Murrumbidgee Ecological Monitoring Program

Annual Report - Sentinel Monitoring 2024

Icon Water

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→ **The Power of Commitment**

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The Power of Commitment

Executive summary

In order to improve water security in the Australian Capital Territory (ACT) region under drought conditions, Icon Water (formerly ACTEW Corporation) constructed the Murrumbidgee to Googong transfer pipeline (M2G) and the upgraded Murrumbidgee Pump Station (MPS). The two assets were constructed in between 2010 and 2012 as part of a suite of water security projects initiated during the Millennium Drought.

The M2G consists of a water intake structure and pump station at Angle Crossing (near the southeastern border of the ACT), a pump outlet at Burra Creek in Burra, New South Wales (NSW) (upstream of Googong Reservoir), and a 12 km pipeline connecting the two pieces of infrastructure. The system is designed to abstract up to a nominal 100 ML/d from the Murrumbidgee River to Burra Creek for run of river flow to the Googong Reservoir drinking water catchment.

The MPS is a pump station located just downstream of the Cotter River confluence on the Murrumbidgee River. The MPS underwent a significant upgrade in 2010 which increased its pumping capacity from 50ML/d to approximately 150 ML/d. Water abstracted from the Murrumbidgee River is pumped to the Mount Stromlo Water Treatment Plant for distribution to Canberra households and businesses.

To enable the assessment of operations of these assets on the ecological condition of associated waterways, Icon Water established the Murrumbidgee Ecological Monitoring Program (MEMP). The MEMP commenced in 2008 prior to construction of the M2G and MPS upgrade. The MEMP is a comprehensive and adaptive program aimed at establishing comprehensive baseline data to allow comparison of ecological conditions before, during and after asset operations. Overall, the MEMP is aimed at investigating the potential impacts of water abstraction from the Murrumbidgee River at Angle Crossing (M2G) and the MPS, and the subsequent changes that may occur in Burra Creek due to increased flows from water pumping (M2G). Implementation and reporting of MEMP outcomes is required to fulfil approval conditions and ongoing operational licence conditions.

To enable effective implementation of the MEMP, the program includes the assessment of three components:

– Component 1 - Angle Crossing (M2G): Focused on the assessment of potential impacts associated with flow reductions in the Murrumbidgee River downstream of the Angle Crossing as a result of water abstraction.
– Component 2 – Burra Creek (M2G): Focused on the assessment of potential impacts associated with elevated and sustained flow increases on aquatic biota and stream geomorphology.
– Component 3 – Murrumbidgee River (MPS): Focused on the assessment of potential impacts associated with flow reductions in the Murrumbidgee River downstream of the MPS as a result of water abstraction.

Different modes of operation are defined for each asset under the MEMP to help target the monitoring program during different modes of operation. With this in mind, the MEMP has adopted a two-stage approach which incorporates sentinel monitoring during standby operation modes and impact monitoring during operation modes.

Sentinel monitoring occurs during standby periods when the risk to ecosystems is deemed to be very low. Monitoring occurs in autumn and spring every three years with the monitoring of six sites (one upstream and one downstream for each component). The purpose of sentinel monitoring is to detect if major catchment-scale changes to the aquatic ecology have occurred during standby periods (i.e. whether baseline conditions have changed) and to understand natural variability in ecological conditions in the absence of operations.

The purpose of this report is to convey the results from 2024 sentinel monitoring and to analyse the results in relation to differences between upstream and downstream sites and the relationship of monitoring results with long term trends. In relation to each component, the following conclusions are made:

– Component 1 - Angle Crossing (M2G): There were no major differences between the upstream and downstream sites in relation to all monitoring elements. While there were generally higher nutrient concentrations and periphyton coverage at the upstream site, this was considered to be due to natural habitat characteristics at each site, rather than a result of M2G operations. As with previous monitoring, the Murrumbidgee River had high concentrations of nutrients but otherwise had generally good water quality.

There was no significant difference in macroinvertebrate communities between downstream and upstream sites. The geomorphology at Angle Crossing did not present any obvious evidence of enhanced erosion or deposition.

- Component 2 – Burra Creek (M2G): There were no major differences between the upstream and downstream sites. While there was lower DO reported at the downstream monitoring site, this was considered to be due to the natural habitat characteristics of each site, rather than a result of M2G operations. As with previous monitoring, Burra Creek had relatively poor water quality with low DO and elevated nutrient concentrations, EC and pH. There was no significant difference in macroinvertebrate communities between downstream and upstream sites. With the exception of upstream site BUR1a, all geomorphology and riparian vegetation monitoring sites presented no obvious evidence of advancing erosion, but instead generally had increased riparian vegetation coverage compared to previous monitoring in 2020/2021.
- Component 3 – Murrumbidgee River (MPS): There were no major differences between the upstream and downstream site in relation to all monitoring elements. As with the Murrumbidgee River at Angle Crossing, nutrient concentrations were elevated, but water quality was otherwise generally good. While higher periphyton coverage was observed downstream in autumn, periphyton coverage was lower in spring. There was no significant difference in macroinvertebrate communities between downstream and upstream sites.

The results of the 2024 sentinel monitoring identified substantial differences in macroinvertebrate and macrophyte community condition compared to previous seasons, representing a long term trend in conditions despite the absence of M2G and MPS operations. While this was the case, these trends were consistent between seasons and between upstream and downstream sites. Thus, the use of current monitoring sites for upstream and downstream comparison under operational conditions are still suitable. The trends observed in macroinvertebrates and macrophyte condition are important observations for the assessment of background conditions and identifying the variability that can naturally occur at monitoring sites.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.5 and the assumptions and qualifications contained throughout the Report.

Contents

Table index

Figure index

1. Introduction

1.1 Background

During the Millenium Drought from 2001 to 2010, dam storage volumes in the Australian Capital Territory (ACT) and surrounding regions of New South Wales (NSW) declined to unprecedented levels. In response, Icon Water developed a water security program that involved upgrading and constructing infrastructure to improve the future water supply for residents of Canberra and Queanbeyan. The water security program included:

– Murrumbidgee to Googong transfer pipeline (M2G): Constructed to pump a nominal 100 ML/d from the Murrumbidgee River at Angle Crossing just within the ACT southern border to Googong Reservoir via Burra Creek.
– Murrumbidgee Pump Station (MPS): Adjacent to the existing Cotter Pump Station and constructed to increase pumping capacity from the Murrumbidgee River from 50 ML/d to 150 ML/d (nominally 100 ML/d).
– Tantangara Reservoir releases: To maintain run of river flow to the M2G abstraction point at Angle Crossing via releases from the reservoir.[1]
– Enlarged Cotter Dam (ECD): Enlargement of the Cotter Dam to 78 GL constructed just downstream of the existing 4 GL Cotter Dam.[1]

Construction of the M2G pipeline was completed in August 2012 and includes a pump station at Angle Crossing that transfers water from the Murrumbidgee River through a 12 km underground pipeline to Burra Creek. The water is then transported a further 13 km by surface flows through Burra Creek into Googong Reservoir in NSW. The system is designed to enable pumping of up to 100 ML/d, with abstraction from Angle Crossing dictated by the capacity of Googong Reservoir and the availability of water in the Murrumbidgee River. Abstraction from the Murrumbidgee River and the subsequent discharges to Burra Creek are directed by the Operational Environmental Management Plan (Icon Water 2022).

The MPS is located just downstream of the Cotter River confluence with the Murrumbidgee River. It is adjacent to the Cotter Pump Station, with both jointly contributing to the water supply of the ACT by transferring water to the Stromlo Water Treatment Plant. The upgraded MPS was commissioned in 2010 and increased pumping capacity from 50 ML/d to 150 ML/d. Pumping is dependent on demand, licence requirements, and water quality. The upgraded infrastructure is also designed to provide a recirculating flow from the Murrumbidgee River to the base of the ECD, providing environmental flows to the lower Cotter River. These recirculating flows are referred to as the Murrumbidgee to Cotter (M2C) transfer. Note that construction of a new Cotter Pump Station is currently underway and is expected to be completed in late 2025. This new pump station will add an additional pumping capacity of 150 ML/d from the Murrumbidgee River.

There are several potential risks to ecological conditions in the Murrumbidgee River and Burra Creek due to operation of the M2G and MPS. In the Murrumbidgee River, risks are generally related to reduced flow due to water abstraction. For example, during periods of low flow there may be a loss of aquatic habitat and changes to macroinvertebrate communities, excessive periphyton growth, a shift to late successional communities dominated by filamentous algae, and a deterioration in water quality. In Burra Creek, some beneficial ecological effects may be expected due to increased flow including greater connectivity between pools allowing more frequent use by fish, increased macroinvertebrate diversity and a reduction in the extent of macrophyte encroachment in the main channel. However, there may also be negative impacts to macroinvertebrate communities, water quality, channel and bank geomorphology, and riparian vegetation associated with the increased flows.

To assess the influence of the construction and operation of the M2G and MPS on ecological conditions in associated waterways, Icon Water developed the Murrumbidgee Ecological Monitoring Program (MEMP) to establish comprehensive baseline conditions and satisfy the Environmental Impact Statement (EIS) and compliance commitments for the projects. Comparisons of this baseline data to conditions during and following construction, as well as during operation of M2G and MPS, can be used to determine if there is a detectable change in ecological conditions. This report presents the results of monitoring that occurred in autumn and spring 2024 as part of the MEMP.

[1] Note that the MEMP does not include monitoring related to releases from Tantangara Reservoir or the Enlarged Cotter Dam.

1.2 Background and adaptive management: changes to the MEMP since 2008

The MEMP has been supported by Icon Water to investigate potential impacts of water abstraction from the Murrumbidgee River and the influence of increased water volumes in Burra Creek on ecological conditions. The MEMP was implemented prior to the commencement of the M2G project, allowing Icon Water to collect pre-abstraction baseline data to compare against the post-abstraction data once the M2G project began operation. Seasonal monitoring has occurred in autumn and spring in several years between 2008 and 2024, with the triggers for monitoring dictated by the requirements for either sentinel monitoring (see Section 1.2.1) or impact monitoring (see Section 1.2.2).

Over the course of the monitoring program, there have been several changes and modifications which have been in line with the adaptive management philosophy of the MEMP (Figure 1). Between spring 2008 and autumn 2013 there were four components being considered as part of the MEMP:

– Component 1: Angle Crossing (M2G)
– Component 2: Burra Creek (M2G)
– Component 3: Murrumbidgee Pump Station (MPS)
– Component 4: Tantangara to Burrinjuck (Tantangara Reservoir releases).

Following the autumn 2013 monitoring, Icon Water reviewed the MEMP which resulted in the discontinuation of Component 3 and Component 4. The MEMP continued to assess Component 1 and Component 2 from spring 2013 to spring 2014.

The most recent and major change to the MEMP followed a peer review by Jacobs (2014). In this review, Component 3 was recommended to recommence, and three modes of operation were defined for the M2G and MPS to help target the monitoring program. These are defined for the M2G as:

– Standby (maintenance) – Ready to run, all components in place and being operated routinely for maintenance purposes. Peak pump volumes are typically 49 ML/d and transferring approximately 50 ML in total.
– Operating (full pump) – Operating in earnest under normal flow conditions, with continuous transfer of bulk water to Googong Reservoir for a period greater than 30 consecutive days.
– Operating (drought conditions: full pump, drought flows) – Operating in earnest under drought flow conditions with continuous transfer of bulk water to Googong Reservoir for a period greater than 30 consecutive days.

In additional to the above three modes, the Operational Environmental Management Plan (Icon Water 2022) includes a ‘Suspension’ mode. This is defined as a period when no water can be transferred as system components may be decommissioned, requiring lead time before start-up.

For the MPS, the modes of operation are defined as:

– Standby – Abstraction from the Murrumbidgee River not occurring. Ready to run, all components in place and being operated routinely for maintenance purposes.
– Recirculating Pump Operation – Flow up to 40 ML/d transferred to the base of the Cotter Dam to provide environmental flows to the lower Cotter River. Water to the Cotter River re-enters the Murrumbidgee River just upstream of the MPS.
– Operating (full pump) – Abstraction of up to 150 ML/d of water for raw water supply to Stromlo Water Treatment Plant for greater than 30 consecutive days. While this is the maximum capacity of the MPS, this abstraction volume rarely occurs due to water quality in the Murrumbidgee River. Hence, smaller volumes are likely to be taken (e.g., 80 ML/d) and shandied with cleaner Cotter River water from the Bendora Main.

During periods of standby for M2G and MPS, the risks from these projects to the ecological condition of the Murrumbidgee River and Burra Creek is minimal. Alternatively, it is anticipated that any risks to these waterways are most likely to manifest during periods of full operation. Following the Jacobs (2014) review a revised MEMP was developed that adopted a two-stage approach which incorporates sentinel monitoring during standby modes, and impact monitoring during the various operation modes. These two types of monitoring are described in sections 1.2.1 and 1.2.2 respectively. The monitoring elements for each component of the revised monitoring program are outlined in Table 1.

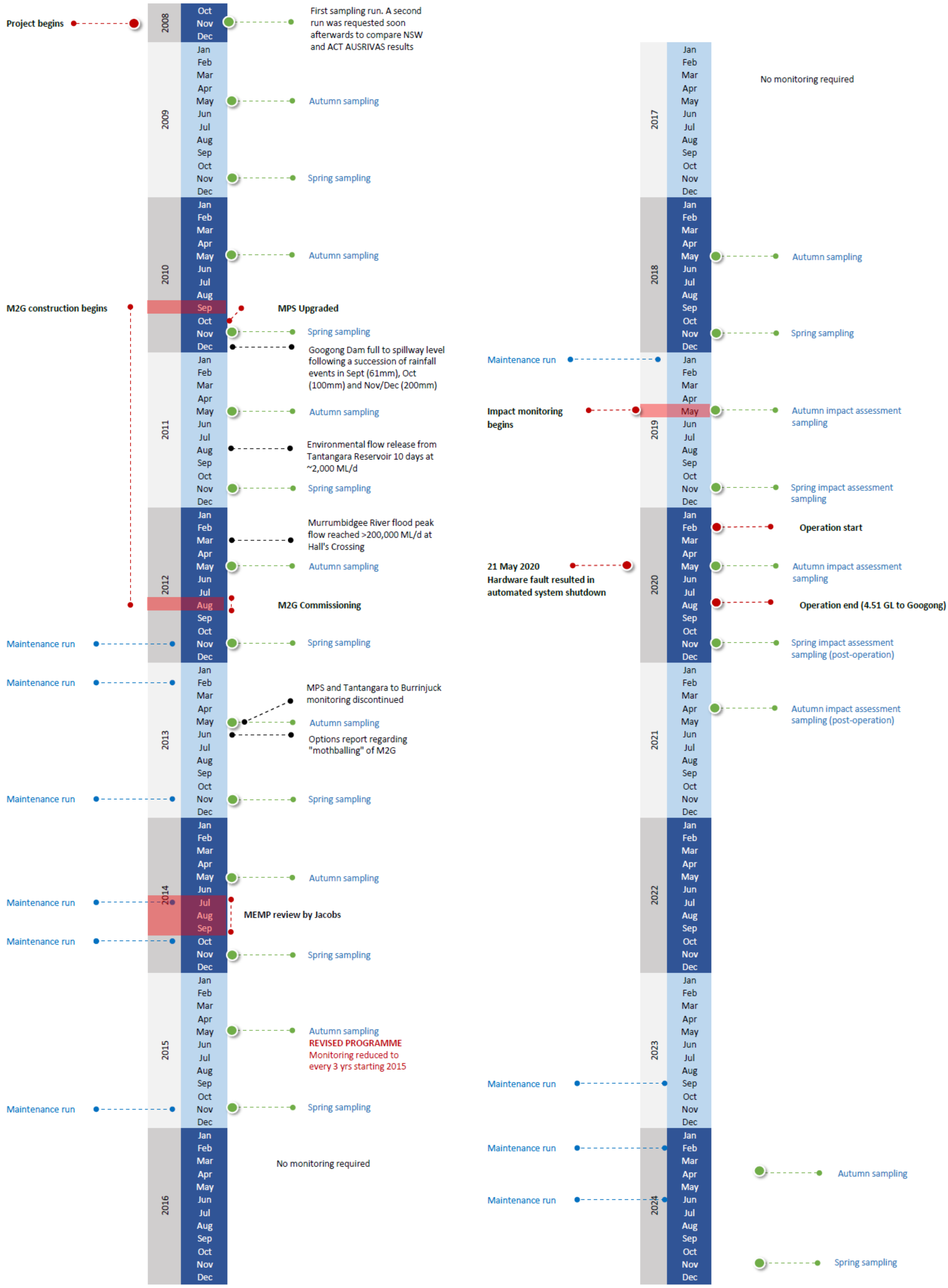


Figure 1 Schematic timeline of the Murrumbidgee Ecological Monitoring Program

Table 1 Monitoring elements associated with the Sentinel and Impact monitoring

Element	Provider	Sentinel		Impact	
		M2G	MPS	M2G	MPS
Online Water Quality	Icon Water	✓	✓	✓	✓
Laboratory Water Quality	GHD	✓	✓	✓	✓
Macroinvertebrates	GHD	✓	✓	✓	✓
Periphyton	GHD	Not required	Not required	✓	✓
Geomorphology	GHD	✓	Not required	✓	Not required
Riparian Vegetation	GHD	✓	Not required	✓	Not required

The M2G Operational Environmental Management Plan (Icon Water 2022) also requires a fish monitoring component that is not a specific component of MEMP sentinel or impact monitoring. The requirements for fish monitoring are summarised in Table 2.

Table 2 Fish monitoring elements required under the MEMP

Element	Provider	Surveillance		Impact		Frequency
		M2G	MPS	M2G	MPS	
Biennial Fish Surveillance Program (Murrumbidgee River only)	ACT Government	✓	✓	✓	✓	Every two years
Burra Creek exotic fish monitoring	Various	✓	Not required	Not required	Not required	Every four years

1.2.1 Sentinel monitoring

The purpose of sentinel monitoring is to understand if major catchment-scale changes to aquatic ecology are taking place and to establish background conditions. Sentinel monitoring began in 2015 and occurs in autumn and spring every three years during periods of standby when the risk to the ecosystem is deemed to be very low. Sentinel monitoring is not required during suspension periods but is required for two sequential seasons ahead of any planned transition back to standby or operating modes. Based on the Jacobs (2014) review, monitoring is undertaken at one upstream site and one downstream site for each component.

Single macroinvertebrate samples are collected from both edge and riffle habitats when present (or two riffle or edge samples where only one habitat is present) and qualitative methods, such as photogrammetry and AUSRIVAS habitat assessments, are used to track the conditions of these sites on a broad spatial and temporal scale. Quantitative periphyton monitoring and hypothesis testing is not required in the sentinel monitoring. Sentinel monitoring has been undertaken in autumn and spring of 2015, 2018 and 2024 (with the 2024 results included in this report).

1.2.2 Impact monitoring

The trigger for impact monitoring is the decision to operate the M2G or MPS infrastructure. This monitoring scenario requires a before/after and control/impact (BACI) approach and relies on replicated monitoring protocols. Several univariate indicators of river health and condition are analysed before and after the operation period at upstream and downstream locations. Qualitative periphyton photogrammetry is also assessed during impact monitoring. The key difference between impact and sentinel monitoring is the number of sites (two upstream and two downstream sites for each component), two replicate macroinvertebrate samples from each habitat (where present) and frequency of monitoring events (addition of before and after operation monitoring) and the level of detail used in the analysis.

Impact monitoring requires at least one monitoring event before the transition to operation mode but ideally incorporates an autumn and spring monitoring season. During operations, impact monitoring happens every season for the duration of pumping. Following operation and after return to standby mode, impact monitoring is required for autumn and spring.

Icon Water made the decision to operate the M2G and MPS in 2019 with operations commencing in February 2020 and finishing in August 2020 (see Figure 1). As a result, impact monitoring for the M2G was undertaken in autumn and spring 2019 prior to operations, in autumn 2020 during the transfer of 4.51 GL to Googong Reservoir, and in spring 2020 and autumn 2021 after the completion of operations.

1.2.3 Environmental flow protection rules

Under Icon Water's current ACT WU67 Licence to Take Water under the *Water Resources Act 2007*, Icon Water is required to maintain environmental flows in the Murrumbidgee River through implementation of baseflow protection rules (Table 3). In order for M2G pumping to be undertaken during standby (maintenance) and operating modes, pumping must be compliant with the following formula:

(River flow at Angle Crossing) - (Abstraction flow at Pipeline Flow Meter) > Month specific baseflow to be protected

*Table 3 **Baseflow protection rules (ML/d) for M2G pumping operations during standby and operation modes***

Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Normal	33.7	22.0	16.0	35.0	55.0	65.0	79.0	99.0	169.0	128.0	130.0	53.0
Drought	132.2	107.0	118.2	98.5	54.1	66.8	89.3	133.6	200.1	145.9	384.9	207.0

The drought protection rules apply when average flow in at least 15 of the 18 (~80%) past dry season months (November to April inclusive) is below the baseflow protection rules for normal conditions. Three gauging stations are used to assess flows for compliance with environmental flow protection rules (Icon Water 2022):

- Upstream Angle Crossing Gauging Station (MURW2 / 41000270): Approximately 1 km upstream of abstraction point on the Murrumbidgee River with flow data used to manage the abstraction regime during operation and maintenance activities. Abstraction flow is also measured at Angle Crossing by the M2G Pipeline Flow Meter. Flows in the Murrumbidgee River at Angle Crossing are not permitted to be below the baseflow protection rules specified in Table 3 over a 24 hour period. However, flow rates are permitted to intermittently exceed baseflow protection rules down to a minimum flow rate of 20ML/d.
- Lobb's Hole Gauging Station (410761): Approximately 2 km downstream of the abstraction point and serves as a backup to the Angle Crossing gauge, as well as providing supplementary water quality and flow data. During operation, a 250 ML/d flow for riffle maintenance in the Murrumbidgee River is required for a period of 24 hours, once every 30 days, as measured at Lobb's Hole (410761).
- Burra Creek at Burra Road Gauging Station (410774): Approximately 3 km downstream of the Burra Creek M2G outlet with flow and water quality data used to manage flows during operation and maintenance. Operation of M2G must not take place if natural flow in Burra Creek is greater than 1,830 ML/d. Pumping also requires the pumps to be started and stopped in a defined sequence to mimic natural catchment runoff patterns. Water quality data is also required to demonstrate compliance with specific water quality targets.

1.2.4 Operations relating to current monitoring period

The most recent monitoring for the MEMP was undertaken as impact monitoring between spring 2019 and autumn 2021 due to the operation of M2G and MPS between February to August 2020. Since August 2020, neither the M2G nor the MPS have required transition to operation mode.

Since transitioning out of operation mode, the M2G has remained in standby mode with three maintenance runs undertaken through to the end of 2024. These operations occurred in September 2023 and then on either side of autumn monitoring in February 2024 and June 2024 (see Figure 1). Combined abstraction from these maintenance runs totalled 325 ML (Icon Water 2024).

Since transitioning out of operation mode, the MPS has remained in standby mode, with the exception of three recirculating pump operations from MPS to the base of Cotter Dam. These operations occurred in June 2023, after autumn sentinel monitoring in May 2024 and within two weeks prior to spring sentinel monitoring in November 2024. Due to the confluence of the Cotter River upstream of the MPS, recirculating pump operations are not considered as abstraction for the purposes of the MEMP.

1.3 Project objectives

The MEMP was established by Icon Water, as a condition of development approvals to evaluate potential impacts of water abstraction from the Murrumbidgee River at Angle Crossing and the MPS (Components 1 and 3) and to evaluate subsequent changes that may occur in Burra Creek due to discharges and increased flows (Component 2). Ultimately, the MEMP has been designed to address a series of hypotheses developed by Jacobs (2014) (see Table 4) and to and determine whether the implementation of management measures, such as flow protection rules, are effective at protecting river health.

While the testing of hypotheses is not part of sentinel monitoring, the collection of background data is required to understand if major catchment-scale changes to aquatic ecology or waterway health are taking place, and to place 'impact/downstream' sites in the context of broader catchment conditions. The monitoring of sentinel sites will also allow a baseline to be re-established should any major catchment disturbance (e.g., large flood event, poor quality following bushfire runoff, etc.) occur. As such, the aim of sentinel monitoring is not to detect trends in catchment condition (which would require more frequent monitoring), but to provide confidence that the condition of potential impact/downstream sites is broadly similar to non-impact/upstream sites across time.

Table 4 Management hypotheses to be tested following impact assessment monitoring for M2G and MPS operations

Hypotheses	Operation(s)
1a: Flow abstraction will not result in the deterioration of the macroinvertebrate community (measured using biological indices) at sites downstream of the abstraction point (Angle Crossing for M2G and downstream of MPS) relative to sites upstream, informed by prevailing conditions in the broader region.	M2G & MPS
1b: Flow discharge to Burra Creek will not result in the deterioration of the macroinvertebrate community (measured using biological indices) at sites downstream of the inflow relative to sites upstream of the abstraction point and informed by prevailing conditions in the broader region.	M2G
2a: Flow abstraction in the Murrumbidgee River will not result in the development of increased periphyton to the extent that it impacts on the quality of the riffle habitat at sites downstream of the abstraction point (Angle Crossing for M2G and downstream of MPS) compared to sites upstream of the abstraction point and informed by prevailing conditions in the broader region.	M2G & MPS
2b: Flow discharge into Burra Creek will not result in the development of increased periphyton to the extent that it impacts on the quality of the riffle habitat at sites downstream of the inflow point compared with sites upstream of the inflow point, and informed by prevailing conditions in the broader region	M2G
3a: Flow transfer to Burra Creek will not result in bank erosion that is beyond that currently occurring in response to natural high flow events.	M2G
3b: Flow discharge to Burra Creek will not result in changes in macrophyte or riparian vegetation that is beyond that currently occurring in response to natural high flow events.	M2G & MPS
4a: Flow abstraction from the Murrumbidgee River will not result in an increased threat to threatened cod species due to decreased pool mixing and consequent water quality impacts.	M2G
4b: Flow discharge to Burra Creek will not result in the introduction of Carp or Oriental Weatherloach populations (via transfer) in Burra Creek or native fish stranding on drawdown	M2G

1.4 Purpose of this report

The purpose of this report is to convey the results from 2024 sentinel monitoring and to analyse the results in relation to differences between upstream and downstream sites and the relationship of monitoring results with long-term trends.

1.5 Scope and limitations

This report has been prepared by GHD for Icon Water and may only be used and relied on by Icon Water for the purpose agreed between GHD and Icon Water as set out in section 1.4 of this report. GHD otherwise disclaims responsibility to any person other than Icon Water arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible. The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared. The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points. Investigations undertaken in respect of this report are constrained by the particular site conditions. As a result, not all relevant site features and conditions may have been identified in this report.
GHD has prepared this report on the basis of information provided by Icon Water and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1.6 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

2. Study area

2.1 Upper Murrumbidgee River

The M2G and MPS are located in the Murrumbidgee River catchment. The Murrumbidgee River flows for approximately 1,600 km from the Snowy Mountains until its confluence with the Murray River in southwestern NSW. The catchment area of the Murrumbidgee River above Angle Crossing is approximately 5,096 km^2. The Murrumbidgee River is constrained upstream by Tantangara Dam, a 252 GL reservoir constructed as part of the Snowy Mountains Scheme. While Tantangara Dam contributes environmental releases to the Murrumbidgee River, on average the releases are less than 10% of inflows into Tantangara Dam (DCCEEW, 2024). Most flows from Tantangara Dam are diverted to Eucumbene Dam in the Snowy River catchment. The diversion of water from the Murrumbidgee River catchment has reduced base flows and the frequency and duration of floods in the Murrumbidgee River. The Murrumbidgee River is impounded again at Burrinjuck Dam, after flowing through the ACT. The Murrumbidgee River from Burrinjuck Dam upstream to its headwaters is generally referred to as the Upper Murrumbidgee.

Land use in the Upper Murrumbidgee includes National Park in the high country and agriculture in the lower valleys and plains. Land use is characterised by low intensity agriculture (predominantly grazing), nature reserves, and urbanisation between Point Hut Crossing and the north-western suburbs of Canberra near the confluence with the Molonglo River. While there is generally a large riparian buffer between urban areas and the Murrumbidgee River, the ACT Government is investigating land releases and infill along the edge of the Murrumbidgee River.

Average annual rainfall in the Upper Murrumbidgee River catchment ranges from greater than 1,400 mm in mountain headwaters to 675 mm at Lobb's Hole (station ID 570985). Between January 2008 and December 2024, mean daily discharge in the Murrumbidgee River was 973 ML/d (Figure 2). The upper Murrumbidgee catchment was significantly affected by the Millennium Drought from 2002 to 2010, with mean daily discharge in 2008 and 2009 being 164 and 111 ML/d, respectively. Impacts from the drought included land degradation, increased stress on surface and groundwater resources, increased soil erosion and a shift from mixed farming and cropping to grazing and reduced stock numbers.

In the spring of 2010, the drought broke in the ACT and surrounding NSW regions with mean daily flows for the years 2010 to 2017 ranging from 381 to 1,816 ML/d. Drought returned between 2018 and 2019 and decreased mean daily discharge to 108 and 101 ML/d, respectively. Drought broke in 2020, and flows increased in the Murrumbidgee River with mean daily discharge between 2020 and 2022 ranging from 852 to 3,760 ML/d, the latter representing the highest annual discharge on record at Lobb's Hole Gauging Station. Following these high flows, discharge declined in 2023 and 2024 with daily discharge for 2023 and 2024 falling below average to 776 and 693 ML/d, respectively.

Burra Creek

Burra Creek is a small, typically perennial but occasionally ephemeral stream which flows north to north-east along the western edge of the Tinderry Range into Googong Reservoir, east of the ACT. Most of the catchment land use is pastoral with small rural holdings. The catchment to the east of Burra Creek is largely protected as Nature Reserve, including Tinderry Nature Reserve, Burra Creek Nature Reserve and Googong Foreshores, which typically comprise natural dry sclerophyll forest.

Burra Creek is characterised by emergent and submerged macrophyte beds with limestone bedrock and frequent pool-riffle sequences. During low flow periods, much of the channel can become choked with macrophytes. Burra Creek is within a large macro-channel in the lower reaches, both upstream and downstream of London Bridge (a natural limestone arch). When Googong Reservoir is at >80% capacity, the lower sections of Burra Creek become inundated by the reservoir.

Flows in Burra Creek have varied considerably since the inception of the MEMP in late 2008 (see Figure 3). Between January 2008 and December 2024, mean daily discharge in Burra Creek was zero on 455 days (7% of days) and above 1,000 ML/d on eight days (1% of days) with a median average of 2.1 ML/d and mean average of 13.3 ML/d.

During the Millenium Drought years of 2008 and 2009, mean daily discharge was 0.16 ML/d and 0.19 ML/d, respectively. In early 2010, the drought broke and there were several high rainfall events throughout most of the year resulting in in a mean daily discharge of 31.5 ML/d. Flows remained above median average conditions between the years 2011 and 2017 with mean daily discharge ranging between 3.9 and 28.5 ML/d. Another drought between 2018 and 2019 brought another decline in average flows in Burra Creek with mean daily discharge of 2.6 and 1.3 ML/d, respectively. During this period, there were few high flow events and summer in 2019 was the driest since 2009. Drought broke in 2020, and flows increased in Burra Creek with mean daily discharge between 2020 and 2022 ranging from 22.1 ML/d and 42.8.0 ML/d, the latter representing the highest daily discharge since 1989. Following these high flows, flows declined in 2023 and 2024 with daily mean discharge for 2023 and 2024 falling to 5.3 and 3.5 ML/d, respectively.

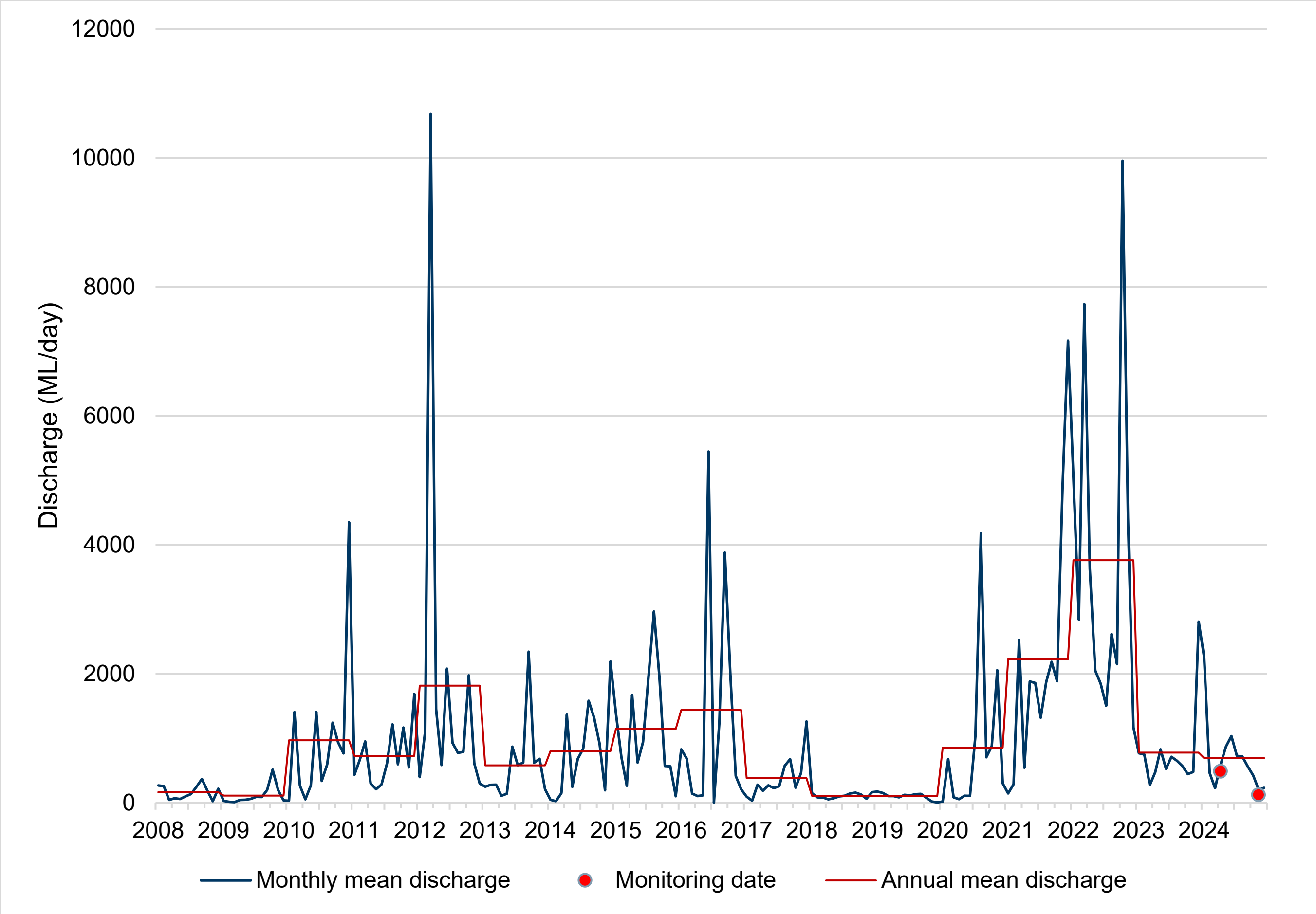


Figure 2 ***Discharge (ML/d) of the Murrumbidgee River at Lobb's Hole (410761) from January 2008 to December 2024. The monitoring dates relate to the 2024 monitoring in autumn and spring***

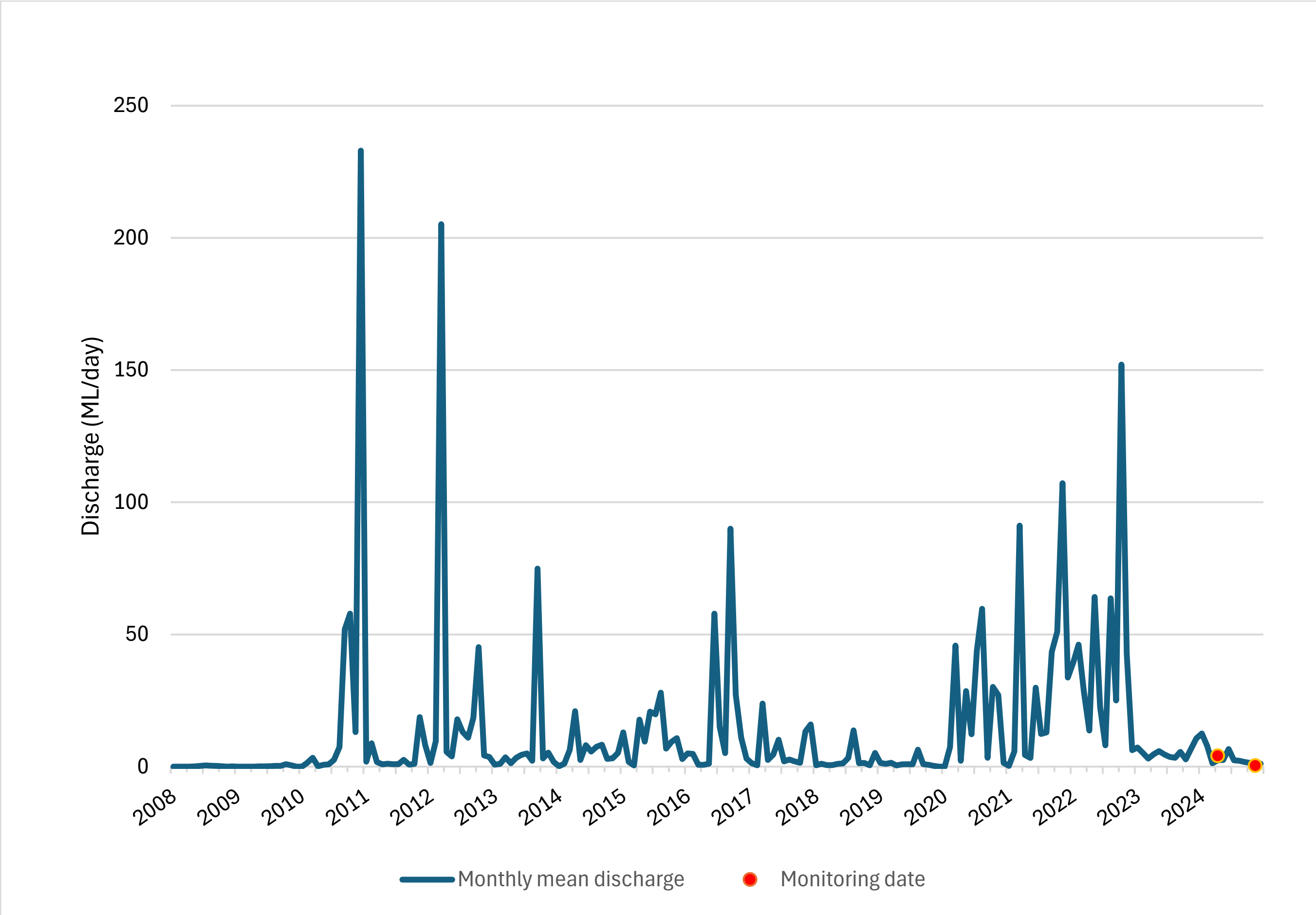


Figure 3 ***Monthly average discharge (ML/d) of Burra Creek at Burra Creek Weir (410774) from January 2008 to December 2024. The monitoring dates relate to the 2024 monitoring in autumn and spring***

3. Methods

Sentinel monitoring during autumn and spring 2024 involved the collection of macroinvertebrate samples, *in situ* water quality monitoring, water quality grab samples, and photogrammetry of vegetation and geomorphological features. A summary of monitoring undertaken for each site is included in Table 1. Note that geomorphology and riparian vegetation monitoring is not required for MPS monitoring sites.

3.1 Monitoring sites

The location of monitoring sites is based on MEMP review recommendations (see Jacobs, 2014). Sentinel monitoring involves the monitoring of six sites, comprising one upstream site and one downstream for each respective infrastructure component (MPS, M2G inlet, M2G outlet). These sites are a subset of existing sites that were previously sampled as part of the original MEMP program (2009-2014). These sites were initially chosen based on several criteria, which included:

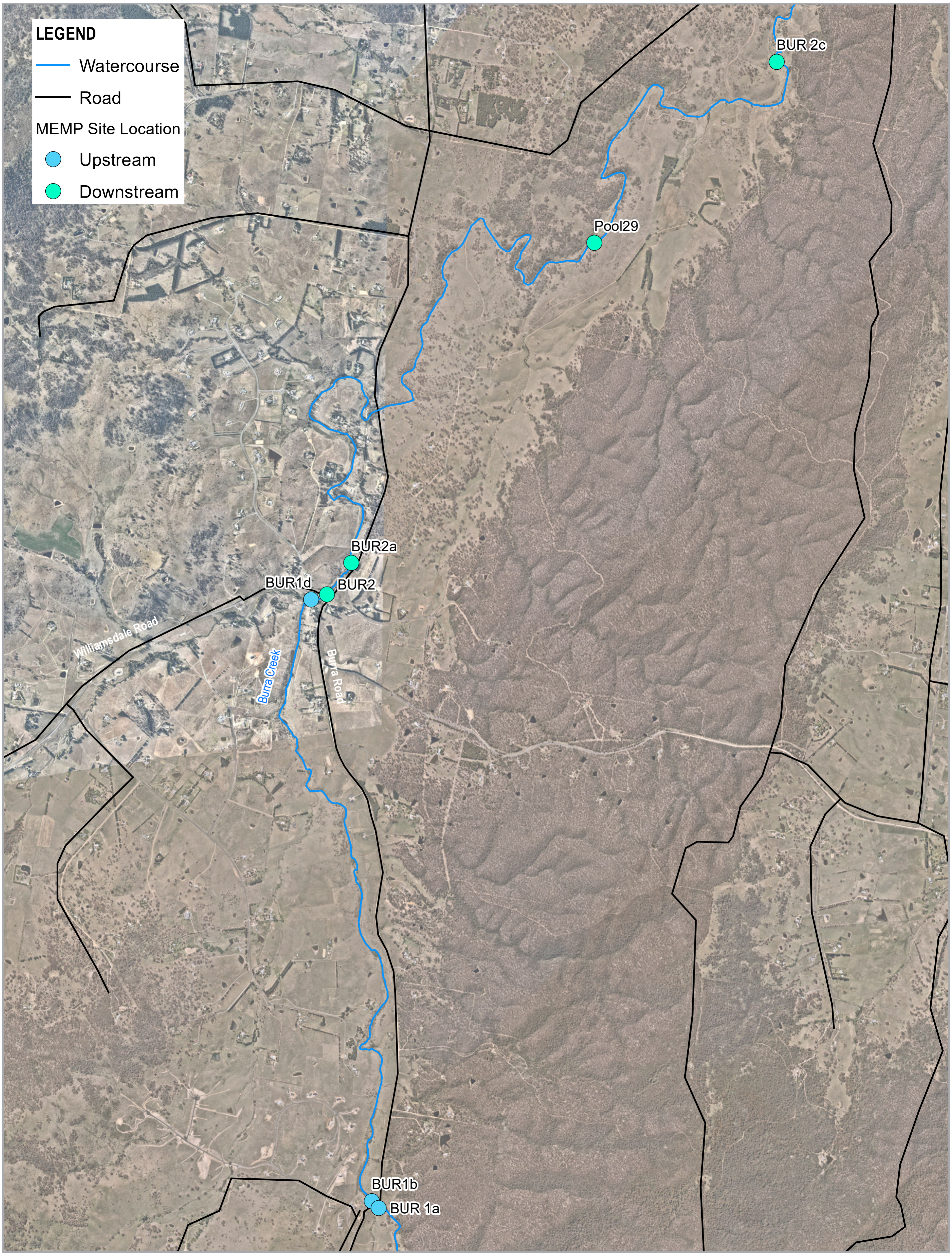
– Safe access and approval from land owners.
– Occurrence of representative habitats (i.e. riffle / pool sequences). If both habitats were not present than sites with riffle zones took priority as they are the most likely to be affected by abstractions.
– Sites which have historical ecological data sets (e.g. Keen, 2001) took precedence over new sites allowing for comparisons through time to help assess natural variability through the system. This is especially important in this program because there is less emphasis on the reference condition and more emphasis on comparisons between and among sites of similar characteristics in the ACT and surrounds over time.

Details of monitoring site locations are included in Table 5. Locations of Burra Creek monitoring sites are shown in Figure 4, and locations of Murrumbidgee River monitoring sites related to the M2G are shown in Figure 5 and the MPS in Figure 6.

Table 5 *MEMP sentinel sites and monitoring summary*

Component		Site	Location	Purpose	Alt. (m)	Land use	Latitude	Longitude	Water quality	Macro-invertebrate	Periphyton	Geo-morphology	Riparian Vegetation
Component 1 (M2G)	Angle Crossing	MUR17	~950 m upstream Angle Crossing	Control	597	Recreation Grazing	-35.586453	149.112817					
		MUR18	~600 m upstream Angle Crossing	Control	597	Grazing	-35.587542	149.109902	✓	✓	✓		
		MUR19	Immediately downstream Angle Crossing	Impact	596	Recreation Grazing	-35.583027	149.109486	✓	✓	✓	✓	
		MUR20	~400 m downstream Angle Crossing	Impact	595	Recreation Grazing	-35.580979	149.111303					
Component 2 (M2G)	Burra Creek	BUR1a	Upstream Burra Rd	Control	801	Grazing	-35.597819	149.227547				✓	
		BUR1b	Upstream Williamsdale Rd	Control	798	Grazing	-35.597536	149.227023					
		BUR1d	Upstream Williamsdale Rd	Control	748	Grazing	-35.555963	149.222150	✓	✓	✓		
		BUR2	Downstream Williamsdale Rd	Impact	746	Grazing	-35.554345	149.224477				✓	✓
		BUR2a	Downstream Williamsdale Rd	Impact	748	Grazing	-35.553320	149.225228	✓	✓	✓	✓	
		Pool29	Googong Foreshore upstream London Bridge Homestead	Impact	688	Recreation	-35.531316	149.245800				✓	✓
		BUR2c	Googong Foreshore upstream London Bridge Arch	Impact	668	Recreation	-35.518833	149.261250				✓	✓
Component 3 (MPS)	Murrumbidgee Pump Station	MUR28up[2]	~450 m upstream of MPS (upstream Cotter River)	Control	462	Recreation	-35.324382	148.950381	✓	✓	✓		
		MUR28down	~150 m upstream of MPS (downstream Cotter River)	Control	462	Recreation	-35.324699	148.950417	✓	✓	✓		
		MUR935[3]	~ 300 m downstream of MPS (Casuarina Sands)	Impact	461	Recreation	-35.319483	148.950211	✓	✓	✓		
		MUR936	~1200 m downstream of MPS	Impact	460	Recreation	-35.317535	148.961213	✓	✓	✓		

[2] Note, MUR28down was sampled in place of MUR28up during autumn 2024 sentinel monitoring. For the purposes of this report, results from autumn sampling have been reported as MUR28up. While different sites were sampled, similarities in the sites are expected to allow for suitable comparisons of long-term broad scale changes in catchment condition.
[3] Note, MUR936 was sampled in place of MUR935 during autumn 2024 sentinel monitoring. For the purposes of this report, results from autumn sampling have been reported as MUR935. While the different sites were sampled, similarities in the sites are expected to allow for suitable comparisons of long-term broad scale changes in catchment condition.



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Kilometers

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GHD

Icon Water
Murrumbidgee Ecological Monitoring Program

Burra Creek
Monitoring Sites

Project No. 12581117
Revision No. 0
Date 20/05/2024

FIGURE 4

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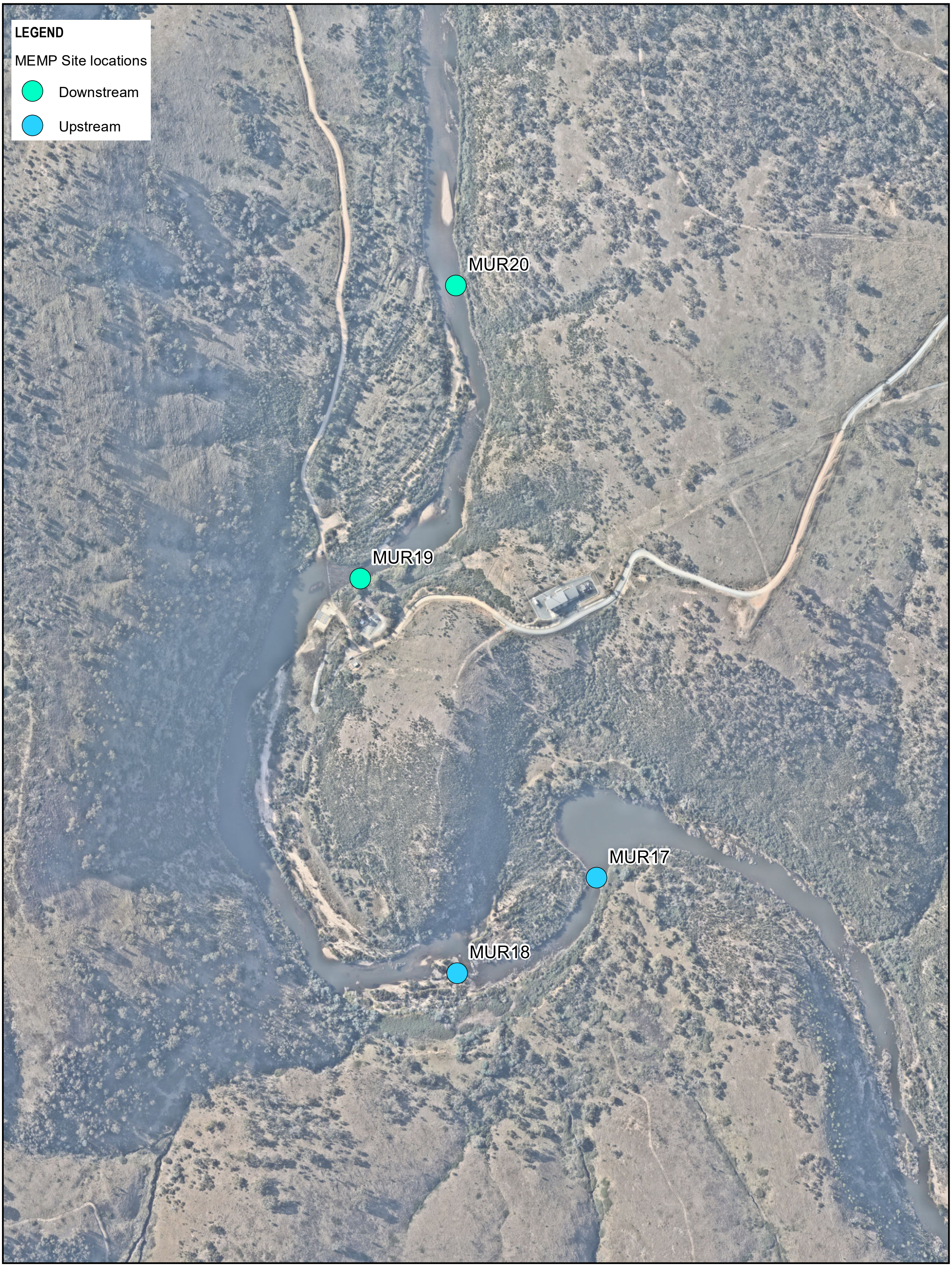
Data source: GHD - Site features. Watercourse, Road - NSWSS ;Imagery Nearmap WMS server. Created by: ehaverkamp



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Meters

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GHD

Icon Water
Murrumbidgee Ecological Monitoring Program

Angle Crossing Monitoring Sites

Project No.	**12581117**
Revision No.	**0**
Date	**20/05/2024**

FIGURE 5

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Horizontal Datum: WGS 1984
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GHD

Icon Water
Murrumbidgee Ecological Monitoring Program

Murrumbidgee Pump Station Monitoring Sites

Project No.	**12581117**
Revision No.	**0**
Date	**20/05/2024**

FIGURE 6

Data source: GHD - Site features. Watercourse, Road - NSWSS. ;Imagery Nearmap WMS server. Created by: ehaverkamp

3.2 Hydrology and rainfall

River flows and rainfall for the sampling period were monitored at gauging stations located: upstream of Angle Crossing (41001702); at Lobb's Hole (downstream of Angle Crossing: 410761 / 570985); at Mt. MacDonald (downstream of the MPS; 410738) and at Burra Creek Weir (at Burra Road: 410774 / 570951). Parameters measured at each station are shown in Table 6. Monitoring data for each of these stations was accessed from the Bureau of Meteorology Water Data Online portal (BOM, 2025).

Table 6 River flow monitoring locations and parameters

Site Code	Location/Notes	Parameters*	Latitude	Longitude	Component of the MEMP
41001702	Murrumbidgee River, U/S of Angle Crossing	Water Level, Discharge, pH, Electrical Conductivity, Dissolved Oxygen, Temperature, Turbidity, Rainfall	-35.5914	149.1204	Angle Crossing
410761, 570985	Murrumbidgee River @ Lobb's Hole (D/S of Angle Crossing)		-35.5398	149.1001	Angle Crossing / Murrumbidgee Pump Station
410774, 570951	Burra Creek D/S Burra Road bridge		-35.5425	149.2279	Burra Creek
410738	Murrumbidgee River @ Mt. MacDonald	Water Level, Discharge	-35.2916	148.9552	Murrumbidgee Pump Station

3.3 Water quality

Water temperature, dissolved oxygen (DO), electrical conductivity (EC) and pH were measured *in situ* using a laboratory calibrated YSI 556 multi-parameter water quality meter as a part of the ACT AUSRIVAS sampling protocols (Nichols et al., 2000). Turbidity was measured in the field using a HACH 2100P turbidimeter and alkalinity was measured using CHEMetrics hand-held titration cells.

Bottled water samples (grab samples) were collected at all sites in accordance with AUSRIVAS protocols (Nichols, et al., 2000) and submitted to NATA accredited laboratory ALS for analysis. Samples were analysed for oxidised nitrogen (NO_x, nitrate + nitrite), total nitrogen (TN), total phosphorous (TP), and total iron and total manganese.

The *in situ* recordings and grab samples provide a snap-shot of conditions at the time of monitoring only to enable interrogation of ecological data (e.g. macroinvertebrate assemblages). To compliment this and provide an understanding of water quality dynamics over a longer period, continuous water quality data was also obtained from relevant gauging stations (see Table 6).

In situ and grab sample results were examined for compliance with default guideline values specified in the *Australian New Zealand Guidelines for Fresh and Marine Water Quality* for healthy ecosystems in upland streams (ANZG 2018) (herein 'ANZG guideline values'). Continuous gauging station data is presented as time series plots.

3.4 Macroinvertebrate monitoring

One riffle sample and one edge sampled were collected from each site, where available. In the absence of available edge habitat, two riffle samples were collected from each site. Both habitats were sampled, where possible, to provide a more comprehensive assessment of each site (Nichols et al., 2000) and potentially allow the program to isolate flow-related impacts from other disturbances. The reasoning behind this is that each habitat is likely to be affected in different ways by changes in flow conditions. Riffle zones, for example, are likely to be one of the first habitats affected by low flows as water abstraction will result in an immediate reduction in flow velocities and inundation level over riffle zones downstream of the abstraction point. Impacts on macroinvertebrate assemblages in edge habitat might be less immediate as it may take some time for the reduced flow conditions to cause loss of macrophyte beds and access to trailing bank vegetation. Therefore, monitoring both habitats better enables assessment of the short-term and longer-term impacts associated with water abstraction.

Samples were collected using the ACT AUSRIVAS protocols outlined in Nichols et al. (2000). Sampling nets and all other associated equipment were washed thoroughly between sites and sampling events to remove any macroinvertebrates retained on them. The samples were placed in separate containers, preserved with 70% ethanol, and clearly labelled inside and out with project information, site code, date, habitat, and sampler details. ACT AUSRIVAS field data sheets were completed at each site.

Processing of samples followed the ACT AUSRIVAS protocols (Nichols et al., 2000). In the laboratory, each preserved sample was placed in a sub-sampler, comprising of 100 (10 X 10) cells (Marchant, 1989). The sub-sampler was agitated to evenly distribute the sample, and the contents of randomly selected cells removed and examined under a dissecting microscope until a minimum of 200 animals were counted. Specimens that could not be identified to the specified taxonomic level (i.e. immature or damaged taxa) were removed from the data set prior to analysis. All remaining animals within the selected cells were identified. Sample processing was repeated three times for each sample (three subsamples per sample) to align with the approach used in previous monitoring events and as recommended in Jacobs review (2014) of the program.

Macroinvertebrates were identified to genus level (where possible) using taxonomic keys outlined in Hawking (2000) and later publications. Genus identification is not a standard requirement of the ACT AUSRIVAS protocol (Nichols et al., 2000) but was recommended by Chessman (2008) during establishment of the MEMP program design.

Several quality control and quality assurance procedures were undertaken during macroinvertebrate processing, including ACT AUSRIVAS QA/QC protocols and the following specific procedures:

– Identification was performed by AUSRIVAS accredited and experienced aquatic ecologists with more than 100 hours of macroinvertebrate identification experience.
– When required, taxonomic experts confirmed identification. Reference collections were also used when required.
– An additional 5% of samples were re-identified by another senior taxonomist.

3.4.1 Univariate analysis

Macroinvertebrate processing data was analysed using a combination of univariate and multivariate techniques. Univariate metrics are often used in a lines-of-evidence approach in river health assessments and have solid foundations in biomonitoring. The univariate techniques include:

– Taxa Richness
– EPT Richness
– SIGNAL-2 Biotic Index
– ACT AUSRIVAS O/E score and Band.

Taxa Richness and EPT Richness

The total number of taxa (Taxa Richness) and number of pollution-sensitive taxa of the orders Ephemeroptera, Plecoptera and Trichoptera (EPT Richness) were calculated at family and genus levels. Taxa richness was calculated as a means of assessing macroinvertebrate diversity with high taxa richness scores usually, though not always, indicating better ecological conditions. In certain instances, high taxa richness may indicate a response to the provision of new habitat or food resources that might not naturally occur and that are the result of anthropogenic activities. EPT taxa are generally considered more sensitive to pollution.

SIGNAL-2 Biotic Index

Stream Invertebrate Grade Number – Average Level (SIGNAL) is a biotic index based on pollution sensitivity values (grade numbers) assigned to aquatic macroinvertebrate families that have been derived from published and unpublished information on their tolerance to pollutants, such as sewage and nitrification (Chessman, 2003). Each family has been assigned a grade between 1 (most tolerant) and 10 (most sensitive). The SIGNAL index is then calculated as the average grade number for all families present in the sample. The resulting index score can then be interpreted by comparison with other sites, with larger values indicating better habitat quality compared to lower values. These grades have been updated and standard errors applied under the SIGNAL-2 model approach developed by Chessman (2003). These changes were introduced to improve the reliability of the SIGNAL index.

AUSRIVAS

AUSRIVAS is a standard approach for assessing the ecological health of freshwater ecosystems through biological monitoring and habitat assessment (Nichols et al., 2000). The AUSRIVAS models are a predictive tool that use site-specific information to predict the macroinvertebrate fauna expected (E) to be present in the absence of environmental stressors. The expected fauna from reference sites with similar sets of predictor variables (physical and chemical characteristics which cannot be influenced by human activities, such as altitude and catchment area) are compared to the observed fauna (O) from monitoring sites and the ratio derived (O/E) is used to indicate the extent of any catchment modification impacts. The O/E ratio is calculated based on expected taxa having a >50% probability of occurrence within test (monitoring) sites (i.e. O/E50). Taxa that are not predicted to occur more than 50% of the time are not included in the O/E scores produced by the model. While this could potentially limit the inclusion of rare and sensitive taxa and could reduce the ability of the model to detect any changes in macroinvertebrate community composition over time (Cao, et al., 2001), the use of fewer but more common taxa is similarly effective in detecting impacts to aquatic ecosystems.

The O/E ratio is allocated into bandwidths (Table 7) which are used to gauge the overall health of each monitoring site (Coysh et al., 2000). AUSRIVAS is based on separate results from both riffle and edge samples, where available. Using a precautionary approach as recommended by Coysh et al. (2000), the overall site condition was based on the farthest band (from the sub- sample) from reference in a particular habitat at a particular site. For example, a site assessed as a Band A in the edge and a Band B in the riffle would be given an overall site assessment of Band B (Coysh et al., 2000).

Table 7 AURIVAS O/E50 band widths and interpretations for the ACT riffle and edge habitats

Band	RIFFLE		EDGE		Explanation
	Autumn	Spring	Autumn	Spring	
X	>1.13	>1.14	>1.18	>1.13	More biologically diverse than expected. Potential enrichment or naturally biologically rich.
A	0.88 – 1.12	0.86 – 1.14	0.83 – 1.17	0.87 – 1.13	Similar to reference. Water quality and / or habitat in good condition.
B	0.63 – 0.87	0.57 – 0.85	0.49 – 0.82	0.61 – 0.86	Significantly impaired. Water quality and/ or habitat potentially impacted resulting in loss of taxa.
C	0.40 - 0.63	0.28 – 0.56	0.15 – 0.48	0.35 – 0.60	Severely impaired. Water quality and/or habitat compromised significantly, resulting in a loss of biodiversity.
D	0.00 - 0.39	0.00 – 0.27	0.00 – 0.14	0.00 – 0.34	Extremely impaired. Highly degraded. Water and /or habitat quality is very low and very few of the expected taxa remain.
OEM	-	-	-	-	Indicates a site is 'Outside the Experience of the Model'.

3.4.2 Multivariate analyses

Multivariate analyses of macroinvertebrate data were examined separately for riffle and edge habitats. Replicates were examined individually (i.e. not averaged) at all sites because the aim is to examine within-site variation in addition to examining patterns among sites. All multivariate analyses were performed using PRIMER version 7 (Clarke and Gorley, 2015).

Data were square-root transformed to increase the contribution of rare or cryptic taxa in the analyses and a similarity matrix developed based on the Bray-Curtis similarity measure (see Clarke and Warwick, 2001). Non-metric multidimensional scaling (NMDS) ordination plots were produced as a visual representation of similarity amongst samples. The number of dimensions (axes) used in the NMDS procedure was based on the resultant stress levels. The stress level is a measure of the distortion produced by compressing multidimensional data into a reduced set of dimensions and will increase as the number of dimensions is reduced and can be considered a measure of "goodness of fit" to the original data matrix (Kruskal, 1964).

The similarity percentages (SIMPER) routine was carried out on the datasets following a significant PERMANOVA test to examine which taxa contributed to the most variation among statistically significant groupings (Clarke and Warwick, 2001). Factors used in the PERMANOVA were year, season (nested within each year) and location (i.e. upstream or downstream).

It is important to note that the multivariate analyses results in this report do indicate large difference in the macroinvertebrate community between years, with the current 2024 results noticeably different. While this is a valid finding in that there has been changes in the composition of the community and abundances of individual taxa, some part of this variation is also related to differences in taxonomy across the years. For example, Blackfly larvae could only be identified to family level resolution in some years (i.e., Simuliidae) due to the presence of immature individuals. In other years, Blackfly larvae were able to be identified to genus (i.e., *Austrosimulium* sp.) as more mature individuals were present. While this does limit the validity of year to year comparisons, it would not reduce the ability to compare upstream and downstream conditions within a season, as the taxonomy was consistent within each season. It is these upstream and downstream comparisons that are the focus of the MEMP.

3.4.3 Periphyton

Representative photographs of the substrate were taken at each site. These photographs were considered representative of the habitat present at each site. Semi-quantitative estimates of the proportion of substrate cover were recorded using the ACT AUSRIVAS field sheet methodology (Nichols, et al., 2000). Periphyton has been included in the monitoring program for Angle Crossing (M2G) and the MPS sites as a means of assessing the influence of flow upon the algal communities downstream of the abstraction points compared to upstream. The aim of this monitoring is to determine whether algal and periphyton communities downstream of Angle Crossing and the MPS are impacted due to reduced flow during operational pumping.

Periphyton has been included in the monitoring program for Burra Creek to monitor the effect flow is having upon algal communities downstream of the M2G discharge outlet. The aim of this monitoring is to determine whether algal communities downstream of the discharge outlet are impacted by alteration of the natural flow regime during operational pumping.

3.5 Photogrammetry

Photogrammetry was used to monitor potential changes in response to the operation of M2G and MPS over and above those occurring naturally. Photogrammetry is an inexpensive and robust alternative to quantitative techniques (O'Connor and Bond, 2007). Using this method, photo points were established at each monitoring location using markers and/or GPS coordinates. Photographs are taken at the same point on a pre-determined temporal scale (nominally every two years) or at times triggered by natural or other unforeseen events (floods).

The aspect of each photograph is determined by either using secondary or tertiary markers or by using landscape features. The resulting photographs provide a robust and valuable resource to help understand the temporal dynamics of the system and provide a visual reference of habitat in relation to the macroinvertebrates results as a measure of river health. This method was applied to monitor vegetation and geomorphology at relevant sites (refer to Table 5).

3.5.1 Riparian and instream vegetation

Photographs were taken at existing photo points to record the current extent of riparian and instream vegetation at relevant sites. Three photos were taken at each point, one facing upstream, one downstream and another directly across the channel. GPS coordinates have been recorded for all photo points, while some sites also have survey pegs inserted to assist in identifying the exact location.

The use of photogrammetry for monitoring the change in vegetation communities and coverage at Burra Creek is considered an efficient method for assessing whether standby (maintenance) and operational pumping is having a significant impact on riparian and instream vegetation (Hall, 2001). These photo points are used for ongoing comparison to future photos to monitor changes in vegetation.

3.5.2 Geomorphology

As with riparian and instream vegetation, photographs were taken at existing photo points to monitor changes in geomorphology. Photo points are located at geomorphological features of interest that were identified in 2015 due to them appearing particularly vulnerable to erosion (GHD, 2015). Each photo point was originally selected to record major geomorphological features and aspects to allow ongoing comparison of erosion (generally with one photograph upstream, one cross channel and one downstream).

The use of photogrammetry at previously identified cross-sections along Burra Creek are considered a robust method for monitoring potential changes in bank erosion and slumping. The photo points collected between autumn 2015 and autumn 2018 are used for ongoing comparison to future photographs taken from these photo points, or with alternate photographs and observations recorded before and after the use of the M2G pipeline for operational purposes.

3.6 Fish

The section of the Murrumbidgee River monitored is known to support a number native and alien fish species, including threatened species under the ACT *Nature Conservation Act 2014* (NC Act), NSW *Fisheries Management Act 1994* (FM Act), and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). These species are identified in Table 8.

Table 8 Threatened fish species known to inhabit the study area

Species	NC Act	FM Act	EBPC Act
Macquarie Perch (*Macquaria australasica*)	E	E	E
Murray Crayfish (*Euastacus armatus*)	V	V	
Murray Cod (*Maccullochella peelii*)	SPS		V
Trout Cod (*Maccullochella macquariensis*)	E	E	E

CE- Critically Endangered, E- Endangered, V- Vulnerable, P- Protected and SPS- Special Protection Status

Fish monitoring in the Murrumbidgee River is carried out every two years by the ACT Government and most recently occurred between February and May 2023. The fish surveys take place at 10 sites between the northern ACT border upstream to Bredbo in NSW (Beitzel et al., 2023). The sites include popular recreational areas such as Casuarina Sands (downstream of MPS), Angle Crossing (M2G) and Kambah Pool and more isolated locations such as Retallacks Hole, and NSW sites Prutties, Lawler Rd and the Bush Heritage property Scottsdale. The technique used for all surveys was boat electrofishing.

Common Carp surveys are undertaken every four years to monitor the effectiveness of carp egg and larvae filters. Targeted Common Carp (*Cyprinus carpio*) surveys were undertaken in the Googong Reservoir catchment by GHD in autumn 2023. The surveys involved the collection of environmental DNA (eDNA) at 10 sites between the M2G discharge in Burra Creek through to the Burra Creek arm of the upper Googong Reservoir and four sites in the Queanbeyan River (GHD, 2023). The full methodology for the surveys is documented in the report '*Detection of Carp in the Upper Googong Reservoir*' (GHD, 2023).

4. Results

4.1 Component 1: Angle Crossing (M2G)

Monitoring of Angle Crossing sites as part of the M2G component was completed on 15 and 16 April 2024 (autumn) and 28 November 2024 (spring).

4.1.1 Rainfall and hydrology

Overall, in the two seasons that monitoring occurred there was lower rainfall compared to historical averages, particularly in spring (Table 9). Both seasons had similar rainfall conditions, each with infrequent periods of minor to moderate rainfall events and similar total rainfall volumes. Rainfall in the region was generally reflected by corresponding changes in flow in the Murrumbidgee River (Table 9).

During autumn 2024, there was a high flow event in April and again in May, each following substantial rainfall and peaking at discharge volumes of approximately 3,000 and 4,200 ML/d at Lobb's Hole, respectively (Figure 7). Autumn 2024 monitoring was undertaken in mid-April following the recession of the first seasonal high flow event, with flows falling to 464 ML/d at the time of monitoring.

Throughout spring 2024, average flow was lower than the preceding autumn with average daily flow generally decreasing as the season progressed (Figure 8). There was one single high flow event throughout spring 2024, which occurred in late September with a peak daily average discharge of approximately 1750 ML/d. Aside from this high flow event, seasonal flow was below average, with mean daily discharge falling to 135 ML/d at Lobb's Hole in mid-November. Spring 2024 monitoring was undertaken in late November which coincided with very low discharge of 145 ML/d at Lobb's Hole.

Table 9 Autumn and spring 2024 rainfall and discharge summaries, upstream Angle Crossing and Lobb's Hole

	Month	Upstream Angle Crossing (41001702)		Downstream Angle Crossing @ Lobbs Hole (570985/410761)	
		Rainfall total (mm)	Mean discharge (ML/d)	Rainfall total (mm)	Mean discharge (ML/d)
Autumn 2024	March	31.2	207.1	37.6	226.5
	April	60.2	537.1	59.0	587.5
	May	32.6[4]	773.4	32.0	871.9
	Season total/average	124	505.5	128.6	561.7
Historical autumn monthly average		52.6	-	48.9	-
Spring 2024	September	21.4	502.7	24.0	561.4
	October	21.6	369.0	31.7	422.1
	November	82.4	174.3	88.0	198.8
	Season total/average	125.4	348.9	143.7	394.4
Historical spring monthly average		64.9	-	62.1	-

[4] Data was not available for four days during May 2024. Data for these days was instead obtained from Gudgenby River at Tennent (570970).

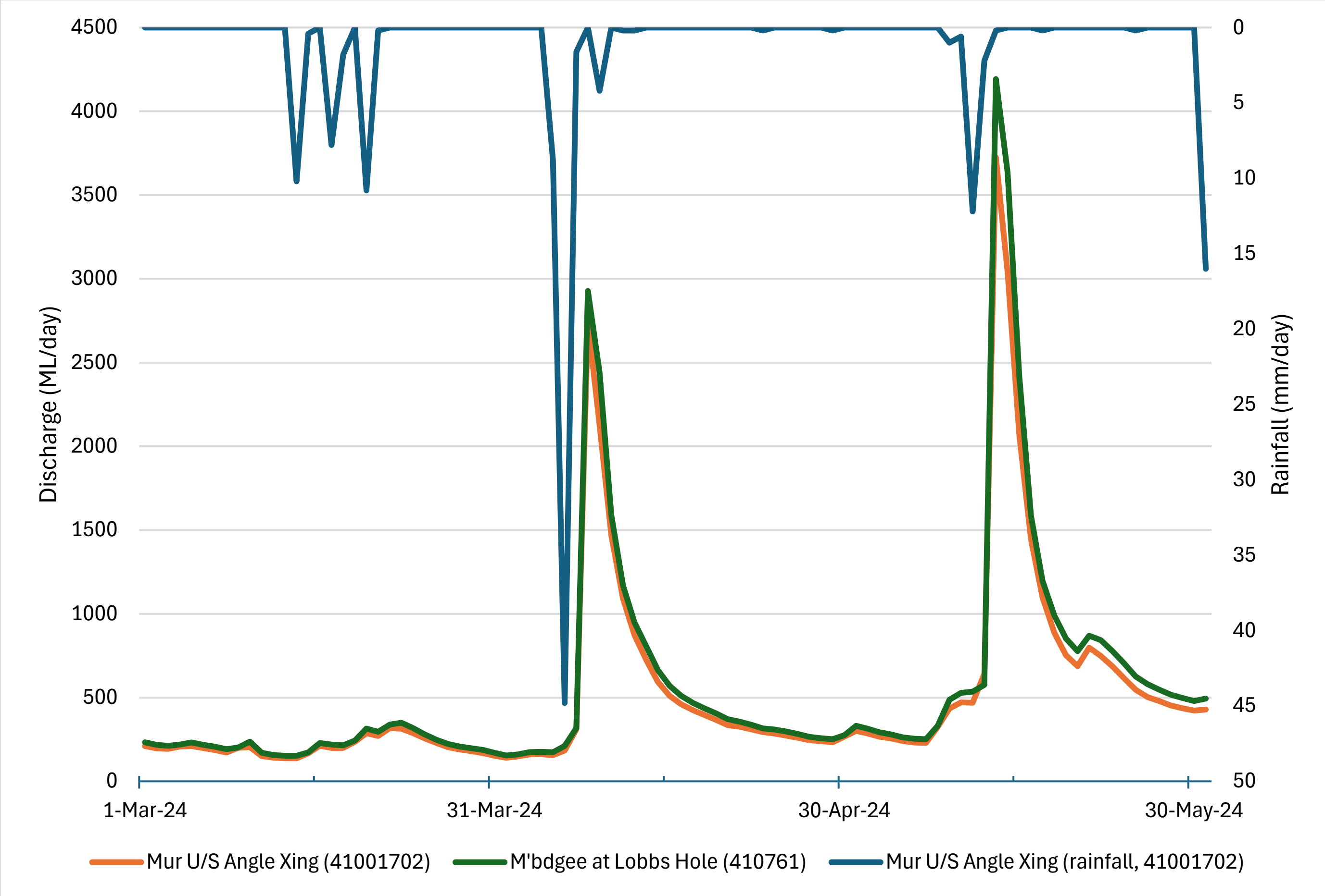


Figure 7 ***Rainfall and hydrograph of the Murrumbidgee River upstream (41004702) and downstream (410761) of Angle crossing in autumn 2024***

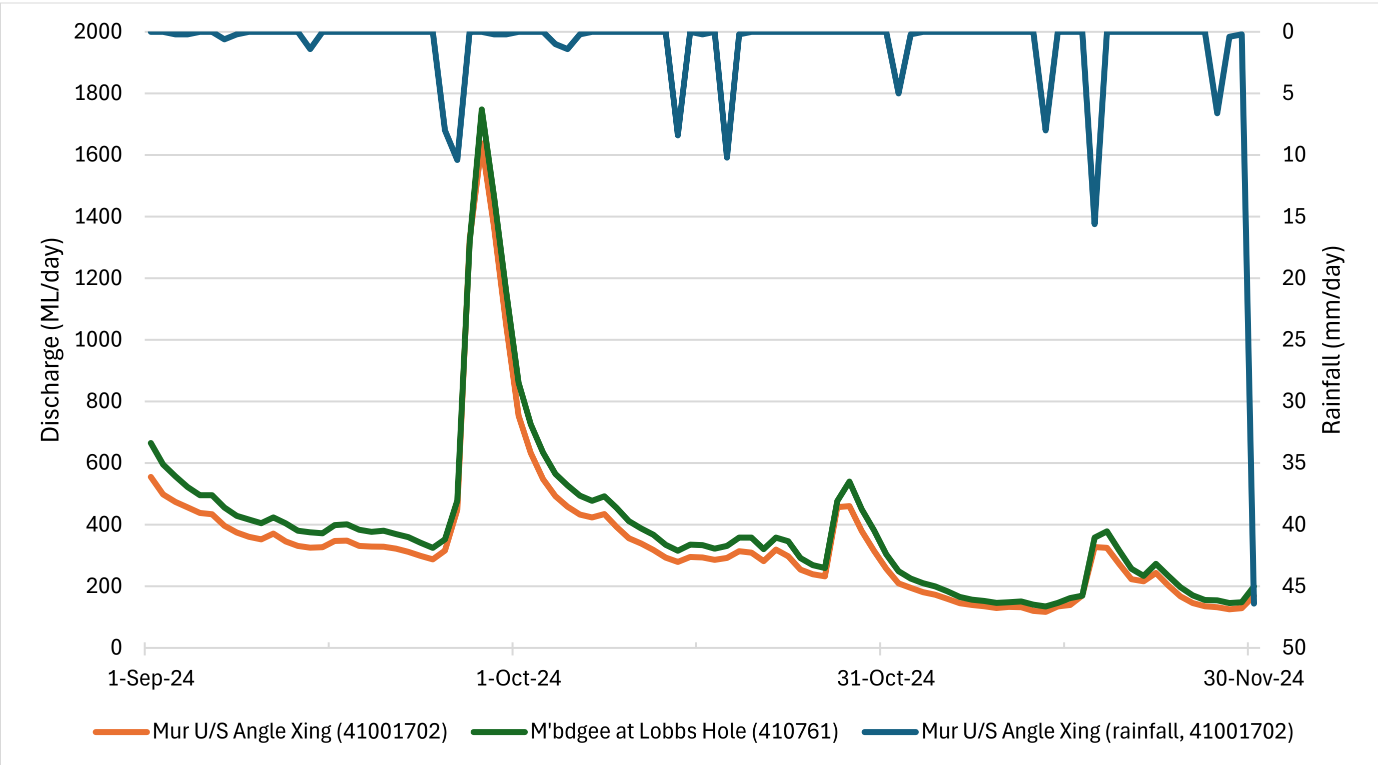


Figure 8 ***Rainfall and hydrograph of the Murrumbidgee River upstream (41004702) and downstream (410761) of Angle crossing in spring 2024***

4.1.2 Water quality

4.1.2.1 In-situ monitoring

In situ and grab sample water quality results are presented in Table 10 and provide a snapshot of conditions during 2024 sentinel monitoring. The results showed elevated concentration of nutrients, particularly TN and TP that exceeded the ANZG guideline value upstream of the M2G abstraction point in both seasons and downstream of the abstraction point in autumn.

Oxidised nitrogen (NO_x) exceeded the guideline value upstream of the abstraction point in autumn but was otherwise below the ANZG guideline value. During autumn, pH was slightly elevated above guideline values but was at or slightly below the pH guideline value in spring. DO, EC, turbidity (NTU), ammonia and manganese were within guideline values upstream and downstream of the abstraction point in both seasons. Note that there is not currently an ANZG guideline value for iron. Overall, the results indicated that there was similar water quality at upstream and downstream locations and the two sites are therefore considered to be suitable as replicate control sites to assess potential changes due to abstraction of water by the M2G.

4.1.2.2 Continuous monitoring

Continuous water quality monitoring measured at gauging stations upstream and downstream of the M2G abstraction point at Angle Crossing is presented in Figure 9 for autumn and Figure 10 for spring. In general, upstream and downstream sites presented similar water quality, with slightly greater stochasticity observed upstream of the abstraction point.

Water temperature was similar at the upstream and downstream sites and reflects seasonal changes in climate, characterised by falling temperatures in autumn and rising temperatures in spring. Between seasons, pH differed notably with exceedances of the ANZG upper guideline value of 8.0 occurring frequently throughout autumn but only occasionally during spring. Daily fluctuations in pH were also observed and are likely an outcome of photosynthesis. When compared against seasonal rainfall (Figure 7 and Figure 8), there were obvious reductions in pH which gradually returned to normal following large rainfall events. Throughout both seasons, pH remained above the ANZG lower guideline value of 6.5. In contrast to 2020 and 2021 impact monitoring, pH was elevated and likely due to low rainfall throughout 2024.

Throughout both seasons, turbidity was generally relatively low and within the ANZG guideline value range of 2 to 25 NTU, However, high flow events (refer to Figure 7 and Figure 8) corresponded with periods of elevated turbidity, reaching approximately 60 NTU in autumn and over 250 NTU in spring. It is noted that several anomalies were recorded and presented as sudden and extreme spikes in turbidity. Interrogation of continuous monitoring data (data recorded every 15 minutes) demonstrates that these anomalies are unlikely to be representative of river conditions at the time of recording due to the conditions not occurring in the 15 minute period before and after these data points.

EC was generally well within the ANZG guideline value range of 30-350 µS/cm upstream and downstream of Angle Crossing in both seasons. The exception to this was upstream of Angle Crossing in the first week of March which was highly stochastic with slight exceedances of the upper guideline value. When compared against seasonal rainfall (Figure 7 and Figure 8), there were also obvious reductions in EC which gradually returned to normal following large rainfall events.

Overall, the continuous monitoring of water quality indicates that there were no consistent patterns suggesting water quality differed between the upstream and downstream locations, except for greater stochasticity above the abstraction point.

Table 10 In-situ water quality results from M2G sites with red cells outside ANZG (2018) default guideline range

Location	Site	Samplin g period	Date	Time	Temp (°C)	EC (µs/cm)	Turbidity (NTU)	pH	D.O. (% Sat.)	D.O. (mg/L)	Alkalinity (mg/L)	NO_x (mg/L)	TP (mg/L)	TN (mg/L)	Ammonia	Total Iron	Total manganese
ANZG (2018) default guideline values					-	**30-350**	**2-25**	**6.5-8.0**	**90-110**	-	-	**0.015**	**0.02**	**0.25**	**0.9**	**-**	**1.9**
Upstream	MUR18	Autumn 2024	16/04/24	1315	17.2	143	9	8.2	100.8	9.7	80	0.02	0.06	0.6	0.05	0.49	0.036
		Spring 2024	28/11/24	915	22.7	96	12	8.0	103.2	8.9	80	<0.01	0.03	0.3	0.027	0.19	0.066
Downstream	MUR19	Autumn 2024	15/04/24	1500	16.0	145	9	8.1	98.8	9.8	80	<0.01	0.03	0.6	0.06	0.52	0.042
		Spring 2024	28/11/24	1115	23.0	91	11	7.8	105.0	9.0	80	<0.01	0.02	0.1	0.017	0.24	0.082

Note: Water Temperature (Temp.), Electrical Conductivity (EC), Dissolved Oxygen (DO), percentage saturation (% Sat.), Nitrite + Nitrate as N (NO_x), Total Nitrogen as N (TN), Total Phosphorus as P (TP)

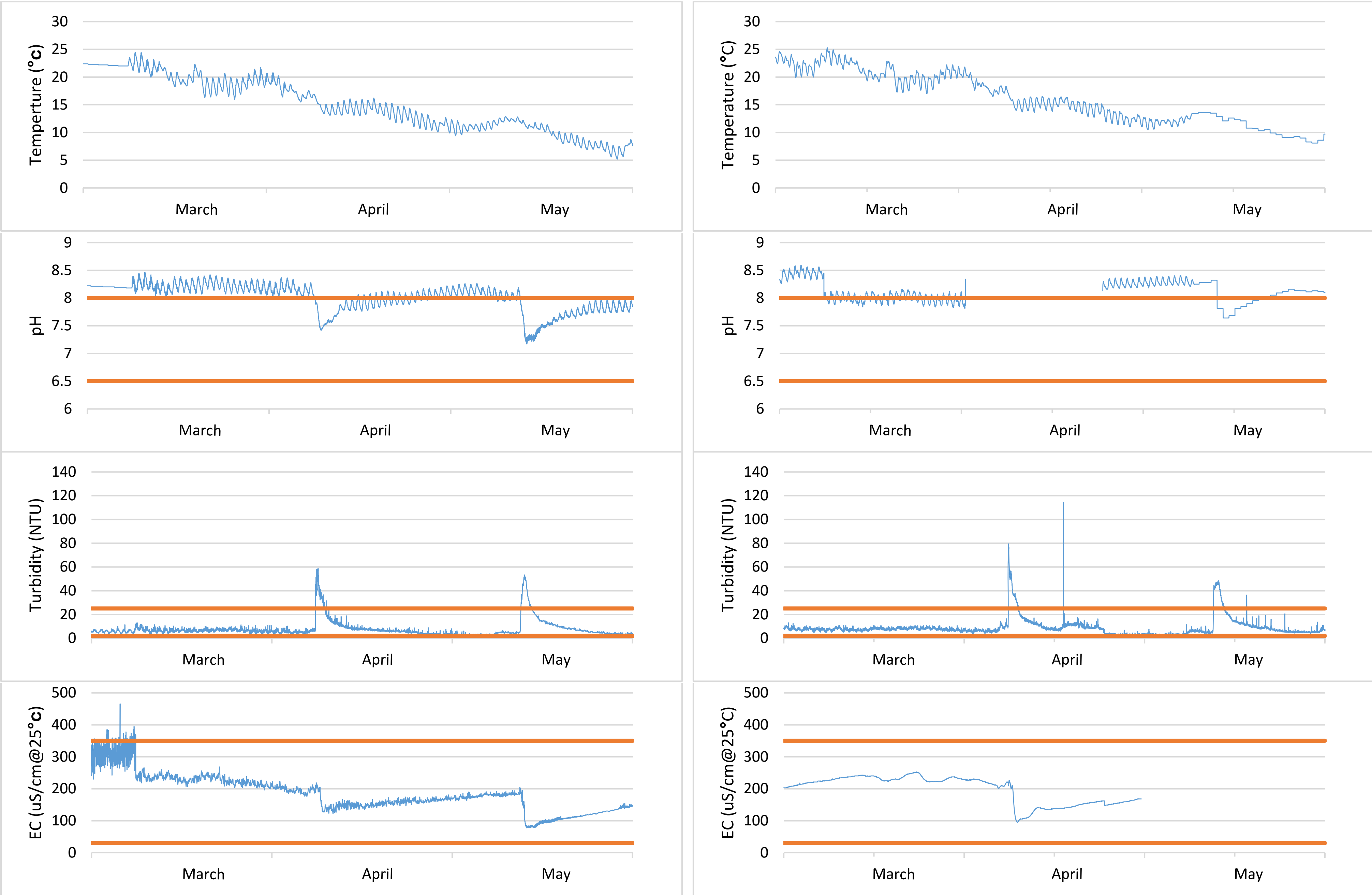


Figure 9 ***Continuous water quality records for autumn 2024 at upstream Angle Crossing (41001702, left) and downstream at Lobbs Hole (410761, right). ANZG guideline values are in orange.***

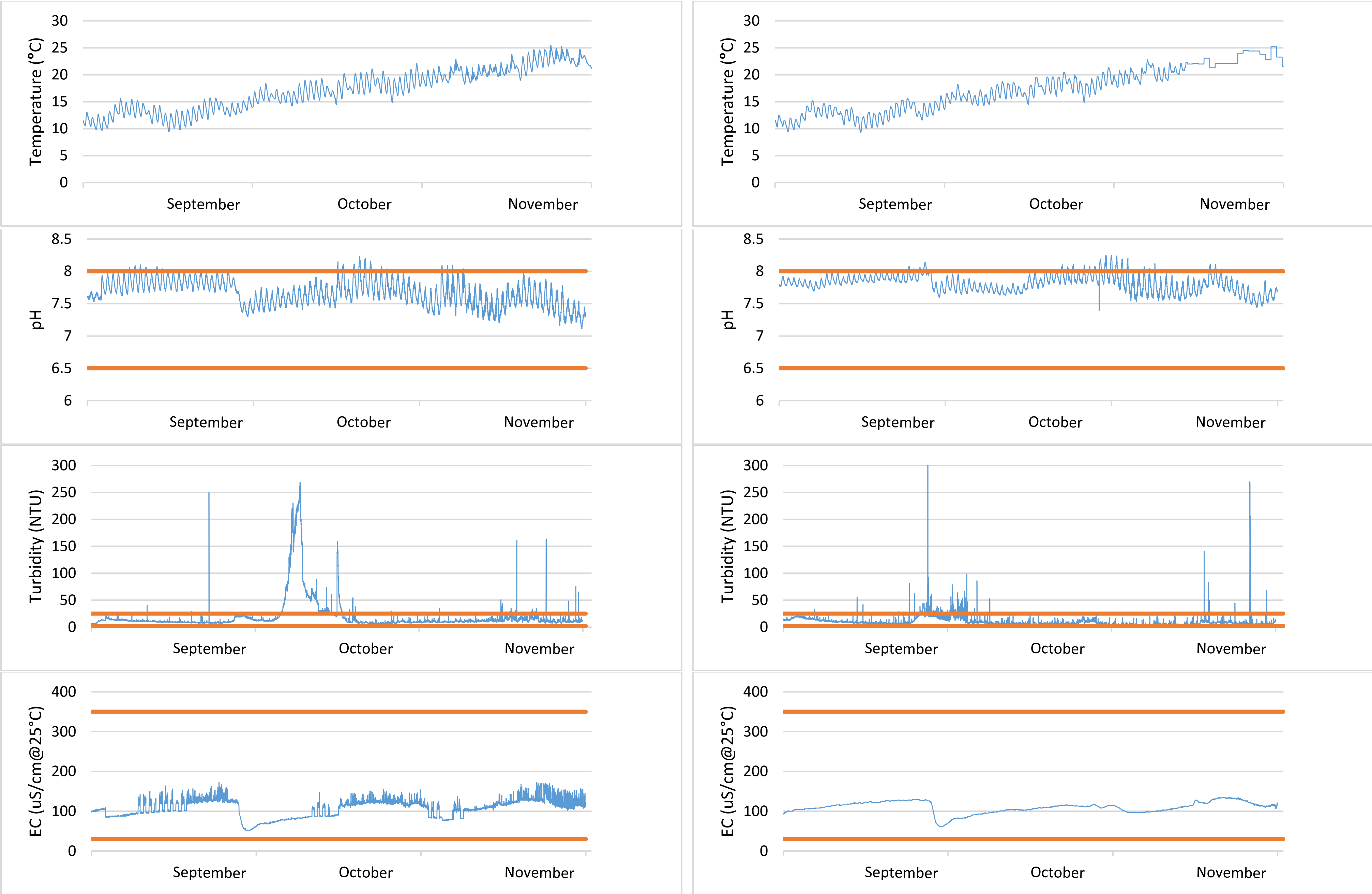


Figure 10 ***Continuous water quality records for spring 2024 from upstream Angle Crossing (41001702, left) and downstream at Lobbs Hole (410761, right). ANZG guideline values are in orange.***

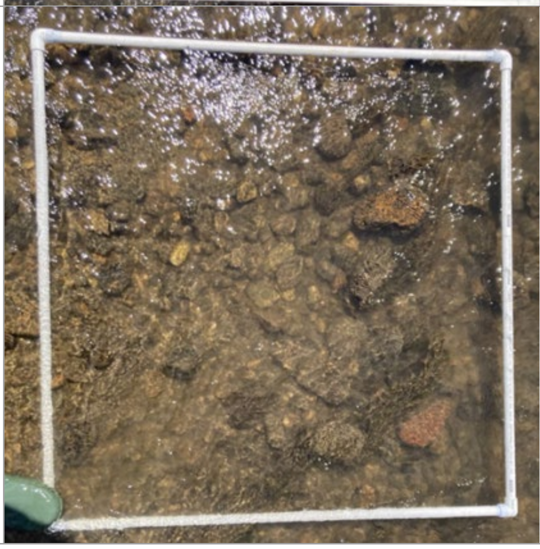
4.1.3 Periphyton

Photographs of periphyton at the M2G monitoring sites are presented in Table 11. Across both seasons, there was no indication of increased periphyton downstream of the M2G abstraction point compared to upstream. Rather, periphyton was observed to be higher at upstream site MUR18 compared to downstream at MUR19. Water milfoil *(Myriophyllum sp.*) was the most abundant submerged macrophyte at the upstream and downstream site in both seasons.

MUR18 - The periphyton coverage in autumn 2024 was 65-90% for the reach and 10-35% for the riffle habitat. During spring 2024, periphyton coverage was 35-65% for the reach and riffle habitat. In autumn 2024, filamentous algae coverage was <10% for the reach and riffle but 10-35% in spring for the reach and riffle. Macrophyte cover was 10-35% for the riffle and reach in autumn 2024, but in spring 2024 was 10-35% for the reach but less than 10% for the riffle.

MUR19 - The periphyton coverage in autumn 2024 and spring 2024 was approximately 35-65% for the reach and 10-35% for the riffle habitat. In autumn and spring 2024, filamentous algae coverage was <10% for the reach and riffle habitat. In autumn 2024, macrophyte cover was 10-35% for the reach but 35-65% for the riffle habitat. In spring 2024, macrophyte cover was 10-35% for the reach and riffle habitat.

Table 11 ***Photographs showing periphyton coverage in riffles of the Murrumbidgee River at M2G sites***

Site	Autumn 2024	Spring 2024
MUR18		
MUR19		

4.1.4 Geomorphology

Geomorphological features at Angle Crossing (MUR19) observed in autumn and spring 2024 have remained relatively unchanged since 2020/2021 (see Table 12). Water levels between autumn and spring were evidently different, with lower water levels in spring 2024 exposing some slight areas of bare ground downstream of Angle Crossing (e.g. photo point 3, photos a and c). In comparison to 2020/2021, there appears to have been recruitment of several small and scattered shrubs (see photo point 2, photo b) but loss of some large riparian trees (exotic willows (*Salix* spp.)) which could potentially have increased the banks vulnerability to erosion under flood scenarios (see photo point 3, photo b). The northern bank downstream of Angle Crossing appeared to be stable with high native sedge and shrub coverage interspersed amongst a sandy to pebbly substrate. In contrast the southern bank was predominantly covered by blackberry with little native vegetation and appeared vulnerable to erosion. There was no evidence of bank scarping or slumping, or any major areas of bare ground that indicated significant erosion has been taking place.

Table 12 Geomorphology at Angle Crossing site MUR19

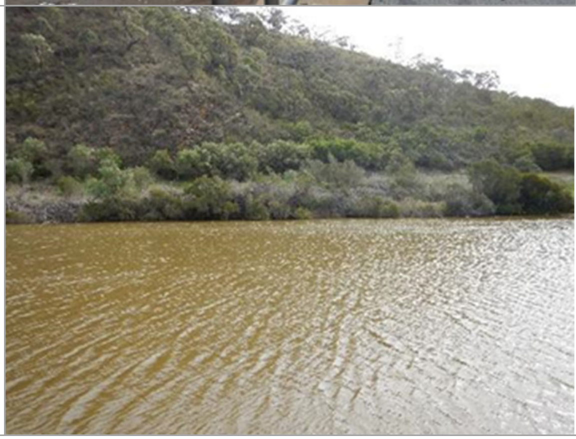
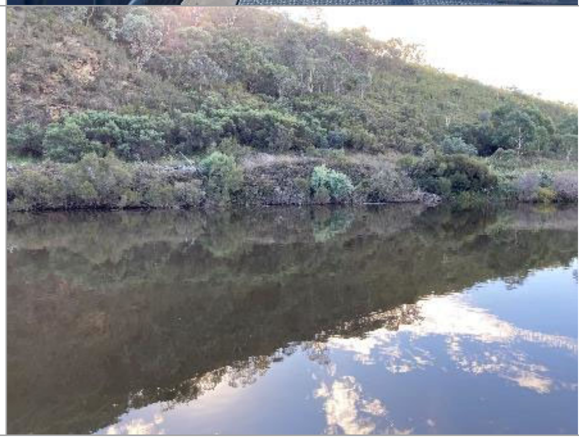
Photo		2020/2021	Autumn 2024	Spring 2024
Photo point 1	a			
	b			
	c			

Photo		2020/2021	Autumn 2024	Spring 2024
Photo point 2	a			
	b			
	c			

Photo		2020/2021	Autumn 2024	Spring 2024
Photo point 3	a			
	b			
	c			

4.1.5 Macroinvertebrates

4.1.5.1 Biological indices

There is minimal edge habitat in this reach of the Murrumbidgee River and therefore no edge samples were collected in either season.

The total taxa richness for M2G sites in the Murrumbidgee River are presented in Table 13. Across the two seasons, total taxa richness ranged from 13 to 20 at family level resolution and 14 to 23 at genus level resolution. There were no noticeable differences in taxa richness between the two seasons. There was no consistent pattern in the data indicating sites downstream of the abstraction point on Angle Crossing had lower taxa diversity than upstream.

Table 13 Total number of taxa from riffle habitats upstream and downstream of the M2G in the Murrumbidgee River

Location	Site	Sample	Autumn 2024		Spring 2024	
			Family	Genus	Family	Genus
Upstream	MUR18	1	13	14	20	23
		2	16	19	17	20
Downstream	MUR19	1	16	17	19	23
		2	14	15	19	22

The EPT richness for M2G sites is presented in Table 14. Across the two seasons, EPT richness ranged from 6 to 9 at family level resolution and 6 to 11 at genus level resolution. EPT richness was slightly higher in spring 2024 compared to autumn. As was found for total taxa richness, there was no consistent pattern in the data indicating sites downstream of Angle Crossing had lower EPT diversity than upstream.

Table 14 Total number of EPT taxa from riffle habitats

Location	Site	Sample	Autumn 2024		Spring 2024	
			Family	Genus	Family	Genus
Upstream	MUR18	1	6	6	7	9
		2	8	10	6	8
Downstream	MUR19	1	8	9	8	11
		2	6	6	9	11

The SIGNAL-2 and AUSRIVAS results for the M2G sites are presented in Table 15. SIGNAL-2 Scores ranged from 4.4 to 5.1 across the two seasons. Although there were often higher SIGNAL-2 scores in autumn 2024 compared to spring 2024, this was not consistent across all samples. All autumn 2024 AUSRIVAS analyses indicated that the predictor variables were outside the experience of the model and consequently, OE50 scores and AUSRIVAS Bands could not be generated for these sites. During spring 2024, the upstream site MUR18 was allocated to AUSRIVAS Band B that possibly suggests significant impairment and fewer families than expected in contrast to the downstream site MUR19 which was allocated Band A. Overall, there was no consistent pattern in the data indicating sites downstream of Angle Crossing had lower SIGNAL-2 scores or AUSRIVAS scores than upstream.

Table 15 SIGNAL-2 scores, AUSRIVAS scores and bandings for riffle habitats

	Site	MUR 18		MUR 19	
	Sample	1	2	1	2
SIGNAL-2 score	Autumn 2024	4.8	4.9	4.9	5.1
	Spring 2024	4.4	4.6	5.0	4.8
AUSRIVAS O/E score	Autumn 2024	OEM	OEM	OEM	OEM
	Spring 2024	0.9	0.9	1.0	1.0
AUSRIVAS Band	Autumn 2024	OEM	OEM	OEM	OEM
	Spring 2024	B	B	A	A
Overall habitat assessment	Autumn 2024	OEM		OEM	
	Spring 2024	B		A	

Table 16 presents AUSRIVAS Bands for Angle Crossing since 2012, indicating that of the sites within the experience of the model, both upstream and downstream were typically placed in Band B. Although the results of the 2024 sentinel monitoring suggest the downstream site had a better community than upstream, this has previously been observed in the absence of operation (i.e., spring 2014) and is likely due to natural variation.

Table 16 Overall site assessments for Angle Crossing sites since 2012 (indicates riffle habitats only)*

Year	Season	Upstream		Downstream	
		MUR 17	MUR 18	MUR 19	MUR 20
2012	Autumn		B	B	
2012	Spring		B	B	
2013	Autumn		B	B	
2013	Spring		B	B	
2014	Autumn		B	B	
2014	Spring		B	A	
2015	Autumn		B	B	
2015	Spring		A	A	
2018	Autumn		B	B	
2018	Spring		A	B	
2019*	Autumn	B	B	B	B
2019*	Spring	B	B	B	B
2020*	Autumn	B	B	B	B
2020*	Spring	B	B	B	B
2021*	Autumn	B	B	B	B
2024*	Autumn	OEM	OEM	OEM	OEM
2024*	Spring		B	A	

4.1.5.2 Multivariate analysis – community composition

The NMDS ordination of macroinvertebrate community samples from riffle habitats from the sentinel monitoring (2015, 2018 and 2024) and impact monitoring (2019, 2020 and 2021) are presented in Figure 11. Note that each point on the NMDS represents a multivariate macroinvertebrate sample (i.e. all taxa collected and their abundances) and those samples close together have a more similar community composition than those further apart.

The spread of samples on the ordination highlights that there were some differences between years, particularly in 2024 that was most different from all other years[5]. Within each year there were also clear differences in the community composition between autumn and spring. However, within each season, there were no consistent differences between samples collected upstream and downstream of the M2G abstraction separation. That is, the upstream samples were not always separated from the downstream samples that would suggest there were differences in the macroinvertebrate communities amongst the two locations.

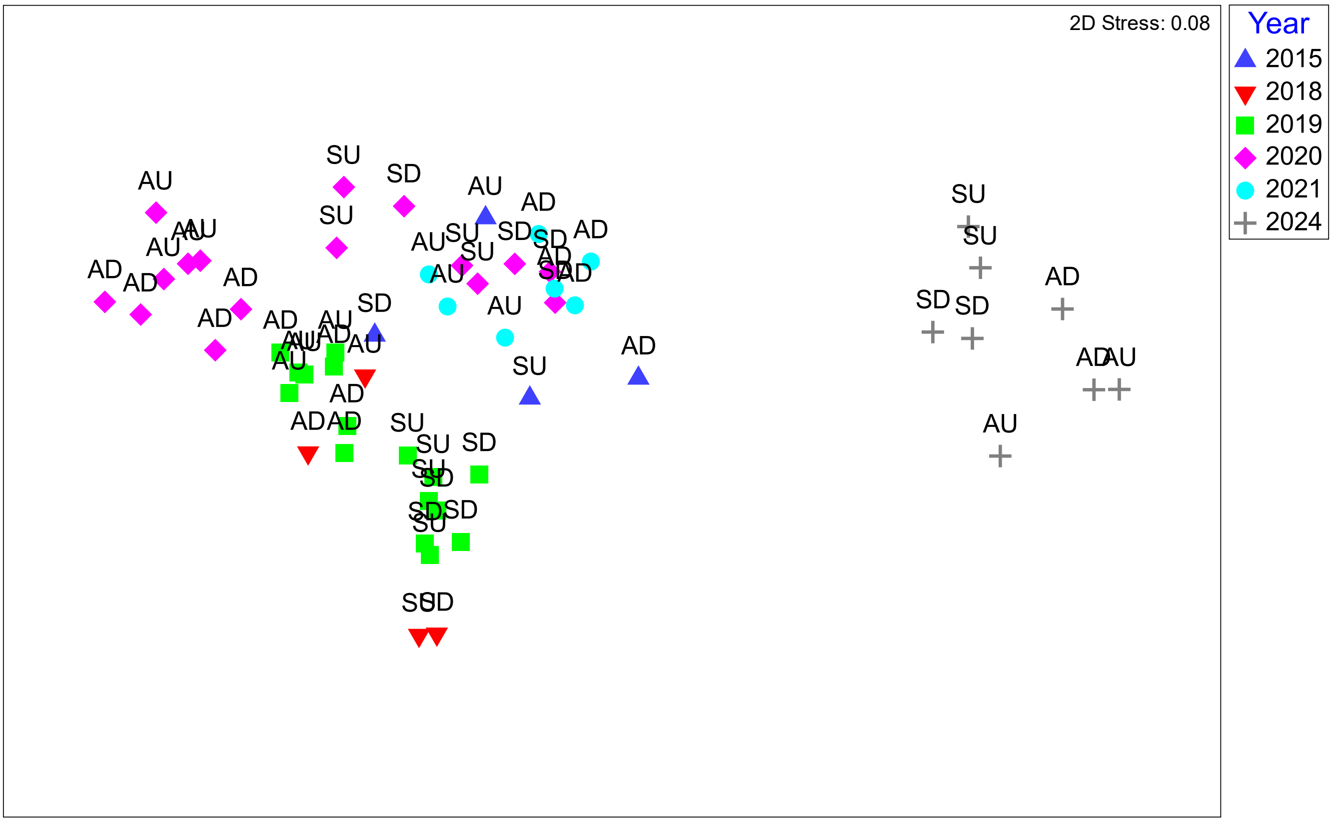


Figure 11 ***MDS ordination of macroinvertebrate communities associated with riffle habitats. A = autumn and S = spring; U = upstream and D = downstream***

The patterns on the NMDS were confirmed by the PERMANOVA that detected significant differences between years (Pseudo-F 2.3, P = 0.048), and seasons within each year (Pseudo-F 13.8, P = 0.001). However, there was also an interaction between season and locations meaning differences upstream and downstream of the abstraction point where not consistent in each season (Pseudo-F 1.6, P = 0.016). Significant differences in the community composition upstream and downstream of the abstraction point were detected in spring 2019 (t = 0.1.7, P = 0.042) and autumn 2020 (t = 1.9, P = 0.027). In all other seasons, there were no significant differences upstream and downstream of the abstraction. Given there were statistical differences upstream and downstream of the abstraction point for the spring 2019 and the autumn 2020 surveys, SIMPER analyses were only conducted for these seasons.

Overall, in both spring 2019 and autumn 2020 most taxa found upstream of the abstraction were also found downstream. However, there were some differences in abundances of some taxa (see Figure 12 and Figure 13). Blackfly larvae (Simuliidae: *Austrosimulium*) contributed highly to the differences with higher average abundances upstream compared to downstream in both seasons. Other taxa generally more abundant upstream included mayfly larvae (Baetidae) although other mayfly larvae (Caenidae) were more abundant downstream. The abundances of midge fly larvae (Chironominae, Orthocladiinae), worms (Oligochaeta), and caddisfly larvae (*Cheumatopsyche, Hydropsychidae*) had no consistent pattern between the upstream and downstream locations.

[5] As discussed in Section 3.4.2, the year-to-year differences are in part due to taxonomy differences during sample processing

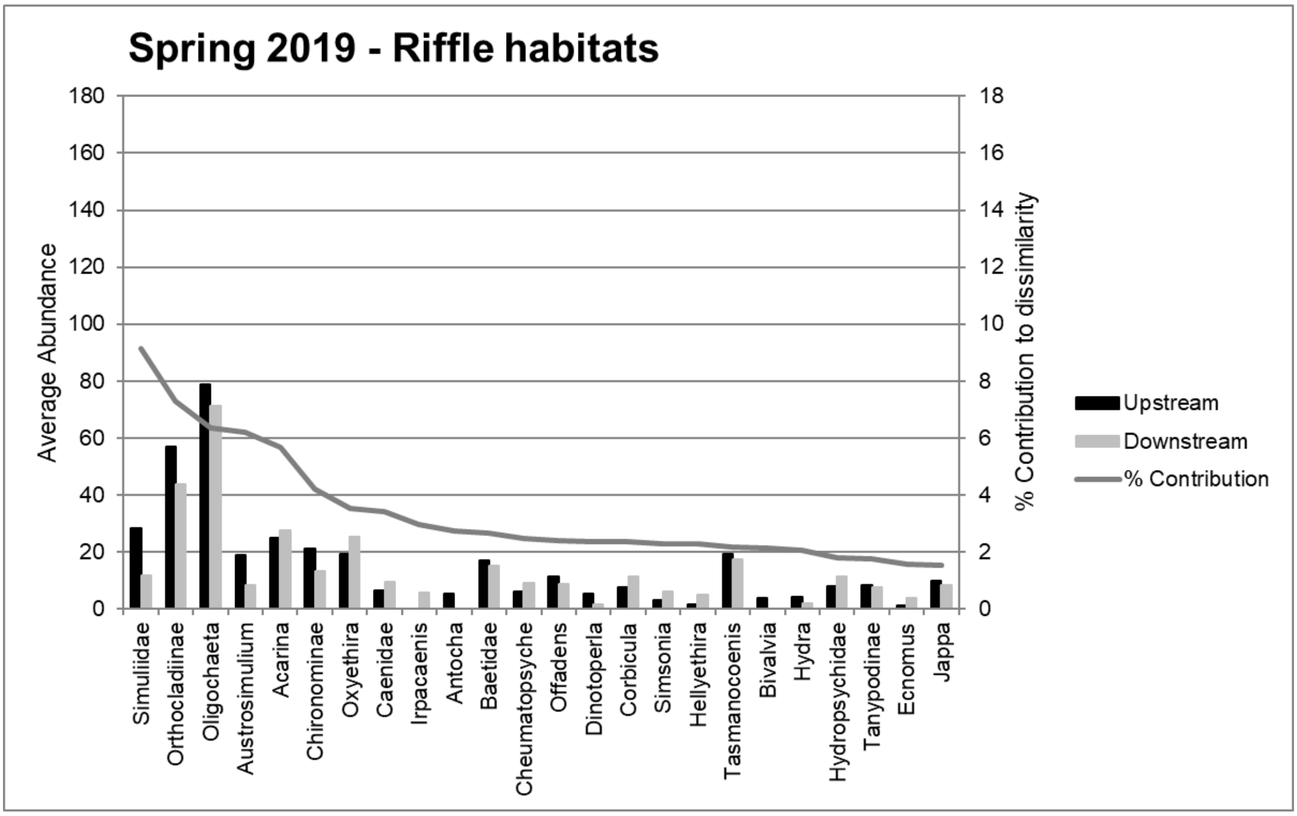


Figure 12 ***Spring 2019 riffle habitat SIMPER analyses identifying those taxa that contributed most to the dissimilarity between upstream and downstream locations associated with Angle Crossing. Taxa that contributed to 80% of the dissimilarity are included and the average dissimilarity between samples was 24.61%. Note that abundances are square-root values***

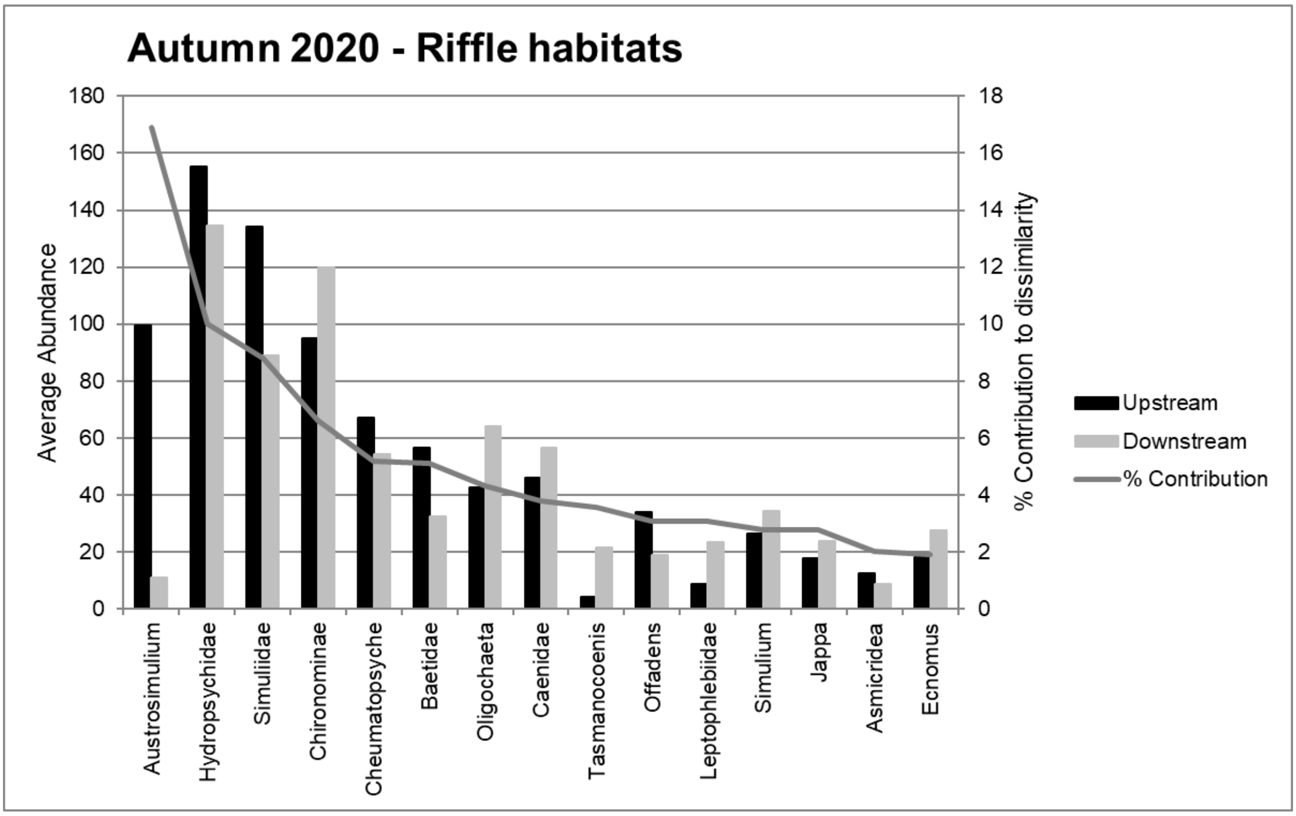


Figure 13 ***Autumn 2020 riffle habitat SIMPER analyses identifying those taxa that contributed most to the dissimilarity between upstream and downstream locations associated with Angle Crossing. Taxa that contributed to 80% of the dissimilarity are included and the average dissimilarity between samples was 29.93%. Note that abundances are square-root values***

4.1.6 Fish

The 2023 monitoring of the Murrumbidgee River surveyed fish populations at ten sites in the ACT and upstream NSW region (Beitzel et al. 2023). Four sites were upstream of the M2G abstraction point (Scottsdale, Lawler Rd, Prutties and Angle Crossing) and six were downstream.

The surveys detected a total of 304 fish from five species (see Figure 14). Both native and alien species were observed across all sites. Common Carp dominated most sites and accounted for 237 (78%) of total fish detected. The exception to this was Scottsdale, the furthest upstream site, where Murray Cod (mainly juveniles) numbers exceeded Common Carp. Murray Cod were detected at all sites with the highest numbers observed at upstream sites Scottsdale and Prutties. One threatened Macquarie Perch and one suspected Trout Cod / Murray Cod hybrid were also detected. Compared to 2021, the most recent surveys did not detect native species Australian Smelt (*Retropinna semoni*) and Western Carp Gudgeon (*Hypseleotris klunzingeri*) and the non-native Gambusia (*Gambusia affinis*).

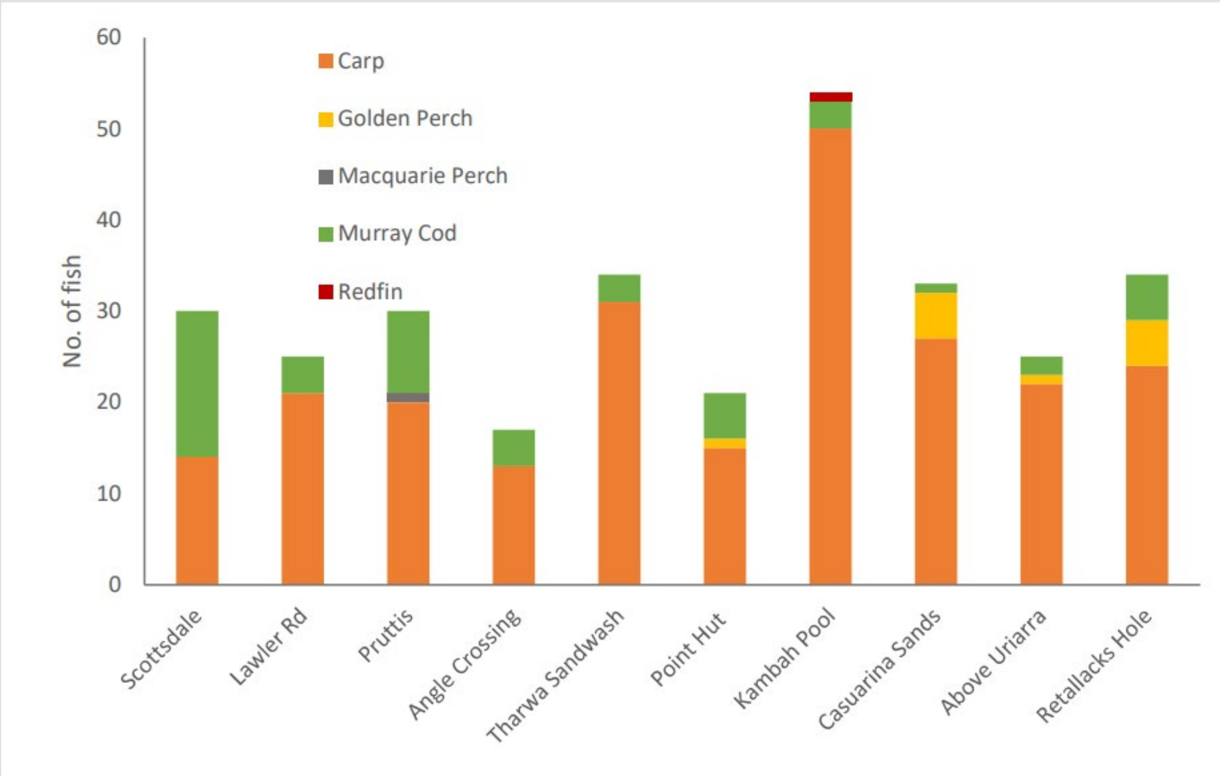


Figure 14 ***Stacked bar chart of catch per site from the 2023 Murrumbidgee River Survey (Beitzel et al. 2023)***

Strong recent recruitment of Murray Cod was evident with a high number of young of year (YOY, <1 year old) detected (see Figure 15). The majority of YOY Murray Cod were from sites upstream of Point Hut, with only one YOY detected downstream of Point Hut. While strong recruitment by Golden Perch was not evident in recent years (see Figure 15), the species was detected further upstream compared to previous years (see Figure 14), thus demonstrating potential upstream movement by juvenile fish.

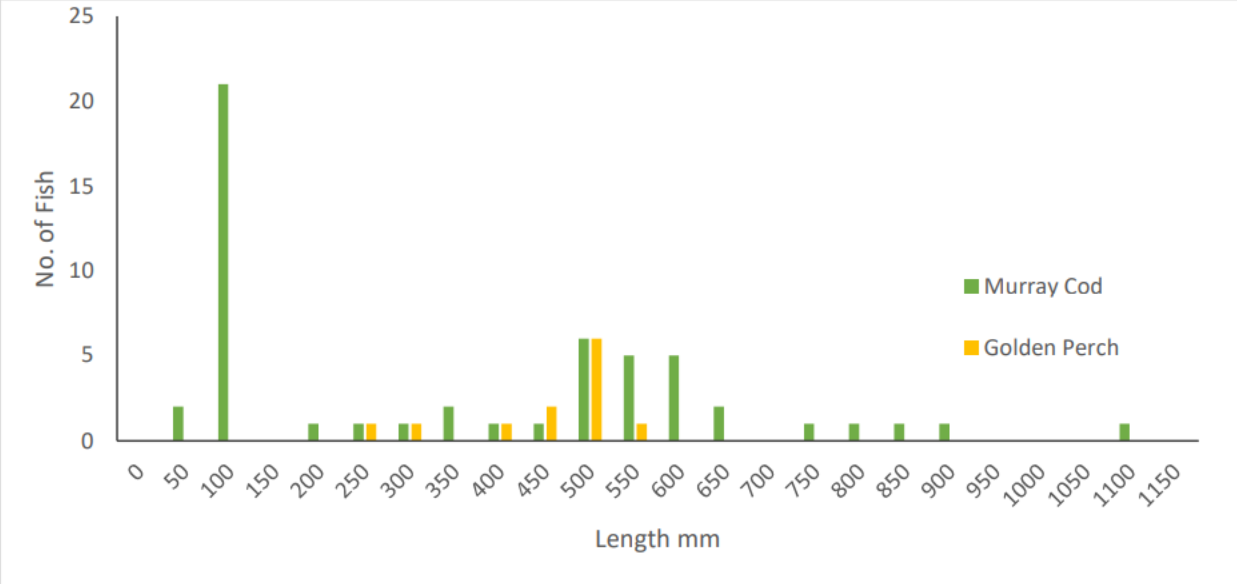


Figure 15 ***Length frequency of Murray Cod and Golden Perch 2023 (Beitzel et al. 2023)***

In comparison to the previous survey in 2021, the proportionate abundance of native fish decreased, while the proportionate biomass of native fish (relative to exotic species) increased (see Figure 16). The increase in native biomass was driven by the continued growth of a large cohort of Murray Cod within the 500-650 mm size class supported by strong YOY recruitment. Despite there being higher numbers of Murray Cod and Golden Perch detected compared to 2021 surveys, the proportionate abundance of native fish decreased due to strong recruitment and survival by Common Carp. It is noted that the survey method employed is restricted to the sampling of deep pool habitat and is not readily capable of detecting common small-bodied natives, such as the riffle inhabiting Mountain Galaxias (*Galaxias olidus*) and edge inhabiting Western Carp Gudgeon. Similarly, the non-native but common Redfin (*Perca fluviatilis*) may have reduced detectability. Therefore, the documented proportionate abundance ratios may not reflect actual fish assemblages at survey locations.

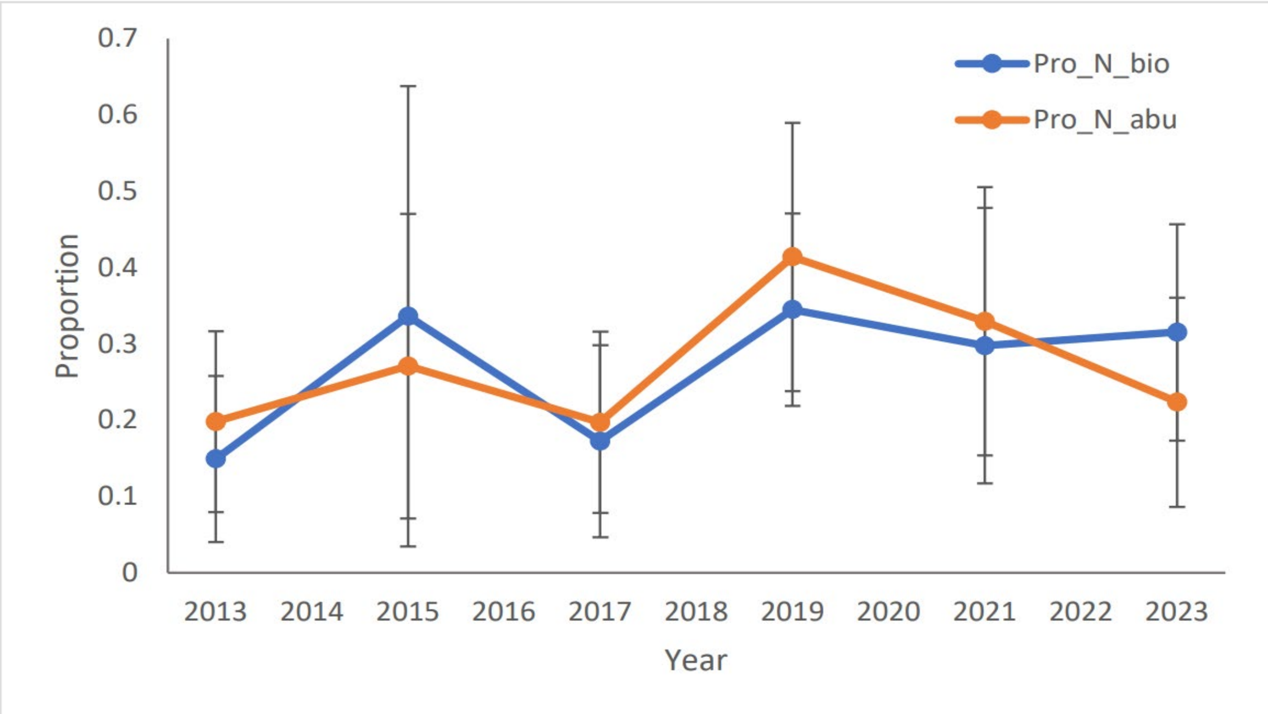


Figure 16 ***Proportion of native biomass (Pro_N_bio) and native abundance (Pro_N_abu) in the Murrumbidgee Fishery Survey 2013-2023 (Beitzel et al. 2023)***

While not part of formal fish surveys, during macroinvertebrate kick sampling in spring 2024 at MUR19, a single Murray Crayfish (listed as vulnerable under the ACT *Nature Conservation Act 2014* and NSW *Fisheries Management Act 2007*) was incidentally collected and returned unharmed. The Murray Crayfish was measured as having a 4.5 cm occipital carapace length (OCL) (see Figure 17).

Figure 17 Murray Crayfish collected at MUR19 in spring 2024

4.2 Component 2: Burra Creek (M2G)

Monitoring of Burra Creek sites as part of the M2G component was completed on 8 and 10 April 2024 (autumn) and 28 and 29 November 2024 (spring).

4.2.1 Rainfall and hydrology

Overall, in the two seasons that monitoring occurred there was lower rainfall compared to historical averages, particularly in spring (Table 17). Both seasons presented similar rainfall conditions with similar overall rainfall volumes and infrequent rainfall events.

Rainfall in the region was generally reflected by corresponding changes in flow in Burra Creek (Table 17). During autumn 2024, there was a high flow event with discharge of 7.69 ML/d in April and two elevated events of 4 ML/d, each of which corresponded with substantial rainfall (Figure 18). Autumn 2024 monitoring was undertaken in early-April the day after the highest flow event of the season, with discharge still up at 4.06 ML/d at the time of sampling.

Throughout spring 2024, average flow was generally lower than the preceding autumn with average daily flow generally decreasing as the season progressed (Figure 19). There was one single high flow event throughout spring 2024, which occurred in late September with a peak daily average discharge of approximately 12 ML/d. Spring 2024 monitoring was undertaken in late November which coincided with very low discharge of 0.5 ML/d.

Table 17 Autumn and spring 2024 rainfall and discharge summaries, Burra Creek at Burra Road

Season	Month	Burra Creek (570951, 410774)	
		Rainfall total (mm)	Mean discharge (ML/d)
Autumn 2024	March	39	1.3
	April	44.2	2.5
	May	33.8[6]	2.5
	Season total/average	117	2.1
Historical autumn monthly average		45.8	-
Spring 2024	September	15.8	1.7
	October	18.8	1.4
	November	94.6	1.0
	Season total/average	129.2	1.4
Historical spring monthly average		62.2	-

[6] Note that eight days were not available at Burra Creek. Queanbeyan River U/s Googong Dam (570816, the nearest alternate site) was used to fill in missing values, where available. However, the nearest site with values for all days in May was the Gudgenby River at Tennant (570970). All remaining values were determined based on this site.

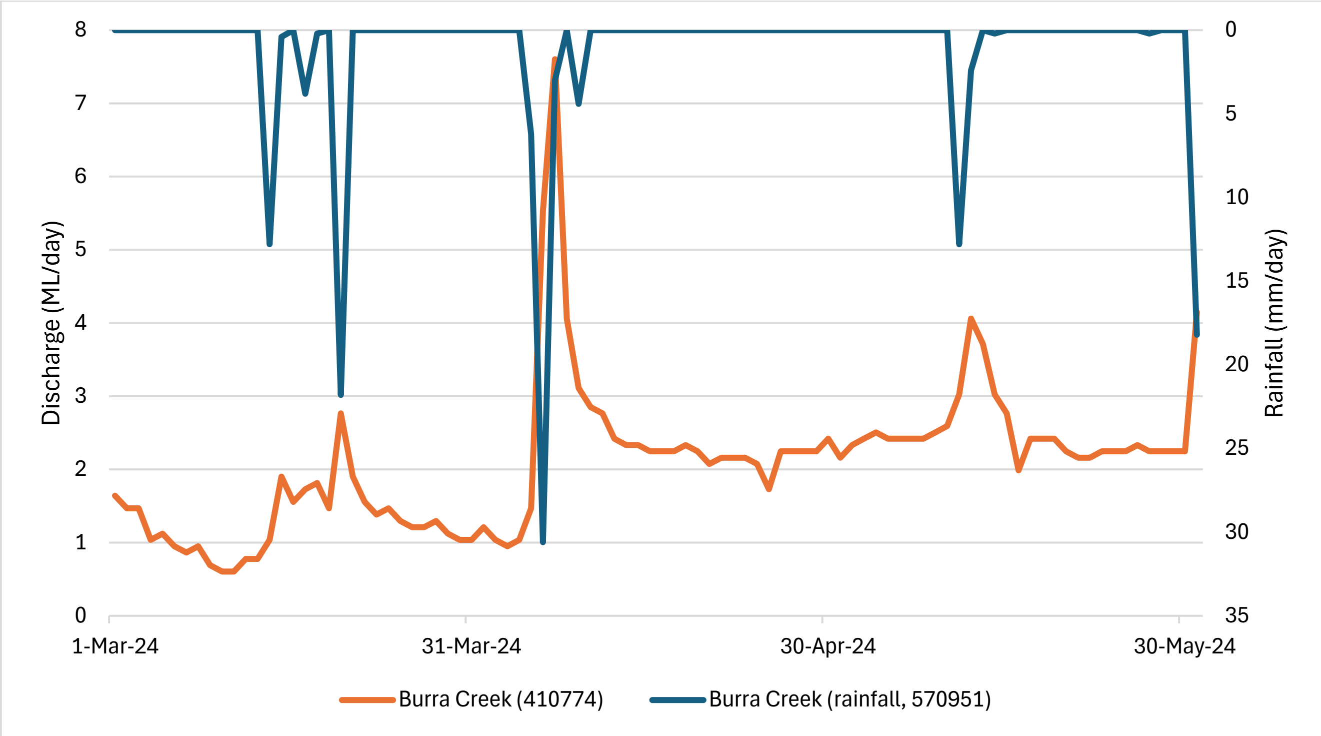


Figure 18 Rainfall and hydrograph of Burra Creek at Burra Road in autumn 2024

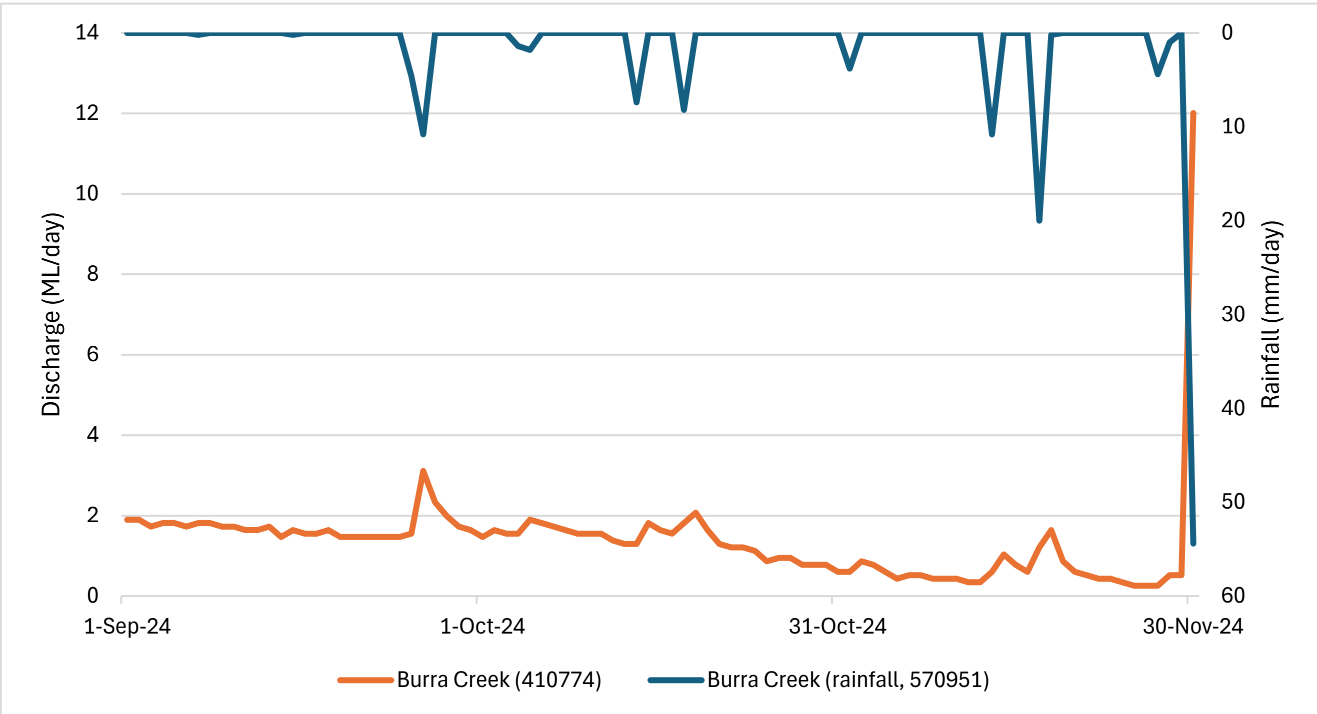


Figure 19 Rainfall and hydrograph of the Burra Creek at Burra Road in spring 2024

4.2.2 Water quality

4.2.2.1 In-situ monitoring

In situ and grab sample water quality results are presented in Table 18 and provide a snapshot of conditions during 2024 sentinel monitoring. Most water quality parameters were similar between sites and between seasons. Turbidity and pH were relatively consistent and complied with ANZG guidelines values at both sites and in both seasons. While there was a difference in alkalinity between seasons, there were no observed differences between upstream and downstream sites. Total iron was also comparable at both sites and between seasons. In contrast, total manganese was elevated in spring compared to autumn but was still well within the ANZG guideline value. Note that there is not currently an ANZG guideline value for iron.

The results indicate that Burra Creek had elevated concentrations of nitrogen, including TN and oxidised forms of nitrogen (NO_X) that exceeded the ANZG guideline values at upstream and downstream sites in both seasons, except for TN at BUR1d in spring 2024. However, TP and ammonia did not exceed ANZG guidelines values at either site in both seasons. EC was also above the ANZG guideline value at both sites and in both seasons, while DO was below the lower ANZG guideline value at both sites and in both seasons. While there were no seasonal trends or obvious upstream and downstream differences, the downstream site BUR2a was observed to have greater variability in DO, with 67% observed in spring and 84% observed in autumn.

Overall, the results demonstrated similarities in water quality parameters between sites and seasons, but there were also some differences which are expected to be an outcome of differences in stream morphology and hydrology at each site.

4.2.2.2 Continuous monitoring

Continuous water quality monitoring measured at Burra Creek gauging station downstream of the M2G pump discharge outlet is presented in Figure 20. In general, autumn and winter presented comparable results in relation to pH and turbidity, while there were seasonal differences in temperature and EC.

In both seasons, pH tended to be slightly above the ANZG upper guideline value. However, large daily fluctuations occurred in spring resulting in pH being within the ANZG upper guidelines value during daylight hours and above the guideline values during nighttime. Turbidity was generally low and well within ANZG guideline values, except for infrequent and short term spikes. Spikes in turbidity corresponded with high flow events (Figure 18 and Figure 19) and reached approximately 45 NTU in autumn and 33 NTU in spring, both of which are relatively insignificant exceedances of the upper ANZG guideline value.

Water temperature reflected seasonal changes, characterised by falling temperatures in autumn and rising temperatures in spring. EC also reflected seasonal changes, characterised by elevated EC in spring with a general increasing trend observed throughout the season. EC was generally above the ANZG guideline value range of 30-350 µS/cm in both seasons. This was especially the case in spring which did not have a day below the upper ANZG guideline value of 350. While this was the case, there were some obvious reductions in EC corresponding to large rainfall events (see Figure 18 and Figure 19). As a result, EC was within the guideline values in March and April 2024 and fell drastically at the end of November following significant rainfall.

Overall, the continuous monitoring of water quality indicates there were no significant differences in water quality between seasons, aside from expected differences in temperature and EC.

Table 18 In-situ water quality results from M2G sites with red cells outside ANZG (2018) default guideline range

Location	Site	Sampling period	Date	Time	Temp (°C)	EC (µs/cm)	Turbidity (NTU)	pH	D.O. (% Sat.)	D.O. (mg/L)	Alkalinity (mg/L)	NOx (mg/L)	TP (mg/L)	TN (mg/L)	Ammonia	Total Iron	Total manganese
ANZG (2018) default guideline values					**-**	**30-350**	**2-25**	**6.5-8.0**	**90-110**	**-**	**-**	**0.015**	**0.02**	**0.25**	**0.9**	**-**	**1.9**
Upstream	BUR1d	Autumn 2024	08/04/24	1330	16.2	442	8	7.8	73.5	7.2	240	0.08	0.01	0.5	0.02	0.69	0.074
		Spring 2024	28/11/24	1430	20.0	471	8	7.7	81	7.2	320	0.02	0.02	0.2	0.014	0.79	0.149
Downstream	BUR2a	Autumn 2024	08/04/24	1500	12.9	444	7	7.9	84.0	8.9	220	0.04	0.01	0.4	<0.01	0.65	0.072
		Spring 2024	28/11/24	1540	22.5	457	9	7.8	67	5.8	320	0.02	0.01	0.3	0.047	0.56	0.106

Note: Water Temperature (Temp.), Electrical Conductivity (EC), Dissolved Oxygen (DO), percentage saturation (% Sat.), Nitrite + Nitrate as N (NO_x), Total Nitrogen as N (TN), Total Phosphorus as P (TP)

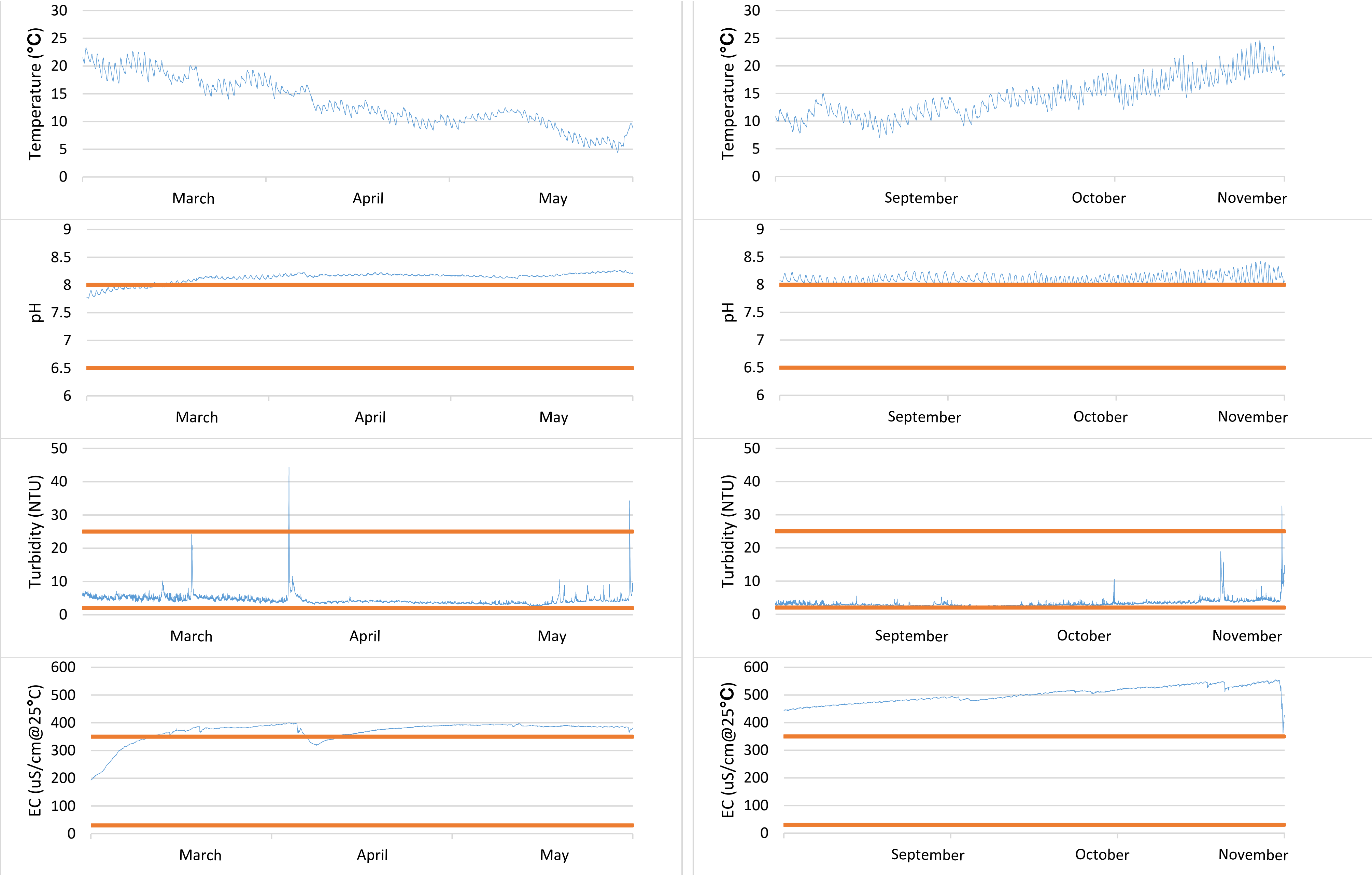


Figure 20 Continuous water quality records for autumn 2024 (left) and spring 2024 (right) from Burra Creek at Burra Road (410774). ANZG guideline values are in orange.

4.2.3 Periphyton

Photographs of periphyton at the Burra Creek monitoring sites are presented in Table 19. In general, there were no major differences in periphyton and filamentous algae coverage between upstream and downstream sites in either season.

In autumn, the upstream site had 65-90% periphyton coverage in the reach whilst the downstream site had 35-65% periphyton coverage. In contrast, the upstream site had <10% periphyton coverage of edge habitat, whilst the downstream site had 10-35% coverage. Filamentous algae coverage was also similar between sites, with <10% coverage observed in the reach and 10-35% in edge habitat at the upstream site, compared to 10-35% coverage in the reach and edge habitat at the downstream site.

***BUR1d* -** The periphyton coverage in autumn 2024 was 65-90% for the reach and riffle habitat and <10% for the edge habitat. In autumn 2024, filamentous algae coverage was <10% for the reach and riffle but 10-35% for the edge. Macrophyte coverage was 10-35% for the reach and riffle habitat but was higher in edge habitat with 35-65% coverage due to large beds of reeds (*Typha* spp. and *Phragmites australis*). In spring, riffle habitat was near absent so comparisons could not be made. However, periphyton and filamentous algae coverage were generally consistent with autumn, except for increased periphyton coverage in edge habitat. Periphyton coverage in spring increased to 10-35% for edge habitat and remained at 65-90% coverage across the reach. Macrophyte coverage also remained consistent between seasons.

***BUR2a* -** The periphyton coverage in autumn 2024 and spring 2024 was approximately 35-65% for the reach and 10-35% for the edge habitat. In autumn and spring 2024, filamentous algae coverage was 10-35% for the reach and edge habitat, with filamentous algae growing predominantly on submerged stems of emergent macrophytes. In autumn and spring 2024, macrophyte cover was >90% for the reach and 65-90% for the edge habitat. The dominant macrophyte was the sedge Great Bulrush (*Schoenoplectus validus*).

Table 19 ***Photographs showing periphyton coverage in Burra Creek***

Site	Autumn 2024	Spring 2024
BUR1d		
BUR2c		

4.2.4 Riparian Vegetation and Geomorphology

Geomorphological features at all Burra Creek sites have remained relatively unchanged since 2020/2021 (see Table 20 - Table 24). However, there was a general trend of increased macrophyte coverage and increased riparian vegetation growth and density. A summary of each site is as follows:

– BUR1a: Cutbank erosion has continued to progress the scarping and slumping of Burra Creek, continuing the migration of the creek towards Burra Road, and eroding the ground beneath the adjoining fence line (see Photo point 1, photo b and Figure 21). Note that BUR1a is upstream of the M2G discharge outlet so erosion is not influenced by M2G pumping. Riparian vegetation was observed to have been further established compared to 2020/2021 with increased vegetation density and tree size (see Table 20). This includes riparian vegetation within the banks of Burra Creek and outside of the creek line.

– BUR2: No obvious geomorphological changes were observed (see Table 21). Emergent macrophytes and riparian trees observed to have been further established in relation to extent and tree size (see Photo point 1 and 2). Compared to 2020/2021, a large willow downstream of Williamsdale Road has since died, and the extent of blackberry has expanded and prevented complete access to Photo point 3.

– BUR2a: No obvious geomorphological changes were observed with scarping of the right bank remaining in a similar condition to 2020/2021 (see Table 22, Photo point 2). Vegetation at the site was similar to previous monitoring.

– Pool 29: No obvious geomorphological changes were observed with significant areas of scarping on the left bank remaining in a similar condition to 2020/2021 (see Table 23, Photo point 1). The point bar visible at Photo point 1 was observed to have new Poplar (*Populus* spp.) growth after former poplars were dislodged and washed away during 2020. There were no other obvious features of intensified erosion or geomorphological change.

– BUR2C: The point bar at Photo point 2 showed some evidence of recent change with reduced groundcover vegetation and/or sand deposition (see Table 24). All other parts of Burra Creek at BUR2C appeared to be similar to 2020/2021 with significant areas of scarping on the left bank remaining in a similar condition to 2020/2021 (see Photo point 2 and 3). Compared to 2020/2021, the extent of macrophytes was observed to be greater and the establishment and continued growth of Poplars in the riparian zone was also evident at Photo point 3.

Figure 21 Bank erosion at BUR1a

Table 20 Geomorphology at BUR1a

Photo		2020/2021	Autumn 2024	Spring 2024
Photo point 1	A			
	B			
	C			

Photo		2020/2021	Autumn 2024	Spring 2024
Photo point 2	A			
	B			
	C			

Photo		2020/2021	Autumn 2024	Spring 2024
Photo point 3	A			
	B			
	c			

Table 21 Geomorphology at BUR2

<table>
<tr><th colspan="2">Photo</th><th>2020/2021</th><th>Spring 2024</th></tr>
<tr><td rowspan="3">Photo point 1</td><td>A</td><td></td><td></td></tr>
<tr><td>B</td><td></td><td></td></tr>
<tr><td>C</td><td></td><td></td></tr>
</table>

Photo point 2	A		
	B		
	C		

Photo point 3	A		
	B		
	C		

Note: Photographs from Autumn 2024 were lost during the upload process so are unable to be presented.

Table 22 Geomorphology at BUR2a

Photo		2020/2021	Autumn 2024	Spring 2024
Photo point 1	A			
	B			
	C			

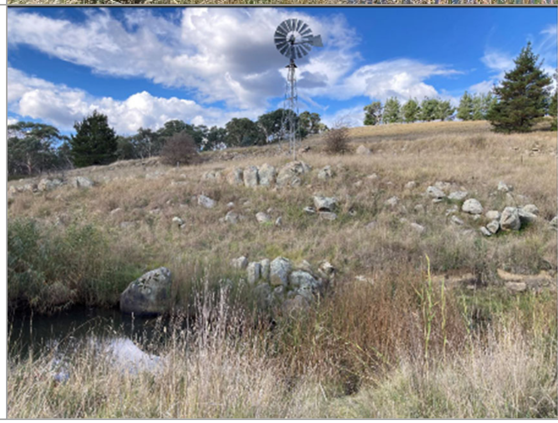
Photo point 2	A			
	B			
	C			

Table 23 Geomorphology at Pool 29

Photo		2020/2021	Autumn 2024	Spring 2024
Photo point 1	A			
	B			
	C			

Photo point 2	A			
	B			
	C			

Photo point 3	A			
	B			
	C			

Table 24 Geomorphology at BUR2C

Photo		2020/2021	Autumn 2024	Spring 2024
Photo point 1	A			
	B			
	C			

Photo point 2	A			
	B			
	C			

Photo point 3				
	A			
	B			
	c			

Photo point 4	A			
	B			
	C			

4.2.5 Macroinvertebrates

4.2.5.1 Biological indices

There is minimal riffle habitat in this reach of Burra Creek and low flow conditions reduced the availability of riffle habitat present. Therefore, no riffle samples were collected for either site in spring 2024. A riffle sample was collected for BUR1d but not BUR2a in autumn 2024. The total taxa richness for M2G sites in Burra Creek are presented in Table 25. Across the two seasons, total taxa richness ranged from 19 to 27 at family level resolution and 21 to 27 at genus level resolution. For edge habitats, there were no noticeable differences in taxa richness between the two seasons. There was no consistent pattern in the data indicating differences in taxa communities when comparing sites upstream and downstream of the discharge point for edge habitats.

Table 25 Total number of taxa from samples upstream and downstream of the M2G outlet in Burra Creek

Location	Site	Sample	Autumn 2024		Spring 2024	
			Family	Genus	Family	Genus
Upstream	BUR1d	1	26	27	20	24
		2	19 (riffle)	21 (riffle)	21	24
Downstream	BUR2a	1	27	27	24	24
		2	26	26	20	24

The EPT richness for Burra Creek sites is presented in Table 26. Across the two seasons, EPT richness ranged from 4 to 7 at family level resolution and 4 to 7 at genus level resolution. EPT richness was slightly higher in autumn 2024 compared to spring. As was found for total taxa richness, there was no consistent pattern in the data indicating sites downstream of the discharge point had different EPT diversity than upstream.

Table 26 Total number of EPT taxa from riffle habitats

Location	Site	Sample	Autumn 2024		Spring 2024	
			Family	Genus	Family	Genus
Upstream	BUR1d	1	5	5	4	5
		2	6 (riffle)	6 (riffle)	6	6
Downstream	BUR2a	1	7	7	4	4
		2	6	6	4	5

The SIGNAL-2 and AUSRIVAS results for the Burra Creek sites are presented in Table 27. SIGNAL-2 ranged from 3.6 to 4.8 across the two seasons. Although there were often higher SIGNAL-2 scores in autumn 2024 compared to spring 2024, this was not consistent across all samples. During both seasons, both upstream and downstream sites were given an overall AUSRIVAS Band B that possibly suggests significant impairment and fewer families than expected. Overall, there was no consistent pattern in the data indicating sites downstream of the discharge point had different SIGNAL-2 scores or AUSRIVAS scores than upstream.

Table 27 SIGNAL-2 scores, AUSRIVAS scores and bandings for samples

	Site	BUR1d		BUR2a	
	Sample	1	2	1	2
SIGNAL-2 score	Autumn 2024	3.9	4.8 (riffle)	4.1	4.3
	Spring 2024	3.6	3.7	3.7	3.9
AUSRIVAS O/E score	Autumn 2024	0.94	0.87 (riffle)	0.80	0.72
	Spring 2024	0.93	0.93	0.86	0.86
AUSRIVAS Band	Autumn 2024	A	B (riffle)	B	B
	Spring 2024	B	B	B	B
Overall habitat assessment	Autumn 2024	B		B	
	Spring 2024	B		B	

Table 28 presents AUSRIVAS Bands for Burra Creek since 2012, indicating that these sites were typically placed in Band B, and on occasion Band A. The results of the 2024 monitoring are similar to previous years. The two seasons of sentinel monitoring did not detect any differences between upstream and downstream sites in 2024.

Table 28 Overall site assessments for Burra Creek sites since 2012

Year	Season	Upstream		Downstream	
		BUR 1b	BUR 1d	BUR 2	BUR 2a
2012	Autumn		B	B	
2012	Spring		B	A	
2013	Autumn		B	B	
2013	Spring		B	A	
2014	Autumn		B	B	
2014	Spring		A	A	
2015	Autumn		B	B	
2015	Spring		X	A	
2018	Autumn		B	B	
2018	Spring		B	B	
2019	Autumn	B	B	B	C
2019	Spring	B	B	B	B
2020	Autumn	B	B	B	B
2020	Spring	B	A	A	B
2021	Autumn	C	C	B	B
2024	Autumn		B		B
2024	Spring		B		B

4.2.5.2 Multivariate analysis – community composition

The NMDS ordination of macroinvertebrate community samples from riffle habitats from the sentinel monitoring (2015, 2018 and 2024) and impact monitoring (2019, 2020 and 2021) are presented in Figure 22. Note that each point on the NMDS represents a multivariate macroinvertebrate sample (i.e. all taxa collected and their abundances) and those samples close together have a more similar community composition than those further apart.

The spread of samples on the ordination highlights that there were some differences between years, particularly in 2024 that was most different from all other years[7]. Within each year there also tended to be differences in the community composition between autumn and spring. However, within each season, there were no consistent differences between samples collected upstream and downstream of the M2G discharge point into Burra Creek. That is, the upstream samples were not always separated from the downstream samples that would suggest there were differences in the macroinvertebrate communities amongst the two locations.

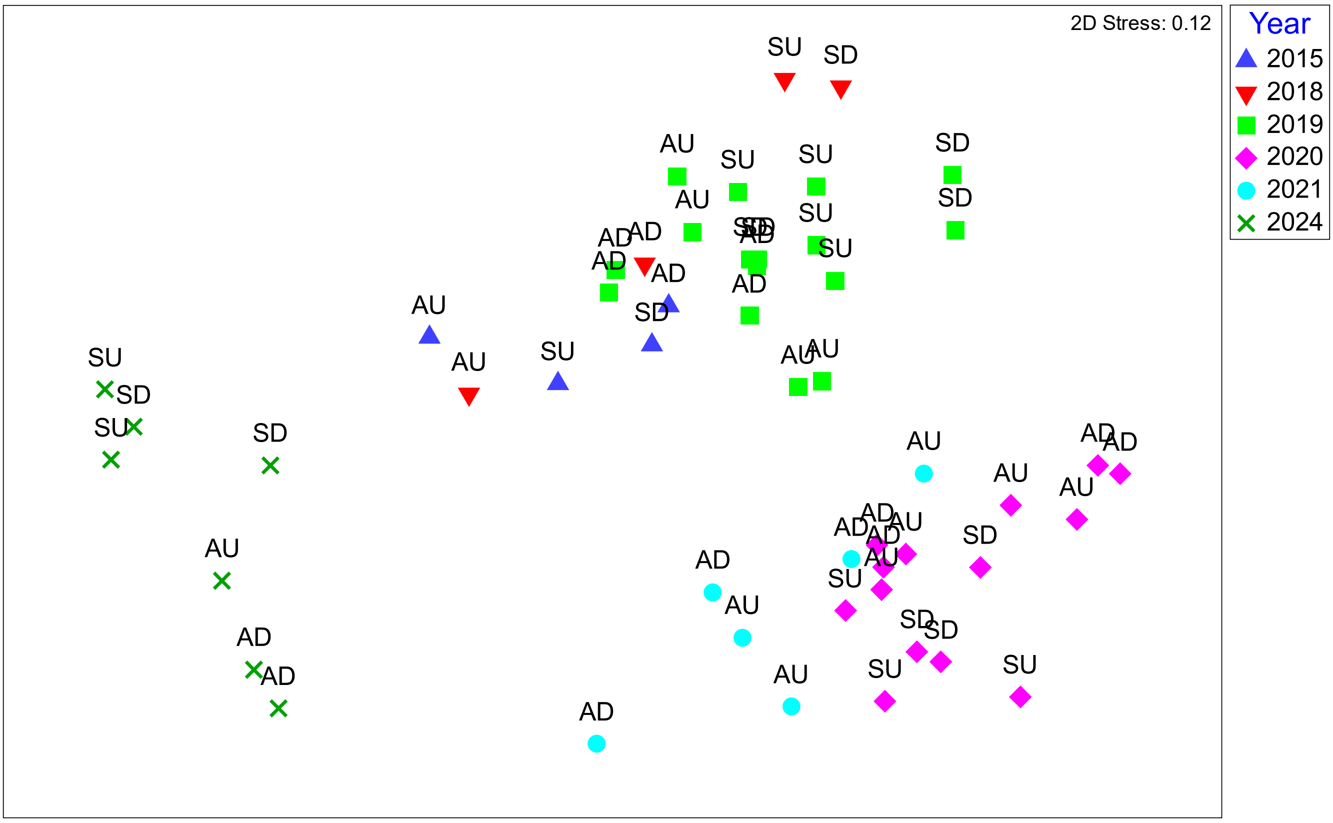


Figure 22 *MDS ordination of macroinvertebrate communities associated with edge habitats. A = autumn and S = spring; U = upstream and D = downstream*

The patterns on the NMDS were confirmed by the PERMANOVA that detected significant differences between years (Pseudo-F 3.3, P = 0.002), and seasons within each year (Pseudo-F 3.8, P = 0.001). However, there was an interaction between season and locations meaning differences upstream and downstream of the abstraction point where not consistent in each season (Pseudo-F 1.5, P = 0.05). Despite this, pairwise comparisons did not detect any significant differences upstream and downstream of the M2G discharge point in any season. Given there were no obvious or statistical differences upstream and downstream of the M2G discharge, no SIMPER analyses have been undertaken.

4.2.6 Fish

The 2023 monitoring of Common Carp in the Googong Reservoir catchment surveyed 14 sites, including 10 sites between the M2G discharge point in Burra Creek through to the Burra Creek arm of the upper Googong Reservoir and four sites in the Queanbeyan River (GHD, 2023). Common Carp were only detected at two sites, both of which were the furthest downstream locations surveyed in Burra Creek.

4.3 Component 3: MPS

Monitoring of the Murrumbidgee sites as part of the MPS component was completed on 15 April 2024 (autumn) and 29 November 2024 (spring).

[7] As discussed in Section 3.4.2, the year-to-year differences are in part due to taxonomy differences during sample processing

4.3.1 Rainfall and hydrology

Overall, in the two seasons that monitoring occurred there was lower rainfall compared to historical averages (Table 25). Both seasons presented similar rainfall conditions, each with infrequent periods of minor to moderate rainfall events and similar total rainfall volumes. Rainfall in the region was generally reflected by corresponding changes in flow in the Murrumbidgee River (Table 25).

During autumn 2024, there was a high flow event in April and again in May, each following substantial rainfall and peaking at approximately 3045 and 3812 ML/d at Mt MacDonald, respectively (Figure 23). Autumn 2024 monitoring was undertaken in mid-April following the recession of the first seasonal high flow event, with discharge falling to 780 ML/d at Mt MacDonald at the time of sampling after peaking at 3045 ML/d six days earlier. Aside from these two major flow events, rainfall and corresponding flows were below average throughout the remainder of the season with seasonal discharge averaging 735 ML/d compared to the historical annual average of 1,531 ML/d at Mt MacDonald between 2008 to 2024.

Throughout spring 2024, average flow was lower than the preceding autumn with average daily flow generally decreasing as the season progressed (Figure 24). There was one single high flow event during spring 2024, which occurred in late September with a peak daily average flow of approximately 2077 ML/d at Mt MacDonald. Aside from this high flow event, seasonal flow was below average, with mean daily discharge falling to 232 ML/d at Mt McDonalds and 135 ML/d at Lobb's Hole in mid-November. Spring 2024 monitoring was undertaken in late November which coincided with very low discharge of 208 ML/d at Mt MacDonald and 145 ML/d at Lobb's Hole. An average seasonal discharge of 638 ML/d was significantly lower than the historical annual average of 1,531 ML/d at Mt MacDonald between 2008 to 2024.

Table 29 Autumn and spring 2024 rainfall and discharge summaries, Lobbs Hole, Cotter River and Mt MacDonald

Season	Month	Lobbs Hole (570985/410761)		Cotter River at Kiosk (410700)	Mt MacDonald (410738)
		Rainfall total (mm)	Mean discharge (ML/d)	Mean flow (ML/d)	Mean discharge (ML/d)
Autumn 2024	March	37.6	226.5	31.2	359.9
	April	59	587.5	76.2	838.8
	May[8]	32	871.9	60.6	1010.9
	Season total/average	128.6	561.7	55.8	735.4
Historical autumn monthly average		48.9	-	-	-
Spring 2024	September	24	561.4	180.8	838.0
	October	31.7	422.1	128.3	647.1
	November	88	198.8	120.9	567.3
	Season total/average	143.7	394.4	143.2	637.8
Historical spring monthly average		62.1	-	-	-

[8] Data was not available for eight days between 30 April and 7 May 2024. Data for these days was instead obtained from Gudgenby River at Tennent (570970).

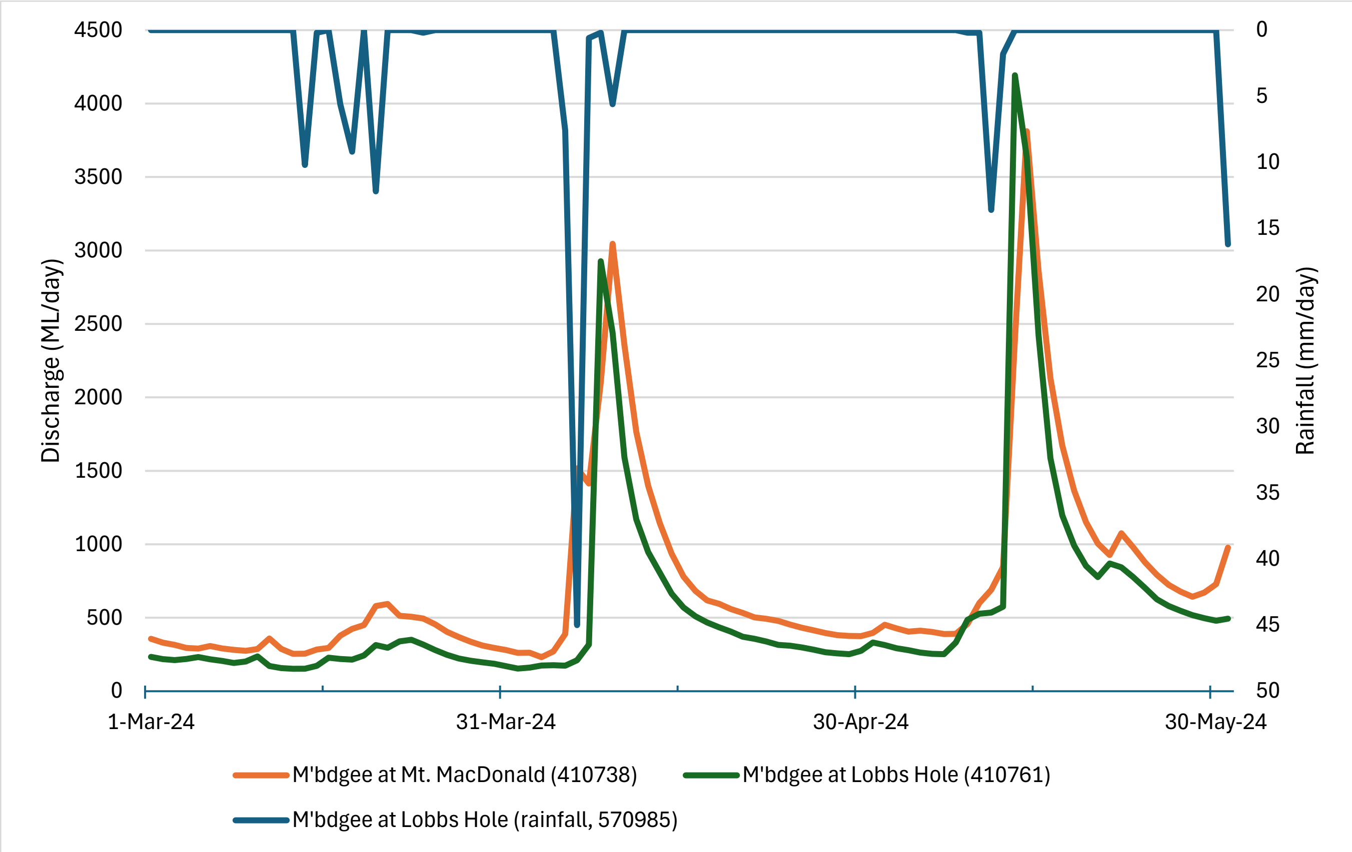


Figure 23 ***Rainfall and hydrograph of the Murrumbidgee River upstream (410761) and downstream (410738) of MPS in autumn 2024***

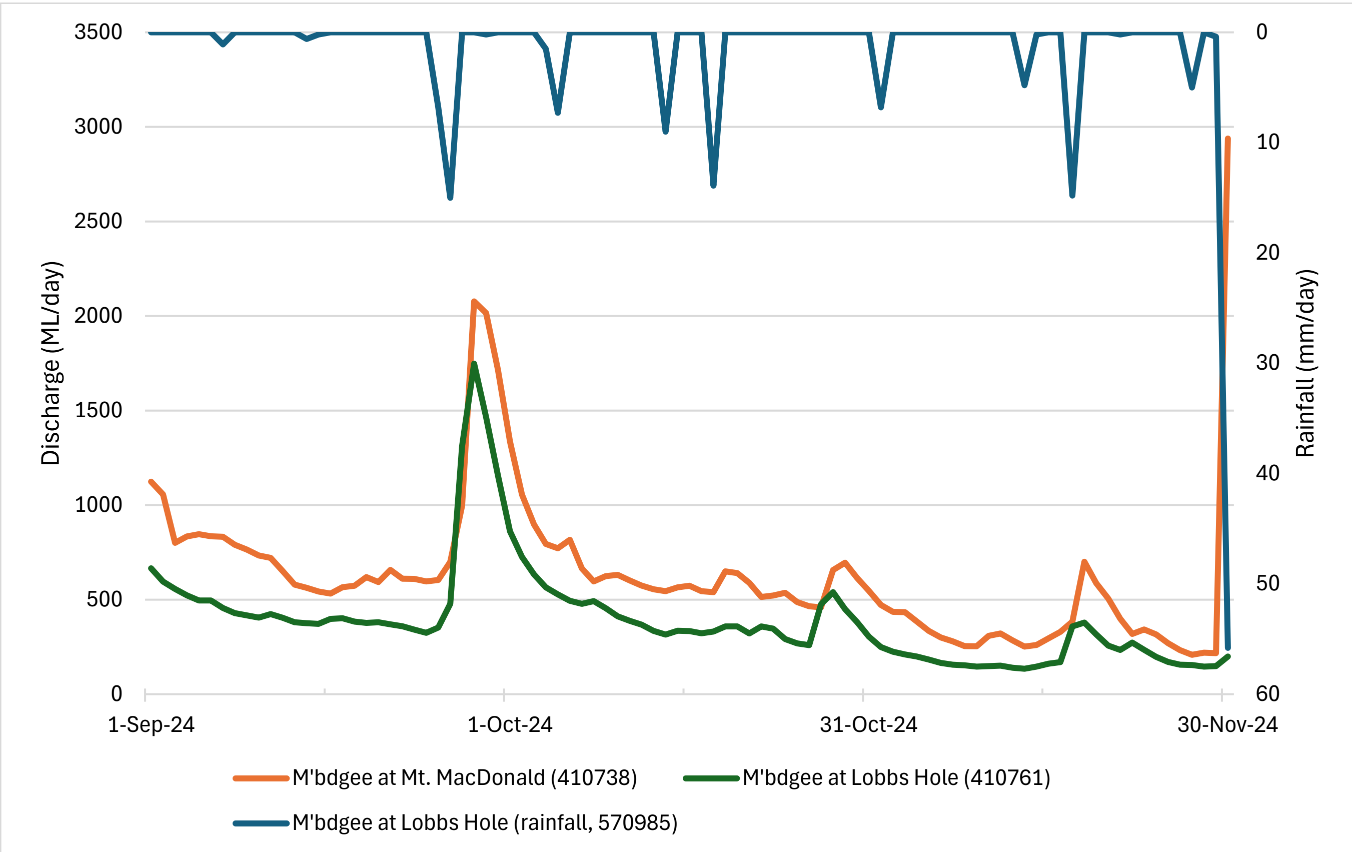


Figure 24 ***Rainfall and hydrograph of the Murrumbidgee River upstream (410761) and downstream (410738) of MPS in spring 2024***

4.3.2 Water quality

4.3.2.1 In-situ monitoring

In situ and grab sample water quality results are presented in Table 30 and provide a snapshot of conditions during 2024 sentinel monitoring. Overall, the results present similar water quality between upstream and downstream sites with some seasonal differences observed.

The results showed elevated concentrations of nutrients, however, there were no obvious trends between seasons or upstream and downstream sites. In autumn 2024, the upstream site was below ANZG guideline values for TN and TP, whereas the downstream site exceeded ANZG guideline values for TN and TP. In spring, both sites exceeded the guideline value for phosphorous, but only the downstream site exceeded the guideline value for TN. All ammonia and NO_x measurements were well within guideline values at both sites and in both seasons.

At the upstream site, pH was 8.0 in both seasons, whereas at the downstream site pH was 8.2 in both seasons. During spring 2024, DO was relatively low at both sites and was slightly below the ANZG guideline value at the downstream site. All other water quality parameters were within guideline values at all sites and for all seasons. Other seasonal differences in water quality included elevated temperatures and slightly elevated turbidity in spring, and although detected in low concentrations manganese was also higher in spring compared to autumn. While detected in low concentrations, ammonia had lower concentrations in spring.

4.3.2.2 Continuous monitoring

Continuous monitoring data for the MPS is obtained from the gauging station on the Murrumbidgee River at Lobb's Hole (downstream of Angle Crossing). This station is also used for continuous monitoring data for Component 1. Therefore, for a description of continuous water quality for Component 3 refer to Section 4.1.2.2 and Figure 9 and Figure 10.

Table 30 In-situ water quality results from MPS sites with red cells outside ANZG (2018) default guideline range

Location	Site	Sampling period	Date	Time	Temp (°C)	EC (µs/cm)	Turbidity (NTU)	pH	D.O. (% Sat.)	D.O. (mg/L)	Alkalinity (mg/L)	NO_x (mg/L)	TP (mg/L)	TN (mg/L)	Ammonia	Total Iron	Total manganese
ANZG (2018) default guideline values						**30-350**	**2-25**	**6.5-8.0**	**90-110**			**0.015**	**0.02**	**0.25**	**0.9**		**1.9**
Upstream	MUR28	Autumn 2024	15/04/2024	1015	12.5	95	7	8.0	99.3	10.5	80	<0.01	<0.01	0.2	0.09	0.16	0.010
		Spring 2024	29/11/2024	0900	24.3	129	11	8.0	90.7	7.6	100	<0.01	0.04	0.4	0.026	0.24	0.081
Downstream	MUR935	Autumn 2024	16/04/2024	1315	17.2	143	9	8.2	100.8	9.7	80	<0.01	0.04	0.5	0.02	0.49	0.037
		Spring 2024	29/11/2024	1045	23.7	119	11	8.2	89.6	7.6	100	<0.01	0.03	0.2	0.011	0.19	0.090

Note: Water Temperature (Temp.), Electrical Conductivity (EC), Dissolved Oxygen (DO), percentage saturation (% Sat.), Nitrite + Nitrate as N (NO_x), Total Nitrogen as N (TN), Total Phosphorus as P (TP)

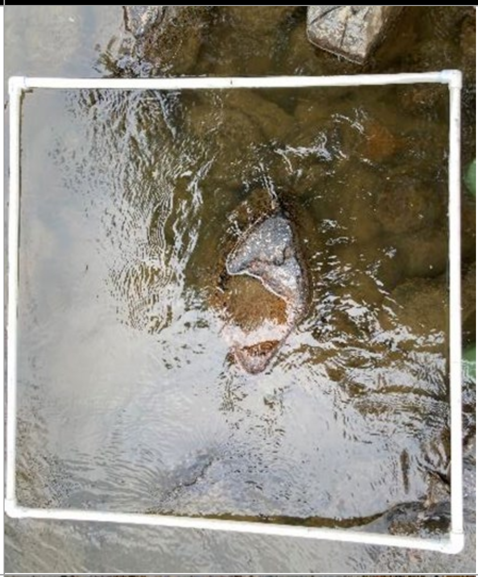
4.3.3 Periphyton

Photographs of periphyton at the MPS monitoring sites are presented in Table 31. There was no consistent indication of increased periphyton downstream of the MPS abstraction point compared to upstream. In autumn 2024, periphyton coverage was higher downstream but in spring 2024 periphyton coverage was lower downstream. At both sites, filamentous algae coverage and macrophyte coverage was low in both seasons. Note that due to the sampling of MUR28down in autumn 2024 and MUR28up in spring 2024, caution should be made in interpreting periphyton results.

***MUR28up* –** The periphyton coverage in autumn 2024 was <10% for the reach and the riffle habitat. During spring 2024, periphyton coverage was 65-90% for the reach and riffle habitat. This discrepancy is likely attributable to the selection of sampling site MUR28down rather than MUR28up during the autumn surveys. The MUR28down site was characterised by a predominantly sandy and gravelly substrate, with a limited presence of boulders. Filamentous algae coverage and macrophyte coverage was <10% for both seasons.

***MUR935* -** The periphyton coverage in autumn 2024 and spring 2024 was approximately 35-65% for the reach but differed between seasons for the riffle. In autumn 2024, periphyton coverage was 10-35% for the riffle habitat. However, similar to MUR28up, periphyton coverage increased in spring and had 35-65% coverage of the riffle habitat. Filamentous algae coverage and macrophyte coverage was <10% for both seasons.

Table 31 Photographs showing periphyton coverage in riffles of the Murrumbidgee River at M2G sites

Site	Autumn 2024	Spring 2024
MUR28		
MUR935		

4.3.4 Macroinvertebrates

4.3.4.1 Biological indices

There is minimal edge habitat in this reach of the Murrumbidgee River and therefore no edge samples were collected in either season of monitoring. The total taxa richness for MPS sites in the Murrumbidgee River are presented in Table 32. Across the two seasons, total taxa richness ranged from 16 to 20 at family level resolution and 18 to 23 at genus level resolution. Overall, there is no indication of higher diversity during either season and no consistent pattern in the data indicating sites downstream of the MPS on the Murrumbidgee River had different taxa diversity than upstream.

Table 32 Total number of taxa from riffle habitats

Location	Site	Sample	Autumn 2024		Spring 2024	
			Family	Genus	Family	Genus
Upstream	MUR28up	1	NA	NA	20	23
		2	NA	NA	17	22
	MUR28down	1	19	21	NA	NA
		2	20	18	NA	NA
Downstream	MUR935	1	NA	NA	16	21
		2	NA	NA	16	22
	MUR936	1	18	19	NA	NA
		2	18	18	NA	NA

The EPT richness for Murrumbidgee River sites is presented in Table 33. Across the two seasons, EPT richness ranged from 6 to 9 at family level resolution and 6 to 10 at genus level resolution. EPT richness was slightly higher in spring 2024 compared to autumn 2024. As was found for total taxa richness, there was no consistent pattern in the data indicating sites downstream of the discharge point or the Cotter River confluence had lower EPT diversity than upstream.

Table 33 Total number of EPT taxa from riffle habitats

Location	Site	Sample	Autumn 2024		Spring 2024	
			Family	Genus	Family	Genus
Upstream	MUR28up	1	NA	NA	7	9
		2	NA	NA	7	8
	MUR28down	1	9	9	NA	NA
		2	6	7	NA	NA
Downstream	MUR935	1	NA	NA	8	10
		2	NA	NA	7	9
	MUR936	1	6	6	NA	NA
		2	6	7	NA	NA

The SIGNAL-2 and AUSRIVAS results for the MPS sites are presented in Table 34. SIGNAL-2 Scores ranged from 4.4 to 5.3 across the two seasons, but there were no noticeable differences between the seasons. Most sites in all seasons were allocated to AUSRIVAS Band B that possibly suggests significant impairment and fewer families than expected. This could be due to potential impacts on water and/or habitat quality.

Autumn 2024 AUSRIVAS analyses indicated that the predictor variables were outside the experience of the model and consequently, OE50 scores and AUSRIVAS Bands could not be generated for MUR28down. Overall, there was no consistent pattern in the data indicating sites downstream of the MPS or Cotter River confluence had different SIGNAL-2 scores or AUSRIVAS scores than upstream.

Table 34 SIGNAL-2 scores, AUSRIVAS scores and bandings from riffle habitats

	Location	Upstream				Downstream			
	Site	MUR28up		MUR28down		MUR935		MUR936	
	Sample	1	2	1	2	1	2	1	2
SIGNAL-2 score	Autumn 2024	NA	NA	5.3	4.8	NA	NA	4.8	4.6
	Spring 2024	4.4	4.5	NA	NA	4.6	4.6	NA	NA
AUSRIVAS O/E score	Autumn 2024	NA	NA	OEM	OEM	NA	NA	0.92	0.92
	Spring 2024	0.89	0.89	NA	NA	0.82	0.93	NA	NA
AUSRIVAS Band	Autumn 2024	NA	NA	OEM	OEM	NA	NA	B	A
	Spring 2024	B	B	NA	NA	B	B	NA	NA
Overall habitat assessment	Autumn 2024	NA		OEM		NA		B	
	Spring 2024	B		NA		B		NA	

Table 35 presents AUSRIVAS Bands for the Murrumbidgee River since 2012. Historically, all sites generally have been allocated to Band A or Band B. The results of the 2024 monitoring are similar to previous years with no consistent differences between sites upstream and downstream of the MPS.

Table 35 Overall AUSRIVAS assessments for MPS sites since 2011(indicates riffle habitats only)*

	Location	Upstream		Downstream	
		MUR28up	MUR 28down	MUR935	MUR936
Autumn	2011		B	B	
Spring	2011		B	B	
Autumn	2012		B	NRA	
Spring	2012		B	B	
Autumn	2013		B	B	
Autumn	2015		A	A	
Spring	2015		B	B	
Spring	2019*		A	A	
Autumn	2020*	B	B	B	B
Spring	2020*	B	B	B	B
Autumn	2021*	B	B	B	B
Autumn	2024*		OEM		B
Spring	2024*	B		B	

NRA = no reliable assessment, Bands were significantly different between habitats.

4.3.4.2 Multivariate analysis – community composition

The NMDS ordination of macroinvertebrate community samples from riffle habitats from the sentinel monitoring (2015, 2018 and 2024) and impact monitoring (2019, 2020 and 2021) are presented in Figure 25. Note that each point on the NMDS represents a multivariate macroinvertebrate sample (i.e. all taxa collected and their abundances) and those samples close together have a more similar community composition than those further apart.

The spread of samples on the ordination highlights that there were some differences between years, particularly in 2024 that was most different from all other years[9]. Within each year there also tended to be differences in the community composition between autumn and spring. However, within each season, there were no consistent differences between samples collected upstream and downstream of the MPS. That is, the upstream samples were not always separated from the downstream samples that would suggest there were differences in the macroinvertebrate communities amongst the two locations.

Despite the clear separation of 2024 from other years on the NMDS, the PERMANOVA did not detect significant differences amongst years. This is likely due to the large degree of overlap of samples from all other years. Within each year, there were significant differences amongst seasons (Pseudo-F = 6.4, P = 0.001), but there was no interaction between season and location which suggests that patterns between the upstream and downstream locations were consistent within each season. However, there were no significant differences in the macroinvertebrate community upstream and downstream of the MPS. Given there were no obvious or statistical differences upstream and downstream of the MPS point, no SIMPER analyses have been undertaken.

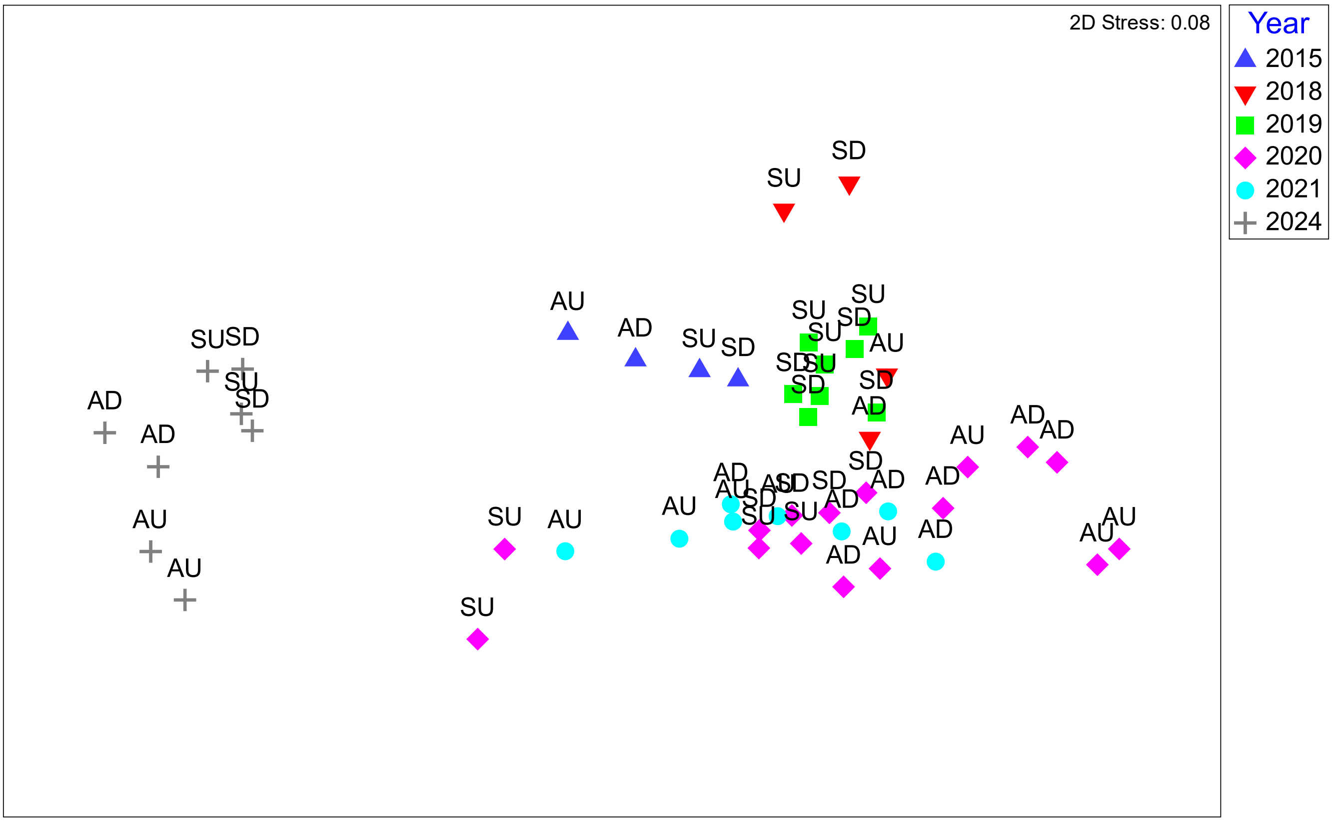


Figure 25 ***MDS ordination of macroinvertebrate communities associated with riffle habitats. A = autumn and S = spring; U = upstream and D = downstream***

[9] As discussed in Section 3.4.2, the year-to-year differences are in part due to taxonomy differences during sample processing

5. Discussion

5.1 Component 1: Angle Crossing (M2G)

5.1.1 Rainfall and hydrology

Overall, in the two seasons that monitoring occurred, there was lower rainfall and river discharge compared to historical averages, particularly in spring. Both seasons presented similar rainfall and discharge conditions, each with infrequent periods of minor to moderate rainfall events and similar total rainfall volumes. In Autumn, mean daily discharge rates at Lobb's Hole varied from 152 ML/d to 4200 ML/y, and averaged 562 ML/d for the year, which is lower than the yearly mean average of 962 ML/d. In Spring, mean daily discharge rates at Lobb's Hole varied from 135 ML/d to 1750 ML/d, and averaged 394 ML/d for the year, which is substantially lower than the historical yearly mean average of 962 ML/d.

Throughout both seasons, river flow at Lobb's Hole was approximately 10-14% greater downstream than that recorded at Angle Crossing. There was no abstraction associated with the M2G during either of the two seasons that monitoring occurred. However, there were three maintenance runs throughout financial year 2023-2024 which occurred in September 2023 and then on either side of autumn monitoring in February 2024 and June 2024. Combined abstraction from these maintenance runs totalled 325 ML (Icon Water, 2024). Therefore, differences in flow upstream and downstream of the abstraction point would have been related to natural downstream inflows and not influenced by pumping. Despite this, the magnitude of differences in flow are not considered large enough to lead to flow induced differences between the upstream and downstream sites. Additionally, in the absence of abstraction, the flows immediately downstream of Angle Crossing at MUR19 are expected to be generally consistent with those at MUR18. As such, valid comparisons of river health can be made between the two locations.

5.1.2 Water quality

Both M2G sites had high nutrient loads with TN and TP exceeding ANZG guideline values at both sites in both seasons. Elevated nutrient levels are typical of the Murrumbidgee River, with elevated nutrients regularly recorded during monitoring for the MEMP. Although TN was elevated, oxidised forms of nitrogen (NO_x) were mostly within ANZG guideline values. Nutrient levels observed in 2024 are not considered to be unusually high compared to previous seasons.

Differences in pH were observed between seasons, with pH elevated above ANZG guideline values at both sites in autumn. Elevated pH in autumn is likely related to reduced photosynthesis and resultant carbon dioxide capture compared to spring. Although pH was elevated in autumn, this is consistent with historical monitoring results for the Murrumbidgee River. Turbidity was also sporadically above ANZG guideline values in both seasons and is related to rainfall events and increased flows. Alternatively, pH and EC generally decreases during elevated rainfall and flow periods. All other water quality parameters were within ANZG guideline values, where available, and were generally consistent with historical results.

Overall, the results demonstrated that there was similar water quality at upstream and downstream locations except for slightly higher nutrient concentrations (TN, TP, NO_x and ammonia) generally being observed upstream compared to downstream. This could be a result of increased nutrient uptake by plants and/or settlement in the large pool immediately upstream of Angle Crossing.

5.1.3 Periphyton

While some seasonal differences were observed in periphyton and filamentous algae coverage between upstream and downstream sites, both sites were generally similar, except for elevated periphyton at upstream site MUR18 in autumn. Elevated periphyton coverage at MUR18 in autumn is potentially a result of water levels forming broad areas of still and slow flowing water. Similarly, MUR18 had higher filamentous algae coverage in spring only, potentially due to reduced turbulence under low flow conditions. The differences in periphyton and filamentous algae coverage between upstream and downstream sites is likely due to differences in site flow characteristics and substratum composition. For example, MUR18 is deeper (slower flows on average) and has more widespread bedrock and boulders compared to MUR19. These differences are also likely to explain differences in filamentous algae and macrophyte coverage between the sites, with higher filamentous algae coverage observed upstream but higher macrophyte coverage observed downstream. The reduced macrophyte coverage observed in spring may have also been influenced by lower flow volumes allowing more comprehensive access and visibility of the riffle in contrast to higher flows in autumn restricting access to the faster flowing parts of riffle habitat that are less likely to be suitable for macrophytes.

Periphyton and filamentous algae coverage in autumn and spring 2024 was higher than previous monitoring in 2020 and 2021 but is generally consistent with previous monitoring. Elevated periphyton and filamentous algae coverage is likely to be due to reduced flows throughout the monitoring season and is not considered to have been nuisance algae growth.

5.1.4 Geomorphology

The geomorphology of MUR19 was observed to be generally consistent between seasons and with past monitoring seasons dating back to 2015. While reduced water levels exposed small areas of bare ground, and while there has been some loss of willow trees on the southern bank, there was no notable erosion, incising, scouring or scarping observed. Compared to previous years, recruitment of several small and scattered shrubs on the southern bank and continued growth of sedge and shrub vegetation on the northern bank was evident. The establishment of these native vegetation communities has likely been supported by low flow conditions. Continued growth of these vegetation communities will likely improve ongoing stability and erosion resistance.

Operation of the M2G is unlikely to increase erosion risk due to the anticipated reduction in shear forces and flow volumes resulting from abstraction. The main risks to geomorphic features downstream of Angle Crossing is considered to be natural flow variation, including high flows, rather than changes from operation of the M2G. It is noted that the geomorphology photos for MUR19 predominantly capture the condition of bank geomorphology. However, the main anticipated impacts of flow abstraction are unlikely to be increased bank erosion, but rather modification to in stream scouring and deposition patterns, including impacts to substrate composition. That being said, it is recommended that photo points be modified to capture instream morphology, including key channelisation and depositional features.

5.1.5 Macroinvertebrate communities and river health assessment

Habitat conditions in the Murrumbidgee River limited the availability of edge habitats for sampling; consequently, river health assessments were primarily based on riffle habitat. Univariate indices revealed no consistent trend indicating differences in river health downstream of Angle Crossing compared to upstream. The indices primarily reflected seasonal variation in macroinvertebrate community composition. Historically, most sites across all seasons were assigned to AUSRIVAS Band B, indicating significant impairment and a lower number of taxa than expected, potentially due to water and/or habitat quality degradation. Multivariate community analyses found minimal differences in macroinvertebrate communities upstream and downstream of the Murrumbidgee to Googong (M2G) abstraction point.

Overall, the condition of impact sites appears broadly comparable to non-impact sites over time. Observed differences are likely attributable to seasonal fluctuations, particularly improved river health during the more productive spring period. Given the continued comparability between sites, no re-establishment of baseline conditions is deemed necessary. However, sentinel monitoring at three-year intervals is recommended to ensure ongoing suitability of sites for future comparisons.

5.1.6 Fish

The 2023 fish monitoring surveys included an increase in total fish numbers captured compared to surveys in 2021, but a reduced number of fish species. Compared to 2021, the 2023 surveys did not detect native species Australian Smelt and Western Carp Gudgeon and the non-native Gambusia. However, unlike 2021, the 2023 surveys involved the capture of Macquarie Perch and a suspected Trout Cod / Murray Cod hybrid. While, Common Carp (*Cyprinus carpio*) dominated most sites, there was strong recruitment by Murray Cod, particularly at upstream site Scottsdale. Scottsdale is the furthest upstream site and was dominated by Murray Cod. The strong recruitment of Murray Cod is likely to be a result of the elevated flows that occurred during 2022 and 2023. Similarly, a broader distribution of Golden Perch is likely to have been a result of high flows providing opportunities for upstream migration. In contrast, Murray Cod YOY recruits were observed to occur almost exclusively at sites above Point Hut and were most prevalent at the most upstream sites. It is not clear why this is the case and why limited recruitment has been observed at downstream sites. However, downstream sites are likely to be the most impacted by sand slugs and other barriers to movement (e.g. Angle Crossing and Point Hut Crossing causeways), particularly under low flow conditions. It may be expected that native fish recruitment is observed to be low in the upcoming 2025 fish surveys. However, due to the M2G not operating since 2020, observations in fish assemblages observed in the 2023 surveys and to be observed in 2025 surveys are unlikely to be influenced by the M2G.

5.2 Component 2: Burra Creek (M2G)

5.2.1 Rainfall and hydrology

Overall, in the two seasons that monitoring occurred there was lower rainfall compared to historical averages, particularly in spring. Both seasons presented similar rainfall conditions with similar overall rainfall volumes and infrequent rainfall events. This is generally typical of Burra Creek, which in previous years has been ephemeral with days of zero flow. In contrast, high flow events can be of significantly greater magnitude compared to average conditions. For example, discharge in November 2010 resulted in average daily discharge peaking at approximately 3869 ML/d. This variability is captured in the comparison of historical mean average discharge (11.2 ML/d) against the historical median (2.1 ML/d). In autumn and spring 2024, there were zero days of no flow and intermittent days of elevated flows, which were small in comparison to historical high flow events, such as that in 2010.

In comparison of mean average and median results for autumn and spring 2024, both measures of average discharge were similar. In autumn, mean average discharge was 2.1 ML/d compared to a median of 2.4 ML/d. In spring, mean average discharge was 1.4 ML/d compared to a median of 1.6 ML/d. These results demonstrate the relative regularity of flows throughout both seasons and lack of major flow events in comparison to other seasons. Although seasonal flows were low compared to previous years, the consistency of flows is likely to have resulted in consistent conditions for macroinvertebrate communities and other ecological elements throughout each season. Therefore, the results recorded at the time of monitoring in autumn and spring 2024 are likely to be generally representative of the longer term conditions occurring more broadly through the season and are less likely to have been influenced by short term events such as drought and high flows.

5.2.2 Water quality

Water quality in Burra Creek had elevated concentrations of nitrogen, including TN and oxidised forms of nitrogen (NO_x) that exceeded the ANZG guideline value at upstream and downstream sites in both seasons. This is consistent with historical observations, which also includes elevated concentrations of TP, elevated pH and EC and low DO. These characteristics were also observed in 2024 monitoring with pH, EC and DO occurring outside of ANZG guideline values during both monitoring seasons. Nutrients have historically been shown to become elevated under low flows and conversely, following runoff events and high flows. Continuous monitoring also demonstrates that rainfall events contribute to increased turbidity and DO and decreased pH and EC.

While there were no seasonal trends or obvious upstream and downstream differences, the downstream site BUR2a was observed to have greater seasonal variability in DO. Variability in DO is likely due to differences in water temperature, turbulence generated by flow, and the breakdown of organic material. For example, water temperatures was substantially different between sites in both seasons, and in both seasons higher DO corresponded with lower temperatures.

The creek channel at Burra Creek at BUR2a is constricted along the edge of a heavily vegetated and muddy river bar which is exposed under low flow conditions. Small patches of sheen were present in muddy areas of dense macrophyte above the flowing water line at BUR2a in both seasons. These areas appear to be high in organic content and are inferably breakdown products from oxidising bacteria in the absence of higher flows. These sheens are a natural biproduct of bacterial degradation of organic matter and are not of concern to the health of Burra Creek. However, increased degradation of organic matter, as exacerbated by low flow conditions (see Section 4.2.1), is expected to have contributed to reduced DO at both sites, especially at BUR2a. In addition to degradation processes, daily fluctuations in DO were also observed and are likely to be a result of photosynthesis reducing carbon dioxide in the water.

Overall, the results demonstrated that water quality parameters are mostly similar between sites and seasons, but there are also some differences which are expected to be an outcome of differences in stream morphology and hydrology at each site. These findings are to be expected in the absence of M2G pumping operations.

5.2.3 Periphyton

There were no major differences in periphyton coverage between upstream and downstream sites in either season. The results align with historical findings and indicate that variability in periphyton coverage is more likely related to natural flow variability, nutrient loads and site-specific habitat conditions rather than an influence of the operation of the M2G. Nutrient enrichment can lead to excessive growth of periphyton, algae and other aquatic macrophytes. Whilst high periphyton and macrophyte coverage was relatively high during 2024 sentinel monitoring, the observed coverage was not considered to be excessive. Maintenance pumping was undertaken in February 2024 and June 2024, approximately two months and five months prior to autumn and spring 2024 sentinel monitoring, respectively. Despite this there was no evidence that operations influenced naturally occurring periphyton coverage.

5.2.4 Riparian Vegetation

Monitoring sites in Burra Creek presented a general increasing trend in macrophyte and riparian vegetation coverage compared to 2020/2021. This trend included establishment of new riparian trees and the continued growth of previously observed trees. Increased vegetation establishment is likely to be part of a natural cycle of damage from increased flows and subsequent revegetation during low flow periods. The establishment and growth of macrophytes and riparian vegetation observed during 2024 monitoring is likely to have improved bank integrity and the ability of Burra Creek to resist erosion under elevated flows, including those experienced during M2G pumping. Maintenance pumping was undertaken in February 2024 and June 2024, approximately two months and five months prior to autumn and spring 2024 sentinel monitoring, respectively. Despite this there were no obvious impacts to macrophytes or riparian vegetation.

At most sites, riparian tree coverage is generally sparse and dominated by exotic species including Willows, Ash and Poplars. While these trees can provide protection against erosion, they can also trigger erosion from falling limbs or trunks, can prevent the establishment of native vegetation, and are associated with several adverse aquatic ecosystem impacts, including reduced water quality and habitat heterogeneity (State of Victoria, 2016). Whilst not occurring extensively at any site, exotic Blackberry was observed at BUR1A, BUR2 and BUR2C. While contributing to riparian vegetation coverage, Blackberry smothers other vegetation and provides limited erosion resistance. Despite broad occurrences of exotic plants in the riparian zone, most Burra Creek sites have extensive coverage of native emergent macrophytes, including Common Reed, Cumbungi, Sedges and Rushes. These macrophytes are likely to provide improved erosion resistance under elevated flows and provide good habitat to aquatic fauna.

5.2.5 Geomorphology

Burra Creek is subject to severe erosion in several reaches across its length due to having highly erodible soils, and a catchment area that is often steep and degraded by former agricultural land use (NSW OEH, 2009). Major erosion hotspots along Burra Creek that are monitored as part of the MEMP include downstream of the M2G discharge outlet and Williamsdale Road at BUR2a and further downstream near London Bridge and Googong Foreshore at Pool 29 and BUR2c. However, significant erosion upstream of the M2G discharge outlet at BUR1a demonstrates that severe erosion in Burra Creek is naturally occurring.

In general, geomorphological features in Burra Creek remained relatively unchanged since 2020/2021 with no sites presenting obvious evidence of worsened erosion, except for upstream of the M2G discharge outlet at BUR1a. Rock riprap at the discharge outlet at BUR2 was observed to be effective with no erosion evident, and significant macrophyte establishment observed during 2024 monitoring.

Natural flows in Burra Creek are highly stochastic with major discharge events exceeding 1000 ML/d eight times during monitoring for the MEMP between 2008 and 2024 (refer to Section 0). Given that natural flow events are significantly greater than the nominal maintenance discharge of 49 ML/d and operational discharge of 100 ML/d, it is unlikely that M2G discharge would significantly contribute to exacerbated erosion in Burra Creek. Maintenance pumping was undertaken in February 2024 and June 2024, approximately two months and five months prior to autumn and spring 2024 sentinel monitoring, respectively. Despite this there were no obvious signs of erosion. Rather, bank integrity appeared to have improved compared to 2020/2021 due to increased macrophyte and riparian vegetation coverage.

5.2.6 Macroinvertebrates and river health assessment

Habitat conditions in Burra Creek limited the availability of riffle habitats for sampling, resulting in river health assessments being primarily based on edge habitat. Univariate indices did not reveal a consistent pattern of reduced river health downstream of the discharge point, particularly during low-flow periods. Across all seasons, most sites were classified within AUSRIVAS Band B, indicating significant impairment and fewer families than expected—likely reflecting impacts on water and/or habitat quality.

Results from the 2024 univariate analyses were consistent with previous years, suggesting that sentinel monitoring across two seasons did not detect differences in macroinvertebrate communities between upstream and downstream locations. This finding was corroborated by multivariate community analyses.

These findings suggest that macroinvertebrate communities in Burra Creek experience some level of disturbance, most likely associated with water quality, and that community composition is influenced by habitat constraints. Despite these impacts, seasonal dynamics—such as increased river health during the more productive spring period—appear unaffected. Notably, these seasonal patterns are consistent both upstream and downstream of the discharge point, highlighting the importance of accounting for broad-scale natural variation when interpreting monitoring results during operational periods.

Future discharges into Burra Creek may support ecological function by improving overall waterway condition and potentially increasing the availability of riffle habitat

Overall, the condition of impact sites appears broadly comparable to non-impact sites over time. Observed differences are likely attributable to seasonal fluctuations, particularly improved river health during the more productive spring period. Given the continued comparability between sites, no re-establishment of baseline conditions is deemed necessary. However, sentinel monitoring at three-year intervals is recommended to ensure ongoing suitability of sites for future comparisons.

5.2.7 Fish

Common Carp were only detected at two sites, both of which were the furthest downstream locations surveyed in Burra Creek. These sites were influenced by backwater from the damming of Googong Reservoir and demonstrated an extension of Common Carp distributions upstream into Burra Creek compared to sampling undertaken at the same locations in February 2019 (UC, 2019). The extension of Common Carp distribution upstream was likely facilitated by increased dam levels resulting in the extension of backwater (suitable habitat) into Burra Creek.

5.3 Component 3: Murrumbidgee Pump Station (MPS)

5.3.1 Rainfall and hydrology

Overall, in the two seasons that monitoring occurred there was lower rainfall and river discharge compared to historical averages, particularly in spring. Both seasons presented similar rainfall and discharge conditions, each with infrequent periods of minor to moderate rainfall events and similar total rainfall volumes. In Autumn, mean daily discharge rates at Mt MacDonald varied from 232 ML/d to 3812 ML/d, and averaged 735 ML/d for the year, which is lower than the yearly mean average of 1531 ML/d. In Spring, mean daily discharge rates at Lobb's Hole varied from 208 ML/d to 1531 ML/d, and averaged 638 ML/d for the year, which is substantially lower than the historical yearly mean average of 1531 ML/d.

There was no abstraction associated with the MPS during either of the two seasons that monitoring occurred. Throughout both seasons, river flow at Mt MacDonald was approximately 30% greater downstream than that recorded at Lobb's Hole. The additional input of the Cotter River in between monitoring sites MUR28up and MUR935 could potentially influence river health and the ability to make valid comparisons between the two sites. However, the contribution of the Cotter River to flows measured at Mt MacDonald were less than 10% in both seasons. Therefore, the magnitude of differences in flow are not considered large enough to lead to flow induced differences between the upstream and downstream sites.

5.3.2 Water quality

Both MPS sites generally had high nutrient loads with TN and TP exceeding ANZG guideline values in most cases. Elevated nutrient levels are typical of the Murrumbidgee River, with elevated nutrients regularly recorded during monitoring for the MEMP. Although TN was elevated, ammonia and oxidised forms of nitrogen (NO_x) were within ANZG guideline values in both seasons. Nutrient levels observed in 2024 are not considered to be unusually high compared to previous seasons.

Differences in pH were observed between sites in both seasons, with a pH of 8.0 at upstream site MUR28up in both seasons, and a pH of 8.2 at downstream site MUR935 in both seasons. The difference in pH between sites could be an outcome of water abstraction, mixing after the confluence with the Cotter River, or as a result of daily fluctuations in pH. It is noted that in both seasons MUR935 was sampled later in the day than MUR28up, which may have contributed to elevated pH due to daily photosynthesis reducing carbon dioxide in the river.

Whilst DO is usually higher during spring due to increased photosynthesis, DO was low at both sites in Spring, and especially at MUR935 which was slightly below the ANZG guideline value. In contrast, ammonia was detected in lower concentrations in spring. This is as expected due to higher temperatures reducing the solubility of ammonia and increased activity by nitrogen fixing bacteria breaking down ammonia. Turbidity was also sporadically above ANZG guideline values in both seasons and is related to rainfall events and increased flows. Alternatively, pH and EC generally decreased during elevated rainfall and flow periods. All other water quality parameters were within ANZG guideline values, where available, and were generally consistent with historical results.

Overall, the results demonstrated similar water quality at upstream and downstream locations and between seasons. This suggests these two sites are suitable as replicate upstream control sites to assess potential changes due to abstraction of water by the MPS.

5.3.3 Periphyton

There was no obvious indication of increased periphyton downstream of the MPS abstraction point compared to upstream. Whilst periphyton coverage was higher at the downstream site in autumn, periphyton coverage was higher at the upstream site in spring. However, both sites were observed to have higher periphyton coverage in spring compared to autumn.

The difference in periphyton coverage between sites and seasons is likely due to a combination of factors, including water temperature, differences in site flow characteristics and substratum composition. For example, the substrate at MUR28down had a higher percentage of sand and gravel content in autumn 2024 than that sampled at MUR28up in spring 2024 and is likely to have reduced potential for periphyton establishment. Whereas in spring 2024, increased periphyton coverage is likely to be related to substrate in addition to lower flow volumes and higher spring temperatures, especially given that monitoring was undertaken in late spring.

5.3.4 Macroinvertebrates and river health assessment

Due to habitat conditions in the Murrumbidgee River, edge habitats were largely absent, necessitating that river health assessments rely primarily on riffle habitats. Univariate indices did not exhibit a consistent spatial trend indicating different ecological conditions at sites downstream of the MPS relative to upstream. Across all sampling periods, most sites were classified within AUSRIVAS Band B, denoting significant ecological impairment and a lower-than-expected macroinvertebrate family richness, potentially attributable to degraded water and/or habitat quality. This outcome was corroborated by multivariate community analyses, which found no statistically significant differences in macroinvertebrate assemblages between sites upstream and downstream of the abstraction point.

Overall, the condition of impact sites appears broadly comparable to non-impact sites over time. Observed differences are likely attributable to seasonal fluctuations, particularly improved river health during the more productive spring period. Given the continued comparability between sites, no re-establishment of baseline conditions is deemed necessary. However, sentinel monitoring at three-year intervals is recommended to ensure ongoing suitability of sites for future comparisons.

6. Conclusion

The MEMP is carried out to investigate potential impacts of water abstraction from the Murrumbidgee River at Angle Crossing (M2G) and the MPS, and the influence of increased water volumes in Burra Creek, on ecological conditions of the Murrumbidgee River and Burra Creek. Sentinel monitoring is undertaken every three years during 'standby' periods when operations are not taking place. Sentinel monitoring was undertaken for the MEMP in autumn and spring 2024, following previous monitoring in autumn 2021. Sentinel monitoring is undertaken to understand if major catchment-scale changes to aquatic ecology are taking place across time at monitoring sites and to establish up to date background conditions that can be compared to conditions during impact monitoring.

Overall, there were no major differences between upstream and downstream sites for the M2G or MPS in the Murrumbidgee River, or the discharge point in Burra Creek. While some minor differences were observed, these illustrate the natural variability within sites and between seasons. The continuation of data collection from sentinel monitoring sites allows comparisons against an increasing body of historical monitoring data. The use of existing sites should therefore enable detection of any potential impacts from operations.

This report includes results from sentinel monitoring 2024. While the M2G and MPS remained in standby mode during both seasons, the M2G was used for three maintenance runs throughout financial year 2023-2024. These runs occurred in September 2023, February 2024 and June 2024 and amounted to a combined abstraction of 325 ML (Icon Water, 2024). While maintenance runs were undertaken during the monitoring year, they were undertaken outside of the autumn and spring monitoring season and obvious differences between upstream and downstream sites were not evident. The key conclusions from the monitoring are:

– Substantially lower rainfall and river discharge occurred during 2024 compared to historical averages, with spring and autumn both presenting infrequent periods of minor to moderate rainfall events. Rainfall conditions corresponded with similarly low river discharge in the Murrumbidgee River and Burra Creek.
– Both the Murrumbidgee River and Burra Creek had high pH and nutrient loads, particularly TN and to a lesser extent TP. Burra Creek also had elevated NO_x.
– DO and EC was typically elevated above ANZG guideline values in Burra Creek. While in the Murrumbidgee River, these parameters are usually within guideline ranges.
– While there was significant periphyton coverage at some sites in spring 2024, there was no excessive coverage of periphyton, filamentous algae or macrophytes at any of the monitoring sites. There was no obvious or consistent difference in periphyton coverage compared between upstream and downstream sites for each of the monitored components.
– All sites monitored for geomorphology did not present any obvious evidence of exacerbated erosion, except for upstream of the M2G discharge outlet at BUR1a. Rock riprap at the discharge outlet at BUR2 was observed to be effective with no erosion evident.
– All sites monitored for riparian vegetation demonstrated similar or greater coverage of riparian vegetation, including increased tree recruitment and continued growth of previously existing trees. Instream macrophyte coverage also appeared to be greater at most sites compared to previous monitoring.
– During low flow periods, edge habitat is reduced in the Murrumbidgee River and riffle habitat is lost in Burra Creek. Despite this, the general health of the two waterways has not dramatically changed over time and variation in these habitats is considered to be due to natural events.
– The macroinvertebrate communities in the Murrumbidgee River and Burra Creek are generally reflective of mild to moderate pollution impacts and/or significant impairment with water quality and/or habitat potentially impacted resulting in loss of taxa.
– The macroinvertebrate community continues to display a high level of seasonal variation suggesting that any impairment due to habitat conditions or operation of the M2G and MPS has not been enough to mask natural variability. While macroinvertebrate communities substantially differed compared to previous seasons, changes in communities were consistent across seasons and upstream and downstream sites. Given that the intent of sentinel monitoring is to monitor for long term trends in ecological condition, the annual findings are important and will help to better inform future impact interpretation and monitoring program design.
– Fish surveys demonstrated that the Murrumbidgee River is dominated by Carp. However, strong recruitment of Murray Cod occurred during periods of higher flows in 2021 and 2022, particularly at upstream sites.

Ongoing eDNA surveys also demonstrated that the M2G is unlikely to be resulting in the transfer and establishment of Carp from the Murrumbidgee River into Burra Creek.

Overall, there were little differences in waterway health upstream and downstream of the M2G and MPS in the Murrumbidgee River, or the discharge outlet in Burra Creek. Due to the similarities of upstream and downstream monitoring sites, the sites are considered suitable for future impact monitoring.

The next round of sentinel monitoring is planned to be conducted in 2027 unless operations recommence. As described in Section 1.2.2, impact monitoring is triggered by the decision to operate M2G and/or MPS infrastructure and requires a before and after assessment approach. Icon Water do not currently plan to recommence operations in the near future.

Table 36 Future monitoring schedule

	A23	S23	A24	S24	A25	S25	A26	S26	A27	S27
Vegetation and geomorphology			✓	✓			✓	✓		
Water quality, periphyton, and macroinvertebrates, periphyton			✓	✓					✓	✓
Fish (Murrumbidgee River)	✓				✓				✓	
Fish (Burra Creek)	✓								✓	

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