenced Discharge Point
m	Metres
mg	Milligrams
mL	Millilitres
ML	Megalitres
mm	Millimetres
MPPS	Mt Piper Power Station
NRAR	Natural Resource Access Regulator
NSW	New South Wales
RL	Reduced level (in mAHD)
SMWTP	Springvale Mine Water Treatment Plant
SSCAD	Sawyers Swamp Creek Ash Dam
STP	Average discharge of the inter-valley transfer water component (i.e. Fish River and Clarence Colliery water) that is reticulated through the Lithgow and Wallerawang townships, and discharged into the Coxs River Catchment from Wallerawang and Lithgow Sewage Treatment Plants
TAS	Total Active Storage
TCR	Thompsons Creek Reservoir
The Approval	Water Supply Works & Water Use Approval 10CA117220
WAL	Water Access Licence 27428
WML	Water Management Licence
WPS	Wallerawang Power Station

Appendix A

A1 – As Released Flows 2023-24

A2 – Corrected and Verified Flows 2023-24

A3 – Thompsons Creek Reservoir Environmental flows 2023-24

A4 – Discharges and Extractions 2023-24

Appendix B

B1 – Site Technician Calibration Report 2023-24

B2 – FRWS Calibration Certificates 2023-24

ENERGY AUSTRALIA NSW TECHNICIAN'S SERVICE REPORT No.

CUSTOMER	Environmental
DATE	11/09/2024
TIME	1030

WORK ORDER	
PTW	N/A
RA	

DEFECT/FAULT DESCRIPTION	
Mt Piper Annual Flow Meter Checks	

Mp Tech TECHNICIAN (Print Name)	John Cox
SPECIAL TOOLS/EQUIPMENT	US300PM Yokogawa Portable Ultrasonic Flowmeter

OBSERVED/FOUND	Annual Maintenance Checks Required
ACTIONS	Checked and reported on specified water flowmeters at Mt Piper Power Station.
RESULTS	See attached check sheets.
P00F15 – OK, P00F25 – OK, P00F45 – OK, P00F50 – OK.	

RECOMMENDATIONS	All flowmeters in good condition and working correctly.

WORK COMPLETE	YES	**TECHNICIAN SIGNATURE**	John Cox

QUALITY CHECK SHEET

POWER STATION: Mt Piper **UNIT:** Station

ULTRASONIC FLOWMETER CHECK SHEET

REFERENCE NUMBER: P00F15

SERVICE: Lyell/Thompsons Creek Make-up Supply “A” Flowmeter

LOCATION: Near Forebay

MANUFACTURER: Yokogawa	**MODEL NO:** US300FM
SERIAL NO: Not Visible	**RANGE:** 0 – 1000 L/s
CLAIMED ACCURACY: +/- 2.0%	**DEVICE CONDITION:** Good
LABELLING: Good	**CABLING:** Good

CALIBRATION DEVICE USED: Yokogawa US300PM

CALIBRATION CHECKS:	TEST 1	TEST 2	TEST 3
Measured flow rate (L/s)	80.5	N/A	N/A
Observed flow quantity	N/A	N/A	N/A
Time taken for this flow	N/A	N/A	N/A
Calculated flow rate	N/A	N/A	N/A
Local Indication (if applicable) (L/s)	84.5	N/A	N/A
Remote Indication (if applicable) (L/s)	84	N/A	N/A

COMMENTS: All flows were fluctuating +/- 2.0 L/s during testing. Measured flow and remote flow within 5%. Results OK. Cleaned probes and applied new ultrasonic gel. Signal strength 3.0 Bars. Only one flow rate checked due to operational requirements.

TECHNICIAN: J Cox	**DATE:** 11/09/2024
CHECKED:	**DATE:**

QUALITY CHECK SHEET

POWER STATION: Mt Piper **UNIT:** Station

ULTRASONIC FLOWMETER CHECK SHEET

REFERENCE NUMBER: P00F25	
SERVICE: Lyell/Thompsons Creek Make-up Supply "B" Flowmeter	
LOCATION: Near Forebay	
MANUFACTURER: Yokogawa	**MODEL NO:** US300FM
SERIAL NO: Not Visible	**RANGE:** 0 – 1000 L/s
CLAIMED ACCURACY: +/- 2.0%	**DEVICE CONDITION:** Good
LABELLING: Good	**CABLING:** Good
CALIBRATION DEVICE USED: Yokogawa US300PM	

CALIBRATION CHECKS:	TEST 1	TEST 2	TEST 3
Measured flow rate (L/s)	94	N/A	N/A
Observed flow quantity	N/A	N/A	N/A
Time taken for this flow	N/A	N/A	N/A
Calculated flow rate	N/A	N/A	N/A
Local Indication (if applicable) (L/s)	94.5	N/A	N/A
Remote Indication (if applicable) (L/s)	96	N/A	N/A

COMMENTS: All flows were fluctuating +/- 2.0 L/s during testing. Measured flow and remote flow within 5%. Results OK. Cleaned probes and applied new ultrasonic gel. Signal strength 3.5 Bars. Only one flow rate checked due to operational requirements.

TECHNICIAN: J Cox	**DATE:** 11/09/2024
CHECKED:	**DATE:**

QUALITY CHECK SHEET

POWER STATION: Mt Piper **UNIT:** Station

TURBINE FLOWMETER CHECK SHEET

REFERENCE NUMBER: P00F45

SERVICE: HP Fire & Domestic Water Fish River Supply Flowmeter

LOCATION: Near Forebay

MANUFACTURER: Yokogawa	**MODEL NO:** AXW300 (Head)/AXW4A(Remote)
SERIAL NO: S5UC00678 847 (Head) S5UB01167 847 (Remote)	**RANGE:** 0 – 500 L/s
CLAIMED ACCURACY: +/- 2.0%	**DEVICE CONDITION:** Excellent
LABELLING: Good	**CABLING:** Good

CALIBRATION DEVICE USED: Yokogawa US300PM

CALIBRATION CHECKS:	TEST 1	TEST 2	TEST 3
Measured flow rate (L/s)	60	90	115
Observed flow quantity	N/A	N/A	N/A
Time taken for this flow	N/A	N/A	N/A
Calculated flow rate	N/A	N/A	N/A
Local Indication (if applicable) (L/s)	59	91.4	118
Remote Indication (if applicable) (L/s)	60	92	118

COMMENTS: Equipment is in good condition. Flowrates were tested and results were within 5%. Results OK.

TECHNICIAN: J Cox	**DATE:** 11/09/2024
CHECKED:	**DATE:**

QUALITY CHECK SHEET

POWER STATION: Mt Piper **UNIT:** Station

TURBINE FLOWMETER CHECK SHEET

REFERENCE NUMBER: P00F50

SERVICE: Station Washdown Water Supply Flowmeter

LOCATION: Near Forebay

MANUFACTURER: Yokogawa	**MODEL NO:** AXW300 (Head)/AXW4A(Remote)
SERIAL NO: S5UC00675 848 (Head) S5UB01164 847 (Remote)	**RANGE:** 0 – 250 L/s
CLAIMED ACCURACY: +/- 2.0%	**DEVICE CONDITION:** Excellent
LABELLING: Good	**CABLING:** Good

CALIBRATION DEVICE USED: Yokogawa US300PM

CALIBRATION CHECKS:	TEST 1	TEST 2	TEST 3
Measured flow rate (L/s)	5.2	N/A	N/A
Observed flow quantity	N/A	N/A	N/A
Time taken for this flow	N/A	N/A	N/A
Calculated flow rate	N/A	N/A	N/A
Local Indication (if applicable) (L/s)	5.1	N/A	N/A
Remote Indication (if applicable) (L/s)	4.9	N/A	N/A

COMMENTS: Equipment was in good condition. Flowrates were tested and results were within 5%. Results OK. Only one flow rate checked due to operational requirements.

TECHNICIAN: J Cox	**DATE:** 11/09/2024
CHECKED:	**DATE:**

ABB MEASUREMENT & ANALYTICS | TEST REPORT

ABB Ability™
Verification for measurement devices

Verification Report for:
WaterMaster

Measurement made easy

Measurement & Analytics Service

Installation Details

Meter Owner	WaterNSW
Machine Name	Mount Piper Power Station Reservoirs
Medium	

Operator Details

Date and Time	11-09-2023 13:24:16
Operator's Name	Blake Wallis
Operator's Signature	

Customer Details

Site Address	WaterNSW Mount Piper Power Station Reservoirs FSO 35165373
Telephone	
Email	

Overall Status - Passed

The flowmeter has passed its internal continuous verification and automatic self-calibration. It is working within +/- 2% of original factory calibration.

ABB Ability Verification for measurement devices verifies the function of the measurement product within the specification limits over the lifetime of the device with a total test coverage > 90% and complies with the requirements for traceable verification according to DIN EN ISO 9001:2015 - section 8.5

Sensor Information	
Sensor Serial No.	525349
Sensor SAP/ERP No.	3K672018310127
Sensor Type	WM Full Bore
Sensor Size	DN 400
Q3	400.110 l/s
Calibration Accuracy	OIML Class 1
Sensor Calibration Factors	128.659 %, -1.460 mm/s
Date of Manufacture	14:46:47 10/08/2018
Sensor User Span/Zero	100.000 %, 0.000 mm/s
User Flow Cutoff/Hysteresis	0.000 %, 20.000 %
Coil Current	180.000 mA
Coil Inductance	468.135 mH
Coil / Loop Resistance	37.198 Ohm

Transmitter Information	
Transmitter Serial No	570
Transmitter SAP/ERP No.	3K672014020767
Application Version	WAJC2547 V01.01.04
MSP Version	__.__.__
Date of Manufacture	13:13:25 20/12/2013
Tx Gain Adjustment	0.040 %
OIML Accuracy Alarms	OFF
Mains Freq	50.000 Hz
Qmax	400.110 l/s
Pulses/Unit	1.000
FS Freq	0.400 Hz
Pulses Limit Freq	100.000 Hz
Meter Mode	Forward And Reverse

Summary Verification of the Sensor

Summary of Results	
Coil Group	PASS
Electrode Group	PASS
Sensor Group	PASS
Transmitter Signal	PASS
Transmitter Driver	PASS
Configuration	PASS

Sensor Data	
Coil Inductance Shift	-0.011 %
Cable Length	0 m
Electrode Backoff Voltage	0.113 V
Electrode Differential Voltage	-0.020 V
Pipe Status	**Full Pipe**

Summary Verification of the Transmitter

Output Group

Pulse Output 41/42		NOT EXECUTED
Applied	**Measured**	**Result**
5250 Hz		
2625 Hz		

Pulse Output 51/52		NOT EXECUTED
Applied	**Measured**	**Result**
5250 Hz		
2625 Hz		

Totalizer Information

	Start	End	Difference
Forward	4311085.000 m^3	4311097.000 m^3	12.000 m^3
Reverse	3625.000 m^3	3625.000 m^3	0.000 m^3
Net	4307460.000 m^3	4307473.000 m^3	13.000 m^3

Comments (Installation, Grounding etc.)

Modbus O/P only in use
Isolate at 11240-1N (24V)

Verification Certificate has been generated by ABB Ability Verification for measurement devices variant "Licensed software testing" (ABB WaterMaster VDF Version 03.32).

ABB Ability Verification for measurement devices Version 03.99.00.5

—

To find your local ABB contact, visit:

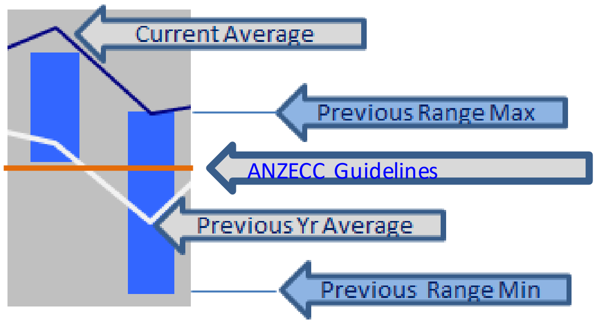
abb.com/contacts

For more information, visit:

abb.com/measurement

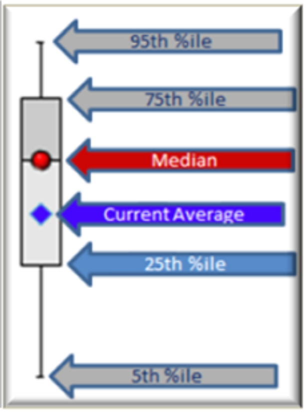
Appendix C

Historical Water Quality Trends & Box and Whisker Graphs – 2014-24



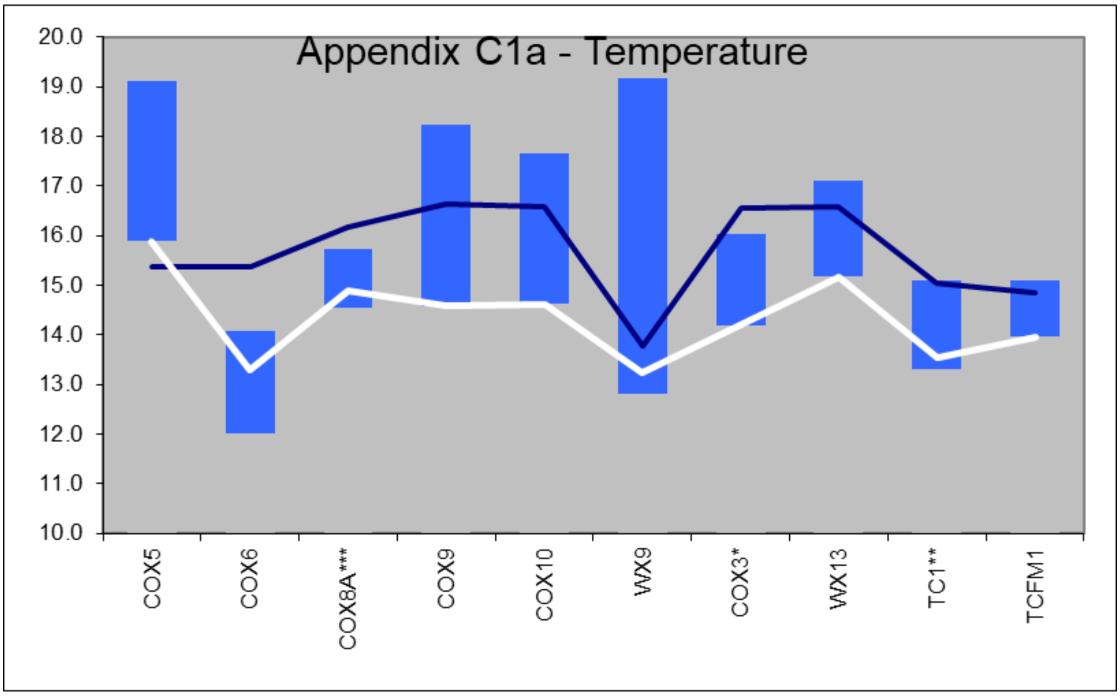
Interpretation of Box and Whisker Plots

(Note: Percentile and Median data represented in all graphs are calculated on the previous 10 years data unless otherwise stated. Refer to Appendices C and F for the full range of raw data.)

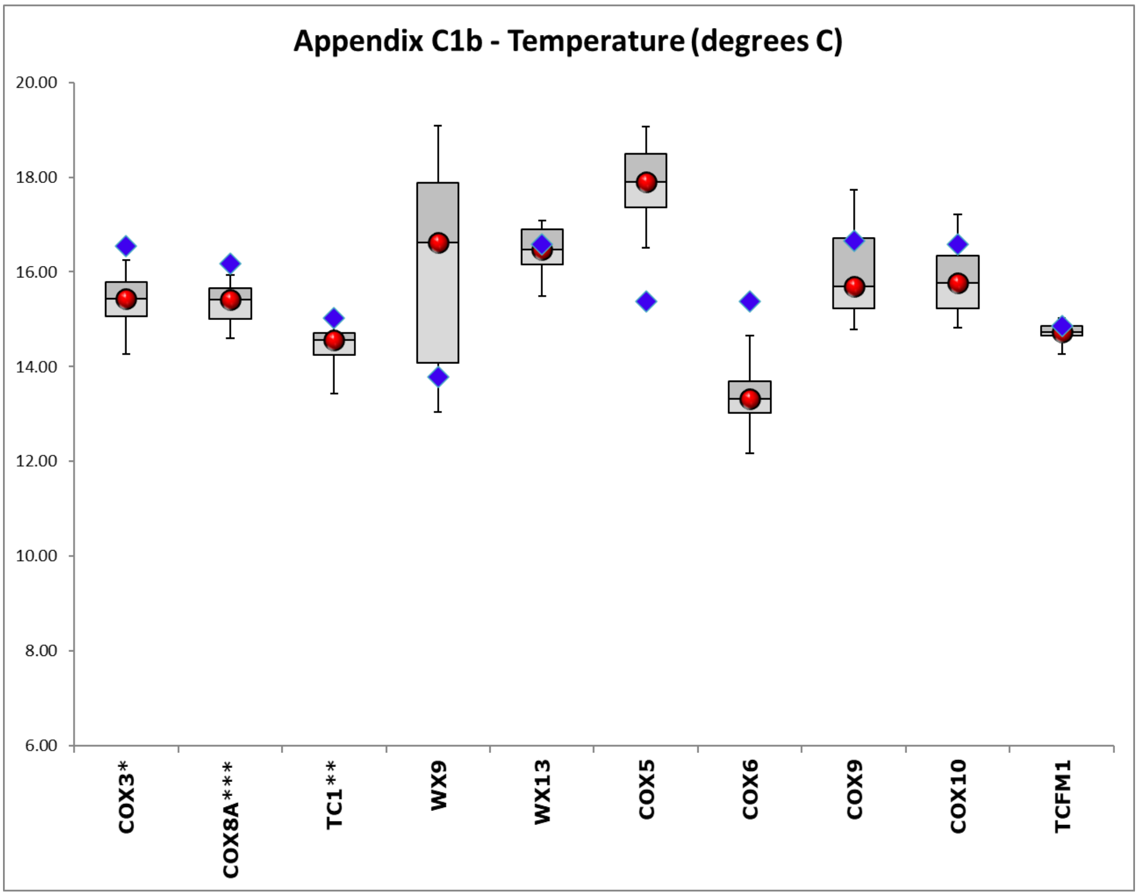


Appendix C1: Temperature

Appendix C1A – Historical Trend for Temperature

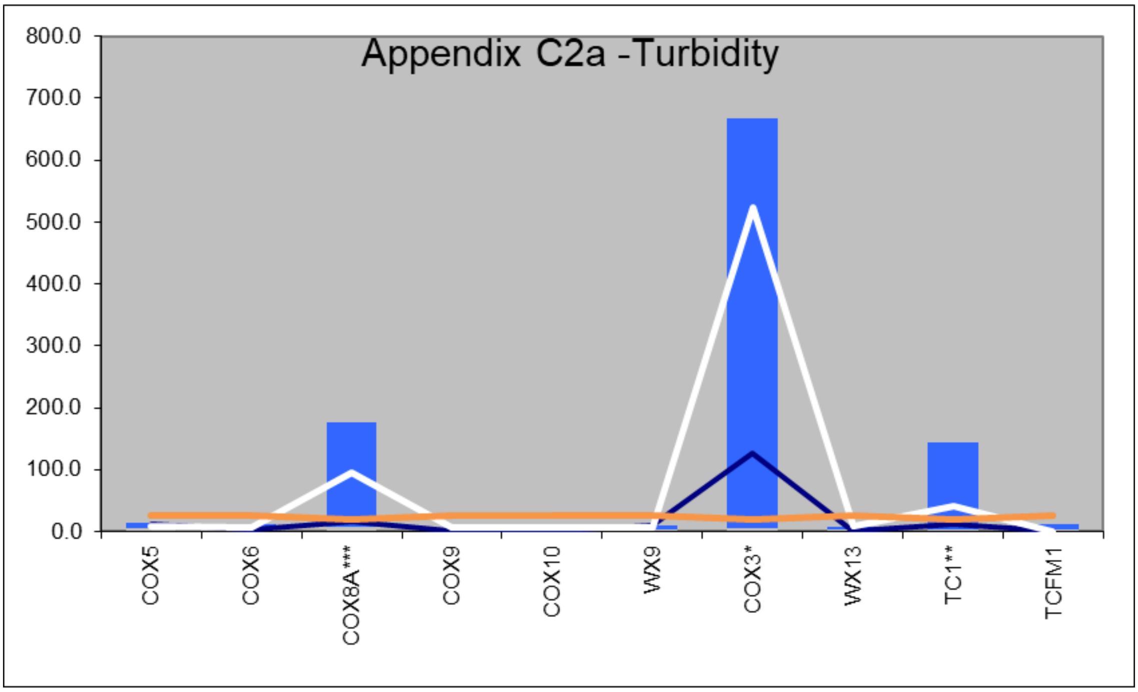


Appendix C1b: Box & Whisker Plot for Temperature

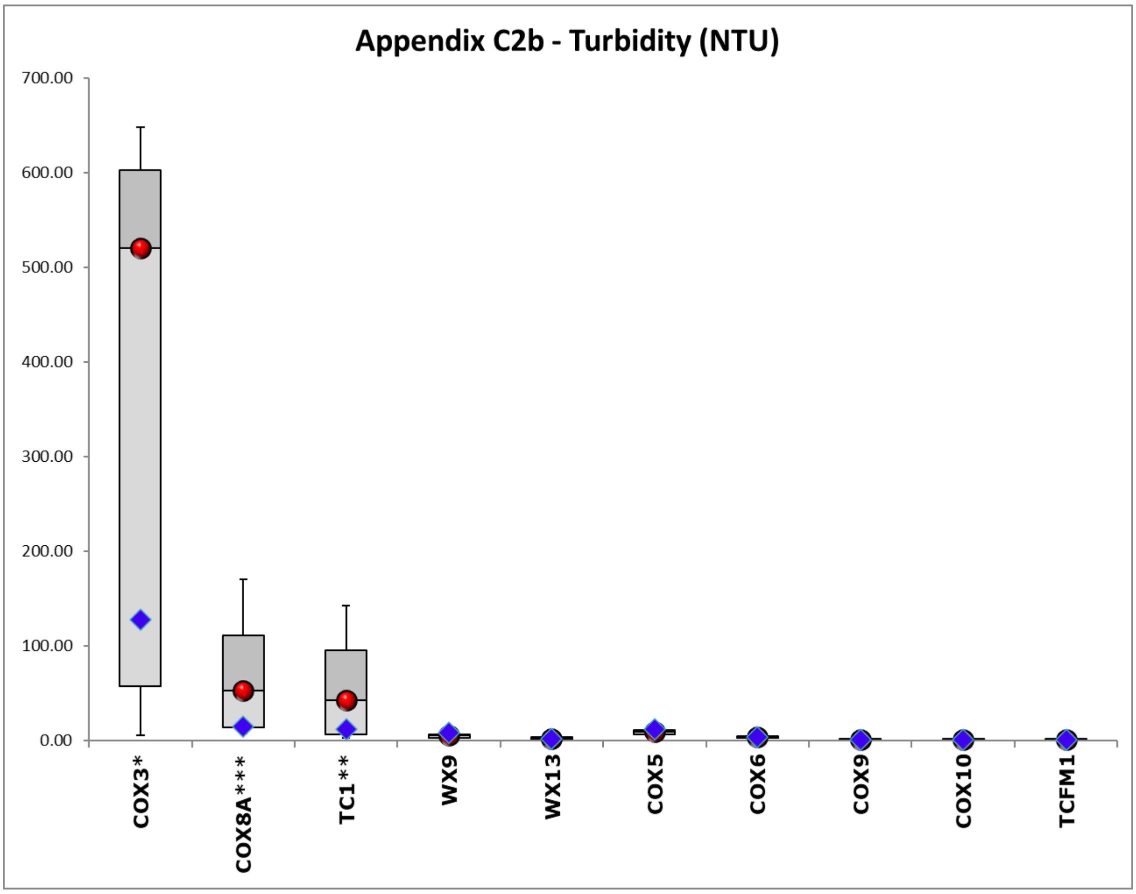


Appendix C2: Turbidity

Appendix C2a: Historical Trend for Turbidity

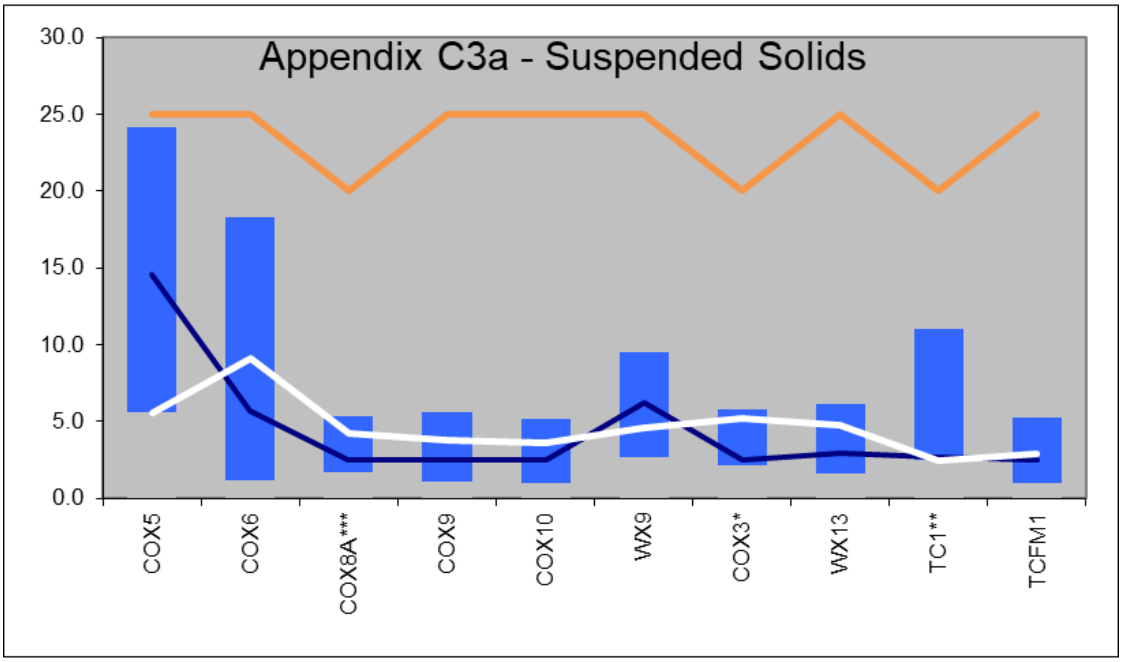


Appendix C2b: Box & Whisker Plot for Turbidity

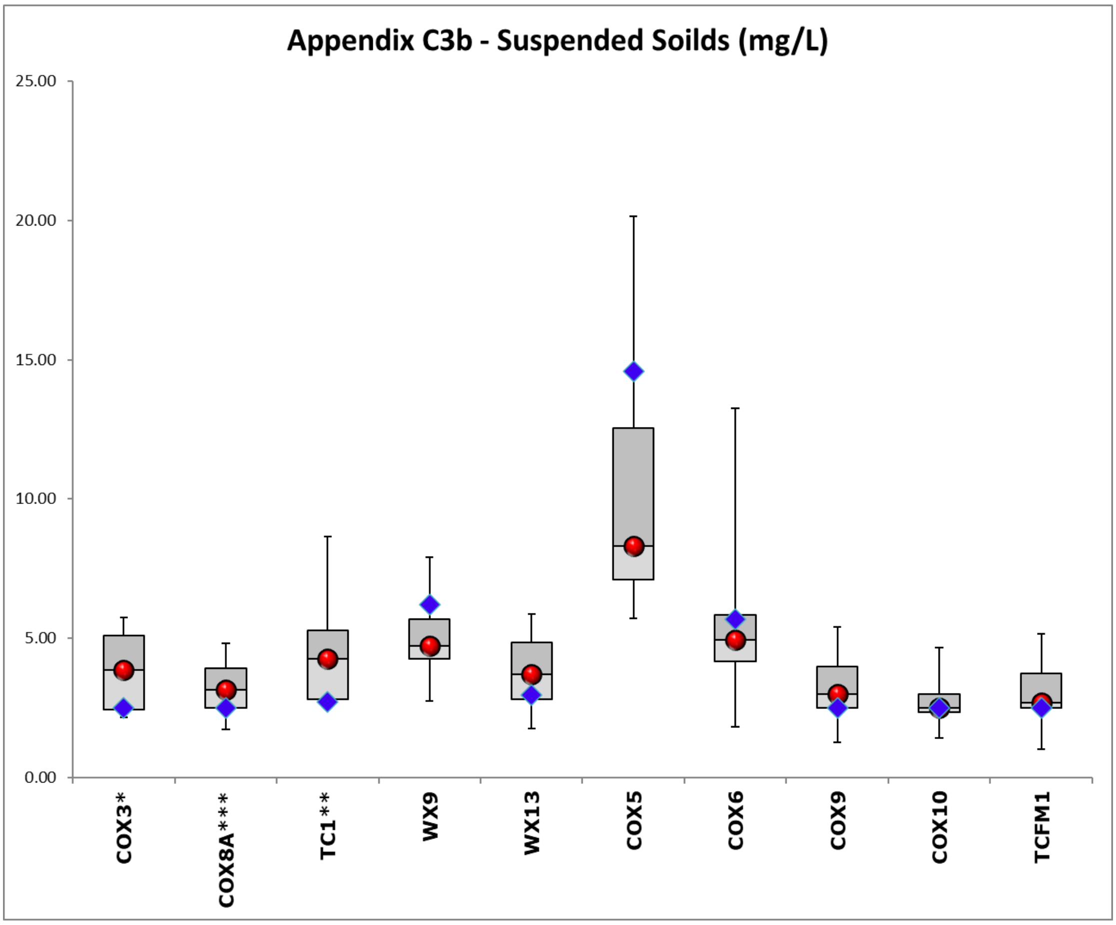


Appendix C3: Suspended Solids

Appendix C3a: Historical Trend for Suspended Solids

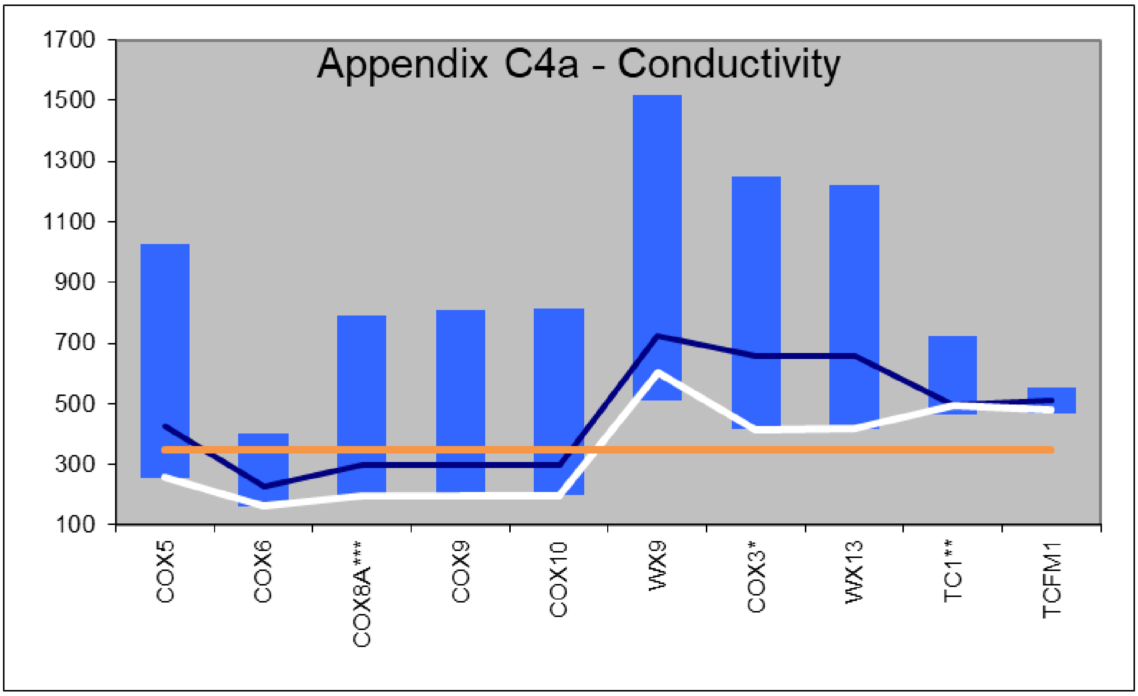


Appendix 3b: Box & Whisker Plot for Suspended Solids

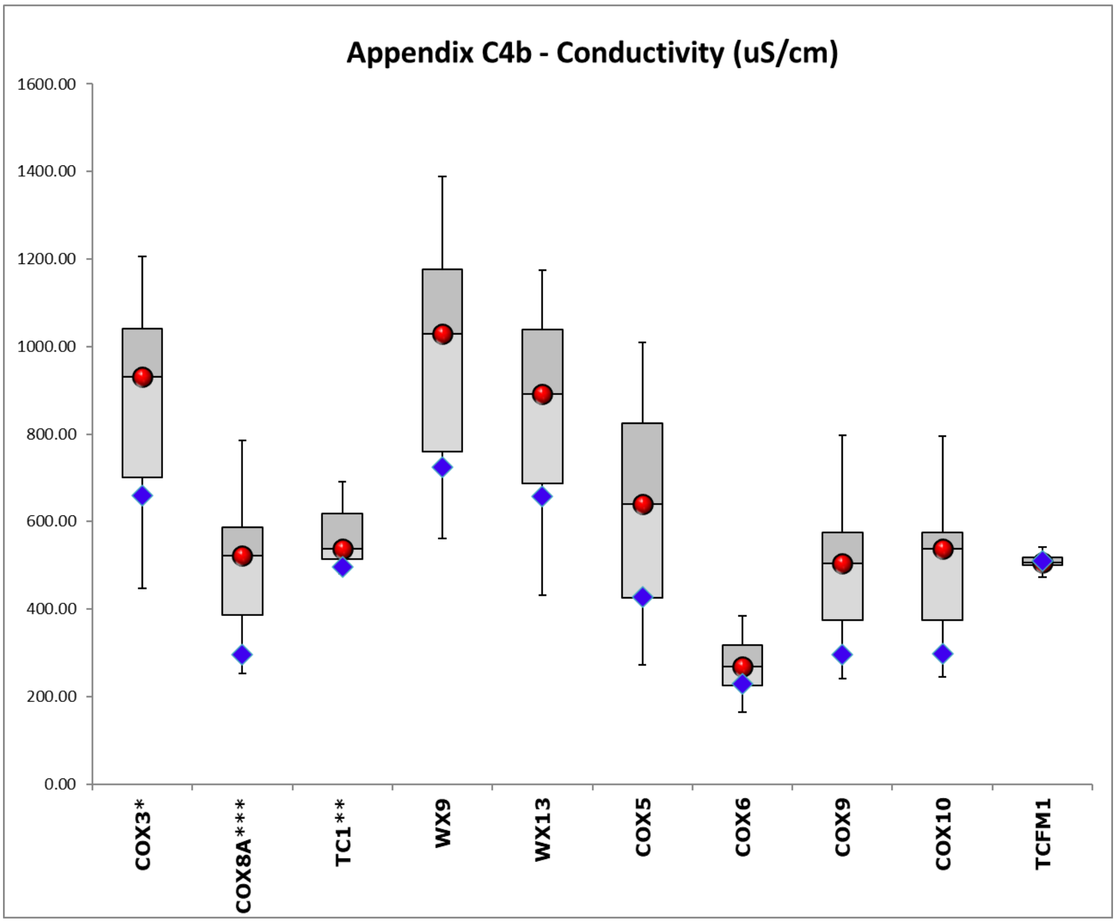


Appendix C4: Conductivity

Appendix C4a: Historical Trend for Conductivity

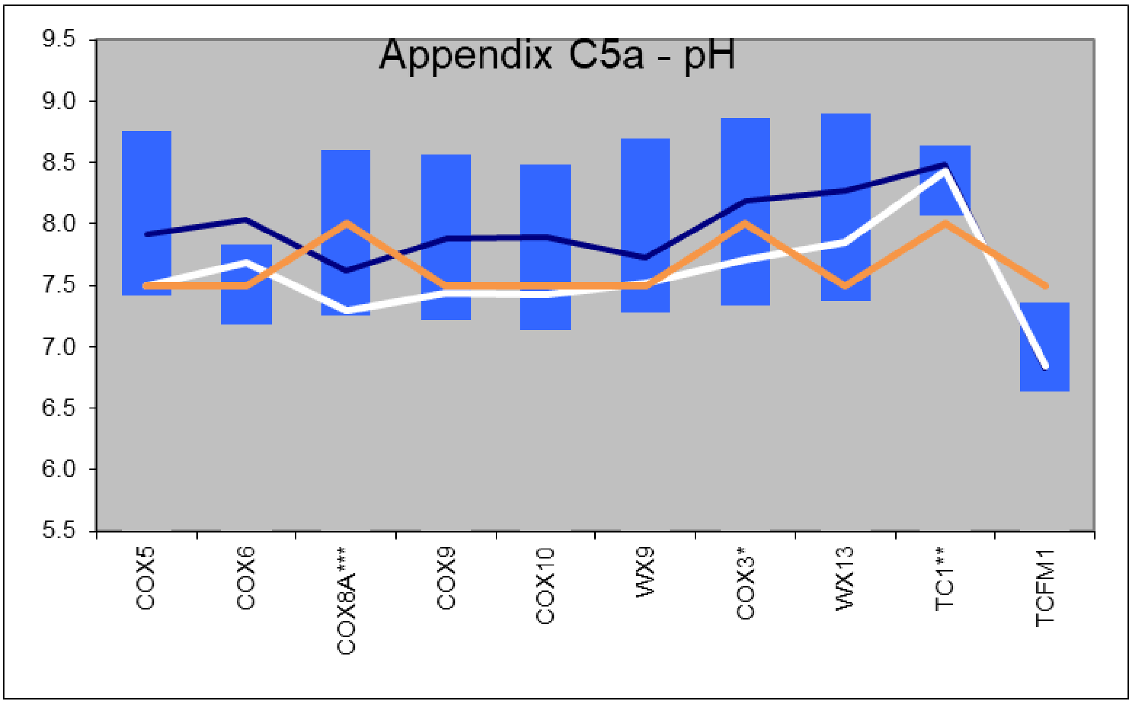


Appendix C4b: Box & Whisker Plot for Conductivity

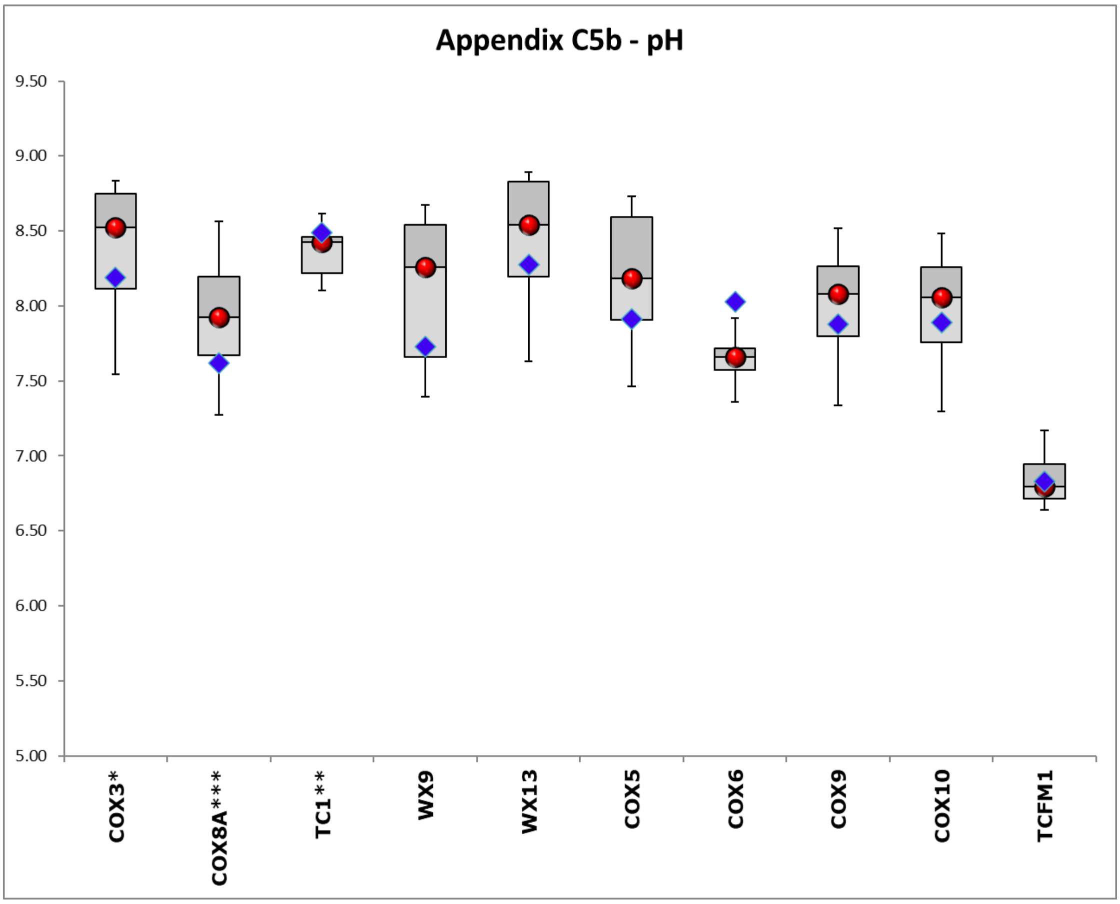


Appendix C5: pH

Appendix 5a: Historical Trend for pH

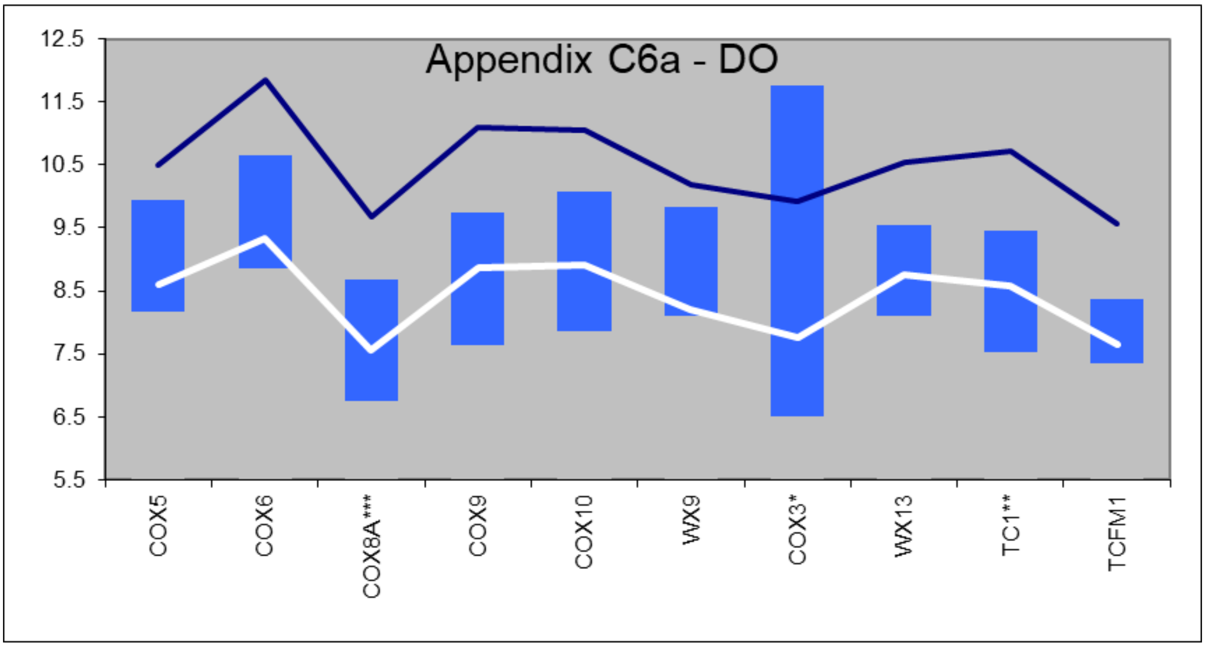


Appendix 5b: Box & Whisker Plot for pH

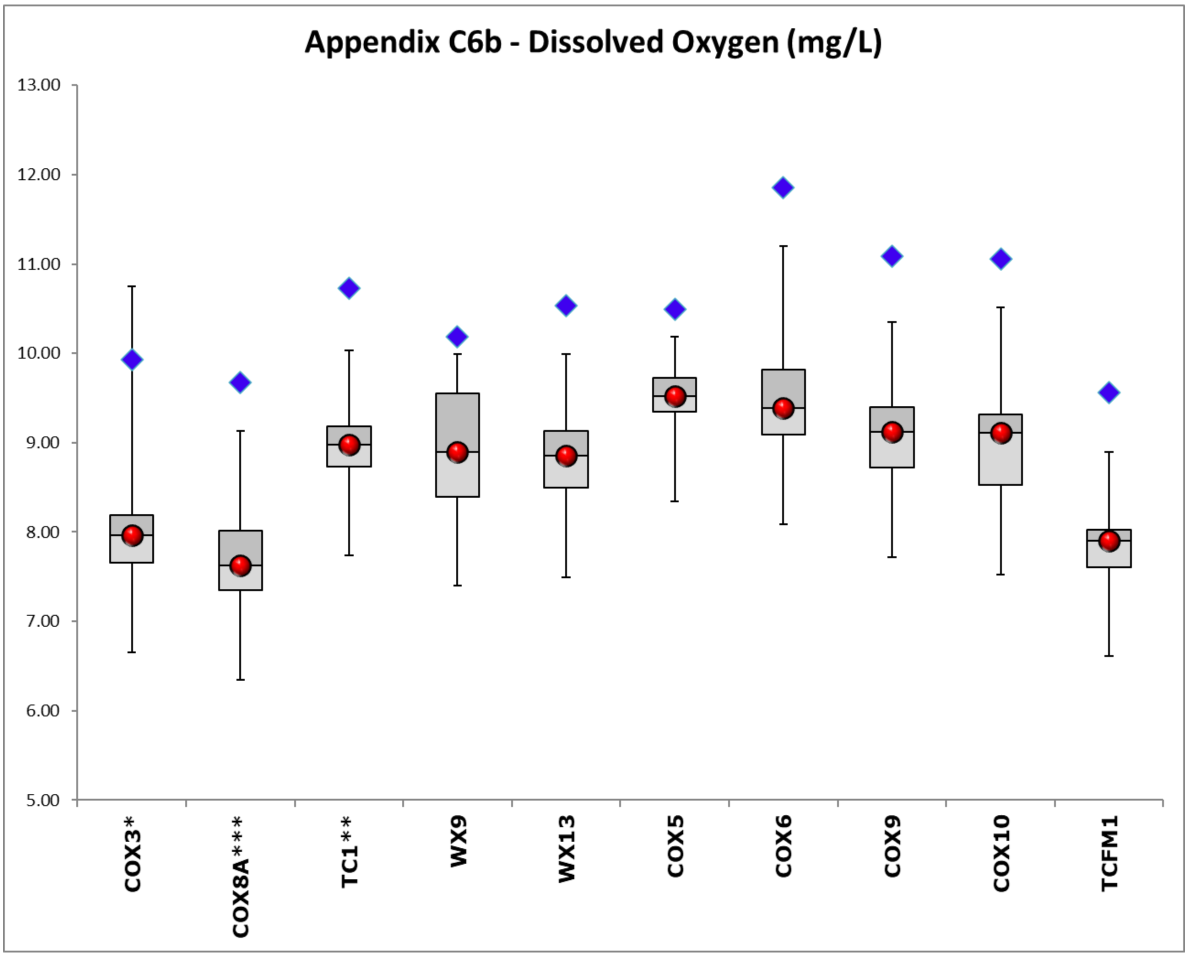


Appendix C6: Dissolved Oxygen (DO)

Appendix C6a: Historical Trend for Dissolved Oxygen

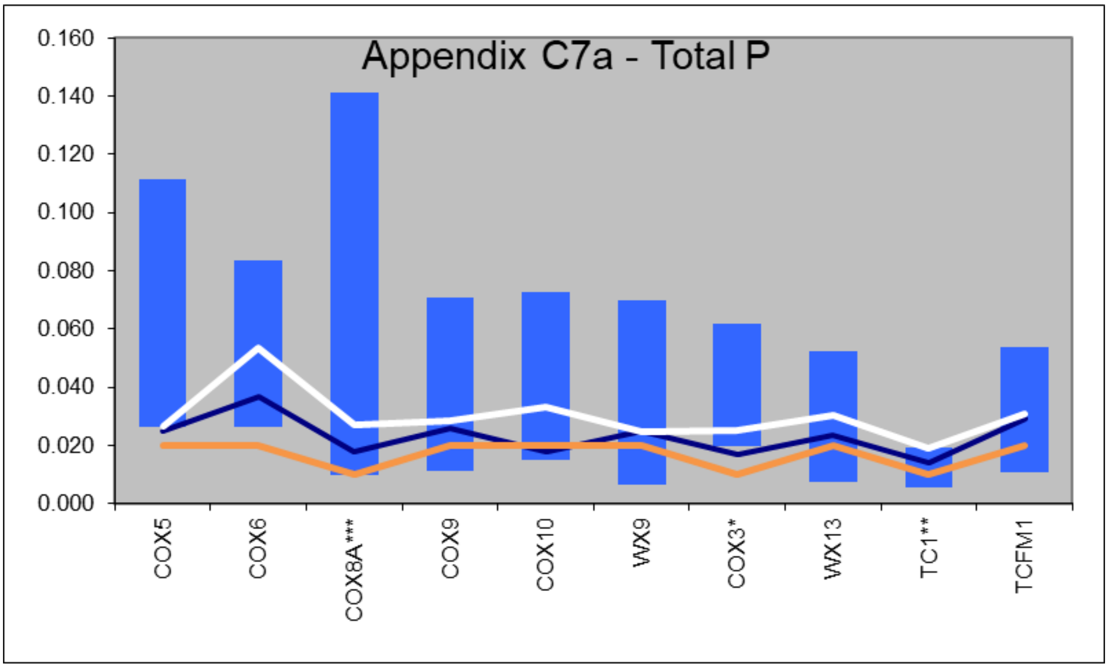


Appendix C6b: Box & Whisker Plot for Dissolved Oxygen

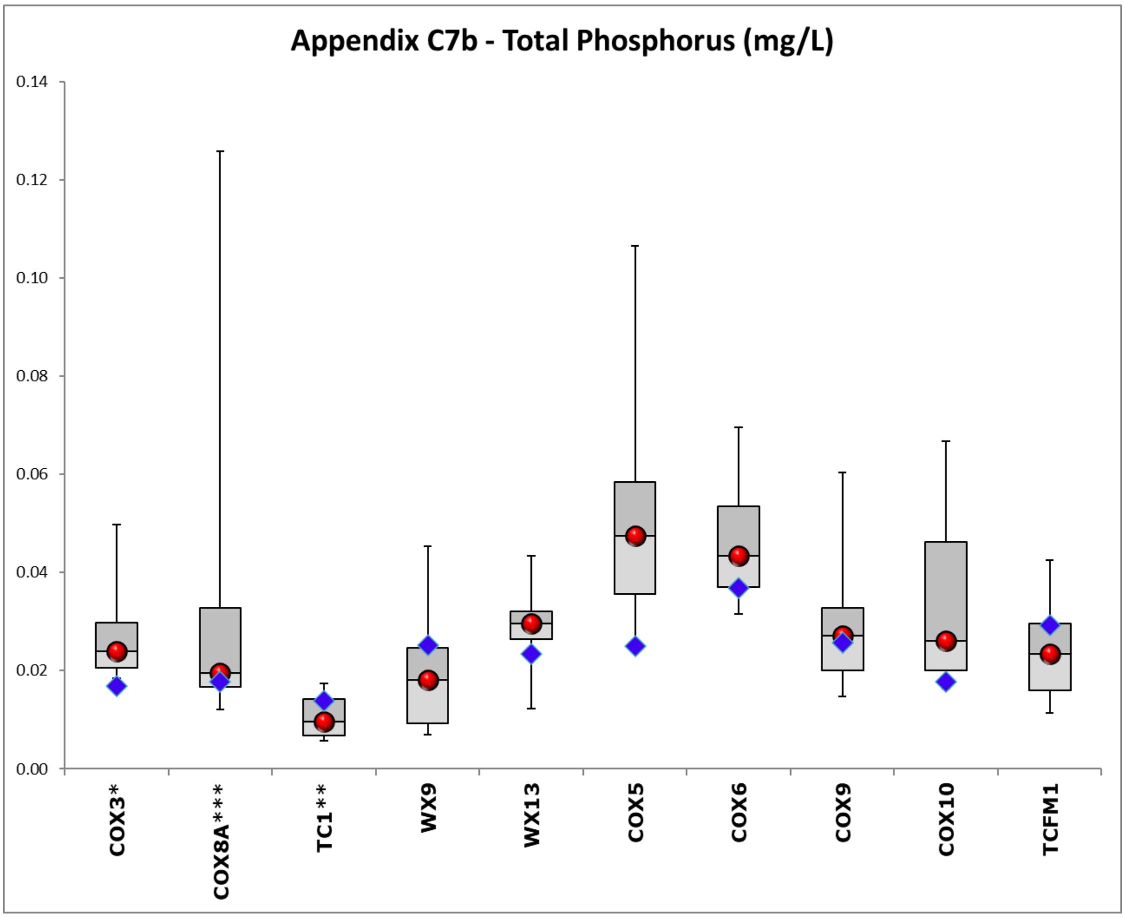


Appendix C7: Total Phosphorous (P)

Appendix 7a: Historical Trend for Total Phosphorous

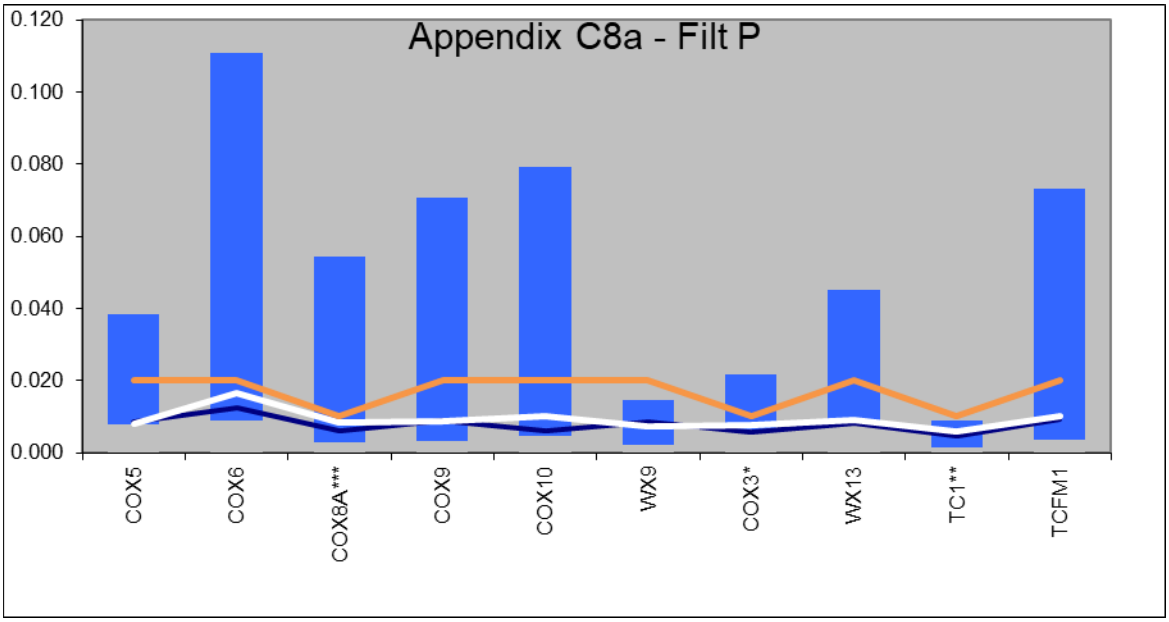


Appendix 7b: Box & Whisker Plot for Total Phosphorous

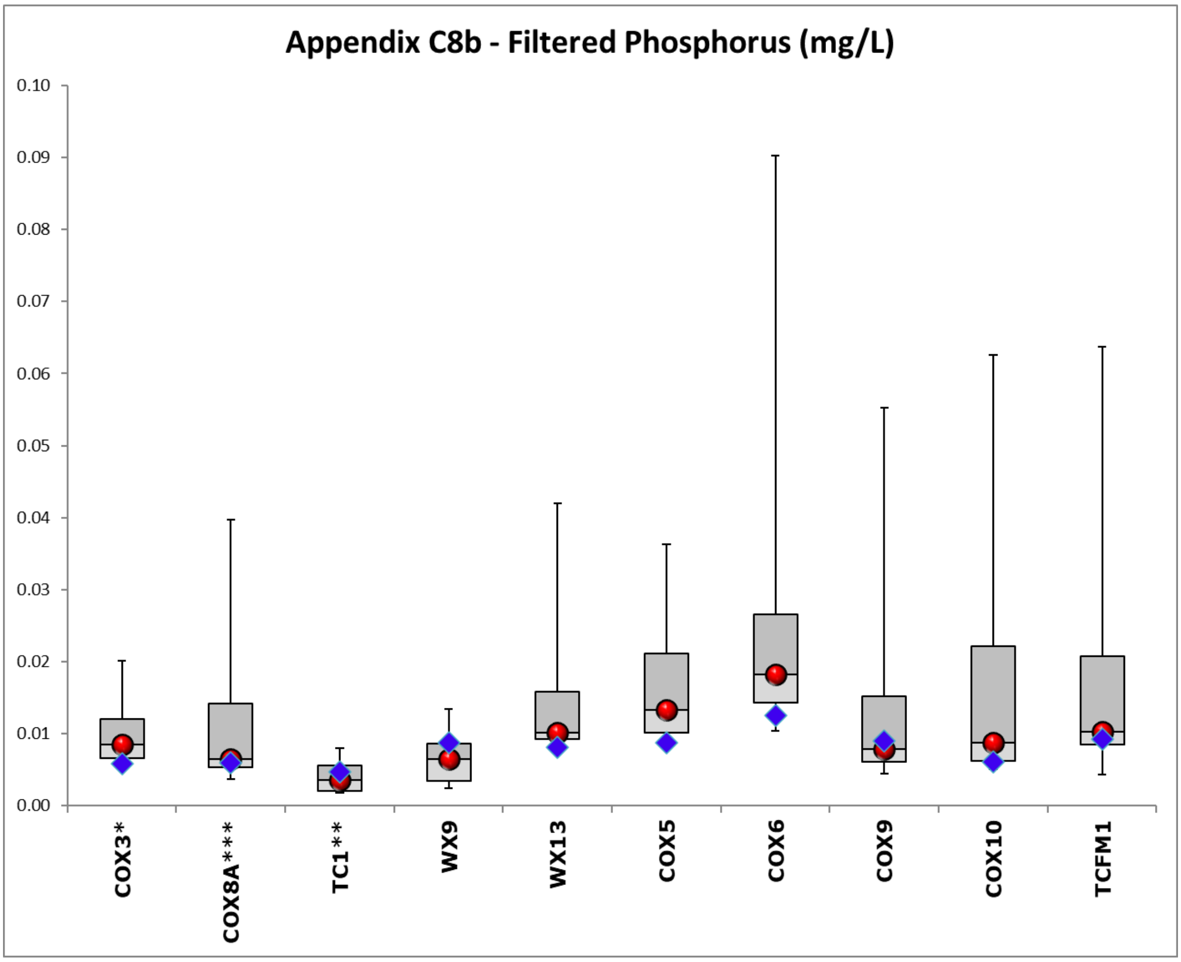


Appendix C8: Filtered Phosphorous (P)

Appendix C8a: Historical Trend for Filtered Phosphorous

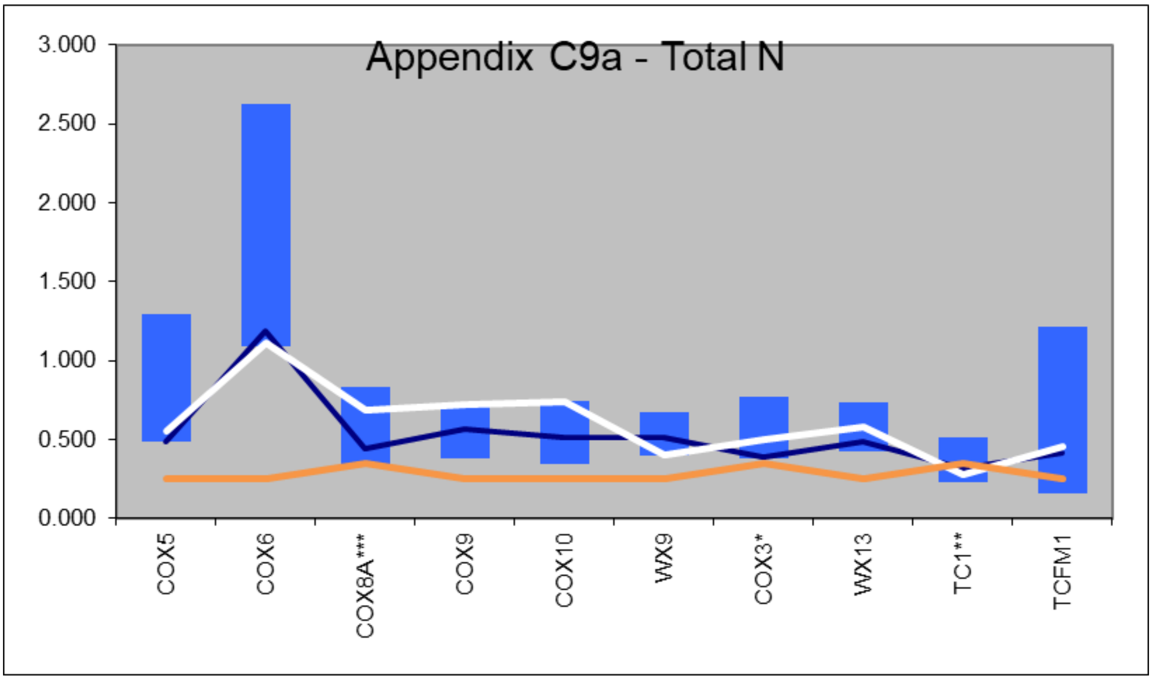


Appendix C8b: Box & Whisker Plot for Filtered Phosphorous

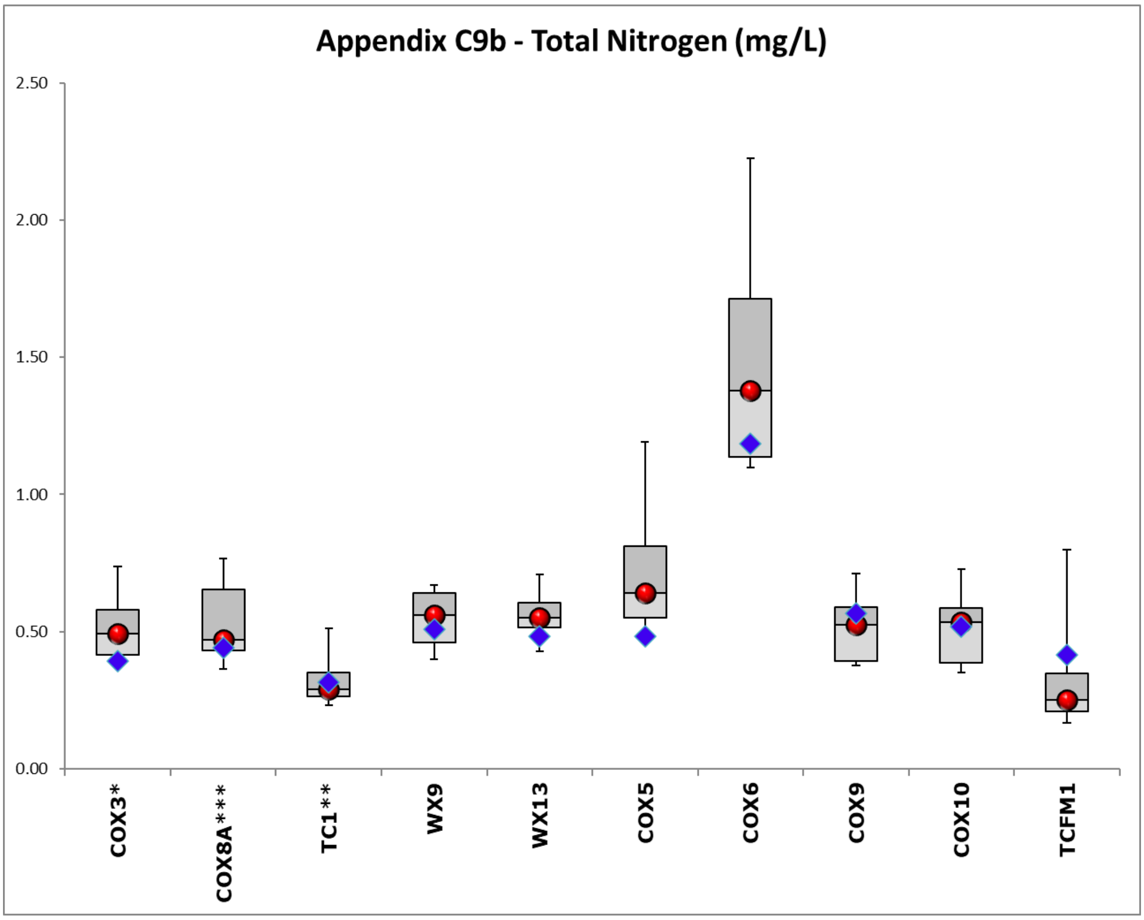


Appendix C9: Total Nitrogen (N)

Appendix C9a: Historical Trend for Total Nitrogen

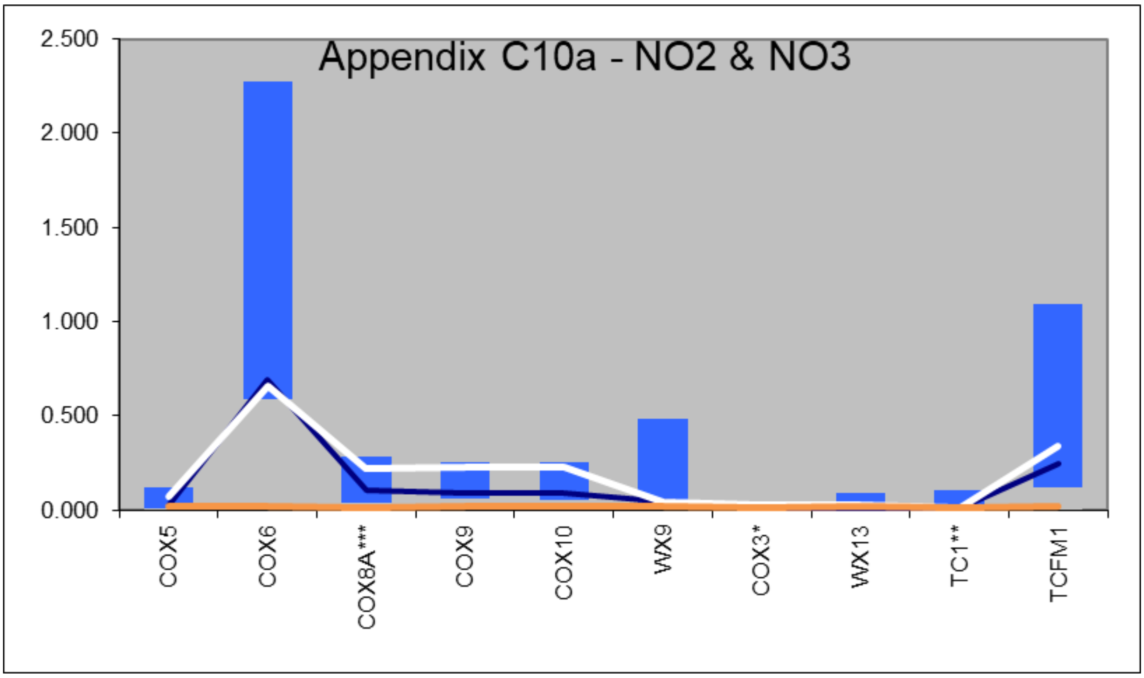


Appendix C9b: Box & Whisker Plot for Total Nitrogen

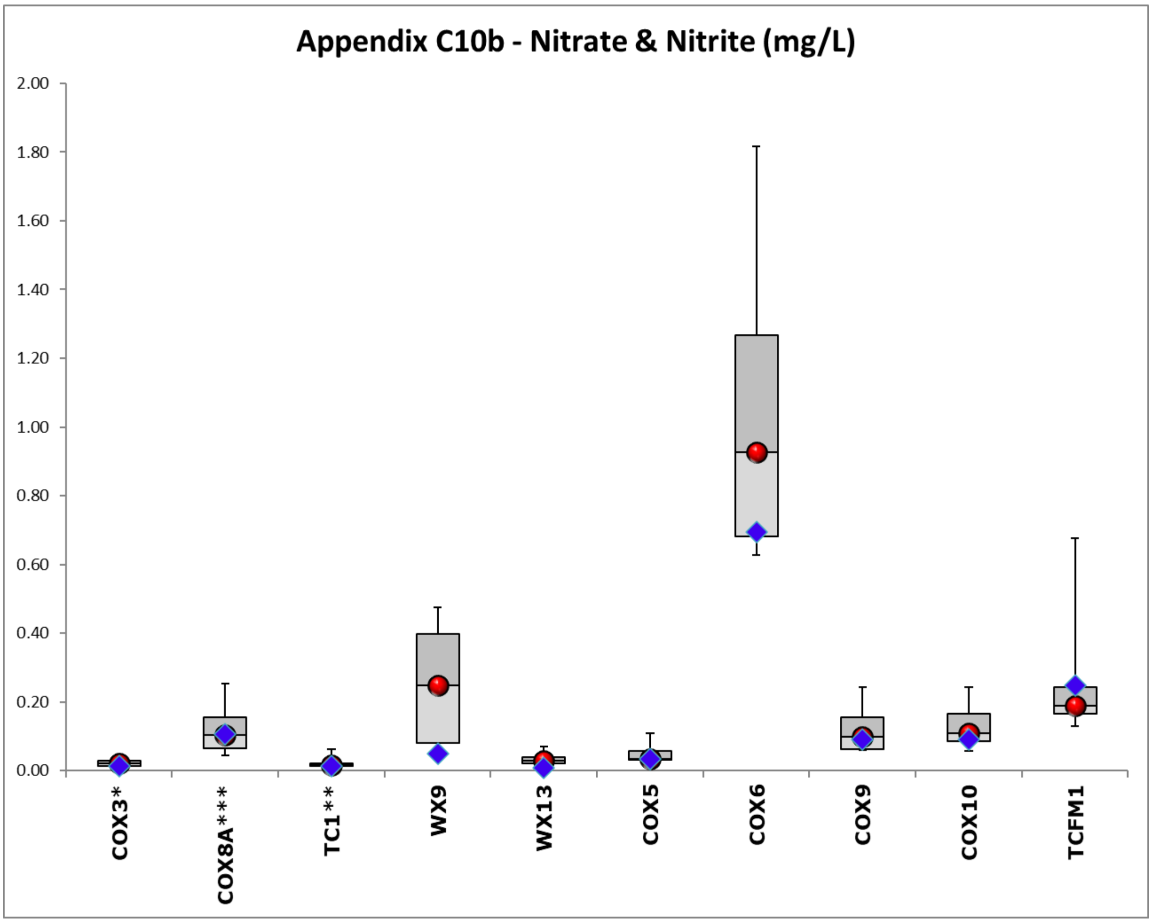


Appendix C10: Nitrate (NO_2) & Nitrite (NO_3)

Appendix C10a: Historical Trend for Nitrate & Nitrite

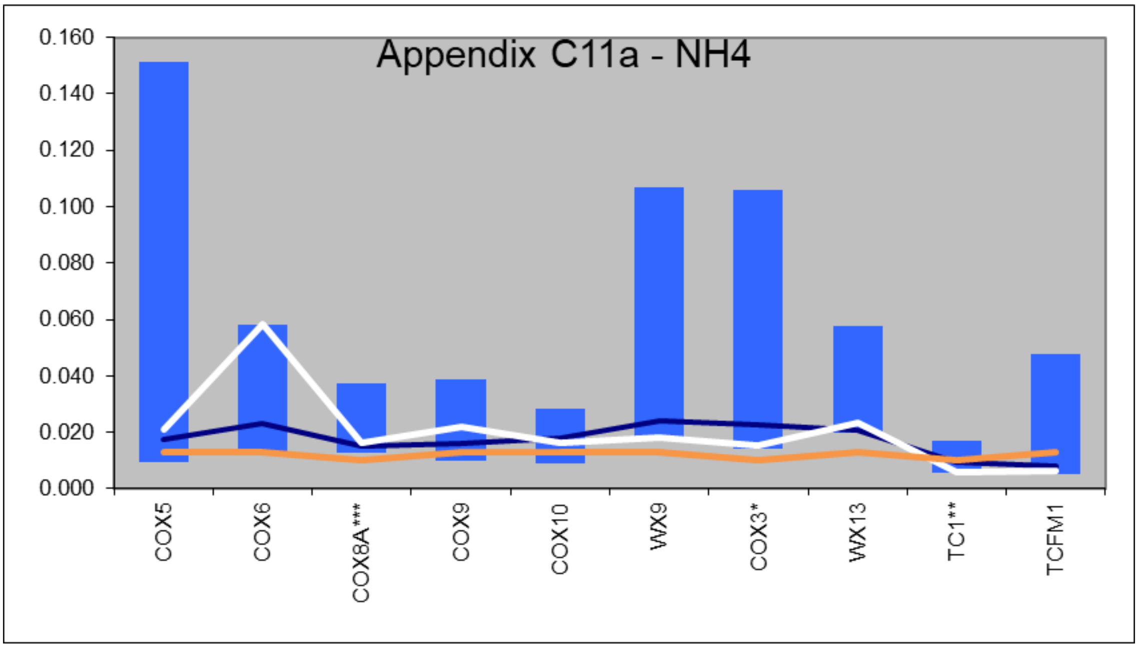


Appendix C10b: Box & Whisker Plot for Nitrate & Nitrite

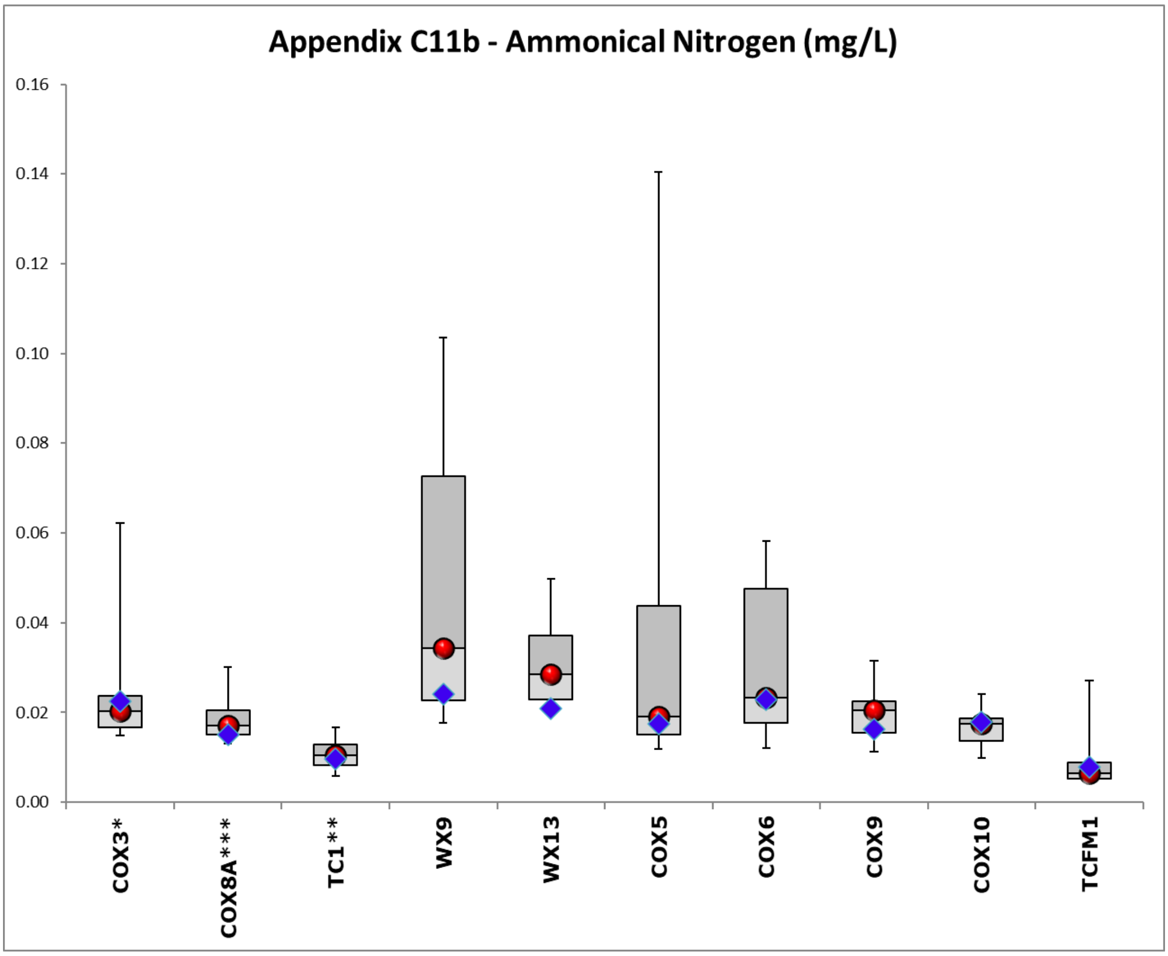


Appendix C11: Ammoniacal Nitrogen (NH_4)

Appendix 11a: Historical trend for Ammoniacal Nitrogen

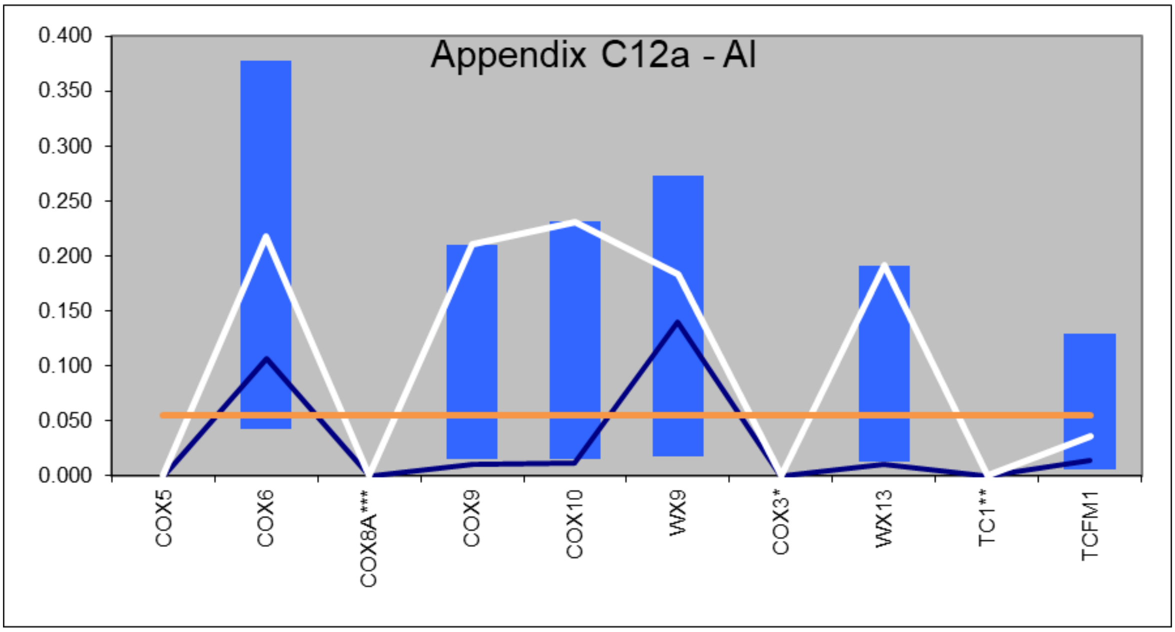


Appendix C11b: Box & Whisker Plot for Ammoniacal Nitrogen

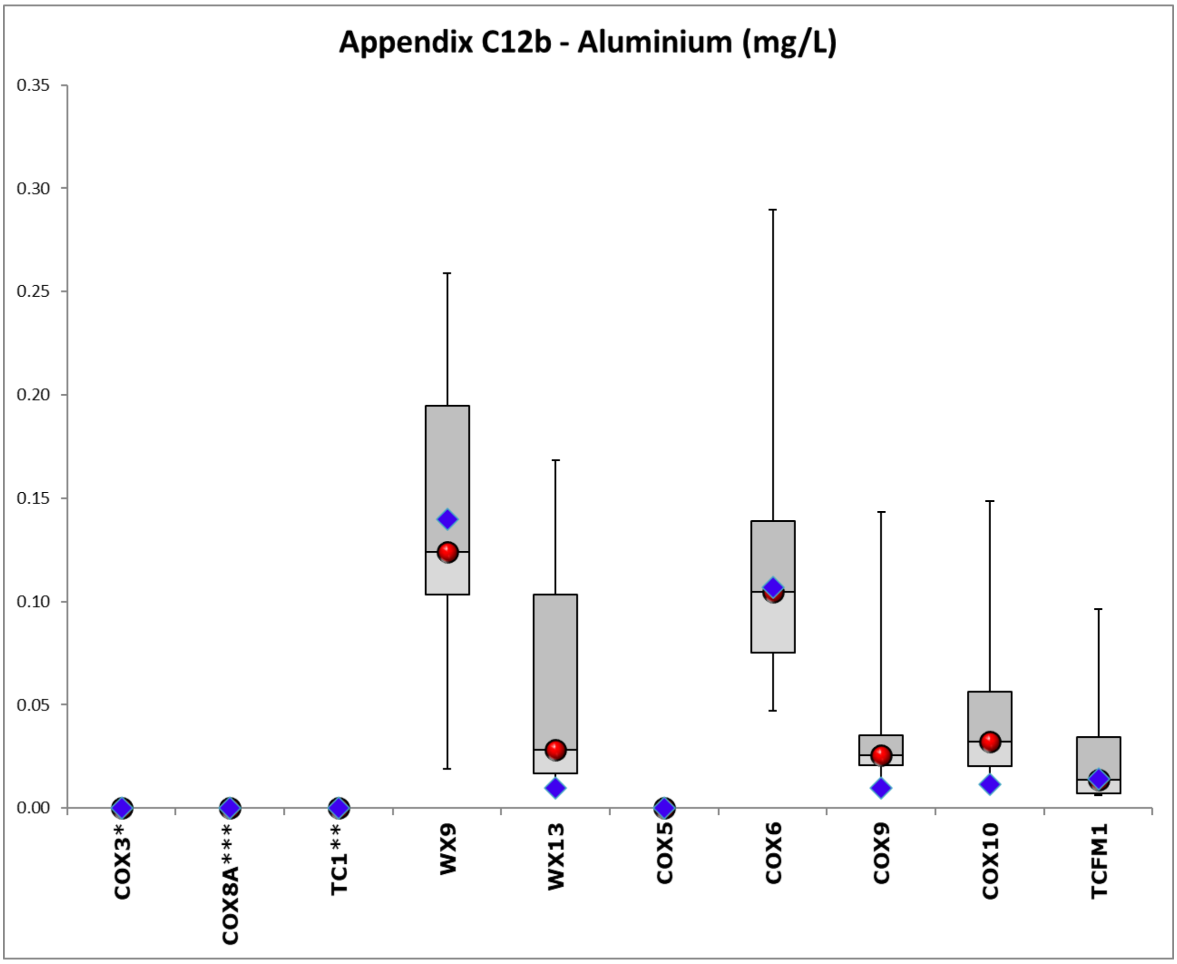


Appendix C12: Aluminium (Al)

Appendix C12a: Historical Trend for Aluminium

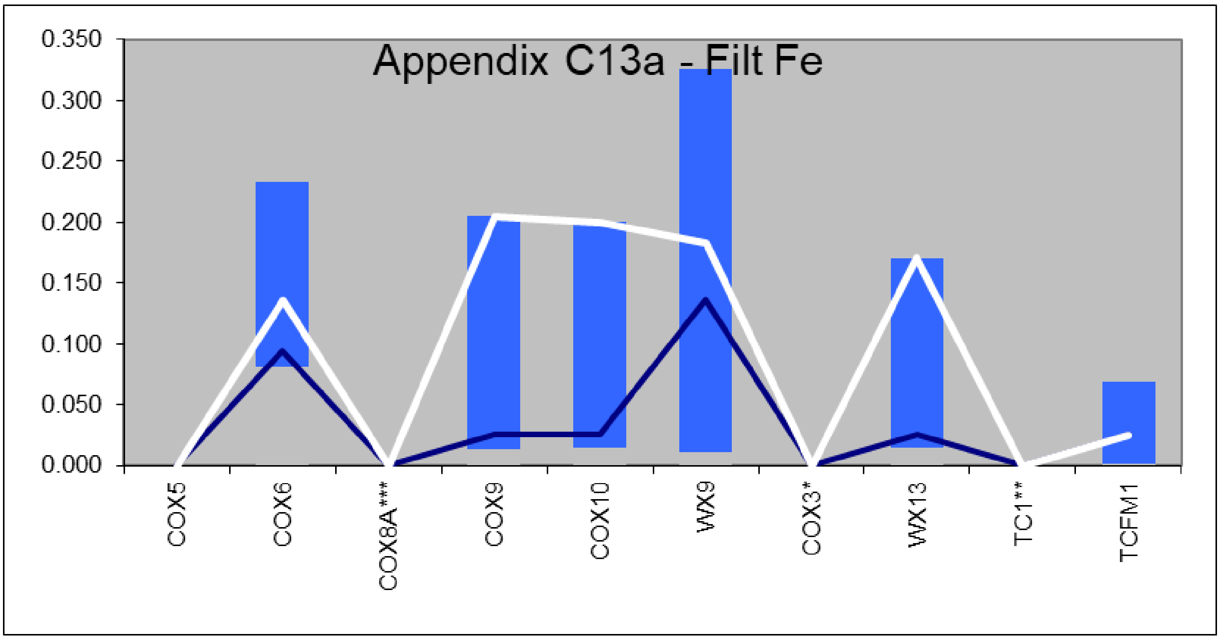


Appendix C12b: Box & Whisker Plot for Aluminium

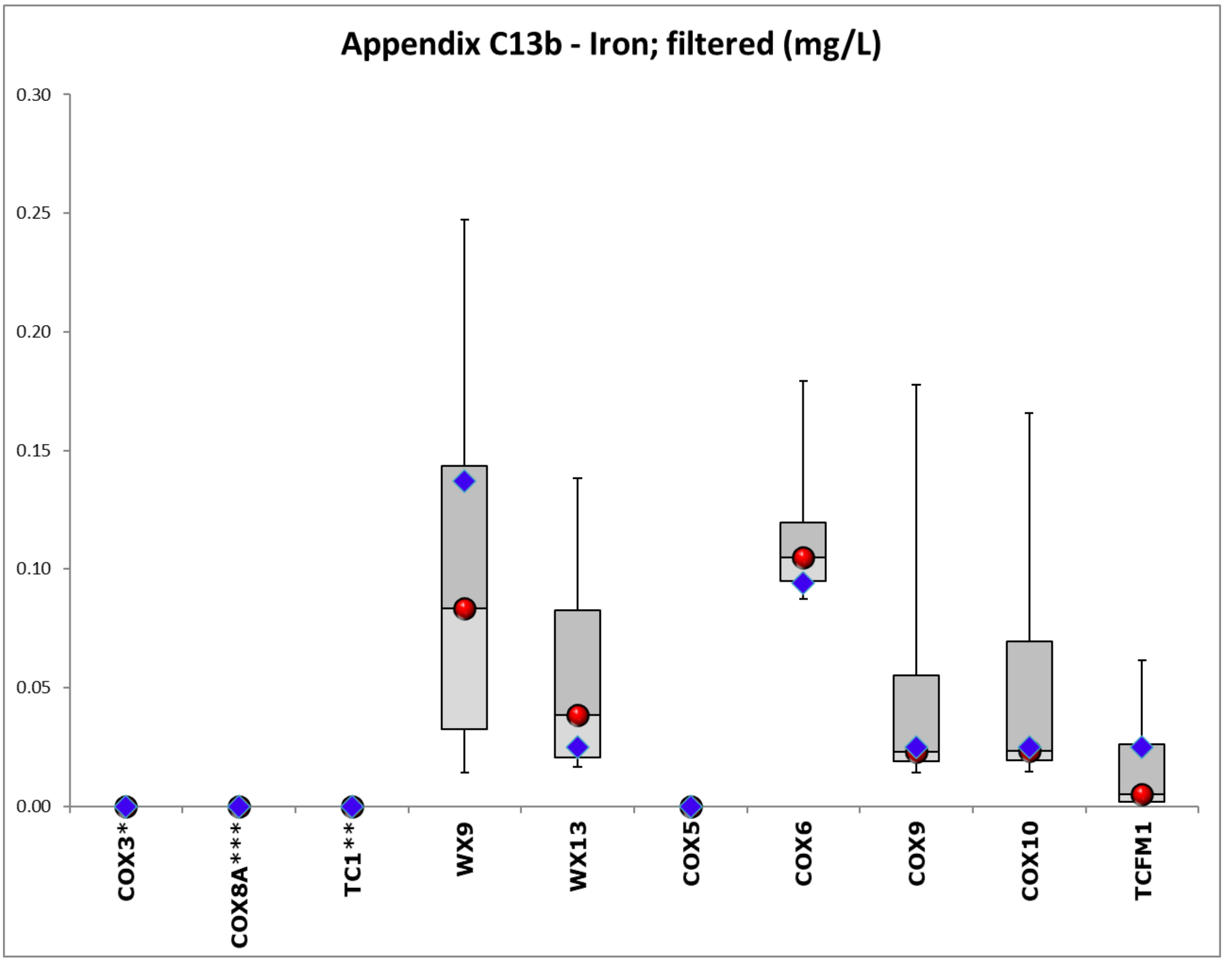


Appendix C13: Filtered Iron (Fe)

Appendix C13a: Historical Trend for Filtered Iron

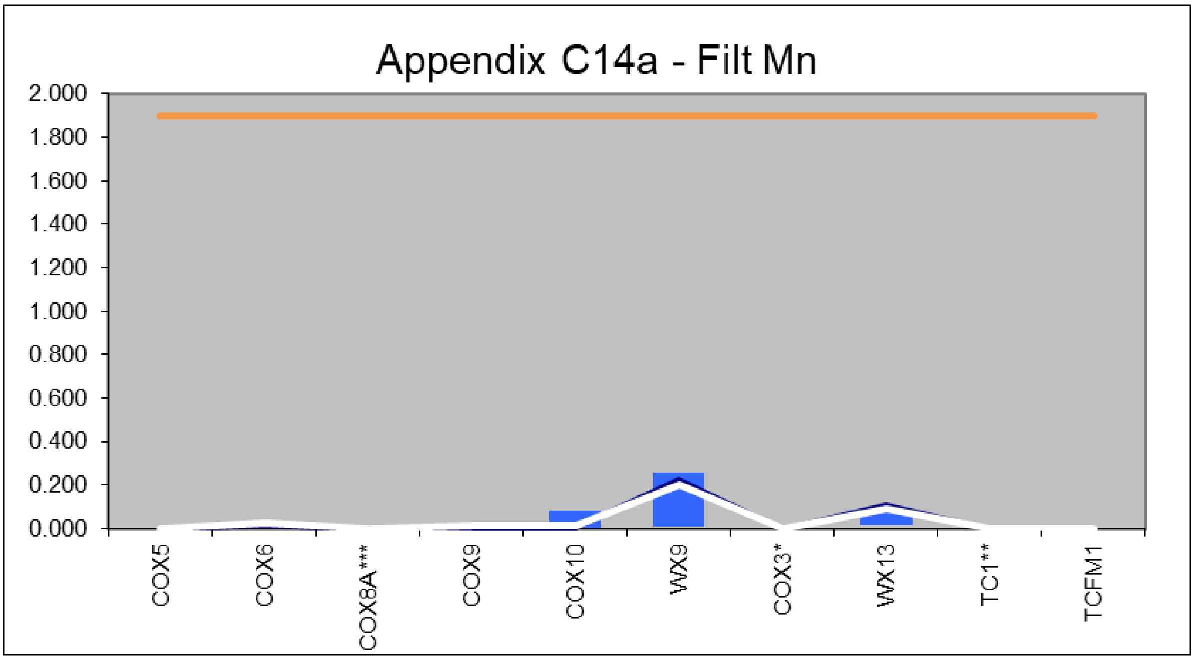


Appendix C13b: Box & Whisker Plot for Filtered Iron

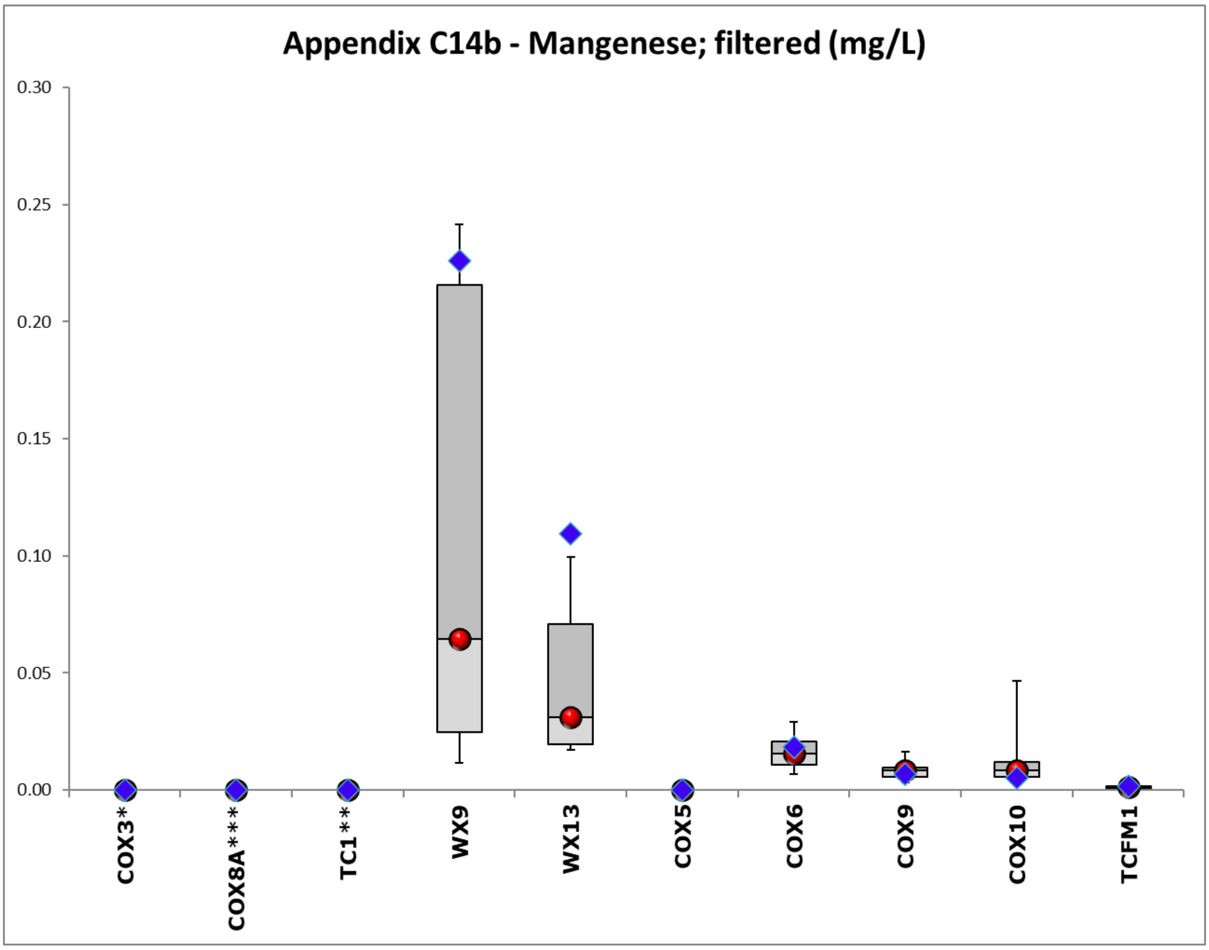


Appendix C14: Filtered Manganese (Mn)

Appendix C14a: Historical Trend for Filtered Manganese

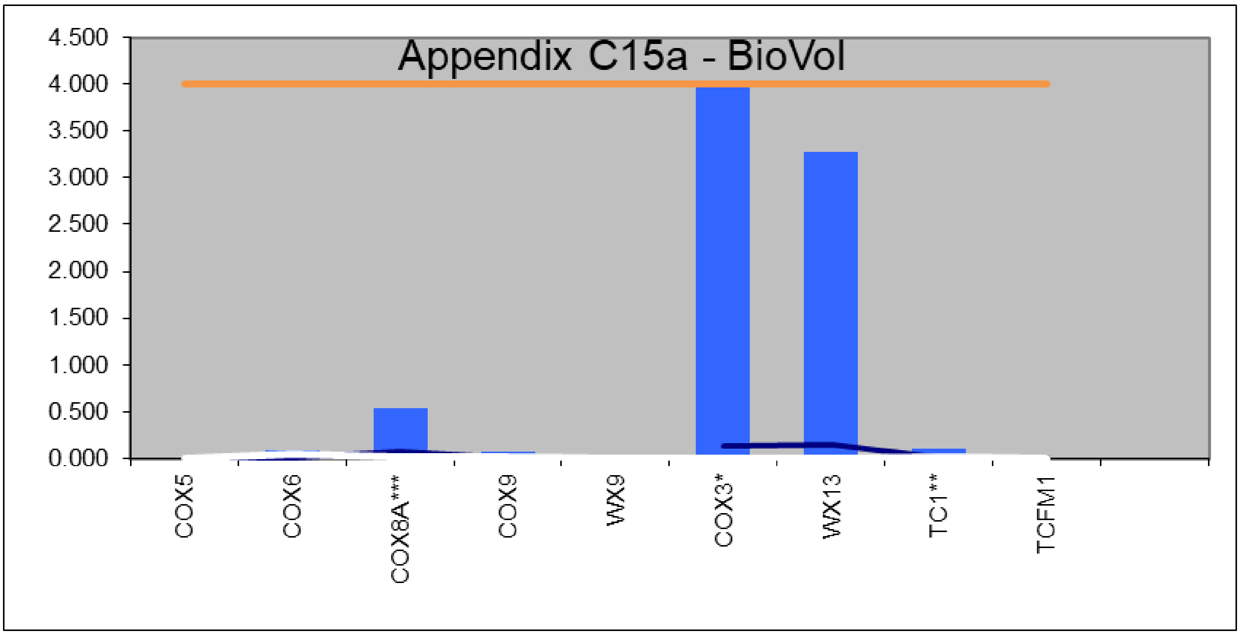


Appendix C14b: Box & Whisker Plot for Filtered Manganese

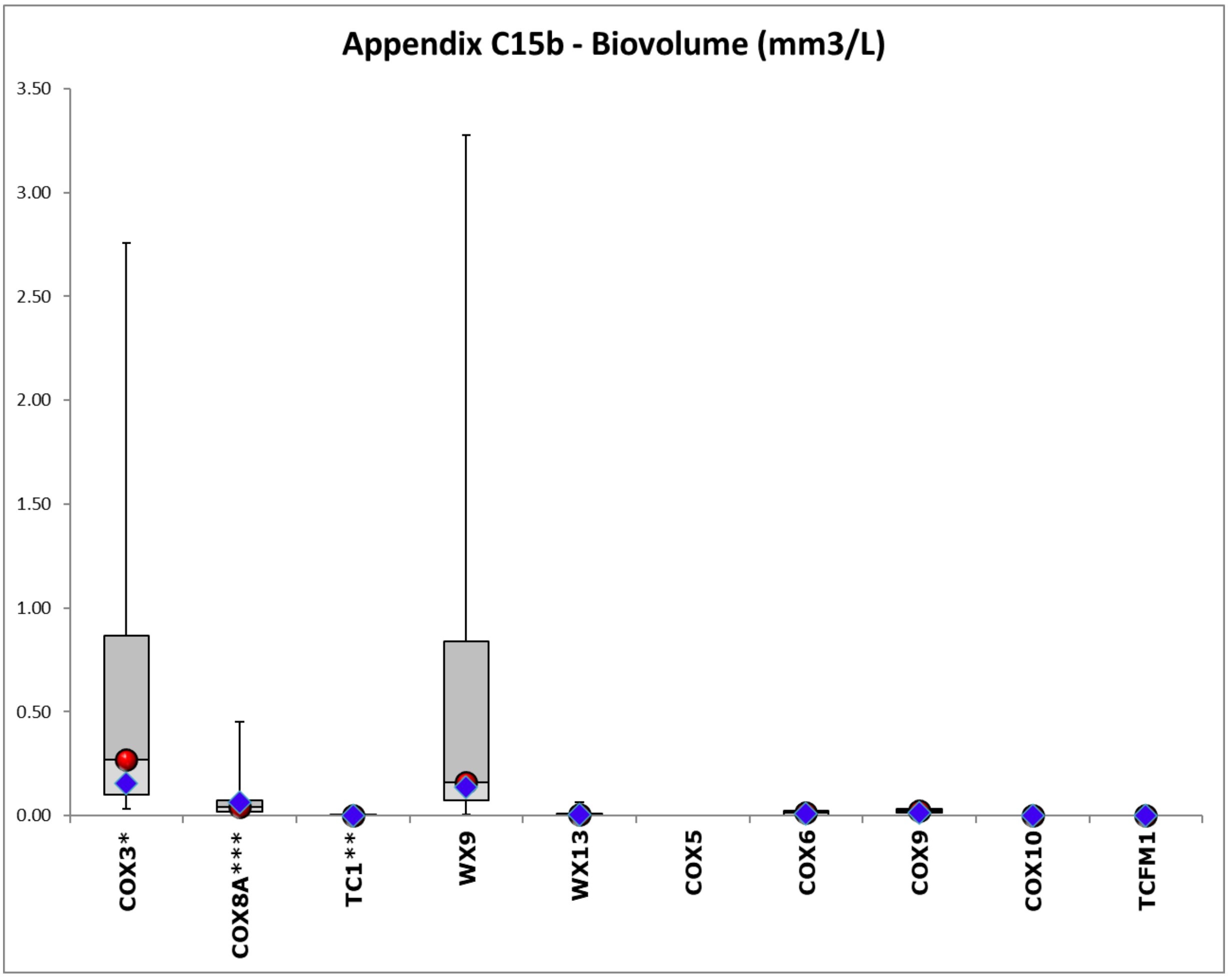


Appendix C15: Biovolume

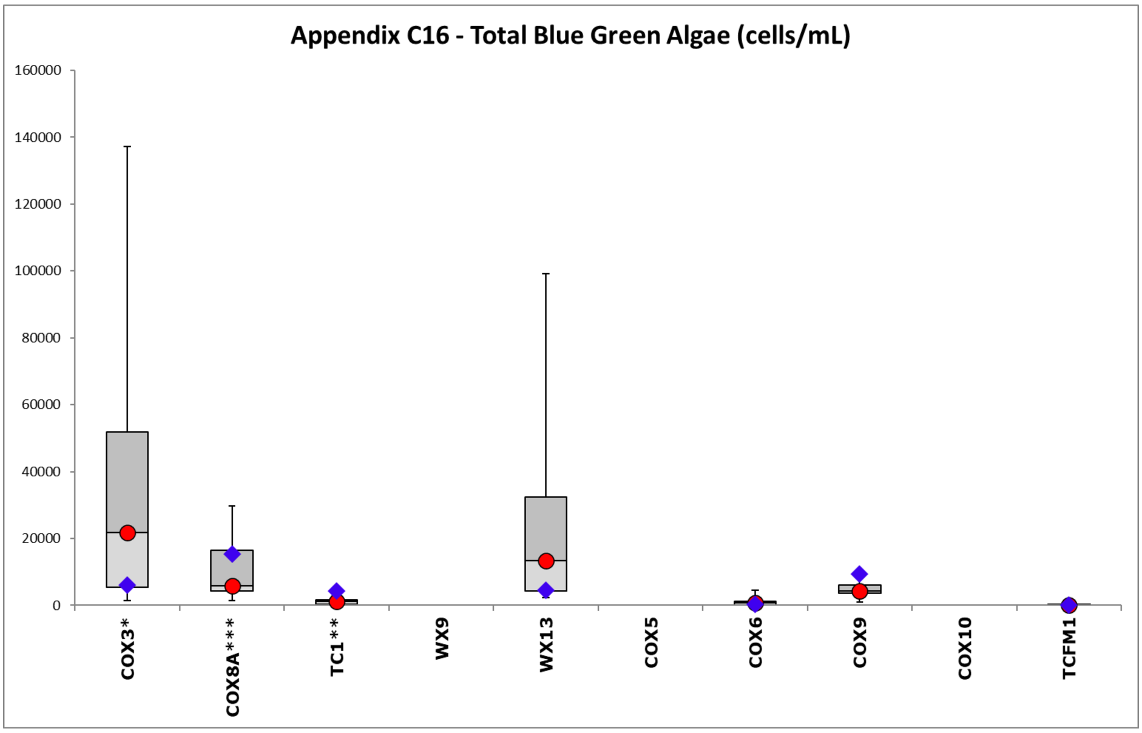
Appendix C15a: Historical Trend for Biovolume



Appendix C15b: Box & Whisker Plot for Biovolume



Appendix C16: Total Blue-Green Algae



Appendix D

D1 – Water Quality Monitoring Sites and Parameters

D2 – Water Quality Site Descriptions

D3 – Map of Water Quality Sites

Appendix D1: Water quality monitoring sites and parameters to be monitored.

Parameter	Unit	WX9	COX5	COX6	TC1	COX3	COX8A	TCFM1	WX13	COX9	COX10
Temperature	°C	•	•	•	•	•	•	•	•	•	•
Turbidity	NTU	•	•	•	•	•	•	•	•	•	•
Electrical Conductivity	µS/cm	•	•	•	•	•	•	•	•	•	•
pH	units	•	•	•	•	•	•	•	•	•	•
Dissolved Oxygen	%	•	•	•	•	•	•	•	•	•	•
Total suspended solids	mg/L	•	•	•	•	•	•	•	•	•	•
Total phosphorus	mg/L			•	•	•	•	•	•	•	•
Filterable phosphorus	mg/L			•	•	•	•	•	•	•	•
Total Nitrogen	mg/L			•	•	•	•	•	•	•	•
Ammonical Nitrogen	mg/L			•	•	•	•	•	•	•	•
Oxidised Nitrogen	mg/L			•	•	•	•	•	•	•	•
Uncombined Ammonia	mg/L			•	•	•	•	•	•	•	•
Metals – Fe, Mn, Al	mg/L	•		•				•	•	•	•
Algal species, abundance	cells/ml			•	•	•	•	•	•	•	•
Cyanobacteria biovolume	mm^3/L			•	•	•	•	•	•	•	•
Instantaneous discharge	ML/day	•	•	•				•	•	•	•

• = Monthly sampling for that parameter required at each site.

Appendix D2: Water quality site descriptions.

Water quality monitoring sites and parameters from the EA NSW WAL

Reservoir inflow sites

WX9 – Coxs River upstream of Lake Wallace at the Wallerawang stream gauge 212054

COX5 – Coxs River upstream of Lake Lyell at the stream flow gauge 212058

COX6 – Farmers Creek upstream of Lake Lyell at the stream gauge site 212042

Reservoir sites

TC1 – Thompsons Creek Reservoir at the dam wall

COX3 – Lake Wallace near the dam wall

COX8A – Lake Lyell near the dam wall

Reservoir outflow sites

TCFM1 – Thompsons Creek below the dam wall at the flow measuring device

WX13 – Coxs River below Lake Wallace at the Bathurst Road Gauge site 212008

COX9 – Coxs River below Lake Lyell upstream of the Lithgow stream gauge 212011

COX10 – Coxs River downstream Lake Lyell

River Health monitoring sites

CR1 – near COX5 at Coxs River upstream of Lake Lyell

EFR2 – near COX9 at Coxs River below Lake Lyell

EFR3 – at McKanes Bridge about 5.5 km below Lyell Dam

EFR4 – at Glenroy Bridge about 10 km below Lyell Dam and just upstream of the River Lett

RR5 – at the Duddawarra Bridge about 24 km below Lyell Dam

Geomorphology monitoring sites

Site 1 – Downstream of Jocks Creek Confluence, upstream Lithgow Gauge 212011

Site 2 – At Lowther Creek and Bowens Creek confluences, upstream of McKanes Falls

Site 3 – Upstream of McKanes Bridge

Site 4 – Downstream of River Lett confluence

Site 5 – At grants Creek confluence

Site 6 – Upstream of Duddawarra Bridge

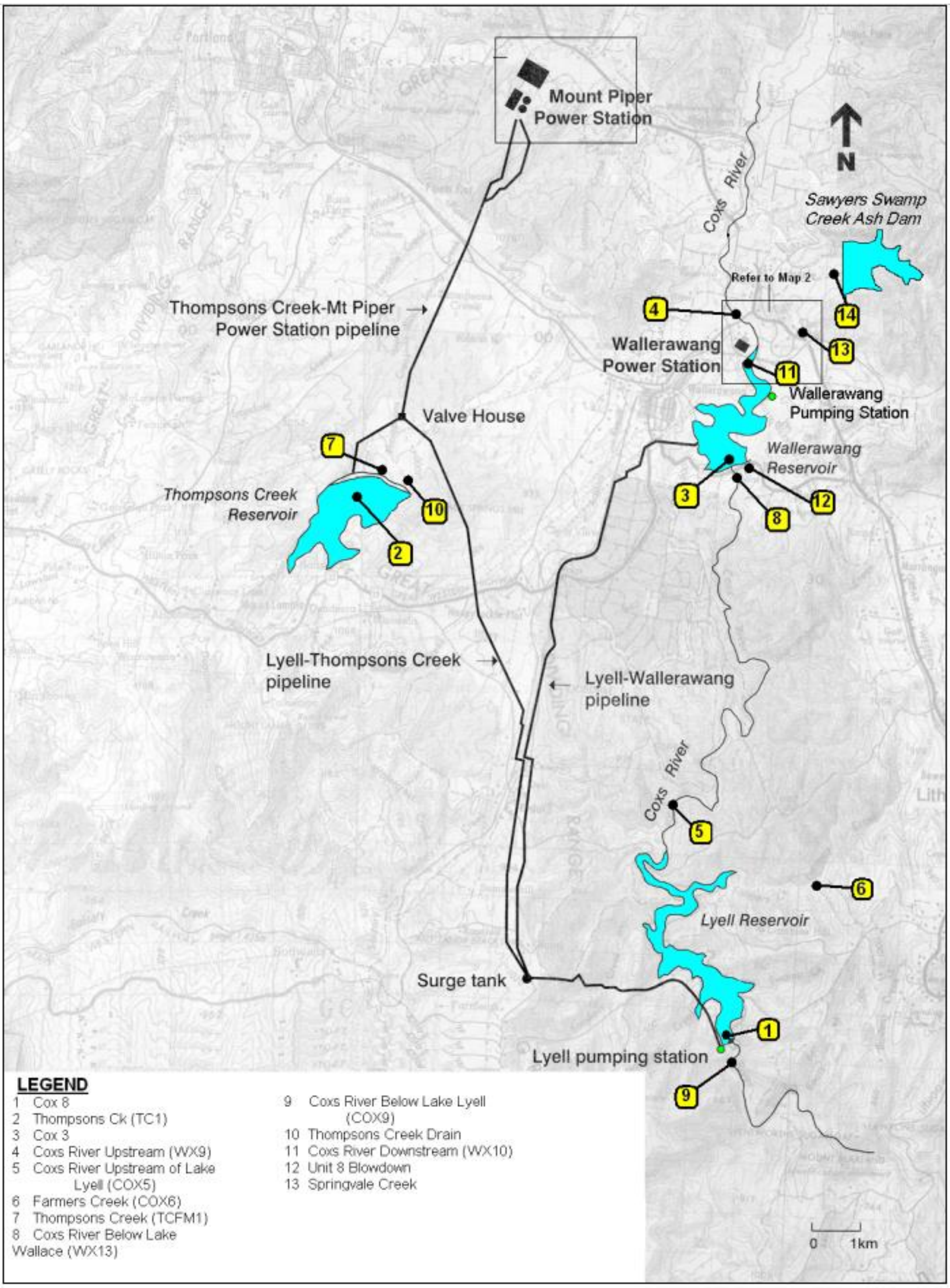
Site 7 – At Ganbenang Creek confluence

Site 8 – At Blackheath Creek confluence

Site 9 – At Cullenbenbong Creek confluence and Sandy Hook

Site 10 – Upstream of Sandy Hook

Appendix D3: Map of water quality monitoring sites



Appendix E

Laboratory QA/QC Records

Unit 12, 2 Eden Park Drive
Macquarie Park 2113
Phone: +61 (0) 2 8870 8434

ABN: 41 000 424 788

Ecolab | Nalco Water - Global Analytical & Microbiology

Quality assurance/quality control program (2024)

The laboratory's Quality assurance/quality control program ensures that sampling activities and analytical data is accurate, reliable and acceptable.

The Quality assurance/quality control program consists of both internal and external measures.

Internal

- Laboratory instrumentation and field equipment are calibrated at the correct intervals, as prescribed in the relevant NATA 'General equipment table'.
- Regular preventative maintenance is carried out on all key laboratory instrumentation and field equipment.
- Trip blanks (where appropriate) are supplied to monitor contamination.
- Certified reference materials are analysed routinely.
- Duplicate analysis is conducted to check precision.
- Laboratory blanks are analysed to monitor contamination.
- Quality control checks on media are performed.
- All records and subsequent reports are systematically checked.
- Quality control charts are used to statistically monitor trends in data.
- The laboratory is regularly internally audited.

External

- Ecolab Global Analytical & Microbiology laboratory participates in regular chemical and microbiological external proficiency testing programs as well as NATA audits as per their surveillance program.

Sampling and Data Collection

- All sampling is performed by trained personnel in accordance with procedure A-2.18 and relevant parts of Australian Standard 5667, for which NATA accreditation is held.
- Site measurements (Dissolved Oxygen, pH, Turbidity, Temperature and Conductivity) and sampling observations (water depth) are recorded and reported in accordance with procedure CA12125.

Sample Bottles

- Pre-labeled sample containers are used for routine sampling and testing.
- The sample bottles are prepared so that samples are preserved in accordance with Australian Standard 5667.1:1998 and Standard Methods for the Examination of Water and Wastewater, 22^{nd} Edition (APHA).

Delivery of Samples

- Eskies and freezer packs are used to maintain the integrity of the samples during transport from the sampling sites to our Global Analytical & Microbiology laboratory (Sydney).

National Association of Testing Authorities, Australia

Scope of Accreditation

Ecolab Pty Ltd

Site

Global Analytical & Microbiology (GAM) – Mount Piper

Accreditation No.	Site No.	Date of Accreditation
1099	15339	22 Jul 2003

Address

350 Boulder Road
Portland, NSW 2847
Australia

ecolab.com/nalco-water

Contact

Mr Hoang Le
P: +61 0421158995
thle@ecolab.com

Availability

Services conditionally available to external clients

Global Analytical & Microbiology (GAM) – Mount Piper

ISO/IEC 17025 (2017)

Environment

SERVICE	PRODUCT	DETERMINANT	TECHNIQUE	PROCEDURE
Analysis for physical and chemical characteristics	Industrial waters - Treated; Potable waters	Chloride	Titration	in-house method CA11047
		pH	Electrometric	APHA 4500 H^+ B in-house method CA12125
		Conductivity	Electrometric	APHA 2510 B in-house method CA11116
		Temperature	Manual	APHA 2550 B in-house method CA12125
		pH	Electrometric	APHA 4500 H^+ B in-house method CA10004
		Sulfate	UV-vis spectrophotometry	in-house method CA11120

SERVICE	PRODUCT	DETERMINANT	TECHNIQUE	PROCEDURE
		Fluoride	Ion selective electrode (ISE)	APHA F^- C in-house method CA11145
		Solids - Suspended	Gravimetric	APHA 2540 D in-house method CA12119
		Turbidity	Nephelometry	APHA 2130 B in-house method CA10002
Sample collection	Bore waters; Surface waters	Not applicable	Grab	AS/NZS 5667.1 AS/NZS 5667.4 AS/NZS 5567.6 AS/NZS 5667.11 in-house method A2.18

The only data displayed is that deemed relevant and necessary for the clear description of the activities and services covered by the scope of accreditation.
Grey text appearing in a SoA is additional freetext providing further refinement or information on the data in the preceding line entry.

Accreditation No.	Site No.	Print date
1099	15339	20 Nov 2023

END OF SCOPE

Appendix F

Raw Water Quality Data for Reservoirs, Inflows and Outflows 2023-24

Appendix G

River Health Monitoring Report 2023-24

Coxs River BMP – 2012 to 2023

Biological Monitoring Program - 2023

November 15, 2024

Prepared for:

EnergyAustralia

COXS RIVER BMP – 2012 TO 2023

Revision	Description	Date
A	Draft	20-10-24
0	Final	15-11-24

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Executive Summary

INTRODUCTION AND AIMS

EnergyAustralia NSW currently relies on water from the Coxs River system as a source of cooling water for Mt Piper Power Station, and previously Wallerawang Power Station before it became non-operational in March 2014. EnergyAustralia's Water Access Licence (the Licence) 10AL116411 and Water Supply Work and Water Use Approval (the Approval) 10CA117220 permit the extraction of water from Lake Lyell and Thompsons Creek Reservoir. The Approval includes a River Health Monitoring component, which details requirements for measuring the response of aquatic ecosystems to a new environmental flow regime (EFR) implemented in October 2011. Since 2002, Stantec (formerly Cardno NSW/ACT Pty Ltd, Cardno Ecology Lab and The Ecology Lab Pty Ltd) has monitored the condition of the macroinvertebrate, periphyton and fish assemblages in the Coxs River, on behalf of EnergyAustralia, and previously Delta Electricity (i.e., Coxs River Biological Monitoring Program – BMP).

The aim of the BMP is to determine if the biotic communities at EFR locations (EFR2, EFR3 and EFR4) on the Coxs River just downstream of Lake Lyell, subject to the new environmental flow regime, are becoming:

- More similar to biotic communities at locations on the Coxs River (R5), and other rivers (ABE and TUR) that are subject to more variable natural (i.e., unregulated) flow; and
- Less similar to biotic communities at locations on the Coxs River (C1) and another river (FISH) that may experience less variable, controlled (i.e., regulated) flow.

At each location, quantitative samples of fauna (macroinvertebrates and fish) and periphyton (small algae and diatoms that are attached to hard surfaces on the stream bed) were collected. At the locations on the Coxs River, aquatic macroinvertebrates associated with pool edge habitats were also sampled using the AUSRIVAS rapid assessment methodology and fish were sampled using backpack electrofishing and baited traps.

This report uses data collected during the most recent monitoring event, undertaken in October 2023, along with data previously collected before and after the implementation of the environmental flow regime, to determine the effect of the flow regime on the aquatic ecology of the Coxs River.

FINDINGS

Prevailing Flow Variability on the Coxs River

Data provided by EnergyAustralia indicate that since implementation of the environmental flow regime, releases of up to almost 800 ML/ day associated with channel maintenance (i.e., assisting with moving settled sediment) have occurred in addition to releases equivalent to some or all of the natural inflows into Lake Lyell. However, flow data available from the WaterNSW website indicated that the Coxs River upstream and downstream of Lake Lyell has experienced flows of greater variability and magnitude than that associated with the environmental flow regime. The finding that control location C1 experienced very similar flow variability to that experienced at locations experiencing environmental flows at EFR2, EFR3 and EFR4 following implementation of the environmental flow regime should also be taken into consideration when interpreting the results of the analyses of macroinvertebrate and periphyton data.

Changes in Biotic Indicators

The findings of the current survey, completed in in October 2023, were consistent with observations made previously in 2017, 2018, 2019, 2020 and 2022. The majority of the significant changes detected in some of the over 50 macroinvertebrate indicators (individual taxon abundances and total number of AUSRIVAS taxa) at EFR locations relative to temporal patterns at R5, up to and including the current survey, supported the hypothesis that macroinvertebrate communities just downstream of Lake Lyell are becoming more similar to that expected in association with natural flows. The most obvious indicator showing this was the increase in abundance of pollution-sensitive leptophlebiid mayflies at EFR2, EFR3 and EFR4 to a level comparable to that at R5 following implementation of the environmental flow regime in October 2011.

In light of the flow variability experienced upstream of Lake Lyell, changes in several macroinvertebrate indicators at EFR2, EFR3 and EFR4 relative to those at C1 were more difficult to interpret. Most of the changes suggested the macroinvertebrate community at EFR locations was becoming more similar to that at C1. This is perhaps not surprising when considering the relatively variable flow experienced at C1 (due largely to upstream releases of water into the river) compared with that just downstream of the dam in the vicinity of EFR2, EFR3 and EFR4. It seems likely that that the macroinvertebrate community present at C1 is more representative of variable rather than controlled flow conditions due to the flow variability experienced.

Changes in macroinvertebrate indicators at EFR2, EFR3 and EFR4 relative to those at the reference locations (FISH, ABE and TUR) on the Fish, Abercrombie and Turon rivers are also difficult to interpret. Given an absence of a gauging station and flow data for FISH it is also unclear if this location experiences flow characteristic of ‘controlled’ conditions or not. Both of the natural flow locations (ABE and TUR) appear to have experienced far greater flow variability and magnitude than in the Coxs River and as a result may support unique macroinvertebrate communities adapted to these conditions. These locations were not sampled in May 2018 or November 2019 due to no flow. Both of these rivers can cease to flow for periods of time and they also differ from the Coxs River in several other ways (i.e., morphology, geographic location etc.), hindering direct comparison.

Changes in numbers of periphyton indicators (diatom, blue-green algae and green algae) among locations provided very little evidence of an influence of the environmental flow regime on these assemblages. Periphyton abundance appears naturally highly variable, and it may take further time before any change attributable to the flow regime can be detected.

Fish data from 2023 also provided inconclusive evidence of changes related to implementation of the environmental flow regime. The relatively lower numbers of fish caught in 2023, 2022 and 2018 compared to 2017 was a pattern consistent across each survey site, with no indication of a decrease in the number of fish at any one location in particular. Rather, the low abundance of fish apparent after 2017 was likely due to higher flows in the Coxs River and its influence on the ability to view and capture fish. Flathead gudgeon caught in 2023 and 2022 were smaller in length than in earlier surveys, though the fewer numbers caught in 2018, 2022 and 2023 prevented thorough assessment of potential changes in flathead gudgeon recruitment attributable to implementation of the environmental flow regime. It is anticipated that with greater flow variability and the resulting changes in river geomorphology, there would be an increase in habitat heterogeneity, thus supporting a greater number and variety of existing and newly created habitat areas for native fish species to utilise.

CONCLUSIONS

Overall, analysis of data collected up to and including 2017, 2018, 2019, 2020, 2022 and most recently in 2023 (the six occasions following the latest revision of the statistical approach) provides evidence that the macroinvertebrate community at the EFR locations just downstream of Lake Lyell have, following implementation of the environmental flow regime, become more similar to what would be expected under natural flow conditions. Given there have been coincidental increases in rainfall and other water inputs since October 2011 that would also have contributed to greater flow variability in the Coxs River, the specific influence of the environmental flow regime cannot be determined. Nevertheless, the finding that many macroinvertebrate taxa appear to be responding to greater flow variability on the Coxs River downstream of Lake Lyell (to which the environmental flow regime and annual channel maintenance flows contribute) suggests that a component of the biotic community immediately downstream of Lake Lyell is becoming more similar to that expected under natural flow conditions. At this stage, findings regarding changes in the periphyton community are inconclusive. Further examination of changes in the abundance of recruits of native fish will be undertaken once data from future surveys become available.

RECOMMENDATIONS

- Monitoring should continue across the same scope of response indicators and at the same locations on the Coxs River and external reference rivers in Spring 2024. This will provide additional confidence around conclusions regarding the influence of flow variability on the biotic community of the Coxs River. It will also help to resolve other detectable effects of the environmental flow regime.
- Future analysis should continue to consider the variability in flow at each individual location, if data are available. Otherwise, any conclusions regarding the response of the biotic communities may be misleading. The identification of other predictors of changes in macroinvertebrate responses, for example metrics associated with flow variability, may also help in identifying underlying relationships between hydrology and communities of aquatic biota on the Coxs River and improve the understanding of the ecological effects of environmental flows.

1 INTRODUCTION

1.1 BACKGROUND AND AIMS

EnergyAustralia NSW (EnergyAustralia) (formerly Delta Electricity) uses water from the Coxs River catchment as a primary source of cooling water for Mt Piper Power Station. Previously, the Coxs River also provided cooling water for Wallerawang Power Station, also operated by EnergyAustralia, before it became non-operational in March 2014 and was sold in September 2020. EnergyAustralia's access to, and obligations for, the use of water resources in the Coxs River catchment are defined in its Water Access Licence 10AL116411 (WAL) and Water Supply Work and Water Use Approval 10CA117220 (the Approval) issued under the *Water Management Act 2000* by the NSW Department of Primary Industries Office of Water (NOW) on 1 July 2011 (revised and approved 24 March 2022). The Approval provides operating parameters for Lake Lyell and Thompsons Creek Reservoir, which form part of the Coxs River system, and contains the following provisions relating to the release of a comprehensive environmental flow regime downstream of Lake Lyell:

- Releases are not required from Lake Lyell, or Thompsons Creek Reservoir if the relevant water body is spilling naturally.
- When the daily volume of natural inflows into Lake Lyell is ≤ 13.6 ML/d, the volume of water that must be released from Lake Lyell shall be equivalent to the natural inflow volume (Transparent Dam Flow Releases).
- When the daily volume of natural inflows into Lake Lyell is > 13.6 ML/d, the volume of water that must be released from Lake Lyell shall be 13.6 ML/d plus 25% of the natural inflow volume above 13.6 ML/d (Translucent Dam Flow Releases).
- If a flow ≤ 800 ML/d is not recorded for at least one hour duration at the Lithgow Gauge in any water year, an Annual Channel Maintenance Flow release of 800 ML/d for a minimum continuous period of two (2) hours is to be made from Lake Lyell as soon as possible following the next natural inflow event (i.e., 600 ML/d for at least 2 hours at Mt Walker gauge on Farmers Creek and 300 ML/d for at least 2 hours at Coxs River at Wallerawang Power Station gauge).

The Approval also contains provisions relating to the Lake Lyell Drought Triggers, including:

- When the total active storage in Lake Lyell, Lake Wallace and Thompsons Creek Reservoir is < 50,000 ML, the Translucent Dam Flow Releases and the Annual Channel Maintenance Flow Releases are not required.
- When the total active storage in Lake Lyell, Lake Wallace and Thompsons Creek Reservoir is < 50,000 ML continuously for less than six months, an inflow volume up to a maximum of 9.0 ML/d shall be released from Lake Lyell (Stage 1 Drought Trigger).
- When the total active storage in Lake Lyell, Lake Wallace and Thompsons Creek Reservoir has been < 50,000 ML for six continuous months or more, an inflow volume up to a maximum of 5.0 ML/d shall be released from Lake Lyell (Stage 2 Drought Trigger).

The Approval also requires EnergyAustralia to implement a River Health Monitoring Program to assess biophysical impacts on the Coxs River downstream of Lake Lyell arising from the environmental flow regime and to estimate the likely longer-term (> 5 year) effects of maintaining the environmental flow regime, in accordance with Condition DS4976-00002 of the Approval. The Coxs River Biological Monitoring Program (BMP), which is one component of the River Health Monitoring Program, is concerned with the effect of the environmental flow regime on the biotic community of the river. The WAL and Approval requires that the BMP test the following hypotheses about the effects of the environmental flow regime on benthic macroinvertebrate communities, periphyton and fish:

- The benthic macroinvertebrate communities in the Coxs River *[sampled following implementation of the environment flow regime]* will be different from those sampled prior to the implementation of the environmental flow regime. Under the environmental flow regime, the Coxs River macroinvertebrate communities will tend to become more similar to communities that experience Natural Flow (unregulated flows – i.e., those that are not influenced by upstream artificial flow controlling features, such as dams) than to those that experience Controlled Flow (regulated flows – i.e., those that are influenced by upstream artificial flow controlling features).
- Under the environmental flow regime, the composition of periphyton (attached algae) in the Coxs River will tend to become more similar to communities that experience Natural Flow than to those that experience Controlled Flow.
- The abundance of all introduced fish in the Coxs River will be lower under the environmental flow regime than under the flow regime that was experienced prior to this.

Previously, these provisions were contained in EnergyAustralia's Water Management Licence (WML) issued by the Department of Infrastructure, Planning and Natural Resources (DIPNR) under the *Water Act 1912*, which was initiated from 1 July 2000. The main objective of the licence was to ensure that EnergyAustralia's access to water was in accordance with the principles of ecologically sustainable development described in Section 6 (2) of the *Protection of the Environment Administration Act 1991* (NSW).

Since 2002, Stantec, (formerly Cardno, and previously Cardno Ecology Lab and The Ecology Lab), has undertaken some or all of the requisite BMP. This BMP required that aquatic macroinvertebrates and periphyton be sampled at least once per year within five reaches of the Coxs River. Additionally, fish were sampled in the same reaches in some of these years. Macroinvertebrates and periphyton were also monitored in other rivers (External Reference Rivers) that also experience Controlled Flow (Wollondilly and Fish rivers) and Natural Flow (Abercrombie, Turon and Tarlo rivers), by Cardno and / or WaterNSW (formerly NOW and DIPNR).

This latest report incorporates the data collected in spring (October) 2023, following the previous survey undertaken in autumn (June) 2022. The June 2022 survey was due to be completed in spring 2021however, high rainfall and water levels in the Coxs River during the latter half of 2021 prevented this survey from being completed and June 2022 provided the next suitable sampling opportunity. The primary aim of this report was to determine whether the environmental flow regime, which prevailed in the Coxs River downstream of Lake Lyell during 2012 to 2022 (**Section 1.3**), has resulted in changes in indicators that could be considered indicative of an improvement in river health and consistent with the specific hypotheses (see above) relating to benthic macroinvertebrate communities, periphyton and fish. This was done by comparing data collected during 2012 to 2023 with those collected prior to this period while the environmental flow regime was not in effect and overall flow variability was smaller than that experienced since 2012. The environmental flow regime was also implemented for a short period of time in 2001 (**Section 1.3**); however, the effect on aquatic ecology was assessed by The Ecology Lab (2003, 2004 and 2005) and by other specialist consultants and is not considered further here.

1.2 EFFECTS OF FLOW REGULATION ON COMPONENTS OF AQUATIC ECOLOGY

Flow regulation can have substantial effects on several aspects of river health. Dams, weirs and other impoundments can alter the natural flow regime of watercourses, leading to changes in flow volume and maximum velocity, and the seasonality, frequency, duration and magnitude of flood events and inundations, among other aspects of flow variability. Compared with the relatively fixed, low flows often characteristic of regulated rivers, more variable natural flows typical of unregulated rivers can benefit aquatic biota in several ways. Greater flow variability can improve water quality measures (including suspended sediment, nutrients, salinity, temperature and dissolved oxygen) in rivers, via mixing of the water column during high flow events. The alteration of physical habitat that occurs during high flow events can also improve habitat heterogeneity, providing additional niches for biota to exploit. For example, large woody debris (an important fish habitat) may be washed into rivers from surrounding bankside areas, while accumulated sediment covering unconsolidated river substrata (e.g., gravel beds, which can also be important habitat for fish) can be cleared away during high flows, thereby increasing fish habitat heterogeneity.

Previous studies have shown that flow regime is pivotal in structuring periphyton (e.g., Biggs 1995, Biggs and Close 1989, Growns and Growns 2001, The Ecology Lab 2003, Robertson et al. 2001) and macroinvertebrate assemblages (e.g., Englund and Malvquist 1996, Pringle et al. 2002). Periphyton are an important food source for other aquatic biota, such as macroinvertebrates, and a producer of oxygen (Lowe and Laliberte 1996). However, excessive periphyton growth is unfavourable to certain sensitive taxa and can result in reduced diversity of organisms (Quinn and Meleason 2002). Disturbed rivers (e.g., regulated and / or those with excessive nutrient inputs from agriculture / pasture) can experience periphyton blooms of thick slimy mats or long filamentous strands that cover most of the riverbed (Quinn and Meleason 2002). Biggs (1995) also showed that periphyton are usually more abundant in reaches where the frequency and velocity of floods are lower. Low flows in rivers have also been found to lead to depauperate macroinvertebrate assemblages dominated by pollution tolerant chironomids (Lake and Marchant 1990, Rader and Belish 1999). Thus, maintenance of flow variability in rivers downstream of flow controlling structures (e.g., dams) must be considered for effective management of overall river health. The implementation of environmental flows that reflect natural flow regimes and their response to patterns in rainfall would help to minimise or mitigate detrimental effects on river health due to flow regulation.

1.3 PREVIOUS STUDIES

Several studies have previously been undertaken for the BMP as part of the WAL and WML. The timing of sampling, specific components of aquatic ecology monitored, and the organisations that undertook the monitoring and relevant reporting are presented in **Table 1.1**. A summary of the monitoring that was undertaken from 1995 to 2023 and the main findings from the associated reports is provided in **Sections 1.3.1** to **1.3.6**. Further detail on the locations and timing of previous surveys is provided in **Sections 2.2** and **2.3**.

Table 1-1 Timing of monitoring on the Coxs and External Reference Rivers undertaken by Australian Museum Business Services (AMBS), The Ecology Lab, Cardno, DIPNR and DNR and the relative monitoring reports.

Years	River(s) Sampled	Sampler	Report Reference
1995, 1996, 1997, 1998	Coxs River	Australian Museum Business Services	AMBS (1995, 1997 and 1999)
2002 to 2004	Coxs River	The Ecology Lab	The Ecology Lab (2003, 2004 and 2005)
	External Reference Rivers	DIPNR	Provided as raw data to EnergyAustralia only
2005 to 2010	Coxs River	The Ecology Lab / Cardno	The Ecology Lab (2006 and 2008a and b), Cardno Ecology Lab (2009 and 2010)
	External Reference Rivers (samples processing by The Ecology Lab / Cardno)	DIPNR	Provided as raw data to EnergyAustralia only
2010 to 2023	Coxs River External Reference Rivers	Cardno	Cardno Ecology Lab (2011, 2012, 2013, 2014), Cardno (2015, 2017, 2018, 2019, 2020, 2021, 2022) and current report)

1.3.1 Pre-2002

The Australian Museum Business Services (AMBS) investigated the effect of environmental flows in the Coxs River prior to 2002 and undertook field sampling of macroinvertebrates and fish in 1995, 1996, 1997 and 1998. The AMBS survey also examined water quality, grain size of river sediments, frogs and riparian vegetation but these components were discontinued thereafter.

The results showed a general improvement in the condition of the Coxs River between 1995 and 1998 (Young et al. 2000). However, trends in river health were not significantly different between environmental flow reaches and reference reaches. The exception to this was a decrease in the abundance of non-native fish that occurred in all reaches, but the rate of decrease was significantly greater in the environmental flow reaches than in the reference reaches.

1.3.2 2002 to 2004

1.3.2.1 Monitoring Undertaken

In 2002, The Ecology Lab was commissioned by Connell Wagner PPI, on behalf of Delta Electricity, to continue with and expand upon the previous studies. The Ecology Lab undertook macroinvertebrate SURBER riffle, AUSRIVAS edge and riffle, periphyton and fish sampling in the Coxs River in 2002, 2003 and 2004. The aims of the study were to:

- Use benthic macroinvertebrates, periphyton and fish as indicators of the condition of the reach of the Coxs River receiving the environmental flow regime, and at other locations not receiving these flows.
- Compare the data collected during the environmental flow regime to those collected prior to the implementation of the environmental flow regime.

The Ecology Lab was also requested to analyse some of the data obtained from this study with riffle macroinvertebrate SURBER and periphyton data collected by DIPNR from External Reference Rivers during 2002 to 2004.

1.3.2.2 Findings

The scope-of-works for The Ecology Lab required statistical analysis of data without detailed assessment of the causes and effect of the environmental flows on aquatic ecology (The Ecology Lab 2003, 2004 and 2005). The assessment of the effects of environmental flows on aquatic ecology, in the context of the existing water quality in the Coxs River, was done by Connell Wagner PPI for Delta Electricity.

The short (approximately one year) period during which the environmental flow regime was in effect was likely insufficient for significant changes in aquatic communities to occur, and thus prevented a full assessment of effects of the new environmental flow regime from being made. Nevertheless, the following observations were made:

- The results of the AUSRIVAS model indicated that the riffle habitat sampled at the location on the Coxs River immediately downstream of Lake Lyell supported fewer macroinvertebrates and was in poorer condition compared with locations further downstream. This was attributed to water, rather than habitat, quality. The macroinvertebrate assemblage sampled here using SURBER also tended to be dissimilar to other locations during spring, primarily due to fewer caenid mayflies compared to other locations.
- Analyses of periphyton data indicated that the periphyton communities at Environmental Flow locations were becoming neither more nor less similar to the communities of periphyton found at the Controlled Flow or Reference Flow locations at External Reference Rivers.
- The abundance of introduced fish present in the Coxs River declined between 1995 and 1998 and then remained low thereafter. However, whilst there were fewer introduced fish present after the flow change than before, this decline occurred before the flow change occurred.

Although the nature of the data made it difficult to make firm conclusions given the planned full environmental release flow occurred for only 12 months due to the extended drought, there was some limited evidence in macroinvertebrate data that supported the hypothesis regarding the beneficial effects of the environmental flow regime (see **Section 1.1**). The periphyton and fish data also did not provide support for the hypotheses that the environmental flow regime, which was in effect during 2001, had affected the periphyton and introduced fish.

1.3.3 2005 to 2010

1.3.3.1 Monitoring Undertaken

Cardno undertook macroinvertebrate SURBER riffle, AUSRIVAS edge and riffle, and periphyton sampling in the Coxs River from 2005 to 2010. Fish sampling was undertaken in the Coxs River in 2006, 2008 and 2009. DIPNR also sampled riffle macroinvertebrates using SURBER and periphyton in External Reference Rivers from 2006 to 2009 and the macroinvertebrate samples were processed by Cardno. However, sampling of the External Reference Rivers was undertaken as part of a separate agreement and the results were not considered in the reporting during these years.

1.3.3.2 Findings

During this period, there were insufficient natural inflows to raise the total active storage above the 50,000 ML threshold required to deactivate the drought trigger instituted in 2002. Consequently, the environmental flow regime could not be implemented and assessment of its effect on the aquatic ecology of the Coxs River could not be undertaken. Despite this, the following observations were reported by Cardno Ecology Lab (2010):

- Although there was little consistency among locations in the pattern of change in riffle assemblages through time, the structure of the macroinvertebrate assemblages sampled at the location immediately downstream of Lake Lyell was often significantly different from those sampled at the other locations. This was attributed to the reduced opportunity for downstream drift of macroinvertebrates into the former due to the lack of spill over from Lake Lyell and small inflows from the surrounding catchment upstream of this location.
- There was also little spatial consistency in the pattern of change in periphyton indicators. Differences between the location immediately downstream of Lake Lyell and those further downstream were possibly related to effects on periphyton growth related to a decrease in the concentration of nutrients resulting from settling and assimilation processes and their general dilution within Lake Lyell. The growth of periphyton in downstream locations may also have been enhanced by nutrients derived from agricultural runoff and the livestock that access the river. The dissimilarity between the periphyton assemblages at the location upstream of Lake Lyell and the other locations was probably related to differences in hydrological regime. The periodic overspills from Lake Wallace would likely increase the rate of sloughing and erosion of periphyton and either result in their downstream drift or mortality.
- The non-native eastern gambusia was often present in relatively large numbers. Non-native wild goldfish (*Carassius auratus*), brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*), were also present. Wild goldfish appeared to be restricted to the reach upstream of Lake Lyell and greater numbers of rainbow trout were also caught here than at other locations.

Among the several recommendations on ways to enhance the BMP, it was recommended that the data collected from the External Reference Rivers be included in future analyses to assist in the assessment of the effect of the environmental flow regime, once it was implemented.

1.3.4 2011 to 2015

1.3.4.1 Monitoring Undertaken

Cardno undertook sampling of macroinvertebrate SURBER riffle, AUSRIVAS edge and riffle and periphyton in the Coxs River, and riffle macroinvertebrates using SURBER and periphyton in External Reference Rivers, in autumn of 2011 to 2015. In the Coxs River, fish were also sampled in autumn of 2012 and 2014.

1.3.4.2 Findings

Evidence that could potentially support the hypothesis that the biotic communities at the locations subject to the environmental flow regime were becoming more similar to those experiencing Natural Flows on the Coxs River during this time was limited and inconclusive (Cardno 2015). AUSRIVAS edge and riffle assemblages and the edge SIGNAL2 Score did provide some evidence supportive of the macroinvertebrate communities at the environmental flow regime locations becoming more similar to that at the Natural Flow location on the Coxs River. However, the marked differences in hydrological regime and hydraulic characteristics that prevailed during the more recent surveys likely contributed to the absence of observable patterns that could have been attributed to environmental flows. The high flow events that occurred in 2010 and 2012, and prior to the surveys undertaken in 2011 and 2013, respectively, likely had had a substantial effect on the biological assemblages in the Coxs River. It is possible that these flows masked potential responses of aquatic biota to the environmental flow regime. In particular, the high flow event of 2010 occurred shortly before implementation of the environmental flow regime and could have influenced biota at the time of the first survey after implementation (i.e., 2011). The differences in observed spatial patterns between surveys are likely to reflect differences in the magnitude and duration of elevated flows, the timing of such flows relative to the surveys and differences in the recovery rates of the biota within the different river systems.

1.3.5 2016 and 2017

1.3.5.1 Monitoring Undertaken

Monitoring in November 2016 and November 2017 was undertaken following the review of the monitoring methods that was completed in mid-2016 (**Section 2.1**). It included sampling of macroinvertebrates and periphyton in Coxs River locations and three of the original five reference river locations. Analysis was undertaken using data collected from 2002 to 2016 (Cardno 2017) and from 2002 to 2017 (Cardno 2018) to assess the effectiveness of the environmental flow regime. This was undertaken using a revised approach to data analysis that was more suitable to detecting change in the various indicators due to the environmental flow regime (**Section 2.6**). Fish were sampled in June 2017 and July 2018.

1.3.5.2 Findings

The results of the analysis of data collected up to and including 2016 indicated changes in several macroinvertebrate responses that were suggestive of the macroinvertebrate communities at EFR2, EFR3 and EFR4 (i.e., those just downstream of Lake Lyell) becoming more similar to those at locations on the Coxs River and other rivers that experience natural flows (R5, ABE and TUR). Such findings provided support for the hypothesis regarding changes in the macroinvertebrate community. The most obvious of these was the increase in abundance of leptophlebiid mayflies at EFR3 and EFR4 to a level comparable to that at R5 following implementation of the environmental flow regime in October 2011. Changes in numbers of periphyton indicators (diatom, blue-green algae, green algae and euglenoid cells) provided very little evidence of an influence of the environmental flow regime on periphyton assemblages.

Following inclusion of data collected in 2017, the results of the analyses indicated the majority (39 of 46) of changes detected in macroinvertebrate responses sampled at EFR2, EFR3 and EFR4 were supportive of the hypothesis that macroinvertebrate communities just downstream of Lake Lyell are becoming more similar to that expected of natural flows. The most obvious of these was the increase in abundance of leptophlebiid mayflies at EFR3 and EFR4 to a level comparable to that at R5 following implementation of the environmental flow regime in October 2011. This indicted that the macroinvertebrate communities at the EFR locations were becoming more similar to what would be expected under natural flow conditions, following implementation of the environmental flow regime. Given the timing of implementation coincided with an apparent increase in rainfall and other water inputs that would also have contributed to greater flow variability in the Coxs River, the specific influence of the environmental flow regime could not be determined. Nevertheless, the finding that many macroinvertebrate taxa appeared to be responding to greater flow variability on the Coxs River downstream of Lake Lyell suggested that a component of the macroinvertebrate community immediately downstream of Lake Lyell was becoming more similar to that expected under natural flow conditions. Findings regarding such changes evident in the periphyton community were less conclusive, though may become more evident in the future if flow variability on the Coxs River is maintained.

1.3.6 2018

1.3.6.1 Monitoring Undertaken

Autumn 2018 surveys were undertaken in May 2018 at each location on the Coxs River and one reference river location (on the Fish River) (Cardno 2019). Sampling was not undertaken at the Abercrombie and Turon rivers due to the absence of flowing water at these locations following periods of low rainfall. Fish were surveyed at locations on the Coxs River in July 2018.

1.3.6.2 Findings

The majority of changes detected in macroinvertebrate responses sampled at EFR2, EFR3 and EFR4 relative to R5 were supportive of the hypothesis that macroinvertebrate communities just downstream of Lake Lyell are becoming more similar to that expected of natural flows. The most obvious of these was the increase in abundance of leptophlebiid mayflies at EFR3 and EFR4 to a level comparable to that at R5 following implementation of the environmental flow regime in October 2011. This taxon is somewhat sensitive to water pollution and has been assigned a Stream Invertebrate Grade Number Average Level (SIGNAL2) score of 7, where 1 indicates a highly pollution tolerant taxon and 10 a highly pollution sensitive taxon (Chessman 2003). Changes in the numbers of oligochaete worms, which appeared to decrease at the EFR locations following implementation, were also supportive of the hypothesis. Although there were some changes in macroinvertebrate responses that were not supportive of the hypothesis, these were less common.

In light of the flow variability experienced upstream of Lake Lyell, changes in several macroinvertebrate indictors at EFR2, EFR3 and EFR4 relative to those at C1 are more difficult to interpret. Most of the changes suggested the macroinvertebrate community was becoming more similar to that at C1. This is perhaps not surprising when considering the relatively variable flow experienced at C1 (due largely to upstream releases of water into the river) compared with that just downstream of the dam in the vicinity of EFR2, EFR3 and EFR4. It seems likely that due to the flow variability experienced at C1 that the macroinvertebrate community present here is more representative of variable rather than controlled flow conditions.

Changes in responses at EFR2, EFR3 and EFR4 relative to those at the reference location (FISH) on the Fish River are also difficult to interpret. Changes were generally indicative of the community becoming less similar to FISH, though evidence was relatively weak. Both the natural flow locations (ABE and TUR) appear to have experienced far greater flow variability and magnitude than that experienced on the Coxs River and as a result may support their own unique community adapted to these conditions. However, these locations were not sampled in May 2018 due to no flow. Both of these rivers cease to flow for periods of time and would also differ in several other ways (such as morphology, geographic location, etc.). Such differences would likely make such comparisons problematic. Comparisons with FISH are also hindered in the absence of flow data and it is unclear if this location experiences flow characteristic of 'controlled' conditions. The findings of the current study (based on data collected up to and including 2018) were largely comparable to those of the most recent study undertaken previously (and based on data collected up to and including

2017). Changes in numbers of periphyton indicators (diatom, blue-green algae and green algae) provided very little evidence of an influence of the environmental flow regime on periphyton assemblages.

Generally, fewer fish were caught in the Coxs River in 2018 and 2019 (see below) than in 2017, though there was no indication of any influence of the flow regime on fish abundance. The few numbers caught overall prevented analysis of change in length frequencies between years, though the length of flathead gudgeon and mountain galaxias caught in 2019 and 2018 were comparable with those caught in 2017.

1.3.7 2019

1.3.7.1 Monitoring Undertaken

Spring 2019 surveys were undertaken in November 2019 at each location on the Coxs River and one reference river location (on the Fish River) (Cardno 2020). Sampling was not undertaken at the Abercrombie and Turon rivers due to the absence of flowing water at these locations following periods of low rainfall.

1.3.7.2 Findings

Changes in the abundance of macroinvertebrates at EFR2 and EFR4 following the analyses of data collected up to November 2019 provided evidence of the macroinvertebrate community here becoming more similar to that at R5 following implementation of the environmental flow regime. A similar, though less substantial change appeared to have occurred at EFR3 also. Such changes support the hypothesis regarding the macroinvertebrate community at the EFR locations becoming more similar to that which would be expected to occur under natural flow conditions. Rather than supporting a community representative of controlled flow conditions, examination of flow data suggests C1 is more likely to support a community representative of relatively variable flow (though possibly to a lesser degree than R5). This was supported by the macroinvertebrate communities at EFR2 and EFR4 appearing to become more, rather than less, similar to that at C1 following implementation. The absence of flow data from FISH hindered the interpretation of changes relative to this location. Changes in the three periphyton responses examined also provided inconclusive evidence regarding the community at EFR2, EFR3 and EFR4 becoming more or less similar to that expected under natural flow.

Overall, the finding that many macroinvertebrate taxa appeared to be responding to greater flow variability on the Coxs River downstream of Lake Lyell suggested that a component of the macroinvertebrate community immediately downstream of Lake Lyell is becoming more similar to that expected under natural flow conditions. Findings regarding changes in the periphyton community were inconclusive, though may become more evident in the future if flow variability on the Coxs River is maintained.

1.3.8 2020

1.3.8.1 Monitoring Undertaken

Autumn 2020 surveys were undertaken in April 2020 at all Sites on the Coxs River and the three current monitoring sites on the external reference rivers (FISH, TUR and ABE) (Cardno 2021). Fish were not sampled in 2020 due to consistent high flows on the Coxs River in the second half of 2020.

1.3.8.2 Findings

The findings of the April 2020 survey were consistent with those observed previously in 2017, 2018 and 2019. The majority of changes detected in macroinvertebrate responses sampled at EFR2, EFR3 and EFR4 relative to R5 up to and including April 2020 were supportive of the hypothesis that macroinvertebrate communities just downstream of Lake Lyell are becoming more similar to that expected of natural flows. The most obvious of these was the increase in abundance of leptophlebiid mayflies at EFR3 and EFR4 to a level comparable to that at R5 following implementation of the environmental flow regime in October 2011. This taxon is somewhat sensitive to water pollution and has been assigned a Stream Invertebrate Grade Number Average Level (SIGNAL2) score of 7, where 1 indicates a highly pollution tolerant taxon and 10 a highly pollution sensitive taxon (Chessman 2003). Changes in the numbers of oligochaete and nematode worms, which appeared to decrease at the EFR locations following implementation, were also supportive of the hypothesis. Although there were some changes in macroinvertebrate responses that were not supportive of the hypothesis, these were less common.

Changes in numbers of periphyton indicators (diatom, blue-green algae and green algae) provided very little evidence of an influence of the environmental flow regime on these assemblages.

Overall, analysis of data collected up to and including 2017, 2018, 2019 and 2020 (the four occasions following the 2016 revision of the statistical approach) provided evidence that the macroinvertebrate community at the EFR locations just downstream of Lake Lyell had become more similar to what would be expected under natural flow conditions, following implementation of the environmental flow regime.

Changes relative to those at the reference rivers were inconclusive and more difficult to interpret. This is likely due to the far greater flow variability and magnitudes at reference rivers (at least at ABE and TUR, for which flow data are available), which may possibly be associated with relatively unique macroinvertebrate community structures (notwithstanding any differences associated with watercourses with varying physical, chemical and geographic conditions).

1.3.9 2022

1.3.9.1 Monitoring Undertaken

Autumn 2022 surveys were undertaken in June 2022 at all Sites on the Coxs River and the three current monitoring sites on the external reference rivers (FISH, TUR and ABE) (Cardno 2022). Fish were also sampled at each Coxs River site in June 2022.

1.3.9.2 Findings

The findings of the June 2022 survey were consistent with those from the most recent previous four surveys. The majority of changes detected in macroinvertebrate responses sampled at EFR2, EFR3 and EFR4 relative to R5 up to and including June 2022 were supportive of the hypothesis that macroinvertebrate communities just downstream of Lake Lyell are becoming more similar to that expected of natural flows. As was the case previously, the most obvious of these was the increase in abundance of leptophlebiid mayflies at EFR3 and EFR4 to a level comparable to that at R5 following implementation of the environmental flow regime in October 2011. Changes in the numbers of oligochaete and nematode worms, which appeared to decrease at the EFR locations following implementation, were also supportive of the hypothesis. Although there were some changes in macroinvertebrate responses that were not supportive of the hypothesis, these were less common.

Changes relative to those at the reference rivers continued to be inconclusive and more difficult to interpret. This is likely due to the far greater flow variability and magnitudes at reference rivers (at least at ABE and TUR, for which flow data are available), which may possibly be associated with relatively unique macroinvertebrate community structures (notwithstanding any differences associated with watercourses with varying physical, chemical and geographic conditions).

Changes in numbers of periphyton indicators (diatom, blue-green algae and green algae) provided very little evidence of an influence of the environmental flow regime on these assemblages.

Overall, analysis of data collected up to and including 2022 provided evidence that the macroinvertebrate community at the EFR locations just downstream of Lake Lyell has become more similar to what would be expected under natural flow conditions, following implementation of the environmental flow regime.

1.4 PREVAILING FLOW REGIME

1.4.1 Environmental Flow Regime Releases

Prior to the WML and WAL, between 1982 (when Lake Lyell became operational) and 1995, water was released from Lyell Dam at a rate of 0.9 ML per day. Following completion of the dam augmentation in 1995, which increased the total storage capacity of Lyell Reservoir from 7,500 ML to 33,500 ML, and following a joint study involving Pacific Power and the Department of Land and Water Conservation (DLWC), provisions for flow release from Lake Lyell dam consisted of a release of 2.6 ML/day, plus a release of 400 ML over 3 days each spring.

The environmental flow regime was first implemented in January 2001 to January 2002 and again, more recently, in October 2011 (see **Table 2-2**). It was still in effect during the current, June 2022 survey. For the six months prior to January 2001, an interim baseline flow of 5 ML/day was released. Between January 2002 and October 2011, the total active storage in the three dams along the Coxs River (i.e., Lake Wallace, Lake Lyell and Thompsons Creek Reservoir) was below 50,000 ML, resulting in activation of the Drought Triggers and a fixed release of either 9 ML/day (January 2002 to August 2002 – Stage 1 Drought Trigger) or 5 ML/day (September 2002 to September 2011 – Stage 2 Drought Trigger). Except for a one-month period in February 2002, when the Drought Trigger was temporarily deactivated, these fixed releases were maintained until October 2011.

Following the deactivation of the Drought Trigger and the implementation of the environmental flow regime in October 2011, the total daily releases into the Coxs River from Lake Lyell have ranged from 0 to 797 ML/day (data supplied by EnergyAustralia). This includes releases of 650 ML and 634 ML on 17 and 18 March 2014, respectively; of 595 ML and 667 ML on 2 and 3 February 2016, respectively; of 505 ML and 526 ML on 14 and 15 November 2017, respectively; and of 353 ML, 797 ML and 298 ML on 10, 11 and 12 December 2018, respectively; all done in association with annual channel maintenance flows. Releases of up to 639 ML/day 16 June to 27 July 2020, up to 354 ML/day 12 November 2020 to 30 December 2020, 277 ML/day 19 January 2021 to 21 March 2021 associated with Annual Channel Maintenance Flows. No Annual Channel Maintenance Flow releases were required subsequent to this due to natural dam spilling following rainfall High flows since November 2021, including 671 ML/day 4 December 2021 to 6 January 2022, 864 ML/day 2 December 2022 to 5 January 2023, and between 100 ML/day and 200 ML/day in February, June, September and November of 2023 were associated with lowering of Lake Lyell water levels for dam maintenance.

1.4.2 Hydrological Conditions on the Coxs River and External Reference Rivers

Figure 1-1 presents flow data from gauging station 212058 on the Coxs River upstream of Lake Lyell (near C1), discharge and spillage data from Lake Lyell Dam (including discharge due to the environmental flow regime), Lithgow station 212011 on the Coxs River between EFR3 and EFR4, and from station 212045 on the Coxs River at Island Hill (approximately 30 km downstream of R5) (see **Figure 2-1** for the location of these stations). **Figure 1-2** presents discharge data from stations 412066 and 421026 on the Abercrombie and Turon rivers, respectively. No gauging station is located on the Fish River and flow data are unavailable. The following is evident in these data:

- An apparent increase in flow variability and maximum daily flow on Coxs River downstream of Lake Lyell from December 2010 onwards. This change is likely to be, at least partly, due to increased rainfall as well as water releases from Springvale Colliery (i.e., Wallerawang Dam, downstream of Springvale Colliery, was spilling for the majority of time between November 2011 and January 2020). It would also include spillage over Lake Lyell Dam and releases as part of the environmental flow regime from October 2011 onwards, in addition to base release from Lake Lyell Dam (up to around 10 ML/day).
- Qualitative examination of flow variability suggests that during the period from July 2001 to December 2010 the hydrological regime upstream of Lake Lyell near C1 was slightly more variable than that experienced downstream of Lake Lyell near EFR2 and EFR3 (as indicated by flow at station 212011

situated between these locations) during the same period. Following December 2010, flow was comparable between these locations.

- The magnitude of the releases associated with the environmental flow regime were generally a small proportion of the total flow recorded approximately 1 km farther downstream at the Lithgow gauge. This flow was likely a result of those from tributaries with confluences between Lake Lyell and the gauge, as well as flows from Lake Lyell, particularly during larger spill events in April 2015 and July to September 2016. Nevertheless, flows associated with the environmental flow regime would have contributed to the increased flow variability and magnitude experienced downstream of Lake Lyell from October 2011 onwards. There was also a large increase in flow at all stations on the Coxs River and external reference rivers during 2022 and early 2023.
- Flow variability and maximum daily flow rate farther downstream on the Coxs River (approximately 30 km downstream of R5 at Island Hill) were far greater than on the Coxs River in the vicinity of Lake Lyell. Flow variability at EFR3 and EFR4 would be expected to be somewhere between that observed here and at the Lithgow station.
- Flow variability and maximum flow on the Abercrombie and Turon rivers were far greater than those experienced at any of the monitoring locations on the Coxs River included in this study.

Given that flows at C1 appear more variable than would be expected under controlled flow, interpretation of changes in biotic data must consider that the biotic assemblage (macroinvertebrates, periphyton and fish) here is likely not representative of that expected to occur downstream of an impoundment.

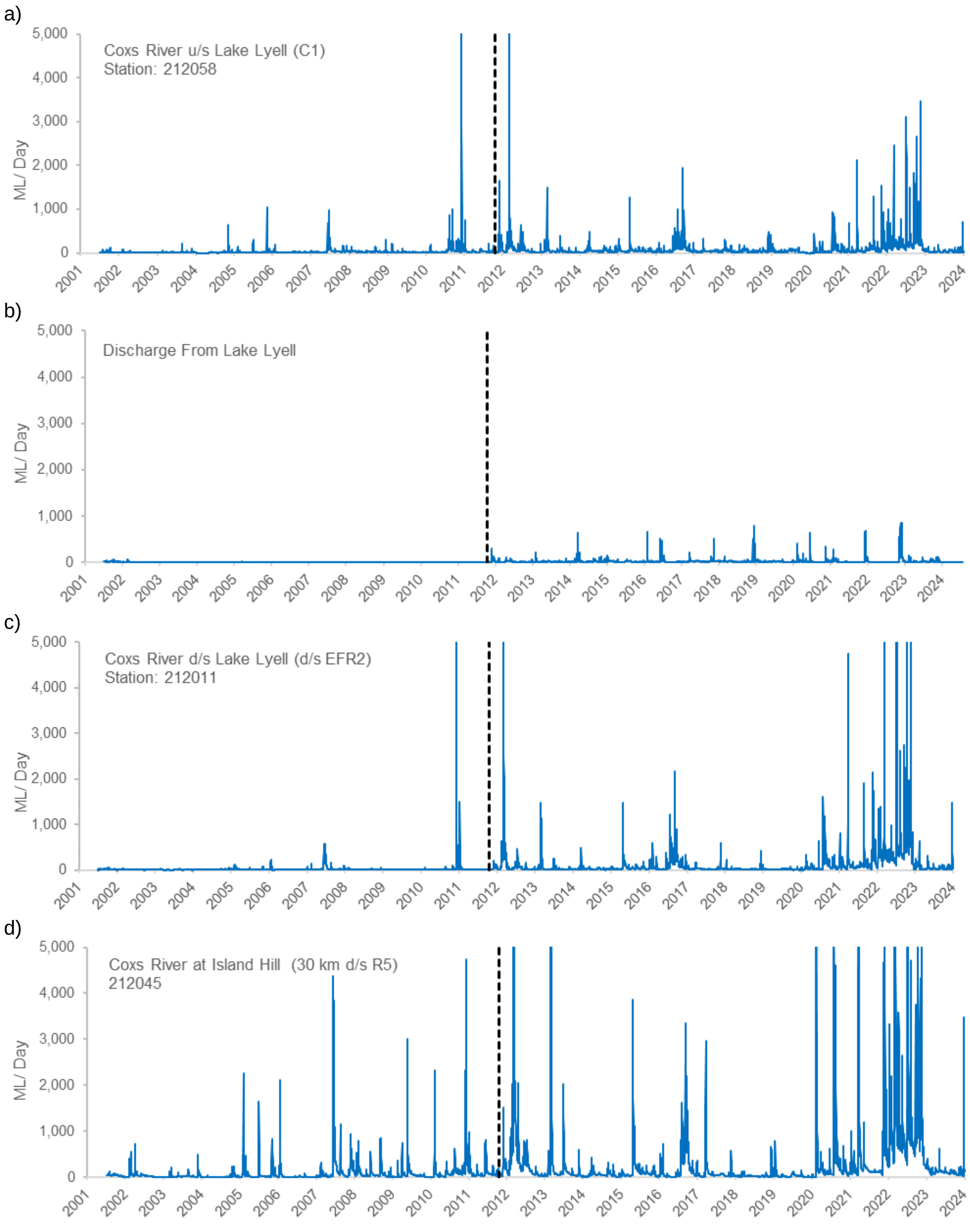

Figure 1-1 **Discharge rate (Megalitres per day – ML/day) on a) Coxs River upstream of Lake Lyell (near C1), b) from Lake Lyell Dam (base release and environmental flow regime releases) just upstream of EFR2, c) between EFR3 and EFR4 and d) Coxs River approximately 30 km downstream of R5 from 1 July 2001 to 31 December 2023. Black hashed line indicates implementation of environmental flow regime in October 2011.**

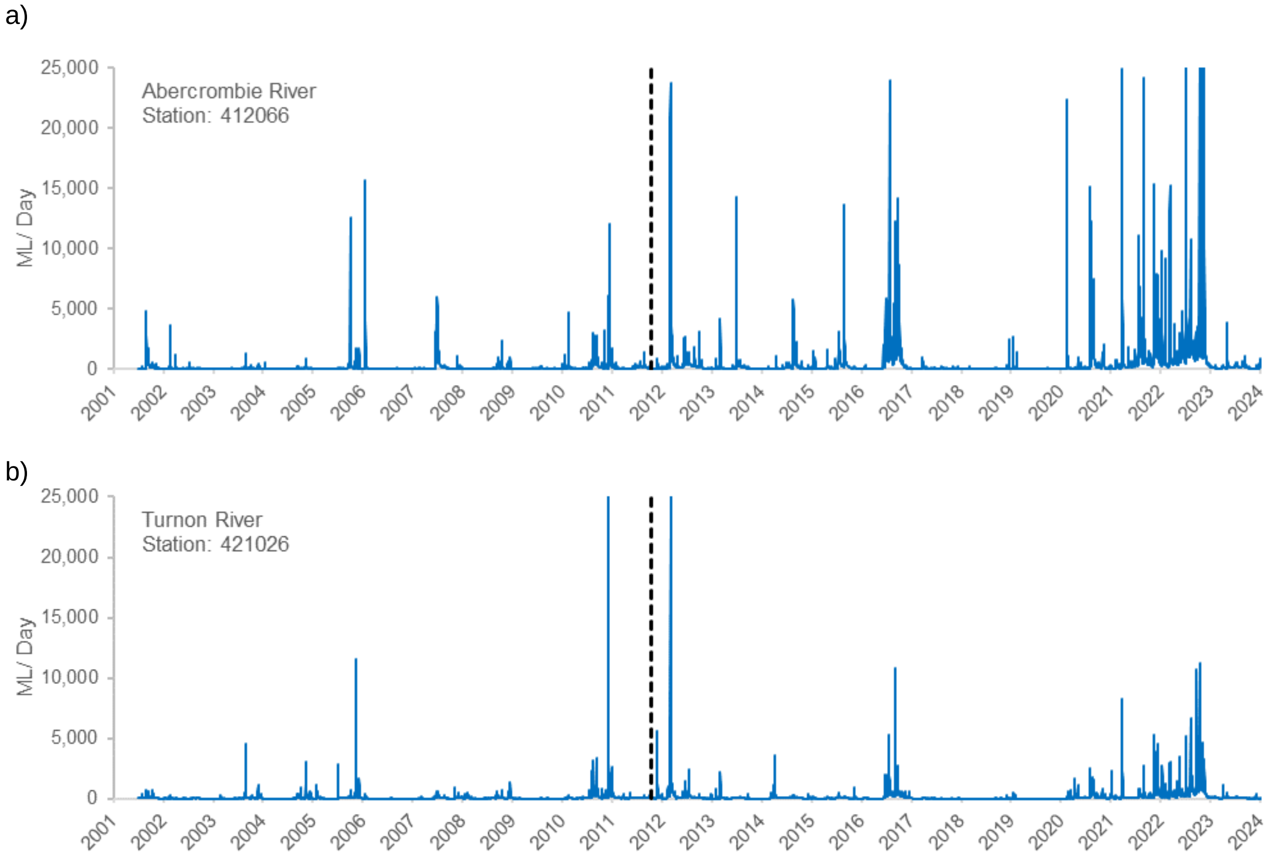

Figure 1-2 **Discharge rate (Megalitres per day – ML/day) on a) the Abercrombie River and b) Turon River from 1 July 2001 to 31 December 2023. Black hashed line indicates implementation of environmental flow regime in October 2011.**

2 METHODS

2.1 PRIOR REVIEW OF MONITORING METHODS

The methods utilised from November 2016 onwards incorporated the outcomes of two meetings between EnergyAustralia, NSW DPI (Water) and Cardno in November 2015 and July 2016, convened to discuss ongoing monitoring associated with the BMP. Agreed key changes are summarised as follows:

- Continuation of monitoring of macroinvertebrates, periphyton and fish at all locations on the Coxs River.
- Monitoring of macroinvertebrates and periphyton to continue on the Fish River, Abercrombie River and Turon River. Monitoring to cease on the Wollondilly River and the Tarlo River, as these rivers do not provide suitable and / or reliable reference data to provide a sufficient measure of variability at this time due to the previous sporadic sampling of these locations (due to frequent high flows and dry conditions) and the lack of data from prior to the implementation of the environmental flow regime.
- Future annual monitoring to alternate between spring and autumn to capture any response that may manifest in one of these seasons only.
- Macroinvertebrate sampling to continue using SURBER and AUSRIVAS edge sampling. AUSRIVAS riffle sampling to cease as riffle assemblages are sampled adequately by SURBER sampling.
- Discontinue use of AUSRIVAS indices as these are biotic indices based on habitat and water quality, rather than flow regime.
- Refocus the objective of the fish monitoring to examination of changes in the recruitment of native species, particularly flathead gudgeons (*Philypnodon grandiceps*) and mountain galaxias (*Galaxias olidus*), which have been the most abundant native species caught previously.

No changes to the periphyton monitoring component were considered necessary.

2.2 MONITORING LOCATIONS

0 describes the position and the flow type (regulated or ‘controlled’ flow, unregulated or ‘natural’ flow, or environmental flows associated with the environmental flow regime) characterising each location included in the BMP. The positions of these locations are mapped in **Figure 2-1** and **Figure 2-2**. At each location, three sites, each spanning a stretch of river approximately 25 m long, were established. The GPS coordinates of the study sites are presented in **Appendix A**.

Table 2-1 Locations on the Coxs and External Reference rivers and their respective flow type (regulated, unregulated or environmental flow regime – EFR), sampled as part of the Coxs River Biological Monitoring Program.

Location	River	Position on River	Flow Type	Monitoring Status
BR	Coxs	0.7 km downstream of Lake Wallace	Regulated*	Current, though not included in detailed analysis as data not available from prior to implementation of the EFR
C1	Coxs	11 km downstream of Lake Wallace		Current
EFR2	Coxs	1 km downstream of Lake Lyell	Environmental flow regime**	Current
EFR3	Coxs	7 km downstream of Lake Lyell		Current
EFR4	Coxs	9.5 km downstream of Lake Lyell		Current
R5	Coxs	12.5 km downstream of EFR4	Unregulated***	Current
FISH	Fish	Hazelgrove Road, Oberon	Regulated	Current
WOL	Wollondilly	Goodman’s Ford		Ceased following review
ABE	Abercrombie	Bummaroo Ford	Unregulated	Current
TUR	Turon	Bathurst Point		Current
TAR	Tarlo	Swallowtail Pass		Ceased following review

*Flows here are regulated (‘controlled’) to some extent due to the release of a 0.7 ML per day riparian flow from Lake Wallace, except when the Wallerawang Dam spills naturally. **This is the specific flow regime of interest and as described in the WAL (**Section 1.1**). ***Flows here are no longer considered to be controlled by the operation of Lake Lyell due to inflows from other tributaries into the Coxs River; rather, this location is considered to experience unregulated (‘natural’) flows.

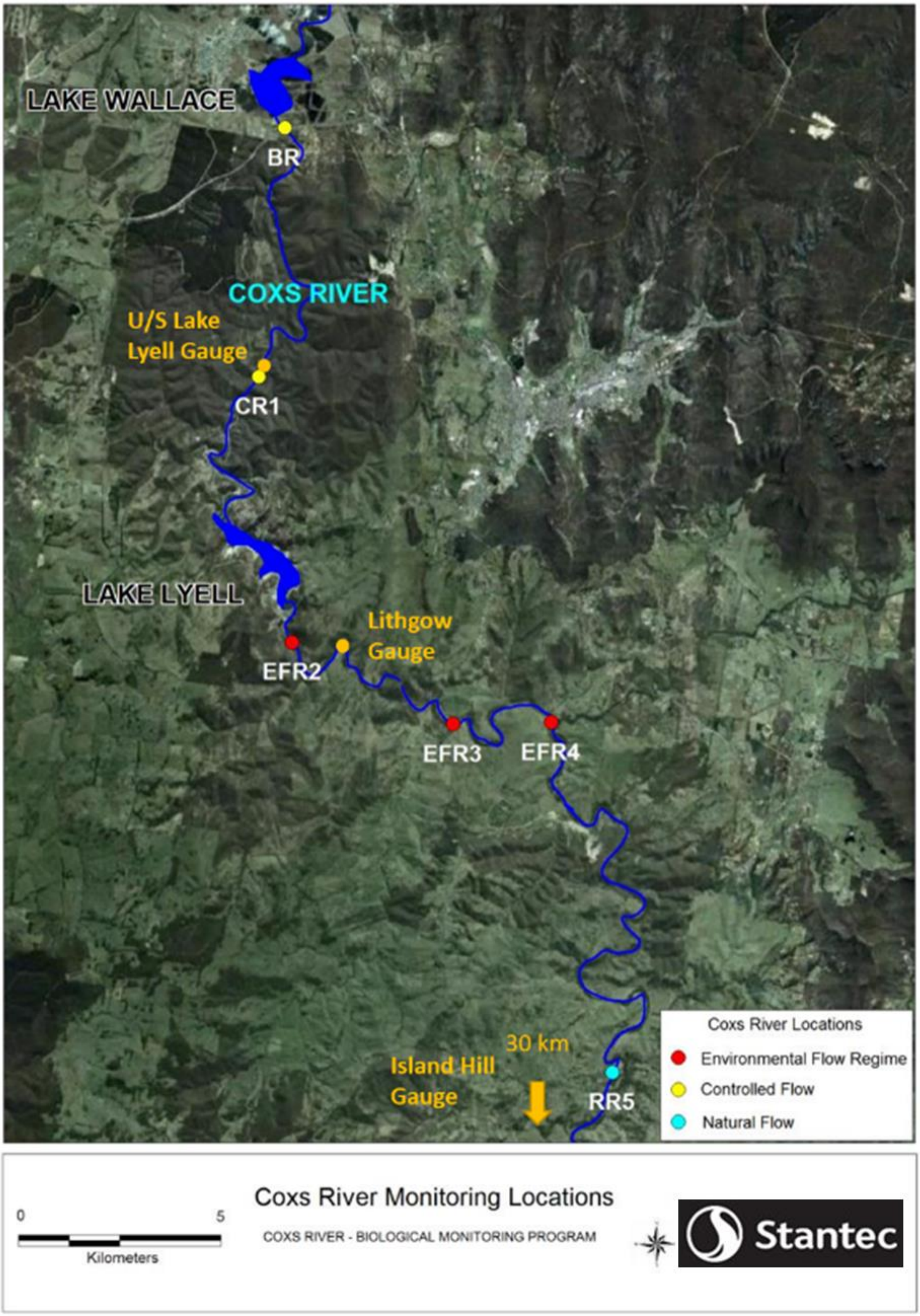

Figure 2-1 **Monitoring locations on the Coxs River as part of the Coxs River Biological Monitoring Program. See Table 2.1 for summary of sampling design. The locations of the gauging stations on the Coxs River are also identified.**

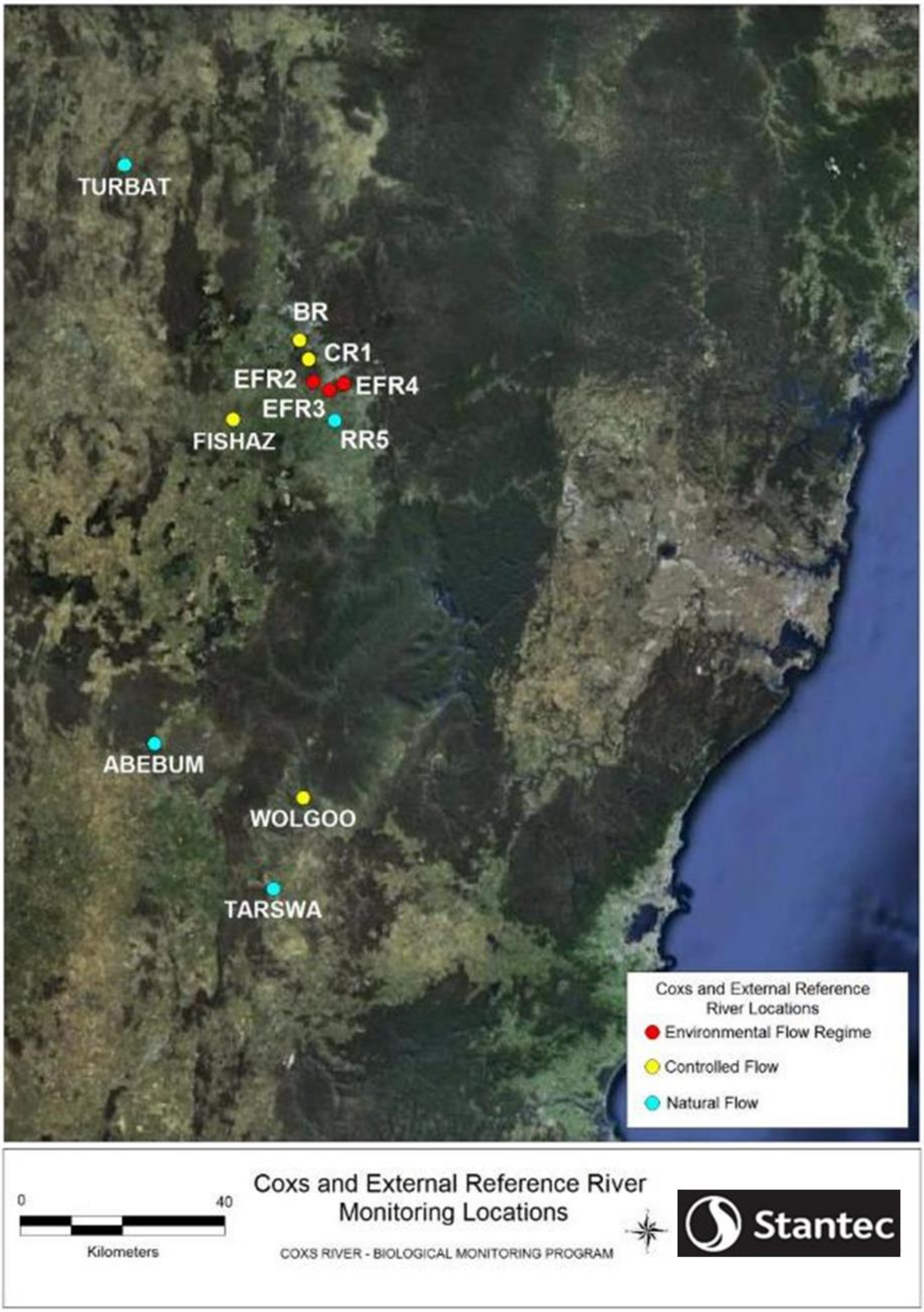

Figure 2-2 Monitoring locations on the External Reference Rivers, relative to those on the Coxs River, monitored as part of the Coxs River Biological Monitoring Program. See Table 2.1 for summary of sampling design.

2.3 TIMING

Table 2.2 identifies the most recent surveys in October 2023 and timing of previous surveys. Sampling at R5 did not commence until 2002 and at BR until 2012. The External Reference Rivers were not sampled every year due to absence of flows during drought or high flows when the rivers were inaccessible. Details on the rationale behind the choice of data for the long-term analyses included in this report are provided in **Sections 2.1 and 2.6.1**. Sampling of fish was undertaken in June 2017, July 2018, June 2022 and October 2023. Fish were not sampled in 2019, 2020 or earlier in 2023 due to consistent high flows in the Coxs River.

Table 2-2 **Timing of sampling. Coloured shading indicates surveys utilised for the long-term analyses in this report and the original flow designation of locations (yellow = controlled flow, blue = natural flow, red = location experiencing the environmental flow regime. Grey shading indicates sampling was undertaken but data were not included in the analyses (Sections 2.1, 2.6.1 and 2.6.3).**

Survey	Coxs River Locations						Ext. Reference River Locations				
	CR1	EFR2	EFR3	EFR4	R5	BR	ABE	TAR	TUR	FISH	WOL
Spring 2023											
Autumn 2022											
Autumn 2020											
Spring 2019							Dry		Dry		
Autumn 2018							Dry		Dry		
Spring 2017											
Spring 2016											
Autumn 2015											
Autumn 2014											
Autumn 2013											
Autumn 2012											
Implementation of the Environmental Flow Regime October 2011											
Autumn 2011											
Autumn 2010											
Spring 2009											
Autumn 2009											
Spring 2008											
Autumn 2008											
Spring 2007											
Autumn 2007											
Spring 2006											
Autumn 2006											
Spring 2005											
Autumn 2005											
Spring 2004											
Autumn 2004											
Spring 2003											
Autumn 2003											
Spring 2002											
Autumn 2002											
Initial 12-month Implementation of the environmental flow regime (January 2001 to January 2002											
Autumn 1998											
Spring 1997											
Spring 1996											
Autumn 1996											
Spring 1995											
Autumn 1995											

Notes: AUSRIVAS sampling undertaken in the Coxs River from 2002, except November 2004 and 2005. SURBER sampling undertaken in the Coxs River from 1995 and in the External Reference Rivers from 2002 except November 2010. Periphyton sampling undertaken in the Coxs and External Reference Rivers from 2002 except for Coxs River locations in spring (November) 2007. Fish sampling undertaken in the Coxs River in autumn and spring of 1995, 1996, 2002, 2003 and 2004, spring of 1997, 2006, 2008 and 2016, and autumn of 1998, 2009, 2012 and 2014. Following this, fish were surveyed in winter (June to August) of 2017, 2018 and 2022 and in October 2023. Fish were not surveyed earlier in 2023 due to high flows on the Coxs River.

2.4 FIELD SAMPLING

2.4.1 Aquatic Macroinvertebrates

Aquatic macroinvertebrates were sampled in two ways:

> **AUSRIVAS pool edge rapid assessment method (RAM); and**

> **SURBER samples collected from riffle habitat (fully quantitative).**

Only SURBER samples were collected at the External Reference Rivers.

2.4.1.1 AUSRIVAS Edge Samples

In the Coxs River, aquatic macroinvertebrates associated with edge habitats were sampled using the AUSRIVAS RAM (Turak et al. 2004). At each location, one sample was collected at each of three sites (A, B and C) using a dip net (250 µm mesh) deployed for periods of 3 to 5 mins along a 10 m length of riverine habitat. The dip net was used to agitate and scoop up material from vegetated river edge habitats. Each RAM sample was rinsed from the net onto a white sorting tray from which animals were picked live using forceps and pipettes. Macroinvertebrates were picked continuously from each sample for a minimum period of forty minutes, after which they were picked at consecutive ten-minute intervals, either until no new specimens had been found or a total of 60 minutes had elapsed (i.e., the initial 40 minutes plus up to another 20 minutes). Care was taken to collect cryptic and fast-moving animals in addition to those that were conspicuous and / or slow. The animals collected from each sample were placed into a labelled jar containing 70% alcohol / water.

Environmental variables including alkalinity, modal river width and depth, percentage boulder or cobble cover, latitude and longitude were recorded in the field. These data were required for running the autumn AUSRIVAS predictive model (if required in the future). Distance from source, altitude and land-slope were determined from appropriate topographic maps. Mean annual rainfall was determined from the regional precipitation maps presented in the AUSRIVAS Sampling and Processing Manual (Turak et al. 2004).

2.4.1.2 SURBER Samples

At each of the three sites at each location, two randomly selected positions within the riffle habitat were sampled by placing a SURBER sampler (0.29 m^2 quadrat, 250 µm mesh net) facing upstream and vigorously agitating the substratum enclosed within the quadrat for a period of two minutes. Agitation was affected by the collector, who rubbed around the surfaces of the rocks and amongst the sediments between and under the rocks. After two minutes, the net was submerged frequently with due care to allow the sediment to accumulate in the bottom of the net. The net was then inverted and its contents rinsed into a labelled plastic bag with 70% alcohol / water as preservative.

2.4.2 Periphyton

Two fist-sized cobblestones from the riffle habitat were sampled at each of three sites at each location. Care was taken to minimise loss of periphyton when removing rocks from the water. Each rock was held over a bucket, carefully scrubbed with a toothbrush and then rinsed into a jar using distilled water. Toothbrushes were also rinsed thoroughly. The contents of each jar were preserved with Lugol's solution, labelled and stored for transport to the laboratory. A new toothbrush was used for each site. Following the scrubbing process, each rock was dried with a towel and wrapped in aluminium foil to measure its surface area. The foil was pushed into all of the grooves and crevices of the rock taking care to prevent the foil wrinkling unnecessarily. Once wrapped, scissors were used to cut away excess foil as precisely as possible to eliminate any overlapping sections. The foil was then removed from the rock and labelled, ensuring that periphyton samples and their corresponding foils were given the same sample number. The foils were weighed in the laboratory and the values converted to areas, by comparison with a known weight to area ratio.

2.4.3 Fish

Fish were sampled using a backpack electrofisher (Model Smith-Root LR24). The operator of the electrofisher discharged an electric pulse into the water, which stunned the fish, allowing them to be easily netted by a second staff member equipped with a dip net. Captured fish were placed into a large box filled with stream water, counted, identified and released. The total length (TL) of each flathead gudgeon and mountain galaxias caught was also measured for determination of age (where information is available). Riffles, shallow pools, and beneath overhanging banks, snags and vegetation were electrofished. Twelve replicate 150 second (s) 'shots' were undertaken at each location (four replicates at each of three sites) during sampling done between 2002 and 2004, while three replicate shots per location (one per site) were undertaken during sampling done between 2006 and 2014. Fish were sampled only on the Coxs River and in selected years (**Table 2.2**). During surveys from 2017 onwards, at each Coxs River location sampling was done along the entire reach of river between Sites A and C, with eight 150 s shots undertaken at each location (20 minutes total per location).

Fish were not sampled in 2019 and 2020 due to consistent high flows.

2.5 LABORATORY METHODS

2.5.1 Aquatic Macroinvertebrates

2.5.1.1 AUSRIVAS Samples

AUSRIVAS samples were sorted under a binocular microscope (at 40 X magnification) and individuals identified to family level with the exception of Oligochaeta and Polychaeta (to class), Ostracoda (to subclass), Nematoda and Nemertea (to phylum), Acarina (to order) and Chironomidae (to subfamily). Up to ten animals of each family were counted, in accordance with Turak et al. (2004). Ten percent of the sample identifications were chosen at random and checked by a second experienced scientist to validate identifications.

2.5.1.2 SURBER Samples

All macroinvertebrates in samples were identified to taxonomic family under a binocular microscope at 40 X magnification, counted and tallied by family. Any freshwater crayfish that had been removed during the sub-sampling process (see below) were included in specimen counts on the datasheets. All identified macroinvertebrates were archived, with individual taxa stored separately in 70% ethanol / water. One-tenth of sample identifications were cross-checked as described above.

Where required, SURBER samples were sub-sampled in the laboratory before further processing. This procedure involved thoroughly rinsing each sample onto a 1 mm mesh sieve, removing any large rocks or large freshwater crayfish and then weighing each sample. The material was then evenly distributed across the sieve's surface and a sub-sample (by weight) of one-half, one-fourth or one-eighth was extracted. The sub-samples and the remainder of each sample were preserved in alcohol in separate, labelled jars. The sub-samples were sorted under a binocular microscope (as described above), whilst the remainder were archived for future processing, if required. Data from entire samples, or one-half or one-fourth sub-samples, were divided by 8, 4 or 2, respectively, to standardise abundances to per one-eighth sub-sample prior to data analyses.

2.5.1.3 Periphyton

Periphyton were identified and enumerated by staff at Just Algae Pty Ltd (Coxs River). Individual cells were identified to genus level and included the main taxonomic groups: diatoms (Class: Bacillariophyceae), green algae (Phylum: Chlorophyta) and blue-green algae (Phylum: Cyanobacteria).

A 50 / 100 ml extract of each periphyton sample from the Coxs River was diluted with distilled water to make up a total volume of 1 L and then homogenised. A 1 ml aliquot was removed from the diluted sample and placed on a Lund cell slide under the microscope. The samples from the External Reference Rivers taken prior to 2016 were processed by the Water Laboratory of the former NSW Office of Water (now NSW DPIE (Water in NSW)). Each sample volume was diluted to 1 L before a 1 ml aliquot was removed.

All periphyton were counted and tallied by genus, with final calculations of cells/ml accounting for dilution/concentration factors. These results were converted into number of cells per cm^2 of rock surface area.

2.6 STATISTICAL METHODS AND INTERPRETATION

2.6.1 Rationale

The objective of the statistical analyses was to identify changes in the selected macroinvertebrate and periphyton indicators of river health at the locations that experienced releases associated with the environmental flow regime (EFR) on the Coxs River (EFR2, EFR3 and EFR4) that may indicate that the biotic communities had become more similar to those at locations that experience natural flow (R5, ABE and TUR), and less similar to locations that experience controlled flow (C1, FISH) (i.e., the hypotheses described in **Section 1.1**). Previously, this was undertaken using Analysis of Variance (ANOVA) within a Before After Control Impact (BACI) framework. This sought to identify a pattern of change through time at the various locations indicative of an influence of the environmental flow regime. However, this approach was hindered by the lack of a consistent pattern in differences among locations in the period prior to implementation of the environmental flow regime.

Following review of the statistical methods in 2016, the current approach was re-focussed to examine changes in the magnitude of difference between EFR locations and each controlled flow or natural flow location, for each macroinvertebrate indicator. Evidence of a change in the magnitude of the difference following EFR implementation may provide evidence of an ecological influence of the regime. Thus, the aim of the analysis was detection of a change in the magnitude of the difference between pairs of locations (environmental flow locations vs. controlled or natural flow locations) through time following implementation of the regime in October 2011. This was achieved by examination of the change in slope of regression lines fitted to difference (response variable) and survey (predictor variable) from the period before EFR implementation to the period after EFR implementation.

The macroinvertebrate indicators examined were the abundance of individual taxa (for those taxa occurring in > 40 samples in the entire dataset) and total number of macroinvertebrate taxa (i.e., taxa richness). Forty was a relatively arbitrary number that helped ensure only taxa with appreciable abundance were examined. The total number of macroinvertebrate taxa found in AUSRIVAS edge samples was also examined. The periphyton responses examined were the total numbers of green, blue-green and diatom cells.

2.6.2 Analysis

The mean of each macroinvertebrate indicator (individual taxon abundance for SURBER and total number of taxa for AUSRIVAS) and periphyton indicator (total number of diatoms, green algae and blue-green algae) was calculated for each location (n = 6 samples per location, except for March 2002 when n = 12) for each survey. The absolute difference between means was then calculated for each environmental flow regime location (EFR2, EFR3 and EFR4) and controlled flow / natural flow location (C1, FISH, R5, ABE and TUR) pair for each survey (noting ABE and TUR were not sampled in all surveys due to low flows). When plotted across a timeline of surveys, the presence of a change in slope in these difference values (i.e., response variable) through time following EFR implementation was assessed by fitting and then comparing two models. The first model was a linear regression of difference using time (i.e., survey as an integer) as the predictor variable, providing a single regression line of constant slope through all surveys. The second was a piecewise regression that fit two separate regression lines, one to data collected before EFR implementation (i.e., surveys done before October 2011) and the second to data collected following EFR implementation (i.e., surveys done after October 2011). By setting the 'knot' of the piecewise regression between the surveys undertaken just before and just after implementation, a separate slope parameter was derived for each regression line. The magnitude and direction of the difference between the two slope parameter estimates provided a measure of the change in trend following EFR implementation. Generalised linear modelling (GLMM) was used to model difference between each pair of locations using a Gamma distribution with a log-link. This was considered appropriate for the positive continuous difference values (following the addition of 1 to ensure all values were positive/greater than 0).

To provide an objective assessment of the presence of a change in slope the quality of the two models was compared using their Akaike Information Criterion (AIC) values. AIC values are based on the goodness of fit of the model (as assessed by the likelihood function) penalised for model complexity (number of estimated parameters), with a lower value indicating a better quality model. In this case, the simple regression and piecewise regression models estimated three and four parameters, respectively. Where the AIC value of the piecewise model was ≤ 2 below that of the simple linear regression model, this was considered evidence of a change in slope following implementation of the environmental flow regime. A difference in AIC values of at least 2 was included as a conservative measure. It is noted also that comparison of AIC values provides a measure of the relative quality of models, rather than their absolute quality or fit. Assessment of model fit was not considered necessary in the context of determining a change in slope of the modelled response, in this case the difference between means. Where the AIC value of the piecewise regression model was ≤ 2 below that of the simple regression model, but examination of the model plots strongly suggested this was due to one data point only, these were considered to provide very little evidence of a change in slope and were not considered further. **Figure 2-3** provides examples of the model plots typical of when the response of an indicator at an environmental flow regime location is becoming less or more similar to that at another location.

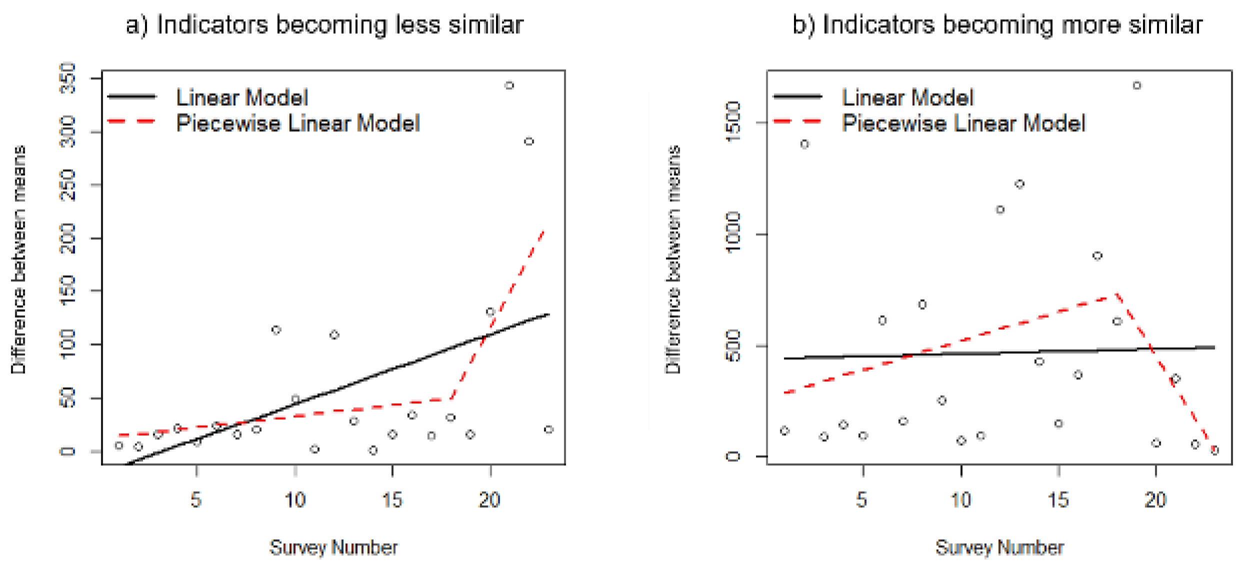

Figure 2-3 **Example model plots demonstrating scenarios where the biotic indicator sampled at an environmental flow regime location is becoming a) less and b) more similar to that at another location following implementation of the environmental flow regime in October 2011 (in these examples following Survey 18 in March 2011).**

This approach reflected that undertaken by the former NSW DPI Office of Water (NOW) in the investigation of the effect of environmental flows on aquatic macroinvertebrates in the Snowy River (Russell et al. 2012). In Russell et al. (2012), the response variable was also the difference in macroinvertebrate indicators evident between locations experiencing different flow regimes, though the analysis considered the overall trend through time, rather than a change in trend, and did not consider individual locations subjected to environmental flows. The analyses undertaken here (i.e., examination of a change in trend evident at each

EFR location) are considered more appropriate in this case, particularly as any changes may be unique to individual EFR locations on the Coxs River.

Analyses and model plots were undertaken using the core packages in the R programming environment. The package ggplot2 was used to plot indicator means and differences between means (i.e., response variables) and relevant location pairs. For brevity, plots are provided only for a selection of response variables and location pairs. Only macroinvertebrate taxa that occurred in over 40 of over 1,000 macroinvertebrate samples collected over the course of the monitoring program were included in the analysis (total of 45 taxa).

2.6.3 Excluded Data

Prior to 2001, data were collected during a period when a different flow regime prevailed (2.6 ML/day, plus a release of 400 ML over 3 days each spring), which would potentially have supported its own unique biotic assemblage. As such, data collected prior to 2001 have not been included in analyses. SURBER samples collected by AMBS from the Coxs River during 1995 to 1998 and from the External Reference Rivers during 2002 to 2004 utilised a sampling / laboratory technique different from that used by The Ecology Lab and Cardno in later surveys. As data collected using different methods are difficult to compare, the data collected by AMBS have been excluded from analyses. There was also a change in the method used by the external laboratory for processing periphyton samples that occurred sometime between 2002 and 2004, so data from this period have been excluded from analyses.

3 RESULTS

3.1 AQUATIC MACROINVERTEBRATES

Table 3-1 summarises the findings of the comparison of simple linear and piecewise regression models of macroinvertebrate SURBER data (the abundance of 50 taxa in SURBER samples and total number of taxa in AUSRIVAS samples). Comparison of magnitude of differences between the EFR locations and the C1 and R5 locations on the Coxs River in October 2023 indicated:

- EFR2: Abundance became more similar to those at C1 and R5 for 17 and 18 taxa, respectively. Abundance became less similar to those at C1 and R5 for 4 and 3 taxa, respectively.
- EFR3: Abundance became more similar to those at C1 and R5 for 6 and 13 taxa, respectively. Abundance became less similar to those at C1 and R5 for 4 and 3 taxa, respectively.
- EFR4: Abundance became more similar to those at C1 and R5 for 12 and 19 taxa, respectively. Abundance became less similar to those at C1 and R5, each for 3 taxa.

Changes in abundance of leptophlebiid mayflies were particularly evident at EFR2, EFR3 and EFR4, becoming more similar to that at R5 (natural flow) following EFR implementation. Comparison of the linear regression and piecewise regression models of the difference in mean abundance between R5 and each of EFR2, EFR3 and EFR4 indicated that in each case, the piecewise regression model provided the better-quality model (**Figure 3-1a-c**). Examination of the slope of each piecewise regression line indicated this was due to a reduction in the difference in abundance between these pairs of locations following EFR implementation (**Appendix B**). In general, the number of leptophlebiids at EFR3 and EFR4, and to a far lesser degree at EFR2, appeared to increase and become increasingly similar to that at R5 from March 2012 to October 2023 (albeit relatively few were recorded at EFR2, EFR3, EFR4 in October 2023) (**Figure 3-2**). Changes in abundance of Philopotamidae (also a family of caddis-fly) (**Figure 3-1d-f**) were also indicative of the macroinvertebrate community at each of the EFR locations becoming more similar to R5. This appeared, at least partly, due to an increase in the number of philopotamids at the EFR locations following EFR implementation (**Figure 3-3**). Other taxa for which abundances at EFR locations appeared to be becoming more similar to that at R5 included Ceratopogonidae (biting midges), Hydrobiosidae (caddis-flies) and Diphlebiidae (damselflies). In each case, the better fit of the piecewise model appears to have been at least partly associated with a general increase in the abundance of these taxa at EFR locations relative to R5, and relative to C1 (controlled flow) in the case of Ceratopogonidae, following EFR implementation.

The abundances of Oligochaeta and Nematoda at EFR location also became more similar to those at R5 (**Figure 3-4**) and C1 (**Figure 3-5**). In these cases, the better fit of the piecewise models appears to have been at least partly associated with a decrease in abundance of these pollution-tolerant taxa at the EFR locations following EFR implementation. However, that there were concurrent post-EFR decreases in these taxa at most other locations (**Figure 3-6** and **Figure 3-7**), and the better fit of the piecewise model may be due to an overall broad-scale decrease in abundance of these taxa that coincided, but was not associated with, the EFR. Similarly, overall decreases in the abundance of Hypogastruridae (a springtail) and Hydropsychidae (a caddis-fly) at most locations appeared to explain, at least partly, why the abundance of these taxa at EFR locations appeared to become more similar to those at C1 and R5, respectively. It is noted also that the relatively variable flow conditions experienced at C1 following the EFR (**Section 1.4**), which was originally intended to provide data typical of controlled flow condition, complicates interpretation of changes at EFR locations relative to C1 (**Section 4.1**).

Abundance at EFR locations became consistently less similar to those at C1 and R5 in the cases of relatively few taxa. At each EFR location, abundance of Conoesucidae became less similar to those at C1 and R5 (**Figure 3-8**). Similar patterns were also observed for Hydrophilidae. While this would appear to suggest the abundance of these taxa at the EFR locations was becoming less similar to that at C1 and / or R5, examination of their abundances (e.g., Conoesucidae – **Figure 3-9**) suggests that this was due to them being largely absent in samples from all Coxs River locations prior to EFR implementation (i.e., effectively no difference in abundance between locations). The general increase in numbers of these taxa at one or more of the EFR locations and at C1 and / or R5 following EFR implementation is possibly related to the general increase in flow and flow variability on the Coxs River through time and its influence on river substratum and habitat quality.

Table 3-1 **Results of linear and piecewise linear regression models of the difference in macroinvertebrate and periphyton community responses (individual taxon abundance and number of taxa in SURBER samples, number of taxa in AUSRIVAS samples and number of periphyton cells) between pairs of locations experiencing environmental flows (EFR2, EFR3 and EFR4) and controlled flow (C1 and FISH) and natural flow (R5), based on AIC values. 'Converge' (Conv.) and 'Diverge' (Div.) indicate the value of the response at locations experiencing the environmental flows was becoming more or less similar, respectively, to that at locations experiencing controlled or natural flow. For further information see Appendix B.**

Taxon Group	Taxon	C1			R5			FISH			ABE			TUR		
		EFR2	EFR3	EFR4	EFR2	EFR3	EFR4	EFR2	EFR3	EFR4	EFR2	EFR3	EFR4	EFR2	EFR3	EFR4
SURBER																
Acarina (watermites)	Hydracarina		Div.													
Arthropleona (springtails)	Hypogastruridae				Conv.	Conv.	Conv.				Div.			Div.	Div.	
Astacidea (freshwater crayfish)	Parastacidae		Conv.	Conv.		Conv.	Conv.			Conv.			Conv.			Conv.
Bivalvia (bivalves)	Corbiculidae / Sphaeriidae	Conv.	Conv.			Conv.	Conv.						Conv.			Conv.
Caridea (freshwater shrimp)	Atyidae		Div.													
Coleoptera (beetles)	Elmidae	Div.														
Coleoptera (beetles)	Psephenidae				Conv.									Conv.		Conv.
Coleoptera (beetles)	Hydrophilidae	Div.	Div.	Div.	Div.	Div.	Div.									
Coleoptera (beetles)	Scirtidae								Div.	Div.						Div.
Coleoptera (beetles)	Dytiscidae										Div.	Div.	Div.			
Crustacea (crustaceans)	Copepoda	Conv.			Conv.			Conv.						Conv.		Conv.
Crustacea (crustaceans)	Ostracoda										Div.		Div.			Div.
Crustacea (crustaceans)	Cladocera	Conv.			Conv.			Conv.		Div.	Conv.			Conv.		
Diptera (flies)	Chironomidae			Conv.			Conv.					Div.	Div.			
Diptera (flies)	Simuliidae												Conv.			
Diptera (flies)	Tipulidae	Conv.										Div.	Div.		Div.	Div.
Diptera (flies)	Ceratopogonidae	Conv.	Conv.	Conv.	Conv.	Conv.	Conv.									
Diptera (flies)	Empididae										Div.	Div.	Div.			
Diptera (flies)	Dolichopodidae			Conv.				Conv.	Conv.	Conv.				Conv.	Conv.	Conv.
Diptera (flies)	Stratiomyidae	Conv.			Conv.					Div.					Div.	Div.
Ephemeroptera (mayflies)	Baetidae	Conv.				Conv.	Conv.		Conv.							
Ephemeroptera (mayflies)	Caenidae															
Ephemeroptera (mayflies)	Leptophlebiidae				Conv.	Conv.	Conv.				Conv.	Conv.				
Gastropoda (freshwater snail)	Planorbidae	Conv.			Conv.				Div.	Div.					Div.	Div.
Gastropoda (snails and slugs)	Ancylidae								Div.			Div.	Div.	Conv.	Div.	Div.
Hemiptera (true bugs)	Corixidae				Div.											
Hemiptera (true bugs)	Veliidae							Div.						Div.	Div.	Div.
Hemiptera (true bugs)	Aphididae	Conv.		Conv.			Conv.	Div.								
Hydroida (hydroids)	Hydridae	Conv.				Div.	Div.	Conv.			Div.			Conv.		
Lepidoptera (butterflies / moths)	Pyralidae							Div.		Div.						
Megaloptera (alderflies)	Corydalidae													Conv.	Conv.	Conv.
Nematodes (roundworms)	Nematoda	Conv.	Conv.	Conv.	Conv.	Conv.	Conv.									
Nematophora (horse-hair worms)	Nematomorpha			Conv.			Conv.				Div.	Div.		Div.	Div.	
Nemertea (ribbon worms)	Nemertea	Conv.			Conv.			Conv.				Div.	Div.	Conv.	Conv.	

Taxon Group	Taxon	C1			R5			FISH			ABE			TUR		
		EFR2	EFR3	EFR4	EFR2	EFR3	EFR4	EFR2	EFR3	EFR4	EFR2	EFR3	EFR4	EFR2	EFR3	EFR4
Odonata / Epiproctophora (dragonflies)	Gomphidae						Conv.									
Odonata / Epiproctophora (dragonflies)	Telephlebiidae				Conv.		Conv.		Conv.	Conv.	Div.					Conv.
Odonata/Zygoptera (damselflies)	Diphlebiidae		Div.		Conv.	Conv.	Conv.								Conv.	
Oligochaeta	Oligochaeta	Conv.	Conv.	Conv.	Conv.	Conv.	Conv.							Conv.	Conv.	
Platyhelminthes (flatworms)	Dugesiidae					Conv.	Conv.									
Plecoptera (stoneflies)	Gripopterygiidae				Conv.		Conv.			Div.						
Pulmonata (snails and slugs)	Physidae	Div.		Div.									Div.			
Trichoptera (caddisflies)	Hydropsychidae	Conv.	Conv.	Conv.	Conv.		Conv.									
Trichoptera (caddisflies)	Ecnomidae	Conv.		Conv.		Conv.			Conv.		Conv.					
Trichoptera (caddisflies)	Hydroptilidae										Div.	Div.	Div.			
Trichoptera (caddisflies)	Leptoceridae	Conv.		Conv.												
Trichoptera (caddisflies)	Hydrobiosidae	Conv.		Conv.	Conv.	Conv.	Conv.									
Trichoptera (caddisflies)	Philopotamidae				Conv.	Conv.	Conv.		Conv.		Conv.	Conv.	Conv.			
Trichoptera (caddisflies)	Conoesucidae	Div.	Div.	Div.	Div.	Div.	Div.				Div.		Div.			
Trichoptera (caddisflies)	Glossosomatidae				Conv.									Div.		
Trichoptera (caddisflies)	Calamoceratidae															
Total Converge		17	6	12	18	13	19	5	5	3	4	2	4	9	5	7
Total Diverge		4	4	3	3	3	3	3	3	6	9	8	10	4	7	7
AUSRIVAS																
Total Number of taxa																
Periphyton																
Diatoms			Div.	Div.					Div.			Div.	Div.			
Blue-Green Algae						Conv.							Div.			Div.
Green Algae													Div.			

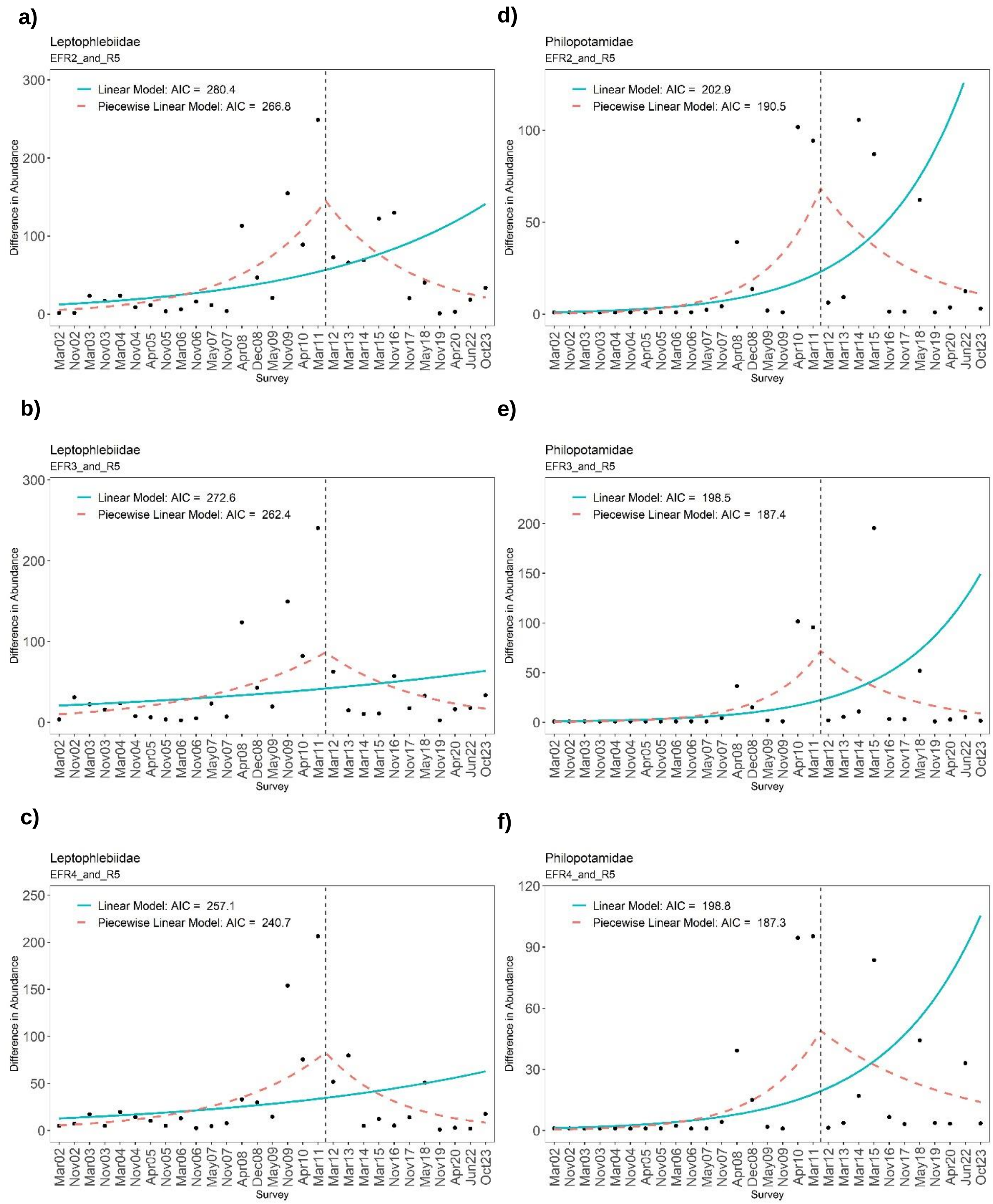

Figure 3-1 **Fitted simple linear and piecewise regression models of the difference in mean a-c) leptophlebiid and d-f) mean Philopotamidae abundance between EFR and R5 locations through time.**

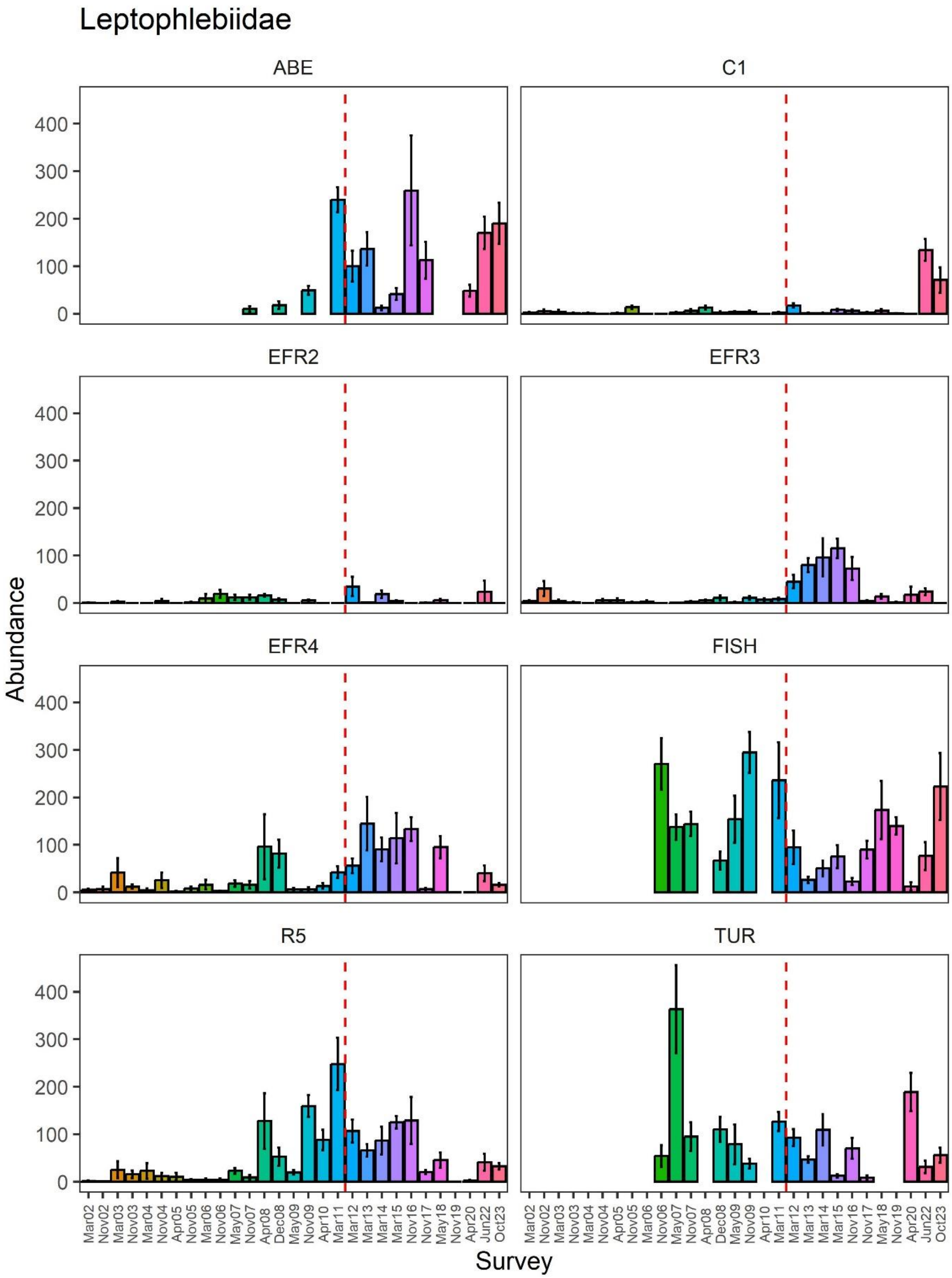

Figure 3-2 **Mean (± standard error (SE)) of leptophlebiids sampled during each survey. Red dashed line indicates timing of the implementation of the environmental flow regime.**

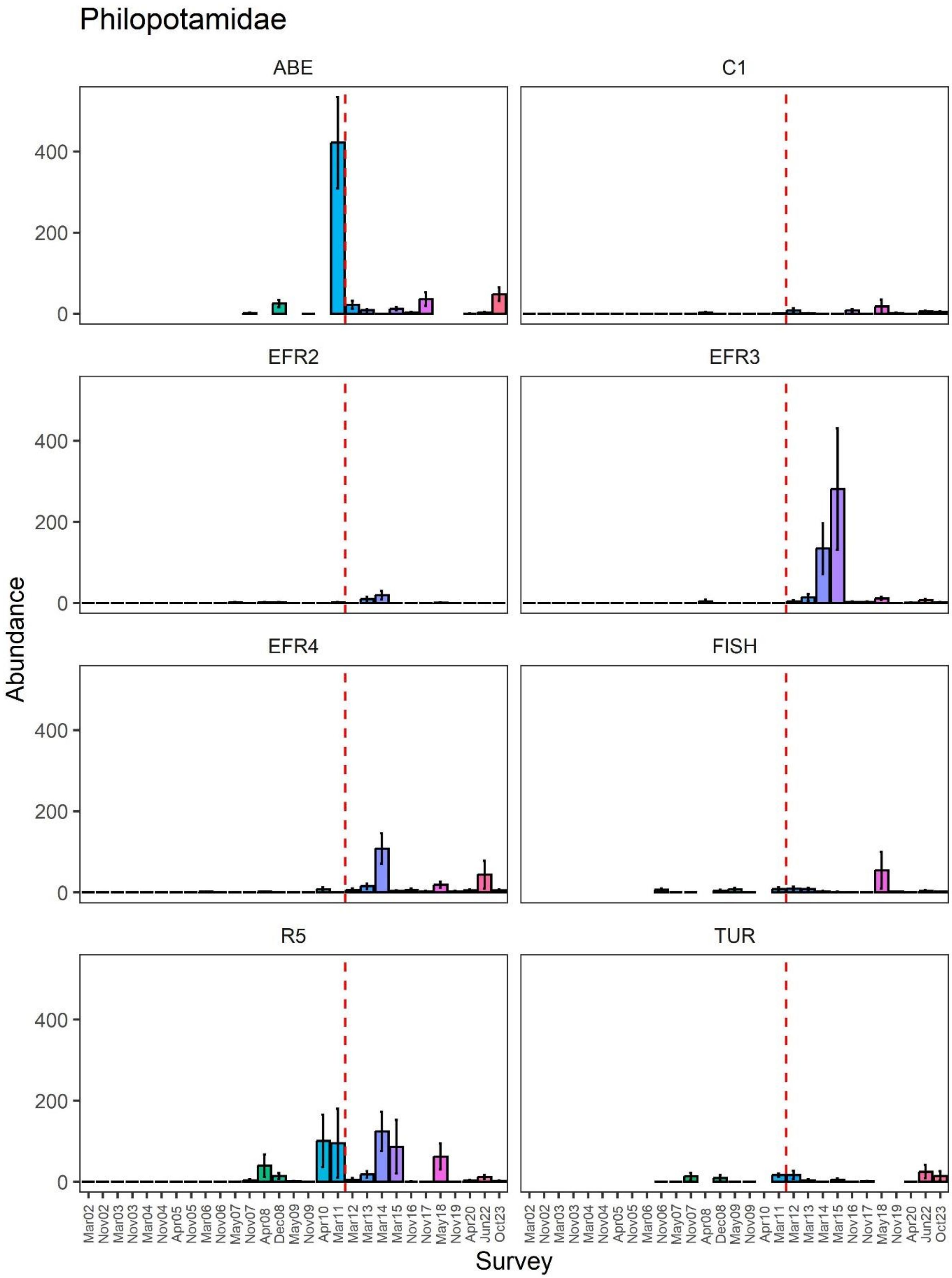

Figure 3-3 **Mean (± standard error (SE)) of philopotamids sampled during each survey. Red dashed line indicates timing of the implementation of the environmental flow regime.**

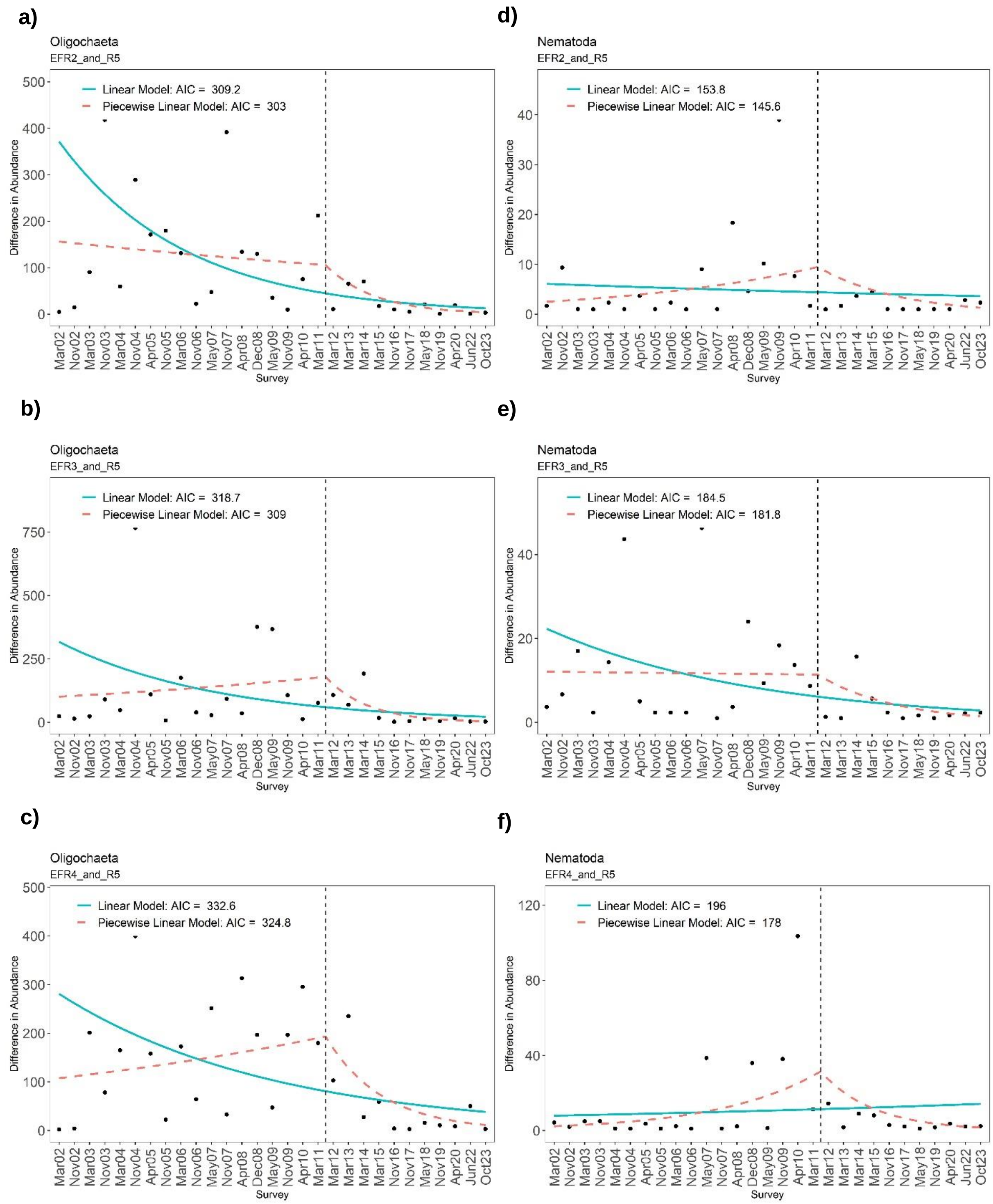

Figure 3-4 **Fitted simple linear and piecewise regression models of the difference in mean a-c) Oligochaeta and d-f) mean Nematoda abundance between EFR and R5 locations through time.**

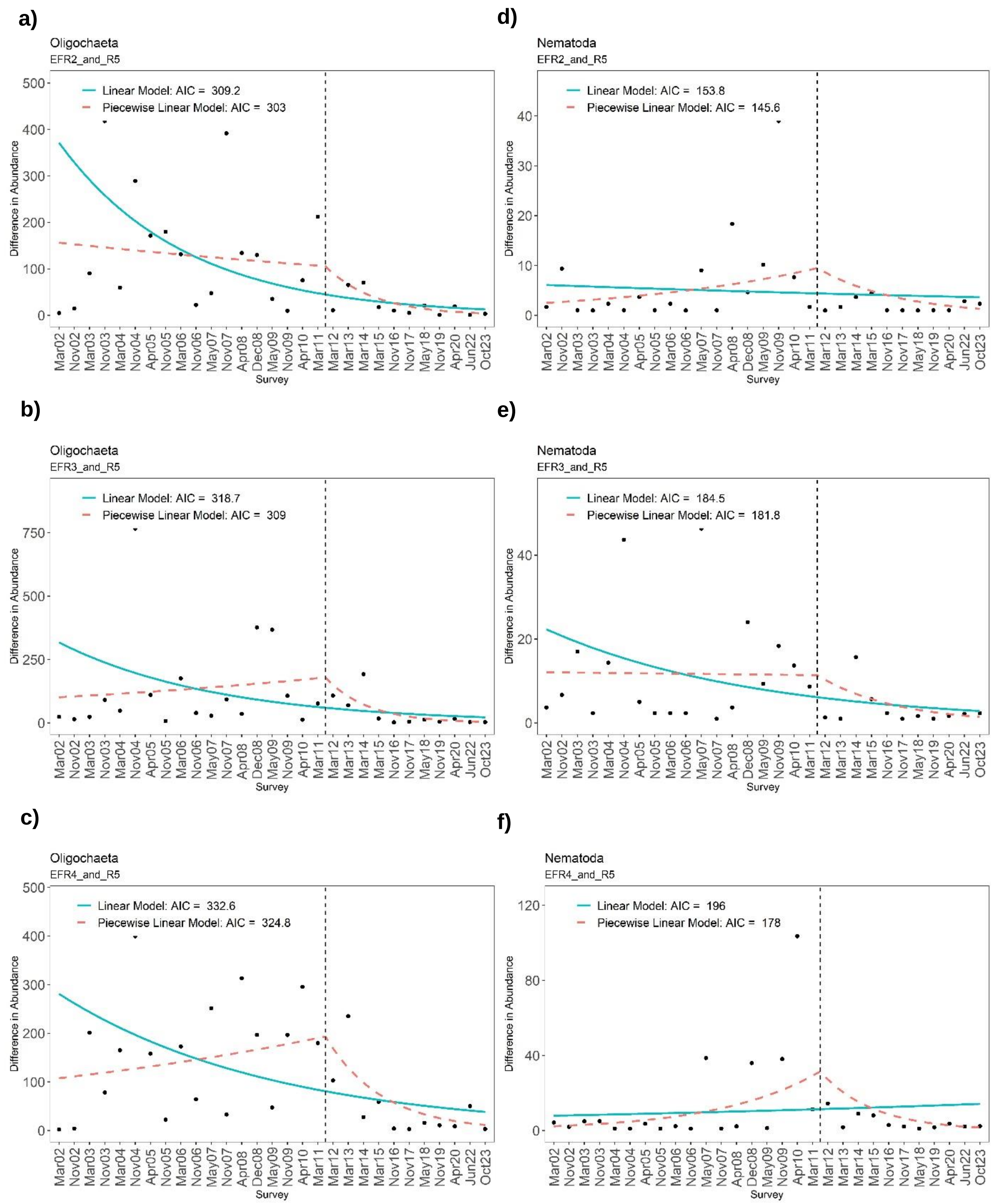

Figure 3-5 **Fitted simple linear and piecewise regression models of the difference in mean a-c) Oligochaeta and d-f) mean Nematoda abundance between EFR and RR5 locations through time.**

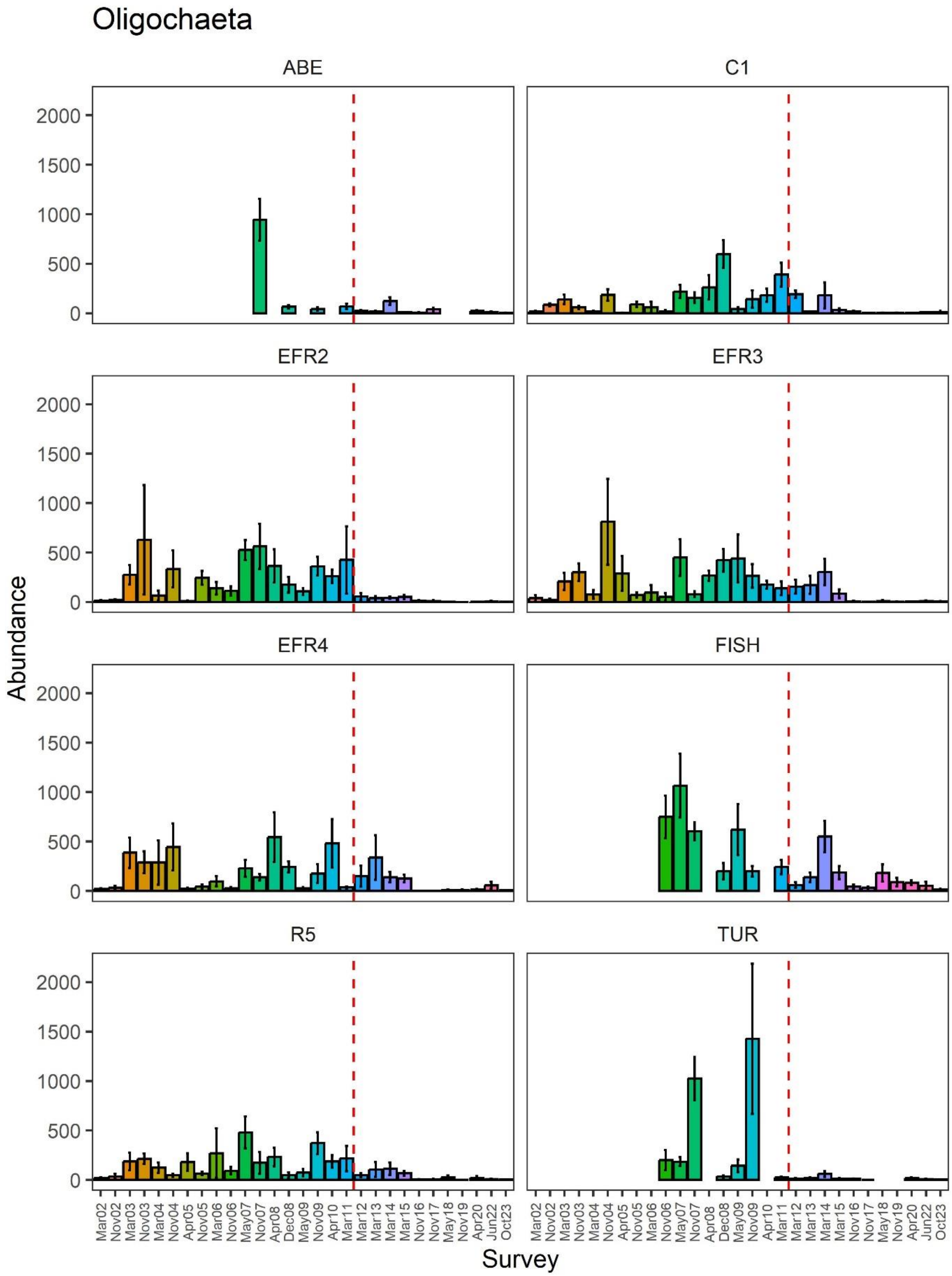

Figure 3-6 **Mean (± standard error (SE)) of Oligochaeta sampled during each survey. Red dashed line indicates timing of the implementation of the environmental flow regime.**

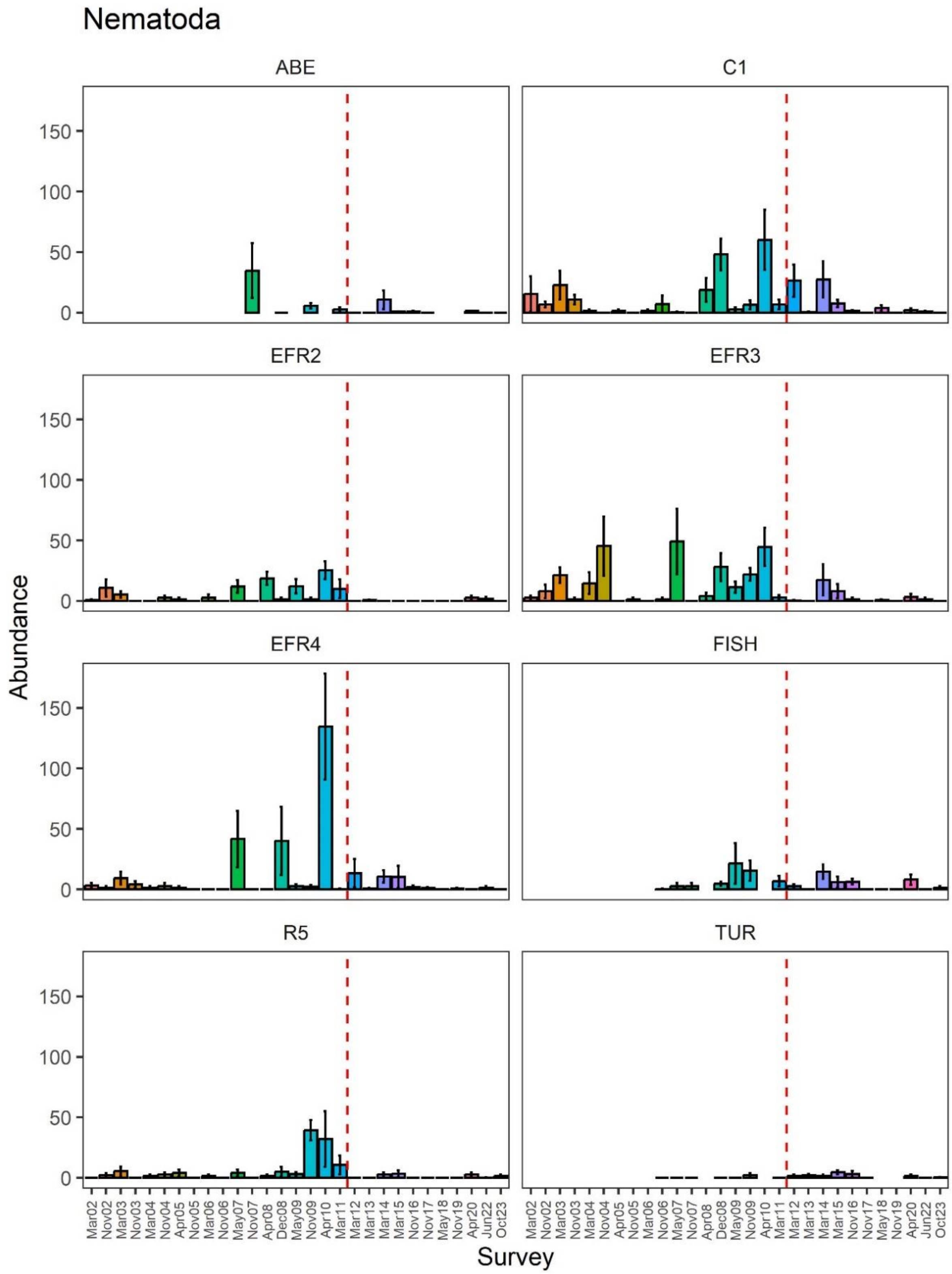

Figure 3-7 **Mean (± standard error (SE)) of Nematoda sampled at each location (except BR) during each survey. Red dashed line indicates timing of the implementation of the environmental flow regime.**

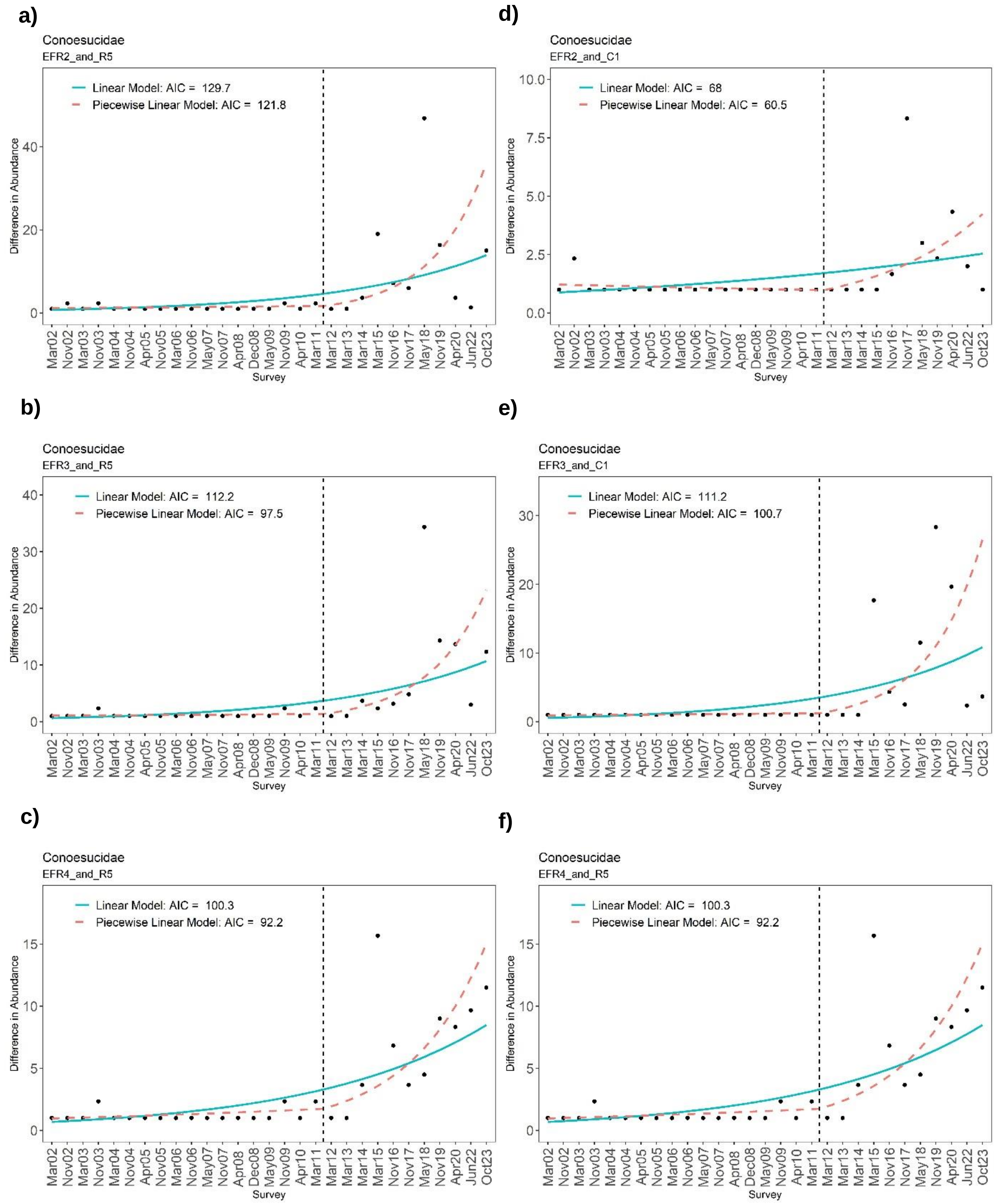

Figure 3-8 **Fitted simple linear and piecewise regression models of the difference in Conoesucidae abundance between locations through time.**

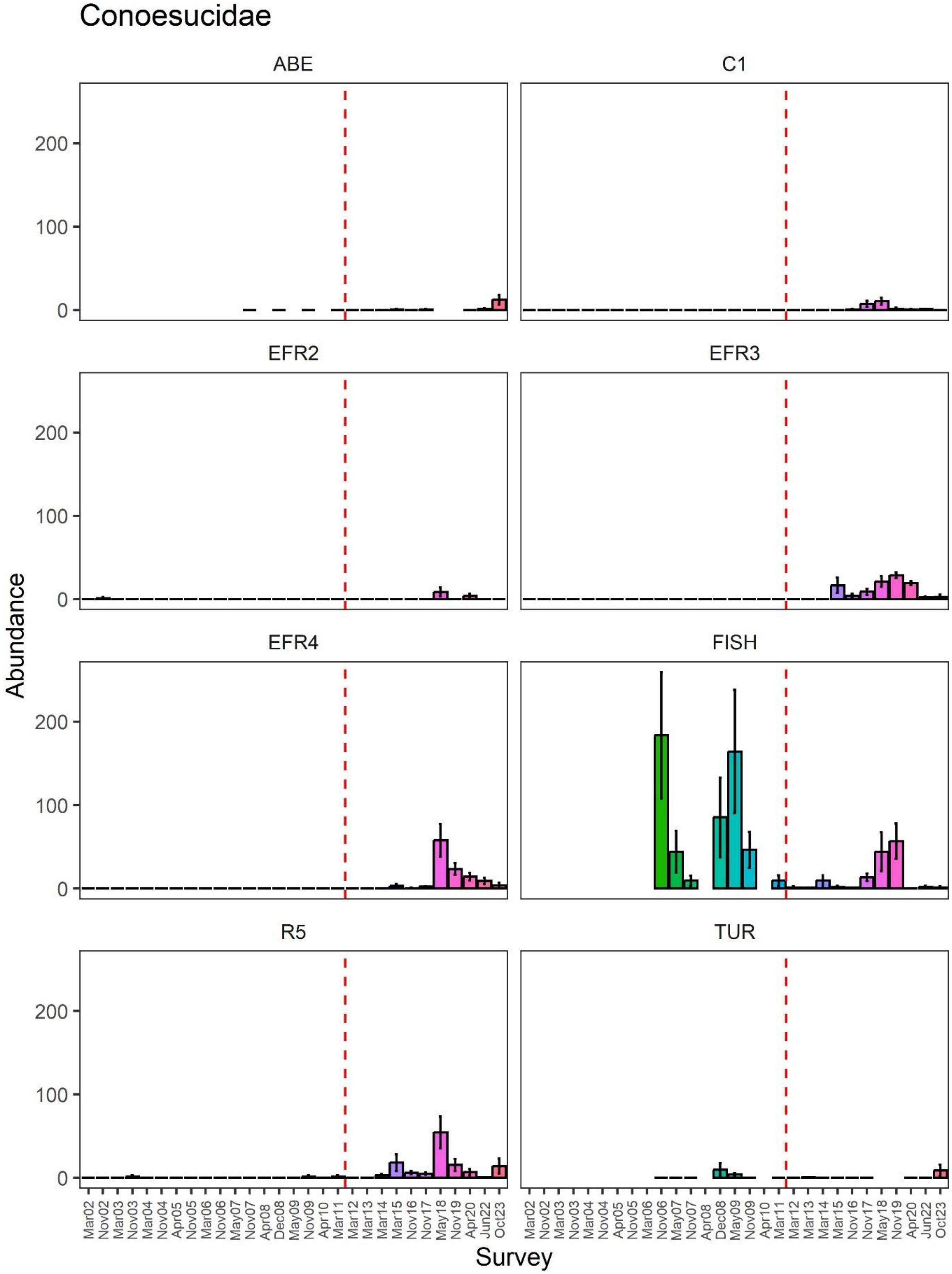

Figure 3-9 **Mean (± standard error (SE)) of Conoesucidae sampled during each survey. Red dashed line indicates timing of the implementation of the environmental flow regime.**

Relatively few taxa displayed consistent changes in abundance at each EFR location indicative of the community becoming more or less similar to those at reference rivers. These were the abundance of Dytiscidae, Empididae and Hydroptilidae becoming less similar to ABE, abundance of Veliidae becoming less similar to TUR, the abundance of Dolichopodidae becoming more similar to FISH and TUR, and the abundance of Corydalidae becoming more similar to TUR. There was no obvious change in the abundance of these taxa at the EFR locations, with most found in relatively low abundance. The exception was Corydalidae, which appeared to become more abundant at the EFR locations and more similar to the abundance at TUR.

Overall, the abundance of individual taxa at each of the EFR locations appeared more likely to become more, rather than less, similar to numbers observed at R5 (**Table 3-1**). At EFR2, EFR3 and EFR4, the abundance of 13 to 19 (26–38%) of the 50 taxa examined became more similar to numbers at R5, compared with 3 to 4 (6–8%) taxa that became less similar to numbers at R5. A similar pattern was observed at EFR2 and EFR4 when compared to C1, and at EFR3 when compared to C1 but at a much smaller magnitude. The abundance of taxa at EFR locations compared to reference river locations were less consistent, with abundances at each EFR location becoming less similar to abundances at ABE being the only consistent pattern.

No changes in the number of taxa identified in AUSRIVAS samples at the EFR locations relative to any other location following EFR implementation were detected (**Table 3-1**).

3.2 PERIPHYTON

Table 3-1 includes the findings of the comparison of simple linear and piecewise models of periphyton based on AIC values. Changes in three periphyton responses coincided with implementation of the environmental flow regime. The number of diatom cells at EFR3 and EFR4 became less similar to the number at C1 (**Figure 3-10a-b**) and ABE (**Figure 3-10c-d**), while those at EFR3 also became less similar to those at FISH (**Figure 3-10e**). The number of blue-green algae cells at EFR4 became less similar to numbers at ABE (**Figure 3-10f**) and TUR (**Figure 3-11a**) and the number of green algae cells at EFR4 became less similar to those at ABE (**Figure 3-11b**). Examination of the mean number of cells suggested the better fit of the piecewise models was due, at least partly, to relatively greater increases in the number of diatom and green algae cells at EFR3 and / or EFR4 compared to C1, ABE, FISH and / or TUR that coincided with EFR implementation. The better fit of the piece-wise model for green algae cells appeared at least partly due to a decrease in the number of cells at EFR4 relative to ABE (**Figure 3-11b**). It is noted that in the case of apparent diverging numbers of cells at EFR4 and ABE for both diatoms and blue-green algae, this appeared to be due to relatively large differences detected in one survey. For diatoms this was associated with a relatively large number of cells at EFR4 compared to ABE in October 2024. For blue-green algae cells this was associated with a relatively large number of cells at EFR4 compared to ABE in April 2020.

The number of blue-green algae cells at EFR3 became more similar to those at R5, apparently due to a decrease in the number of cells at EFR3 and R5 following implementation of the environmental flow regime.

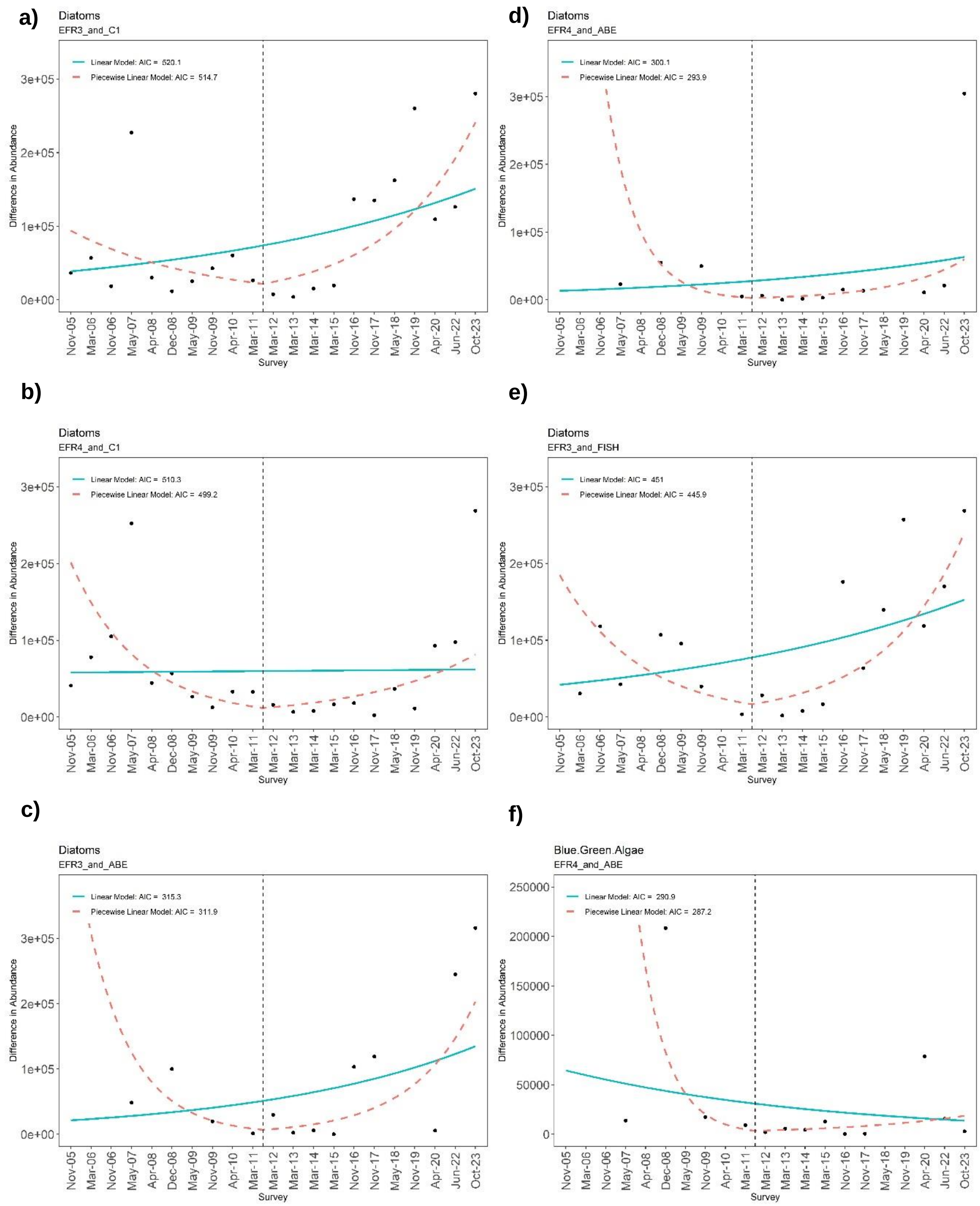

Figure 3-10 **Fitted simple linear and piecewise regression models of the difference in mean a-e) diatom and f) blue-green algae cells between EFR and control / reference locations through time.**

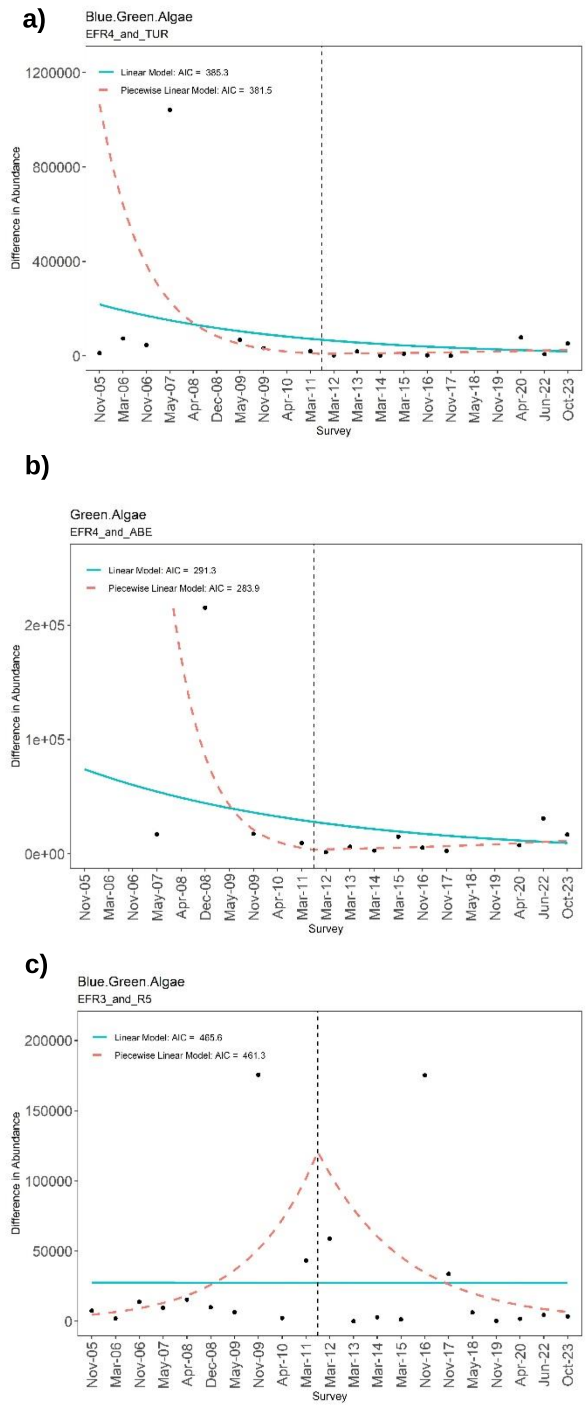

Figure 3-11 Fitted simple linear and piecewise regression models of the difference in mean a) blue-green algae, b) green algae and c) blue-green cells between EFR and control / reference locations through time.

3.3 FISH

The lengths of fish caught in 2023 are provided in **Appendix C** and the numbers of each fish species caught in 2023, 2022, 2018 and 2017 are provided in **Table 3-2**, **Table 3-2**, **Table 3-3**, **Table 3-4** and **Table 3-5**, respectively. Numbers of fish caught in 2023 were comparable to numbers caught in 2022 and 2018, although fewer individuals of each species were caught in 2023, 2022 and 2018 compared with 2017. In particular, far fewer native flathead gudgeons were caught after 2017. Length frequency histograms for flathead gudgeon are provided in **Figure 3-12**. The small numbers of flathead gudgeon caught has prevented formal analysis to detect differences in length frequencies between the surveys. However, the length of fish caught in 2018 at C1 (both 45 mm) and EFR2 (50 mm and 60 mm) were within the size ranges of those caught at these locations in 2017. Albeit few individuals were caught overall in 2022, it is notable that the lengths of flathead gudgeons caught in 2022 (at C1, EFR2 and EFR4) were smaller than any caught at those locations in 2017 and 2018. Those caught at EFR3 in 2022 were also smaller than any other individual caught at any other location in 2017 and 2018. The two flathead gudgeons caught in 2023 (at EFR2) were 25 mm in length.

Table 3-2 Numbers of fish caught whilst electrofishing at locations on the Coxs River during October 2023. Shaded text indicates non-native species.

Common Name	Scientific Name	BR	C1	EFR2	EFR3	EFR4	R5
Rainbow Trout	*Oncorhynchus mykiss*	3	2	1	4	1	2
Brown Trout	*Salmo trutta*			2		4	
Redfin Perch	*Perca fluviatilis*		1			2	
Eastern Gambusia	*Gambusia holbrooki*						
Galaxiid	*Galaxias* sp.	2					7
Flathead Gudgeon	*Philypnodon grandiceps*			2			
Shortfinned eel	*Anguilla australis*	1					

Table 3-3 Numbers of fish caught whilst electrofishing at locations on the Coxs River during June 2022. Shaded text indicates non-native species.

Common Name	Scientific Name	BR	C1	EFR2	EFR3	EFR4	R5
Rainbow Trout	*Oncorhynchus mykiss*	3	3		3		
Brown Trout	*Salmo trutta*		1	1			
Redfin Perch	*Perca fluviatilis*			3			
Eastern Gambusia	*Gambusia holbrooki*						
Galaxiid	*Galaxias* sp.					3	12
Flathead Gudgeon	*Philypnodon grandiceps*		1	4		5	

Table 3-4 Numbers of fish caught whilst electrofishing at locations on the Coxs River during July 2018. Shaded text indicates non-native species.

Common Name	Scientific Name	BR	C1	EFR2	EFR3	EFR4	R5
Rainbow Trout	*Oncorhynchus mykiss*	7	3	3	1	1	
Brown Trout	*Salmo trutta*		1	3			
Redfin Perch	*Perca fluviatilis*						
Eastern Gambusia	*Gambusia holbrooki*			1	1	1	
Galaxiid	*Galaxias* sp.	1			3	2	1

Flathead Gudgeon	*Philypnodon grandiceps*		2	2	3		
Wild Goldfish	*Carassius auratus*			1			5

Table 3-5 **Numbers of fish caught whilst electrofishing at locations on the Coxs River during June 2017. Shaded text indicates non-native species.**

Common Name	Scientific Name	BR	C1	EFR2	EFR3	EFR4	R5
Rainbow Trout	*Oncorhynchus mykiss*	73	38	2	11	2	5
Brown Trout	*Salmo trutta*	19		1	1		
Redfin Perch	*Perca fluviatilis*	1	1				
Eastern Gambusia	*Gambusia holbrooki*	1	1		1	4	
Mountain Galaxiid	*Galaxias olidus*			1		6	9
Flathead Gudgeon	*Philypnodon grandiceps*	6	18	36			

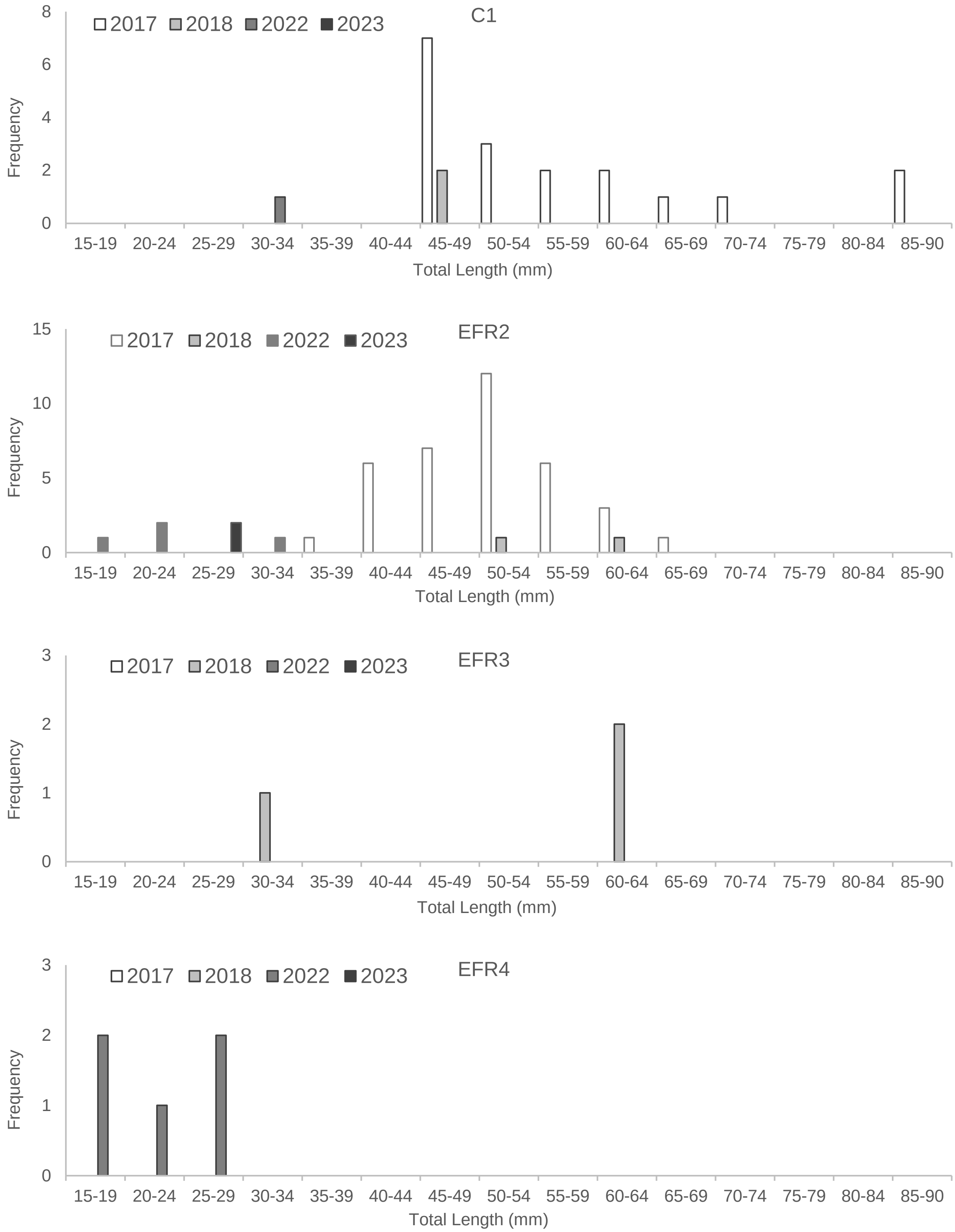

Figure 3-12 **Length frequency histograms for flathead gudgeon caught during backpack electrofishing in the Coxs River in July 2027, June 2018, June 2022 and October 2023. Flathead gudgeon were not caught at R5.**

4 DISCUSSION

4.1 AQUATIC MACROINVERTEBRATES

Changes in several macroinvertebrate responses indicate that the communities at EFR2, EFR3 and EFR4 (i.e., those just downstream of Lake Lyell) are becoming more similar to those at R5 (the location on the Coxs River that experiences natural flow). Such findings provide support for the hypothesis regarding changes in the macroinvertebrate community (**Section 1.1** and **Box 1**).

The benthic macroinvertebrate communities in the Coxs River [sampled following implementation of the environment flow regime] will be different from those sampled prior to the implementation of the environmental flow regime. The Coxs River macroinvertebrate communities will tend to become more similar to communities that experience Natural Flow (unregulated flows, i.e. those that are not influenced by upstream artificial flow controlling features, such as dams) than to those that experience Controlled Flow (regulated flows, i.e. those that are influenced by upstream artificial flow controlling features) under the environmental flow regime.

Box 1. Hypothesis concerning changes in macroinvertebrate communities on the Coxs River in response to the environmental flow regime.

Overall, more taxa displayed changes in abundance that were indicative of the community at the EFR locations becoming more similar to that at R5, a natural-flow location, than the number that suggested the community was becoming less similar to that at R5. In particular, changes detected for 18, 13 and 19 taxa at EFR2, EFR3 and EFR4, respectively, were suggestive of the community at these locations becoming more similar to that at R5, compared with only 3 taxa at each of EFR2, EFR3 and EFR4 that suggested the opposite. It is noted also that, given the macroinvertebrate assemblage would be expected to include some taxa that are habitat generalists in addition to those that prefer particular environments, not all taxa may be expected to change abundance at the EFR locations following implementation of the environmental flow regime.

Compared to the most recent previous survey in June 2022, the findings of the 2023 survey represent a further increase of 1, 3 and 4 taxa at EFR2, EFR3 and EFR4, respectively, that became more similar to R5. While the surveys were done at different times of year, this broadly suggests that the macroinvertebrate assemblage on this reach of the Coxs River is continuing to become more similar to that expected under natural flow conditions. Although the number of taxa included in the analysis has varied among the current study (50), June 2022 (52) and April 2020 (48), the overall proportion of taxa that have become more similar, compared to less similar, to R5 has increased during this period. It is noted also that given the macroinvertebrate assemblage would be expected to include some taxa that are habitat generalists in addition to those that prefer particular environments, not all taxa may be expected to change abundance at the EFR locations following implementation.

One of the most obvious changes evident in the current and other recent previous studies from November 2016 onward, was the apparent increase in abundance of leptophlebiid mayflies at the EFR locations following implementation of the environmental flow regime in October 2011, with numbers increasing to become more similar to that at R5 – a result also noted in previous Cardno (2018, 2019, 2020, 2021 and 2022) reports. This taxon is somewhat sensitive to water pollution and is assigned a Stream Invertebrate Grade Number Average Level (SIGNAL2) score of 7, where 1 indicates a highly pollution tolerant taxon and 10 a highly pollution sensitive taxon (Chessman 2003). Leptophlebiidae was also one of the taxa that contributed most to differences in the macroinvertebrate assemblage between regulated- and unregulated-flow tributaries in a study of the Hunter River in NSW (Cortez et al. 2012), with this taxon apparently more abundant in unregulated rivers characterised by 'natural flow'. Cortez et al. (2012) also indicated that the abundances of Gomphidae (a family of dragonfly), Philopotamidae (a family of caddisfly) and Psephenidae (a family of water beetle) were also greater in unregulated rivers than in regulated rivers. Similarly, in the Coxs River Philopotamidae also increased in abundance following EFR implementation and became more similar to R5. In contrast, here was little evidence of such patterns in Gomphidae in the Coxs River, though Psephenidae appeared more abundant at EFR2 and philopotamids tended to be more abundant at EFR2, EFR3 and EFR4 following implementation of the EFR. In the cases of each of these taxa, abundances at these EFR locations became more similar to those at R5.

Changes in the abundances of oligochaetes and nematodes also provided inconclusive evidence of an influence of the environmental flow regime. In each case, a decrease in abundance to a level more similar to R5 was noted at each EFR location following EFR implementation. However, such decreases may have been associated with a broad-scale reduction in abundances irrespective of the EFR. A similar, though less pronounced pattern was also observed in the abundances of nematophora and nemertea (worm-like taxa). Decreases in abundance of these taxa are likely due to greater flow and flow variability following implementation of the environmental flow regime, and habitat conditions becoming less favourable to these taxa, which are often found in accumulations of soft sediments in slower flowing water.

Not all changes in macroinvertebrate responses suggested macroinvertebrate communities just downstream of Lake Lyell are becoming increasingly similar to what would be expected under natural flow conditions. For example, Hydrophilidae and Conoesucidae abundances at EFR locations have become less similar to those at R5. In these cases, however, the generally low abundances made confident identification of changes problematic and such findings should be treated with caution. Changes indicative of an influence of the environmental flow regime are far more likely to be detected with confidence in taxa that are naturally relatively abundant, irrespective of any influence of flow variability.

Changes in the abundance of macroinvertebrate taxa at EFR2, EFR3 and EFR4 relative to those at C1 are difficult to interpret due to the relatively variable flow experienced at C1 from late 2010, including the period when the environmental flow regime was implemented from October 2011 onwards (it had originally been anticipated that flow at C1 would have remained relatively consistent and low before and after implementation). Changes in abundances of macroinvertebrates at EFR2 and EFR4, and to a lesser degree EFR3, are generally supportive of the interpretation that the community in EFR locations is broadly becoming more similar to that at C1. This is possibly related to flow variability and magnitude at the EFR locations becoming more similar to those at C1 following EFR implementation (**Section 1.4.2**). The relatively variable and greater magnitude of flow observed at C1 (compared with flow measured at the Lithgow gauge located between EFR2 and EFR3) throughout 2001 to 2023 suggest that C1 probably supports a community more representative of natural rather than controlled flow, at least relative to those at the EFR locations.

Patterns of change among the EFR locations have not always been consistent. Changes at EFR3 were less likely to indicate abundances were becoming more similar to C1, compared with EFR2 and EFR4. There are several potential reasons why this may be the case. Flow variability, along with potential reductions in downstream drift of macroinvertebrates, and variability in habitat quality and availability among locations irrespective of the environmental flow regime could, at least partly, explain why there was not a more consistent pattern of change between EFR locations and C1. Differences in the type and availability of food resources in the form of leaves and large woody debris at the various locations could also be a contributing factor (Cardno Ecology Lab 2011). Differences in measures of water quality, such as EC, for which a potential gradient along the Coxs River was identified in previous surveys (Cardno Ecology Lab 2015), may also have an influence on the type and numbers of macroinvertebrates and periphyton present at different locations and / or times. Each taxon could be expected to respond differently to variability in these factors, further complicating the identification and interpretation of overall patterns. The timing of surveys with respect to high flow events may also influence the detection of changes. Several researchers have reported that the effects of floods on macroinvertebrate assemblages are relatively short-lived and have attributed this to the capacity of many invertebrate taxa to recover rapidly from disturbance (Scrimgeour & Winterbourn 1989; Wallace 1990; Matthaei et al. 2000; Scarsbrook 2002).

Changes in values of macroinvertebrate responses at EFR2, EFR3 and EFR4 relative to FISH, ABE and TUR on the external reference rivers provide inconclusive evidence regarding an effect of the environmental flow regime. This was perhaps not surprising given flow variability and magnitude at ABE and TUR were much greater than those observed on the Coxs River and that these conditions may be associated with unique macroinvertebrate communities, complicating such comparisons (Cardno 2018) (notwithstanding any differences associated with watercourses with varying physical, chemical and geographic conditions). Interpretation of changes at EFR2, EFR3 and EFR4 relative to any apparent changes at FISH is also difficult in the absence of data on the flow variability in the Fish River.

It is possible that changes in abundance of those taxa for which the most obvious pieces of evidence of an effect of the environmental flow regime have been observed (e.g., leptophlebiids and oligochaetes), have to some degree stabilised. In these cases, the greatest rate of change in difference in abundances between locations was observed in the first few years following EFR implementation. Following this, the new abundances appear to have largely been maintained, with a relatively modest increase in the number of taxa becoming more similar to R5 in the most recent two surveys. However, even if abundances have generally stabilised, a small fluctuation in numbers of taxa displaying a response to the environmental flow regime each survey would still be expected.

4.2 PERIPHYTON

Changes in numbers of periphyton indicators (diatom, blue-green algae and green algae cells) among locations provided very little evidence of an influence of the environmental flow regime on periphyton assemblages. In the current study, only the number of blue-green algae cells at EFR3 became more similar to that at R5. In 2022, only the number of green algae cells at EFR3 became more similar to that at R5. When data up to and including 2018 (Cardno 2019) and 2020 (Cardno 2021) were included in the analyses, changes were detected in the cases of only three pairs of locations, none of which were indicative of the periphyton assemblage at the EFR locations becoming more similar to that at R5. Previously in 2017 (Cardno 2018), changes suggestive of the number of blue-green algae cells and green algae cells at one or more of the EFR locations becoming more similar to those at ABE and TUR provided limited evidence to suggest that the community at the EFR locations is becoming more similar to what would be expected to occur under variable flow conditions. In the current study, changes in the number of diatom, blue-green algae and green algae cells at EFR3 and / or EFR4 relative to ABE and TUR suggested the opposite.

In a study on periphyton in New Zealand, the taxonomic composition of periphyton communities were usually only affected by extended periods of low flow that were coupled with nutrient enrichment, which resulted in proliferations of green filamentous algae, while other disturbances in the flow regime generally had no affect (Biggs 1995). In another study, such conditions have also been shown to result in a higher richness of periphyton taxa (Biggs and Smith 2002). However, these New Zealand rivers probably differ greatly from the Coxs River in that they may well be flood dominated, and thus contain considerably different periphyton communities. Growns and Growns (2001) examined diatom communities in New South Wales and showed that the regulated flows of the Cordeaux, Cataract and Nepean dams had modified their taxonomic composition. However, subsequent repeat studies by The Ecology Lab (2000) and Ecowise (2002) found no difference between these regulated reaches and unregulated reaches. Similarly, a small study in the Murray River in South Australia compared in-dam and downstream periphyton and concluded that their composition was more affected by large-scale natural events than by flow regulation (Burns and Walker 2000). It is possible that Burns and Walker's (2000) study was subject to a large-scale natural event, such as a flood, which affected their results. Also, the Murray River and the Coxs River are very different systems, so would not be expected to show the same patterns. Both Biggs (1995) and Growns and Growns (2001) suggested that communities were affected more by hydrology than water quality, even though both factors play a significant and often synergistic role. Factors influencing periphyton growth include floods, water speed, sunlight, streambed stability, nutrients and grazing invertebrates (Quinn and Meleason 2002). Different taxa are also likely to respond differently, and relatively rapidly or slowly, to variability in flow. It is possible also that the (albeit relatively small) flow variability experienced on the Coxs River prior to the implementation of the environmental flow regime was sufficient to maintain some components of the periphyton community during this time.

4.3 FISH

Flathead gudgeons generally grow to around 80 mm in length (McDowell 1996). This suggests that the flathead gudgeons caught in June 2017 were mostly adult fish, with a smaller number of potential recruits (primarily at BR) from the spring 2016 / summer 2017 spawning event. While current assessment of the proportion of new recruits is hindered in the absence of length–growth functions, NSW DPI (Fisheries) is undertaking research into the growth of flathead gudgeon. The low numbers of flathead gudgeon caught in 2018, 2022 and 2023 has prevented any more than cursory examination of differences in lengths of fish caught in those surveys and that done 2017. There was no indication of any temporal differences in lengths of fish caught at any of the locations, though the individuals caught in 2022 and 2023 tended to be smaller (and thus younger) than those caught previously. This could reflect a later time of spawning throughout the Coxs River during 2022 and possibly linked with the much greater flows in the river during this time.

Although lower numbers of fish were caught in 2018, 2022 and 2023 compared with 2017, this was consistent across all locations and there was no indication of a decrease in the number of fish at any one location. Greater flow variability and resulting changes in river geomorphology could be expected to increase habitat heterogeneity, providing a greater number and variety of niches, including new and existing ones, for native species of fish to exploit. Woody debris (an important fish habitat) may be washed into the river during high flow events and accumulations of fine sediments (which may smother gravel beds and other fish habitat) may be cleared away. Changes in the numbers of native species would almost certainly be associated with changes in the numbers of non-native species, which could be expected to compete with and / or predate on the native species. In 2017 and some surveys prior to that, large numbers of brown trout and rainbow trout were caught at the most upstream locations, particularly at BR and C1. This is likely due to stocking of these fish in Lake Wallace, with individuals migrating downstream into the Coxs River during high flow events when water overtops the dam wall. Brown trout have also been stocked within BR for several years, while redfin perch, another non-native and predatory fish, were also caught for the first time during the BMP at the two most upstream locations. Redfin perch has recently been found to be abundant in Lake Wallace, possibly following deliberate or inadvertent introduction. Large numbers of these fish would be expected to influence numbers of flathead gudgeon and mountain galaxiids due to predation, potentially masking any positive effect on their abundance due to the environmental flow regime.

5 CONCLUSIONS

Macroinvertebrates

In comparison with earlier studies, the current 2023 study provided evidence that the macroinvertebrate communities in the sections of the Coxs River subject to environmental flows (EFR locations) are becoming more similar to macroinvertebrate communities at downstream reference site R5. Such changes support the hypothesis regarding the macroinvertebrate community at the EFR locations becoming more similar to that which would be expected to occur under natural flow conditions. Rather than supporting a macroinvertebrate community representative of controlled flow conditions, examination of flow data suggests C1 is more likely to support a community representative of relatively variable flow (though possibly to a lesser degree than R5). This is evidenced by the macroinvertebrate communities at EFR2 and EFR4, and to a lesser degree EFR3, appearing to become more, rather than less, similar to the community at C1 following EFR implementation. In contrast, comparison of patterns of changes at EFR locations with those at the reference rivers are inconclusive and more difficult to interpret. This is likely due to the far greater flow variability and magnitude experienced at ABE and TUR, and other factors such as variable morphologic and geographic conditions, which collectively may be associated with unique macroinvertebrate communities (notwithstanding any differences associated with watercourses with varying physical, chemical and geographic conditions). The absence of flow data from FISH hinders the interpretation of changes at EFR locations relative to this location.

Nevertheless, the finding that many macroinvertebrate taxa appear to be responding to greater flow variability on the Coxs River downstream of Lake Lyell suggests that a component of the macroinvertebrate community immediately downstream of Lake Lyell has become more similar to that expected under natural flow conditions. It is possible that changes in macroinvertebrate indicators have not stabilised, and that further changes, if any, in the abundance of taxa may take some time to become evident.

Periphyton

Periphyton responses examined provided inconclusive evidence as to whether the periphyton communities at EFR2, EFR3 and EFR4 are becoming more or less similar to that expected under natural flows. Given these assemblages are likely to take time to adapt to altered flow conditions, further monitoring is recommended.

Fish

At this stage the effect of the environmental flow regime on recruitment of native flathead gudgeon is unclear. This is due to the overall low numbers of this species caught at all locations on the Coxs River. Nevertheless, the Coxs River does provide habitat for this native species and for the native mountain galaxias.

Further examination of changes in the abundance of recruits of native fish will be undertaken once data from future surveys become available.

6 RECOMMENDATIONS

- Monitoring should continue across the same scope of response indicators and at the same locations on the Coxs River and external reference rivers as planned for 2024. This will provide additional confidence around conclusions regarding the influence of flow variability on the biotic community of the Coxs River. It will also help to resolve other detectable changes in biotic indicators indicative of an effect of the environmental flow regime.
- Future analysis must continue to consider the variability in flow at each individual location, if data are available. Otherwise, any conclusions regarding the response of the biotic communities may be misleading. The identification of other predictors of changes in macroinvertebrate responses, for example metrics associated with flow variability, may also help in identifying underlying relationships between hydrology and communities of aquatic biota on the Coxs River and improve the understanding of the ecological effects of environmental flows.

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APPENDICES

Appendix A GPS COORDINATES

River	Location	Site	Easting	Northing
Coxs	CR1	A	6291661	228207
	CR1	B	6291683	228176
	CR1	C	6291698	228074
	BR	A	6297751	228601
	BR	B	6297729	228625
	BR	C	6297393	228566
	EFR2	A	6285601	229032
	EFR2	B	6285650	229031
	EFR2	C	6285724	228963
	EFR3	A	6283855	232815
	EFR3	B	6283853	232775
	EFR3	C	6283817	232714
	EFR4	A	6284016	235074
	EFR4	B	6284069	234944
	EFR4	C	6284165	234710
	R5	A	6276170	236738
	R5	B	6276101	236648
	R5	C	6276072	236508
Abercrombie	ABEBUM	A	6212945	752170
	ABEBUM	B	6212954	752217
	ABEBUM	C	6212955	752247
Turon	TURBAT	A	6336575	750243
	TURBAT	B	6336524	750259
	TURBAT	C	6336484	750348
Tarlo	TARSWA	A	6181997	225366
	TARSWA	B	6181842	225328
	TARSWA	C	6181666	225291
Fish	FISHAZ	A	6282404	763989
	FISHAZ	B	6282348	769077
	FISHAZ	C	6282337	769117
Wollondilly*	WOLGOO	A-C	6200059	230159

Datum: WGS 84, Zone 56H

Appendix B MODEL SELECTION RESULTS

i) SURBER Macroinvertebrates

Comparison	Taxon	AIC Diff	Coef 1	Coef 2	Comparison	Taxon	AIC Diff	Coef 1	Coef 2
EFR2 vs C1	Hydridae	10.85	0.066	-0.195	EFR2 vs C1	Veliidae	-1.44		
EFR2 vs R5	Hydridae	-1.03			EFR2 vs R5	Veliidae	-1.22		
EFR2 vs ABE	Hydridae	4.27	-0.546	0.408	EFR2 vs ABE	Veliidae	0.00		
EFR2 vs TUR	Hydridae	4.48	0.190	-0.395	EFR2 vs TUR	Veliidae	6.68	-0.361	0.335
EFR2 vs FISH	Hydridae	5.64	0.113	-0.287	EFR2 vs FISH	Veliidae	2.25	-0.274	0.301
EFR3 vs C1	Hydridae	-1.82			EFR3 vs C1	Veliidae	-1.37		
EFR3 vs R5	Hydridae	2.68	-0.100	0.125	EFR3 vs R5	Veliidae	-1.75		
EFR3 vs ABE	Hydridae	0.00			EFR3 vs ABE	Veliidae	0.00		
EFR3 vs TUR	Hydridae	1.38			EFR3 vs TUR	Veliidae	6.91	-0.346	0.344
EFR3 vs FISH	Hydridae	-1.07			EFR3 vs FISH	Veliidae	-0.55		
EFR4 vs C1	Hydridae	-1.28			EFR4 vs C1	Veliidae	-1.93		
EFR4 vs R5	Hydridae	3.45	-0.102	0.134	EFR4 vs R5	Veliidae	-0.78		
EFR4 vs ABE	Hydridae	0.00			EFR4 vs ABE	Veliidae	0.00		
EFR4 vs TUR	Hydridae	1.38			EFR4 vs TUR	Veliidae	7.99	-0.356	0.384
EFR4 vs FISH	Hydridae	-1.07			EFR4 vs FISH	Veliidae	1.93		
EFR2 vs C1	Dugesiidae	-1.91			EFR2 vs C1	Corixidae	-1.67		
EFR2 vs R5	Dugesiidae	0.15			EFR2 vs R5	Corixidae	9.74	-0.120	0.223
EFR2 vs ABE	Dugesiidae	-0.87			EFR2 vs ABE	Corixidae	0.00		
EFR2 vs TUR	Dugesiidae	-0.83			EFR2 vs TUR	Corixidae	-1.92		
EFR2 vs FISH	Dugesiidae	-0.90			EFR2 vs FISH	Corixidae	-1.89		
EFR3 vs C1	Dugesiidae	-1.68			EFR3 vs C1	Corixidae	-1.83		
EFR3 vs R5	Dugesiidae	3.50	0.071	-0.282	EFR3 vs R5	Corixidae	1.40		
EFR3 vs ABE	Dugesiidae	0.16			EFR3 vs ABE	Corixidae	0.02		
EFR3 vs TUR	Dugesiidae	1.79			EFR3 vs TUR	Corixidae	-1.70		
EFR3 vs FISH	Dugesiidae	-0.48			EFR3 vs FISH	Corixidae	-1.76		
EFR4 vs C1	Dugesiidae	-1.10			EFR4 vs C1	Corixidae	0.40		
EFR4 vs R5	Dugesiidae	10.83	0.098	-0.313	EFR4 vs R5	Corixidae	-0.98		
EFR4 vs ABE	Dugesiidae	-2.00			EFR4 vs ABE	Corixidae	-0.38		
EFR4 vs TUR	Dugesiidae	-0.79			EFR4 vs TUR	Corixidae	-1.13		
EFR4 vs FISH	Dugesiidae	-0.60			EFR4 vs FISH	Corixidae	0.05		
EFR2 vs C1	Nemertea	8.58	0.068	-0.317	EFR2 vs C1	Corydalidae	-2.00		
EFR2 vs R5	Nemertea	20.13	0.152	-0.434	EFR2 vs R5	Corydalidae	-1.95		
EFR2 vs ABE	Nemertea	0.59			EFR2 vs ABE	Corydalidae	0.75		
EFR2 vs TUR	Nemertea	5.70	0.198	-0.484	EFR2 vs TUR	Corydalidae	4.47	0.274	-0.313
EFR2 vs FISH	Nemertea	9.52	0.248	-0.547	EFR2 vs FISH	Corydalidae	1.41		
EFR3 vs C1	Nemertea	-1.54			EFR3 vs C1	Corydalidae	-0.92		
EFR3 vs R5	Nemertea	1.46			EFR3 vs R5	Corydalidae	1.22		
EFR3 vs ABE	Nemertea	6.50	-0.330	0.272	EFR3 vs ABE	Corydalidae	-0.92		
EFR3 vs TUR	Nemertea	3.15	0.059	-0.172	EFR3 vs TUR	Corydalidae	11.68	0.368	-0.465
EFR3 vs FISH	Nemertea	-1.04			EFR3 vs FISH	Corydalidae	-1.08		
EFR4 vs C1	Nemertea	-1.60			EFR4 vs C1	Corydalidae	-1.60		
EFR4 vs R5	Nemertea	-1.01			EFR4 vs R5	Corydalidae	-1.23		
EFR4 vs ABE	Nemertea	9.70	-0.381	0.361	EFR4 vs ABE	Corydalidae	-1.54		
EFR4 vs TUR	Nemertea	-1.88			EFR4 vs TUR	Corydalidae	7.99	0.338	-0.376
EFR4 vs FISH	Nemertea	-1.95			EFR4 vs FISH	Corydalidae	-0.73		
EFR2 vs C1	Nematoda	8.38	0.059	-0.312	EFR2 vs C1	Dytiscidae	-0.30		
EFR2 vs R5	Nematoda	8.20	0.076	-0.266	EFR2 vs R5	Dytiscidae	0.24		
EFR2 vs ABE	Nematoda	-0.96			EFR2 vs ABE	Dytiscidae	10.50	-0.487	0.480
EFR2 vs TUR	Nematoda	-1.06			EFR2 vs TUR	Dytiscidae	-1.44		
EFR2 vs FISH	Nematoda	0.00			EFR2 vs FISH	Dytiscidae	0.00		
EFR3 vs C1	Nematoda	7.45	0.019	-0.281	EFR3 vs C1	Dytiscidae	-1.96		
EFR3 vs R5	Nematoda	2.73	-0.003	-0.195	EFR3 vs R5	Dytiscidae	-1.96		
EFR3 vs ABE	Nematoda	1.29			EFR3 vs ABE	Dytiscidae	10.50	-0.487	0.474
EFR3 vs TUR	Nematoda	-1.98			EFR3 vs TUR	Dytiscidae	-1.75		
EFR3 vs FISH	Nematoda	-0.10			EFR3 vs FISH	Dytiscidae	0.00		
EFR4 vs C1	Nematoda	9.89	0.065	-0.326	EFR4 vs C1	Dytiscidae	-1.44		

Comparison	Taxon	AIC Diff	Coef 1	Coef 2	Comparison	Taxon	AIC Diff	Coef 1	Coef 2
EFR4 vs R5	Nematoda	18.02	0.151	-0.438	EFR4 vs R5	Dytiscidae	-0.89		
EFR4 vs ABE	Nematoda	-0.94			EFR4 vs ABE	Dytiscidae	10.47	-0.483	0.473
EFR4 vs TUR	Nematoda	-2.00			EFR4 vs TUR	Dytiscidae	-1.69		
EFR4 vs FISH	Nematoda	-2.00			EFR4 vs FISH	Dytiscidae	0.00		
EFR2 vs C1	Nematomorpha	-0.69			EFR2 vs C1	Hydrophilidae	6.24	-0.007	0.413
EFR2 vs R5	Nematomorpha	0.55			EFR2 vs R5	Hydrophilidae	8.16	-0.078	0.215
EFR2 vs ABE	Nematomorpha	15.59	-0.490	0.469	EFR2 vs ABE	Hydrophilidae	0.00		
EFR2 vs TUR	Nematomorpha	5.83	-0.378	0.340	EFR2 vs TUR	Hydrophilidae	-1.89		
EFR2 vs FISH	Nematomorpha	-1.51			EFR2 vs FISH	Hydrophilidae	-1.92		
EFR3 vs C1	Nematomorpha	0.38			EFR3 vs C1	Hydrophilidae	3.65	0.004	0.347
EFR3 vs R5	Nematomorpha	-0.06			EFR3 vs R5	Hydrophilidae	4.30	-0.066	0.135
EFR3 vs ABE	Nematomorpha	2.47	-0.319	0.261	EFR3 vs ABE	Hydrophilidae	-1.48		
EFR3 vs TUR	Nematomorpha	5.13	-0.426	0.384	EFR3 vs TUR	Hydrophilidae	-1.89		
EFR3 vs FISH	Nematomorpha	-0.69			EFR3 vs FISH	Hydrophilidae	-1.60		
EFR4 vs C1	Nematomorpha	4.38	0.034	-0.245	EFR4 vs C1	Hydrophilidae	4.64	0.009	0.368
EFR4 vs R5	Nematomorpha	4.89	0.038	-0.225	EFR4 vs R5	Hydrophilidae	13.10	-0.082	0.280
EFR4 vs ABE	Nematomorpha	-0.24			EFR4 vs ABE	Hydrophilidae	1.63		
EFR4 vs TUR	Nematomorpha	-2.00			EFR4 vs TUR	Hydrophilidae	-1.94		
EFR4 vs FISH	Nematomorpha	0.22			EFR4 vs FISH	Hydrophilidae	-0.39		
EFR2 vs C1	Corbiculidae/Sphaerii	10.44	0.256	-0.434	EFR2 vs C1	Scirtidae	-2.00		
EFR2 vs R5	Corbiculidae/Sphaerii	-0.27			EFR2 vs R5	Scirtidae	-1.46		
EFR2 vs ABE	Corbiculidae/Sphaerii	0.24			EFR2 vs ABE	Scirtidae	0.00		
EFR2 vs TUR	Corbiculidae/Sphaerii	-1.01			EFR2 vs TUR	Scirtidae	-0.50		
EFR2 vs FISH	Corbiculidae/Sphaerii	-1.95			EFR2 vs FISH	Scirtidae	1.53		
EFR3 vs C1	Corbiculidae/Sphaerii	3.43	0.063	-0.329	EFR3 vs C1	Scirtidae	-1.14		
EFR3 vs R5	Corbiculidae/Sphaerii	4.62	0.114	-0.375	EFR3 vs R5	Scirtidae	-1.33		
EFR3 vs ABE	Corbiculidae/Sphaerii	0.45			EFR3 vs ABE	Scirtidae	0.00		
EFR3 vs TUR	Corbiculidae/Sphaerii	-1.62			EFR3 vs TUR	Scirtidae	-1.31		
EFR3 vs FISH	Corbiculidae/Sphaerii	1.42			EFR3 vs FISH	Scirtidae	2.13	-0.201	0.256
EFR4 vs C1	Corbiculidae/Sphaerii	1.45			EFR4 vs C1	Scirtidae	0.62		
EFR4 vs R5	Corbiculidae/Sphaerii	7.44	0.075	-0.337	EFR4 vs R5	Scirtidae	-0.65		
EFR4 vs ABE	Corbiculidae/Sphaerii	3.04	0.172	-0.467	EFR4 vs ABE	Scirtidae	0.00		
EFR4 vs TUR	Corbiculidae/Sphaerii	3.00	0.083	-0.353	EFR4 vs TUR	Scirtidae	3.55	-0.134	0.183
EFR4 vs FISH	Corbiculidae/Sphaerii	-1.03			EFR4 vs FISH	Scirtidae	4.14	-0.228	0.282
EFR2 vs C1	Ancylidae	0.40			EFR2 vs C1	Elmidae	4.23	-0.007	0.173
EFR2 vs R5	Ancylidae	0.99			EFR2 vs R5	Elmidae	-0.23		
EFR2 vs ABE	Ancylidae	-1.87			EFR2 vs ABE	Elmidae	-1.44		
EFR2 vs TUR	Ancylidae	2.69	0.159	-0.330	EFR2 vs TUR	Elmidae	-0.85		
EFR2 vs FISH	Ancylidae	-1.99			EFR2 vs FISH	Elmidae	-1.90		
EFR3 vs C1	Ancylidae	-1.78			EFR3 vs C1	Elmidae	-0.09		
EFR3 vs R5	Ancylidae	-1.32			EFR3 vs R5	Elmidae	-0.46		
EFR3 vs ABE	Ancylidae	8.53	-0.601	0.728	EFR3 vs ABE	Elmidae	-1.29		
EFR3 vs TUR	Ancylidae	2.05	-0.277	0.332	EFR3 vs TUR	Elmidae	-0.53		
EFR3 vs FISH	Ancylidae	4.39	-0.360	0.366	EFR3 vs FISH	Elmidae	-1.63		
EFR4 vs C1	Ancylidae	-0.67			EFR4 vs C1	Elmidae	-1.65		
EFR4 vs R5	Ancylidae	-1.11			EFR4 vs R5	Elmidae	1.20		
EFR4 vs ABE	Ancylidae	11.43	-0.793	0.926	EFR4 vs ABE	Elmidae	-2.00		
EFR4 vs TUR	Ancylidae	3.63	-0.375	0.411	EFR4 vs TUR	Elmidae	1.55		
EFR4 vs FISH	Ancylidae	1.71			EFR4 vs FISH	Elmidae	-0.54		
EFR2 vs C1	Planorbidae	12.04	0.064	-0.183	EFR2 vs C1	Psephenidae	-0.84		
EFR2 vs R5	Planorbidae	11.50	0.066	-0.190	EFR2 vs R5	Psephenidae	4.11	0.039	-0.194
EFR2 vs ABE	Planorbidae	-2.00			EFR2 vs ABE	Psephenidae	-1.06		
EFR2 vs TUR	Planorbidae	-0.37			EFR2 vs TUR	Psephenidae	2.12	0.060	-0.405
EFR2 vs FISH	Planorbidae	-1.94			EFR2 vs FISH	Psephenidae	0.25		
EFR3 vs C1	Planorbidae	-0.85			EFR3 vs C1	Psephenidae	-0.71		
EFR3 vs R5	Planorbidae	-0.61			EFR3 vs R5	Psephenidae	-2.00		
EFR3 vs ABE	Planorbidae	0.00			EFR3 vs ABE	Psephenidae	-1.89		
EFR3 vs TUR	Planorbidae	6.83	-0.327	0.325	EFR3 vs TUR	Psephenidae	1.87		
EFR3 vs FISH	Planorbidae	3.47	-0.233	0.211	EFR3 vs FISH	Psephenidae	-1.98		
EFR4 vs C1	Planorbidae	-0.25			EFR4 vs C1	Psephenidae	1.30		
EFR4 vs R5	Planorbidae	-0.08			EFR4 vs R5	Psephenidae	1.45		

Comparison	Taxon	AIC Diff	Coef 1	Coef 2	Comparison	Taxon	AIC Diff	Coef 1	Coef 2
EFR4 vs ABE	Planorbidae	0.00			EFR4 vs ABE	Psephenidae	0.47		
EFR4 vs TUR	Planorbidae	8.35	-0.351	0.351	EFR4 vs TUR	Psephenidae	3.81	0.080	-0.429
EFR4 vs FISH	Planorbidae	2.60	-0.224	0.205	EFR4 vs FISH	Psephenidae	-1.92		
EFR2 vs C1	Physidae	4.42	-0.085	0.347	EFR2 vs C1	Chironomidae	-0.27		
EFR2 vs R5	Physidae	-0.03			EFR2 vs R5	Chironomidae	-1.11		
EFR2 vs ABE	Physidae	0.00			EFR2 vs ABE	Chironomidae	-0.22		
EFR2 vs TUR	Physidae	-0.85			EFR2 vs TUR	Chironomidae	-1.59		
EFR2 vs FISH	Physidae	-0.01			EFR2 vs FISH	Chironomidae	-1.01		
EFR3 vs C1	Physidae	-0.79			EFR3 vs C1	Chironomidae	1.13		
EFR3 vs R5	Physidae	-1.92			EFR3 vs R5	Chironomidae	1.66		
EFR3 vs ABE	Physidae	-1.03			EFR3 vs ABE	Chironomidae	2.55	-0.593	0.515
EFR3 vs TUR	Physidae	-1.41			EFR3 vs TUR	Chironomidae	-1.82		
EFR3 vs FISH	Physidae	-2.00			EFR3 vs FISH	Chironomidae	-1.88		
EFR4 vs C1	Physidae	3.16	-0.098	0.313	EFR4 vs C1	Chironomidae	3.82	0.018	-0.198
EFR4 vs R5	Physidae	-0.18			EFR4 vs R5	Chironomidae	2.33	0.013	-0.269
EFR4 vs ABE	Physidae	2.65	-0.694	0.643	EFR4 vs ABE	Chironomidae	2.21	-0.588	0.538
EFR4 vs TUR	Physidae	-0.33			EFR4 vs TUR	Chironomidae	-1.85		
EFR4 vs FISH	Physidae	0.57			EFR4 vs FISH	Chironomidae	-1.81		
EFR2 vs C1	Oligochaeta	8.46	-0.005	-0.339	EFR2 vs C1	Ceratopogonidae	4.33	0.124	-0.255
EFR2 vs R5	Oligochaeta	6.20	-0.022	-0.288	EFR2 vs R5	Ceratopogonidae	6.94	0.128	-0.315
EFR2 vs ABE	Oligochaeta	-0.13			EFR2 vs ABE	Ceratopogonidae	-0.89		
EFR2 vs TUR	Oligochaeta	2.52	-0.032	-0.385	EFR2 vs TUR	Ceratopogonidae	-1.79		
EFR2 vs FISH	Oligochaeta	-1.93			EFR2 vs FISH	Ceratopogonidae	-0.03		
EFR3 vs C1	Oligochaeta	10.26	0.011	-0.364	EFR3 vs C1	Ceratopogonidae	2.63	0.102	-0.209
EFR3 vs R5	Oligochaeta	9.73	0.033	-0.391	EFR3 vs R5	Ceratopogonidae	11.77	0.146	-0.347
EFR3 vs ABE	Oligochaeta	-1.25			EFR3 vs ABE	Ceratopogonidae	-0.91		
EFR3 vs TUR	Oligochaeta	4.36	-0.008	-0.438	EFR3 vs TUR	Ceratopogonidae	-1.62		
EFR3 vs FISH	Oligochaeta	-0.03			EFR3 vs FISH	Ceratopogonidae	-1.54		
EFR4 vs C1	Oligochaeta	5.53	0.028	-0.272	EFR4 vs C1	Ceratopogonidae	5.73	0.129	-0.241
EFR4 vs R5	Oligochaeta	7.80	0.033	-0.304	EFR4 vs R5	Ceratopogonidae	7.84	0.128	-0.271
EFR4 vs ABE	Oligochaeta	-2.00			EFR4 vs ABE	Ceratopogonidae	0.47		
EFR4 vs TUR	Oligochaeta	-0.10			EFR4 vs TUR	Ceratopogonidae	-1.54		
EFR4 vs FISH	Oligochaeta	-1.83			EFR4 vs FISH	Ceratopogonidae	-1.62		
EFR2 vs C1	Cladocera	5.27	0.152	-0.407	EFR2 vs C1	Simuliidae	1.03		
EFR2 vs R5	Cladocera	4.02	0.111	-0.352	EFR2 vs R5	Simuliidae	-0.19		
EFR2 vs ABE	Cladocera	4.02	0.380	-0.875	EFR2 vs ABE	Simuliidae	1.79		
EFR2 vs TUR	Cladocera	7.75	0.300	-0.736	EFR2 vs TUR	Simuliidae	-1.99		
EFR2 vs FISH	Cladocera	3.76	0.282	-0.591	EFR2 vs FISH	Simuliidae	-2.00		
EFR3 vs C1	Cladocera	-0.06			EFR3 vs C1	Simuliidae	-1.90		
EFR3 vs R5	Cladocera	1.00			EFR3 vs R5	Simuliidae	-1.04		
EFR3 vs ABE	Cladocera	-0.73			EFR3 vs ABE	Simuliidae	0.82		
EFR3 vs TUR	Cladocera	-2.00			EFR3 vs TUR	Simuliidae	-0.69		
EFR3 vs FISH	Cladocera	-1.92			EFR3 vs FISH	Simuliidae	-1.70		
EFR4 vs C1	Cladocera	-0.61			EFR4 vs C1	Simuliidae	-1.78		
EFR4 vs R5	Cladocera	-1.66			EFR4 vs R5	Simuliidae	-1.47		
EFR4 vs ABE	Cladocera	-15.55			EFR4 vs ABE	Simuliidae	5.67	0.587	-0.843
EFR4 vs TUR	Cladocera	-1.44			EFR4 vs TUR	Simuliidae	-1.28		
EFR4 vs FISH	Cladocera	10.72	-0.095	0.099	EFR4 vs FISH	Simuliidae	-0.92		
EFR2 vs C1	Copepoda	10.51	0.152	-0.491	EFR2 vs C1	Tipulidae	3.56	0.104	-0.233
EFR2 vs R5	Copepoda	13.29	0.184	-0.528	EFR2 vs R5	Tipulidae	-1.39		
EFR2 vs ABE	Copepoda	-8.22			EFR2 vs ABE	Tipulidae	-2.00		
EFR2 vs TUR	Copepoda	8.05	0.278	-0.727	EFR2 vs TUR	Tipulidae	-1.53		
EFR2 vs FISH	Copepoda	5.45	0.204	-0.585	EFR2 vs FISH	Tipulidae	-0.46		
EFR3 vs C1	Copepoda	0.00			EFR3 vs C1	Tipulidae	-1.36		
EFR3 vs R5	Copepoda	0.00			EFR3 vs R5	Tipulidae	-0.87		
EFR3 vs ABE	Copepoda	0.00			EFR3 vs ABE	Tipulidae	3.38	-0.680	0.812
EFR3 vs TUR	Copepoda	0.00			EFR3 vs TUR	Tipulidae	2.04	-0.505	0.640
EFR3 vs FISH	Copepoda	0.00			EFR3 vs FISH	Tipulidae	1.73		
EFR4 vs C1	Copepoda	-0.83			EFR4 vs C1	Tipulidae	-0.58		
EFR4 vs R5	Copepoda	-0.14			EFR4 vs R5	Tipulidae	-0.96		
EFR4 vs ABE	Copepoda	-1.94			EFR4 vs ABE	Tipulidae	5.57	-0.745	0.953

Comparison	Taxon	AIC Diff	Coef 1	Coef 2	Comparison	Taxon	AIC Diff	Coef 1	Coef 2
EFR4 vs TUR	Copepoda	4.69	0.330	-0.678	EFR4 vs TUR	Tipulidae	2.22	-0.326	0.460
EFR4 vs FISH	Copepoda	-0.73			EFR4 vs FISH	Tipulidae	1.10		
EFR2 vs C1	Ostracoda	-2.00			EFR2 vs C1	Stratiomyidae	3.65	0.028	-0.127
EFR2 vs R5	Ostracoda	0.78			EFR2 vs R5	Stratiomyidae	2.00	0.020	-0.114
EFR2 vs ABE	Ostracoda	5.71	-0.499	0.417	EFR2 vs ABE	Stratiomyidae	0.00		
EFR2 vs TUR	Ostracoda	-1.41			EFR2 vs TUR	Stratiomyidae	0.21		
EFR2 vs FISH	Ostracoda	-1.99			EFR2 vs FISH	Stratiomyidae	1.80		
EFR3 vs C1	Ostracoda	-1.93			EFR3 vs C1	Stratiomyidae	-0.30		
EFR3 vs R5	Ostracoda	-1.57			EFR3 vs R5	Stratiomyidae	-1.96		
EFR3 vs ABE	Ostracoda	1.28			EFR3 vs ABE	Stratiomyidae	0.00		
EFR3 vs TUR	Ostracoda	-1.96			EFR3 vs TUR	Stratiomyidae	2.45	-0.140	0.168
EFR3 vs FISH	Ostracoda	-1.84			EFR3 vs FISH	Stratiomyidae	0.00		
EFR4 vs C1	Ostracoda	-1.39			EFR4 vs C1	Stratiomyidae	-0.59		
EFR4 vs R5	Ostracoda	-1.98			EFR4 vs R5	Stratiomyidae	1.41		
EFR4 vs ABE	Ostracoda	16.16	-0.578	0.553	EFR4 vs ABE	Stratiomyidae	0.00		
EFR4 vs TUR	Ostracoda	4.70	-0.194	0.230	EFR4 vs TUR	Stratiomyidae	3.87	-0.119	0.143
EFR4 vs FISH	Ostracoda	-0.70			EFR4 vs FISH	Stratiomyidae	6.97	-0.119	0.130
EFR2 vs C1	Atyidae	-1.48			EFR2 vs C1	Empididae	-1.75		
EFR2 vs R5	Atyidae	-1.82			EFR2 vs R5	Empididae	-1.88		
EFR2 vs ABE	Atyidae	1.91			EFR2 vs ABE	Empididae	11.59	-0.675	0.655
EFR2 vs TUR	Atyidae	-1.61			EFR2 vs TUR	Empididae	-1.64		
EFR2 vs FISH	Atyidae	-0.23			EFR2 vs FISH	Empididae	1.28		
EFR3 vs C1	Atyidae	2.24	-0.084	0.100	EFR3 vs C1	Empididae	-1.99		
EFR3 vs R5	Atyidae	1.79			EFR3 vs R5	Empididae	-1.23		
EFR3 vs ABE	Atyidae	0.00			EFR3 vs ABE	Empididae	5.49	-0.607	0.508
EFR3 vs TUR	Atyidae	-0.91			EFR3 vs TUR	Empididae	-0.72		
EFR3 vs FISH	Atyidae	0.48			EFR3 vs FISH	Empididae	-1.01		
EFR4 vs C1	Atyidae	-1.83			EFR4 vs C1	Empididae	-0.41		
EFR4 vs R5	Atyidae	-2.00			EFR4 vs R5	Empididae	-0.13		
EFR4 vs ABE	Atyidae	0.00			EFR4 vs ABE	Empididae	6.92	-0.622	0.523
EFR4 vs TUR	Atyidae	-1.54			EFR4 vs TUR	Empididae	-1.40		
EFR4 vs FISH	Atyidae	1.49			EFR4 vs FISH	Empididae	-0.55		
EFR2 vs C1	Parastacidae	0.72			EFR2 vs C1	Dolichopodidae	0.17		
EFR2 vs R5	Parastacidae	0.36			EFR2 vs R5	Dolichopodidae	-0.50		
EFR2 vs ABE	Parastacidae	-1.26			EFR2 vs ABE	Dolichopodidae	-1.53		
EFR2 vs TUR	Parastacidae	-0.50			EFR2 vs TUR	Dolichopodidae	2.08	0.205	-0.312
EFR2 vs FISH	Parastacidae	-1.07			EFR2 vs FISH	Dolichopodidae	6.92	0.148	-0.227
EFR3 vs C1	Parastacidae	2.01	0.016	-0.069	EFR3 vs C1	Dolichopodidae	-1.50		
EFR3 vs R5	Parastacidae	5.07	0.028	-0.097	EFR3 vs R5	Dolichopodidae	-1.54		
EFR3 vs ABE	Parastacidae	0.00			EFR3 vs ABE	Dolichopodidae	-1.81		
EFR3 vs TUR	Parastacidae	-1.87			EFR3 vs TUR	Dolichopodidae	2.58	0.213	-0.327
EFR3 vs FISH	Parastacidae	-1.42			EFR3 vs FISH	Dolichopodidae	3.74	0.119	-0.178
EFR4 vs C1	Parastacidae	4.59	0.038	-0.099	EFR4 vs C1	Dolichopodidae	3.00	0.014	-0.035
EFR4 vs R5	Parastacidae	2.62	0.026	-0.091	EFR4 vs R5	Dolichopodidae	-0.51		
EFR4 vs ABE	Parastacidae	5.85	0.136	-0.251	EFR4 vs ABE	Dolichopodidae	-1.43		
EFR4 vs TUR	Parastacidae	2.07	0.051	-0.150	EFR4 vs TUR	Dolichopodidae	3.75	0.221	-0.346
EFR4 vs FISH	Parastacidae	3.17	0.065	-0.163	EFR4 vs FISH	Dolichopodidae	6.94	0.135	-0.210
EFR2 vs C1	Hydracarina	-1.77			EFR2 vs C1	Hydrobiosidae	6.02	0.067	-0.140
EFR2 vs R5	Hydracarina	-1.81			EFR2 vs R5	Hydrobiosidae	6.88	0.045	-0.282
EFR2 vs ABE	Hydracarina	-1.80			EFR2 vs ABE	Hydrobiosidae	-2.00		
EFR2 vs TUR	Hydracarina	0.51			EFR2 vs TUR	Hydrobiosidae	-0.01		
EFR2 vs FISH	Hydracarina	-1.20			EFR2 vs FISH	Hydrobiosidae	-1.69		
EFR3 vs C1	Hydracarina	5.63	-0.283	0.414	EFR3 vs C1	Hydrobiosidae	1.71		
EFR3 vs R5	Hydracarina	-0.52			EFR3 vs R5	Hydrobiosidae	3.89	0.039	-0.212
EFR3 vs ABE	Hydracarina	0.83			EFR3 vs ABE	Hydrobiosidae	-1.38		
EFR3 vs TUR	Hydracarina	-1.80			EFR3 vs TUR	Hydrobiosidae	-1.24		
EFR3 vs FISH	Hydracarina	-2.00			EFR3 vs FISH	Hydrobiosidae	-1.03		
EFR4 vs C1	Hydracarina	-0.55			EFR4 vs C1	Hydrobiosidae	9.20	0.112	-0.271
EFR4 vs R5	Hydracarina	-1.71			EFR4 vs R5	Hydrobiosidae	8.71	0.090	-0.313
EFR4 vs ABE	Hydracarina	-0.01			EFR4 vs ABE	Hydrobiosidae	-1.17		
EFR4 vs TUR	Hydracarina	-0.21			EFR4 vs TUR	Hydrobiosidae	0.22		

Comparison	Taxon	AIC Diff	Coef 1	Coef 2	Comparison	Taxon	AIC Diff	Coef 1	Coef 2
EFR4 vs FISH	Hydracarina	-0.32			EFR4 vs FISH	Hydrobiosidae	-0.24		
EFR2 vs C1	Hypogastruridae	-0.73			EFR2 vs C1	Glossosomatidae	-1.94		
EFR2 vs R5	Hypogastruridae	8.32	0.061	-0.262	EFR2 vs R5	Glossosomatidae	2.66	0.142	-0.253
EFR2 vs ABE	Hypogastruridae	18.17	-0.429	0.424	EFR2 vs ABE	Glossosomatidae	-0.74		
EFR2 vs TUR	Hypogastruridae	5.15	-0.355	0.333	EFR2 vs TUR	Glossosomatidae	2.69	-0.370	0.456
EFR2 vs FISH	Hypogastruridae	-1.74			EFR2 vs FISH	Glossosomatidae	-0.48		
EFR3 vs C1	Hypogastruridae	-1.86			EFR3 vs C1	Glossosomatidae	-1.91		
EFR3 vs R5	Hypogastruridae	3.66	0.026	-0.169	EFR3 vs R5	Glossosomatidae	-0.10		
EFR3 vs ABE	Hypogastruridae	0.00			EFR3 vs ABE	Glossosomatidae	-1.28		
EFR3 vs TUR	Hypogastruridae	3.10	-0.255	0.254	EFR3 vs TUR	Glossosomatidae	-1.55		
EFR3 vs FISH	Hypogastruridae	-1.86			EFR3 vs FISH	Glossosomatidae	0.12		
EFR4 vs C1	Hypogastruridae	-1.74			EFR4 vs C1	Glossosomatidae	-0.88		
EFR4 vs R5	Hypogastruridae	8.47	0.047	-0.200	EFR4 vs R5	Glossosomatidae	-1.16		
EFR4 vs ABE	Hypogastruridae	0.00			EFR4 vs ABE	Glossosomatidae	-2.00		
EFR4 vs TUR	Hypogastruridae	0.68			EFR4 vs TUR	Glossosomatidae	0.16		
EFR4 vs FISH	Hypogastruridae	-1.71			EFR4 vs FISH	Glossosomatidae	-0.39		
EFR2 vs C1	Caenidae	-0.80			EFR2 vs C1	Hydroptilidae	-1.37		
EFR2 vs R5	Caenidae	-1.40			EFR2 vs R5	Hydroptilidae	-1.99		
EFR2 vs ABE	Caenidae	-0.37			EFR2 vs ABE	Hydroptilidae	4.41	-0.556	0.567
EFR2 vs TUR	Caenidae	-0.62			EFR2 vs TUR	Hydroptilidae	-1.99		
EFR2 vs FISH	Caenidae	-0.30			EFR2 vs FISH	Hydroptilidae	1.71		
EFR3 vs C1	Caenidae	1.93			EFR3 vs C1	Hydroptilidae	-0.50		
EFR3 vs R5	Caenidae	-1.76			EFR3 vs R5	Hydroptilidae	-1.99		
EFR3 vs ABE	Caenidae	0.16			EFR3 vs ABE	Hydroptilidae	9.85	-0.656	0.701
EFR3 vs TUR	Caenidae	0.66			EFR3 vs TUR	Hydroptilidae	-2.00		
EFR3 vs FISH	Caenidae	0.66			EFR3 vs FISH	Hydroptilidae	-1.18		
EFR4 vs C1	Caenidae	0.22			EFR4 vs C1	Hydroptilidae	-0.09		
EFR4 vs R5	Caenidae	-2.00			EFR4 vs R5	Hydroptilidae	-1.97		
EFR4 vs ABE	Caenidae	-1.00			EFR4 vs ABE	Hydroptilidae	2.25	-0.512	0.516
EFR4 vs TUR	Caenidae	0.37			EFR4 vs TUR	Hydroptilidae	-2.00		
EFR4 vs FISH	Caenidae	0.40			EFR4 vs FISH	Hydroptilidae	0.10		
EFR2 vs C1	Baetidae	3.19	0.256	-0.337	EFR2 vs C1	Philopotamidae	-1.36		
EFR2 vs R5	Baetidae	-0.37			EFR2 vs R5	Philopotamidae	12.44	0.290	-0.464
EFR2 vs ABE	Baetidae	-1.78			EFR2 vs ABE	Philopotamidae	2.88	0.532	-0.708
EFR2 vs TUR	Baetidae	0.20			EFR2 vs TUR	Philopotamidae	-1.56		
EFR2 vs FISH	Baetidae	-1.97			EFR2 vs FISH	Philopotamidae	-1.83		
EFR3 vs C1	Baetidae	-1.91			EFR3 vs C1	Philopotamidae	-1.59		
EFR3 vs R5	Baetidae	2.04	0.093	-0.249	EFR3 vs R5	Philopotamidae	11.04	0.295	-0.493
EFR3 vs ABE	Baetidae	-1.14			EFR3 vs ABE	Philopotamidae	4.06	0.672	-0.881
EFR3 vs TUR	Baetidae	-0.85			EFR3 vs TUR	Philopotamidae	1.74		
EFR3 vs FISH	Baetidae	2.71	0.105	-0.392	EFR3 vs FISH	Philopotamidae	2.51	0.477	-0.737
EFR4 vs C1	Baetidae	-1.20			EFR4 vs C1	Philopotamidae	-1.16		
EFR4 vs R5	Baetidae	2.80	0.098	-0.257	EFR4 vs R5	Philopotamidae	11.47	0.265	-0.384
EFR4 vs ABE	Baetidae	-1.52			EFR4 vs ABE	Philopotamidae	3.82	0.566	-0.718
EFR4 vs TUR	Baetidae	-1.99			EFR4 vs TUR	Philopotamidae	1.21		
EFR4 vs FISH	Baetidae	1.49			EFR4 vs FISH	Philopotamidae	-0.80		
EFR2 vs C1	Leptophlebiidae	1.70			EFR2 vs C1	Hydropsychidae	4.83	0.126	-0.334
EFR2 vs R5	Leptophlebiidae	13.58	0.188	-0.371	EFR2 vs R5	Hydropsychidae	2.55	0.103	-0.239
EFR2 vs ABE	Leptophlebiidae	6.67	0.601	-0.599	EFR2 vs ABE	Hydropsychidae	-0.98		
EFR2 vs TUR	Leptophlebiidae	-1.23			EFR2 vs TUR	Hydropsychidae	-2.00		
EFR2 vs FISH	Leptophlebiidae	-1.62			EFR2 vs FISH	Hydropsychidae	-1.94		
EFR3 vs C1	Leptophlebiidae	-1.68			EFR3 vs C1	Hydropsychidae	7.29	0.092	-0.297
EFR3 vs R5	Leptophlebiidae	10.14	0.124	-0.279	EFR3 vs R5	Hydropsychidae	-0.18		
EFR3 vs ABE	Leptophlebiidae	8.13	0.474	-0.458	EFR3 vs ABE	Hydropsychidae	-1.66		
EFR3 vs TUR	Leptophlebiidae	-0.69			EFR3 vs TUR	Hydropsychidae	-1.99		
EFR3 vs FISH	Leptophlebiidae	-1.52			EFR3 vs FISH	Hydropsychidae	-1.95		
EFR4 vs C1	Leptophlebiidae	-0.95			EFR4 vs C1	Hydropsychidae	9.07	0.132	-0.342
EFR4 vs R5	Leptophlebiidae	16.41	0.156	-0.375	EFR4 vs R5	Hydropsychidae	8.16	0.036	-0.304
EFR4 vs ABE	Leptophlebiidae	0.07			EFR4 vs ABE	Hydropsychidae	-1.97		
EFR4 vs TUR	Leptophlebiidae	-0.99			EFR4 vs TUR	Hydropsychidae	-1.94		
EFR4 vs FISH	Leptophlebiidae	-1.82			EFR4 vs FISH	Hydropsychidae	-0.59		

Comparison	Taxon	AIC Diff	Coef 1	Coef 2	Comparison	Taxon	AIC Diff	Coef 1	Coef 2
EFR2 vs C1	Diphlebiidae	-1.97			EFR2 vs C1	Ecnomidae	7.66	0.162	-0.221
EFR2 vs R5	Diphlebiidae	18.64	0.120	-0.317	EFR2 vs R5	Ecnomidae	1.26		
EFR2 vs ABE	Diphlebiidae	1.64			EFR2 vs ABE	Ecnomidae	5.12	0.542	-0.599
EFR2 vs TUR	Diphlebiidae	0.71			EFR2 vs TUR	Ecnomidae	-1.62		
EFR2 vs FISH	Diphlebiidae	-1.97			EFR2 vs FISH	Ecnomidae	-1.02		
EFR3 vs C1	Diphlebiidae	8.43	-0.117	0.215	EFR3 vs C1	Ecnomidae	-1.08		
EFR3 vs R5	Diphlebiidae	17.15	0.127	-0.321	EFR3 vs R5	Ecnomidae	2.34	0.035	-0.206
EFR3 vs ABE	Diphlebiidae	0.00			EFR3 vs ABE	Ecnomidae	0.93		
EFR3 vs TUR	Diphlebiidae	2.69	0.164	-0.342	EFR3 vs TUR	Ecnomidae	-1.35		
EFR3 vs FISH	Diphlebiidae	-0.24			EFR3 vs FISH	Ecnomidae	2.44	0.280	-0.420
EFR4 vs C1	Diphlebiidae	-1.15			EFR4 vs C1	Ecnomidae	4.54	0.157	-0.272
EFR4 vs R5	Diphlebiidae	18.61	0.099	-0.283	EFR4 vs R5	Ecnomidae	-0.62		
EFR4 vs ABE	Diphlebiidae	-1.62			EFR4 vs ABE	Ecnomidae	-1.36		
EFR4 vs TUR	Diphlebiidae	1.50			EFR4 vs TUR	Ecnomidae	-1.94		
EFR4 vs FISH	Diphlebiidae	-1.06			EFR4 vs FISH	Ecnomidae	-1.04		
EFR2 vs C1	Gomphidae	-1.03			EFR2 vs C1	Conoesucidae	7.43	-0.012	0.153
EFR2 vs R5	Gomphidae	-1.98			EFR2 vs R5	Conoesucidae	7.89	0.021	0.272
EFR2 vs ABE	Gomphidae	-1.32			EFR2 vs ABE	Conoesucidae	6.23	-0.071	0.277
EFR2 vs TUR	Gomphidae	-1.04			EFR2 vs TUR	Conoesucidae	0.03		
EFR2 vs FISH	Gomphidae	-0.58			EFR2 vs FISH	Conoesucidae	-0.65		
EFR3 vs C1	Gomphidae	1.70			EFR3 vs C1	Conoesucidae	10.53	0.017	0.275
EFR3 vs R5	Gomphidae	1.64			EFR3 vs R5	Conoesucidae	14.73	0.014	0.256
EFR3 vs ABE	Gomphidae	-1.83			EFR3 vs ABE	Conoesucidae	-1.57		
EFR3 vs TUR	Gomphidae	0.92			EFR3 vs TUR	Conoesucidae	-1.91		
EFR3 vs FISH	Gomphidae	-1.99			EFR3 vs FISH	Conoesucidae	-0.78		
EFR4 vs C1	Gomphidae	-0.98			EFR4 vs C1	Conoesucidae	19.79	-0.005	0.354
EFR4 vs R5	Gomphidae	4.46	0.068	-0.269	EFR4 vs R5	Conoesucidae	8.11	0.034	0.171
EFR4 vs ABE	Gomphidae	-1.93			EFR4 vs ABE	Conoesucidae	7.68	-0.053	0.311
EFR4 vs TUR	Gomphidae	0.59			EFR4 vs TUR	Conoesucidae	0.06		
EFR4 vs FISH	Gomphidae	-1.64			EFR4 vs FISH	Conoesucidae	0.10		
EFR2 vs C1	Telephlebiidae	0.05			EFR2 vs C1	Calamoceratidae	-1.32		
EFR2 vs R5	Telephlebiidae	3.26	0.016	-0.138	EFR2 vs R5	Calamoceratidae	-0.19		
EFR2 vs ABE	Telephlebiidae	3.01	-0.276	0.244	EFR2 vs ABE	Calamoceratidae	-1.98		
EFR2 vs TUR	Telephlebiidae	-1.99			EFR2 vs TUR	Calamoceratidae	-1.52		
EFR2 vs FISH	Telephlebiidae	-1.33			EFR2 vs FISH	Calamoceratidae	-1.96		
EFR3 vs C1	Telephlebiidae	-0.48			EFR3 vs C1	Calamoceratidae	-1.15		
EFR3 vs R5	Telephlebiidae	1.72			EFR3 vs R5	Calamoceratidae	-1.89		
EFR3 vs ABE	Telephlebiidae	0.00			EFR3 vs ABE	Calamoceratidae	0.00		
EFR3 vs TUR	Telephlebiidae	-1.57			EFR3 vs TUR	Calamoceratidae	0.00		
EFR3 vs FISH	Telephlebiidae	4.12	0.067	-0.170	EFR3 vs FISH	Calamoceratidae	-0.56		
EFR4 vs C1	Telephlebiidae	-0.28			EFR4 vs C1	Calamoceratidae	-2.00		
EFR4 vs R5	Telephlebiidae	4.49	0.014	-0.121	EFR4 vs R5	Calamoceratidae	1.23		
EFR4 vs ABE	Telephlebiidae	0.00			EFR4 vs ABE	Calamoceratidae	0.00		
EFR4 vs TUR	Telephlebiidae	2.41	0.101	-0.242	EFR4 vs TUR	Calamoceratidae	0.00		
EFR4 vs FISH	Telephlebiidae	3.37	0.083	-0.196	EFR4 vs FISH	Calamoceratidae	-1.33		
EFR2 vs C1	Gripopterygiidae	-20.50			EFR2 vs C1	Leptoceridae	8.06	0.049	-0.240
EFR2 vs R5	Gripopterygiidae	3.23	0.151	-0.249	EFR2 vs R5	Leptoceridae	-1.32		
EFR2 vs ABE	Gripopterygiidae	-0.72			EFR2 vs ABE	Leptoceridae	-1.98		
EFR2 vs TUR	Gripopterygiidae	-1.88			EFR2 vs TUR	Leptoceridae	-1.00		
EFR2 vs FISH	Gripopterygiidae	-1.80			EFR2 vs FISH	Leptoceridae	0.60		
EFR3 vs C1	Gripopterygiidae	-1.48			EFR3 vs C1	Leptoceridae	0.30		
EFR3 vs R5	Gripopterygiidae	-1.91			EFR3 vs R5	Leptoceridae	1.99		
EFR3 vs ABE	Gripopterygiidae	-1.87			EFR3 vs ABE	Leptoceridae	-1.70		
EFR3 vs TUR	Gripopterygiidae	-1.45			EFR3 vs TUR	Leptoceridae	0.45		
EFR3 vs FISH	Gripopterygiidae	-1.50			EFR3 vs FISH	Leptoceridae	1.25		
EFR4 vs C1	Gripopterygiidae	-1.36			EFR4 vs C1	Leptoceridae	3.97	0.026	-0.237
EFR4 vs R5	Gripopterygiidae	2.83	0.113	-0.277	EFR4 vs R5	Leptoceridae	-0.20		
EFR4 vs ABE	Gripopterygiidae	-2.00			EFR4 vs ABE	Leptoceridae	-0.43		
EFR4 vs TUR	Gripopterygiidae	0.36			EFR4 vs TUR	Leptoceridae	0.84		
EFR4 vs FISH	Gripopterygiidae	3.49	-0.329	0.555	EFR4 vs FISH	Leptoceridae	1.10		
EFR2 vs C1	Aphididae	3.37	0.039	-0.204	EFR2 vs C1	Pyralidae	-1.66		

Comparison	Taxon	AIC Diff	Coef 1	Coef 2	Comparison	Taxon	AIC Diff	Coef 1	Coef 2
EFR2 vs R5	Aphididae	0.75			EFR2 vs R5	Pyralidae	-1.53		
EFR2 vs ABE	Aphididae	0.00			EFR2 vs ABE	Pyralidae	-1.81		
EFR2 vs TUR	Aphididae	0.82			EFR2 vs TUR	Pyralidae	0.39		
EFR2 vs FISH	Aphididae	5.02	-0.309	0.307	EFR2 vs FISH	Pyralidae	3.54	-0.311	0.407
EFR3 vs C1	Aphididae	0.31			EFR3 vs C1	Pyralidae	-1.05		
EFR3 vs R5	Aphididae	-1.12			EFR3 vs R5	Pyralidae	0.27		
EFR3 vs ABE	Aphididae	0.00			EFR3 vs ABE	Pyralidae	-1.96		
EFR3 vs TUR	Aphididae	-0.47			EFR3 vs TUR	Pyralidae	-2.00		
EFR3 vs FISH	Aphididae	1.87			EFR3 vs FISH	Pyralidae	-1.79		
EFR4 vs C1	Aphididae	3.46	0.031	-0.117	EFR4 vs C1	Pyralidae	-1.99		
EFR4 vs R5	Aphididae	10.83	0.053	-0.143	EFR4 vs R5	Pyralidae	-1.45		
EFR4 vs ABE	Aphididae	0.00			EFR4 vs ABE	Pyralidae	1.52		
EFR4 vs TUR	Aphididae	-1.92			EFR4 vs TUR	Pyralidae	-1.68		
EFR4 vs FISH	Aphididae	1.87			EFR4 vs FISH	Pyralidae	3.09	-0.241	0.220

ii) AUSRIVAS Total Number of Taxa

Comparison	AIC Diff
EFR2 vs C1	-1.77
EFR2 vs R5	-1.96
EFR3 vs C1	-2.00
EFR3 vs R5	-1.27
EFR4 vs C1	-1.99
EFR4 vs R5	-1.73

iii) Periphyton

Comparison	Taxon	AIC Diff	Coef 1	Coef 2	Comparison	Taxon	AIC Diff	Coef 1	Coef 2
EFR2 vs C1	Diatoms	-0.265			EFR2 vs C1	Green Algae	-1.967		
EFR2 vs R5	Diatoms	-1.523			EFR2 vs R5	Green Algae	0.469		
EFR2 vs ABE	Diatoms	0.002			EFR2 vs ABE	Green Algae	1.117		
EFR2 vs TUR	Diatoms	-1.333			EFR2 vs TUR	Green Algae	-1.985		
EFR2 vs FISH	Diatoms	-1.905			EFR2 vs FISH	Green Algae	-1.263		
EFR3 vs C1	Diatoms	5.429	-0.154	0.384	EFR3 vs C1	Green Algae	-1.913		
EFR3 vs R5	Diatoms	1.165			EFR3 vs R5	Green Algae	1.852		
EFR3 vs ABE	Diatoms	3.407	-0.449	0.772	EFR3 vs ABE	Green Algae	-1.000		
EFR3 vs TUR	Diatoms	-1.993			EFR3 vs TUR	Green Algae	-0.877		
EFR3 vs FISH	Diatoms	5.026	-0.254	0.508	EFR3 vs FISH	Green Algae	-1.927		
EFR4 vs C1	Diatoms	11.136	-0.299	0.484	EFR4 vs C1	Green Algae	-1.787		
EFR4 vs R5	Diatoms	-1.975			EFR4 vs R5	Green Algae	0.977		
EFR4 vs ABE	Diatoms	6.179	-0.659	0.953	EFR4 vs ABE	Green Algae	7.460	-0.698	0.806
EFR4 vs TUR	Diatoms	1.159			EFR4 vs TUR	Green Algae	-1.696		
EFR4 vs FISH	Diatoms	-1.055			EFR4 vs FISH	Green Algae	-1.087		
EFR2 vs C1	Blue Green Algae	-1.448							
EFR2 vs R5	Blue Green Algae	-0.615							
EFR2 vs ABE	Blue Green Algae	-0.280							
EFR2 vs TUR	Blue Green Algae	-1.254							
EFR2 vs FISH	Blue Green Algae	-2.000							
EFR3 vs C1	Blue Green Algae	-1.667							
EFR3 vs R5	Blue Green Algae	4.307	0.342	-0.619					
EFR3 vs ABE	Blue Green Algae	-1.268							
EFR3 vs TUR	Blue Green Algae	-1.697							
EFR3 vs FISH	Blue Green Algae	-1.995							
EFR4 vs C1	Blue Green Algae	1.245							
EFR4 vs R5	Blue Green Algae	-1.730							
EFR4 vs ABE	Blue Green Algae	3.689	-0.706	0.867					
EFR4 vs TUR	Blue Green Algae	3.822	-0.509	0.613					
EFR4 vs FISH	Blue Green Algae	0.830							

Appendix C FISH NUMBERS AND LENGTHS 2023

Species	BR	C1	EFR2	EFR3	EFR4	R5
						Length (mm)
Rainbow Trout	50	25	10	30	200	20
	50	50		12.5		
	80			12.5		
				12.5		
Brown Trout			15		15	
					15	
					15	
					15	
Redfin Perch		70			100	
					150	
					150	
Galaxiid	20					20
	20					20
						20
						40
						40
						40
						60
Flathead Gudgeon			25			
			25			
Shortfinned eel	200					