



Darling Baaka River Health Project 2023 to 2025

Chapter 4 Water Quality Index

Department of Climate Change,
Energy, the Environment and Water



Acknowledgement of Country

Department of Climate Change, Energy, the Environment and Water acknowledges the Traditional Custodians of the lands where we work and live.

We pay our respects to Elders past, present and emerging.

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4. Water quality

4.1 What do we mean by water quality?

Water quality refers to the condition of the water in terms of physical, chemical and biological properties.

Different parameters can be analysed to assess water quality including temperature, oxygen, salinity, turbidity and the concentrations of nutrients, metals, microorganisms and pesticides (Uddin et al. 2021; Gorde and Jadhav 2013). Often these variables differ greatly between groundwaters and surface waters, due to the environments that surround these different water sources. For example, surface waters typically have higher oxygen and algal concentrations than groundwaters.

Water quality can vary significantly depending on the type and location of the waterway, and fluctuates over daily, seasonal and decadal timescales. This natural variability makes it particularly challenging to detect both acute and short-lived impacts, as discrete water quality sampling provides only a snapshot of conditions at one moment in time. Consequently, the accuracy and robustness of a water quality assessment are highly influenced by the frequency and spatial density of sampling, which in turn affect the conclusions that can be drawn from the data. Continuous automatic water samplers improve the temporal resolution of sampling but are limited in the metrics they can analyse.

4.2 Why use water quality in river health assessments?

Good quality clean water is an essential resource for humans in terms of drinking water, recreational activities and agriculture. Water quality is also critically important for biodiversity as it is a component of habitat for aquatic biota, with many species fundamentally reliant on specific water conditions for feeding, shelter and reproduction (Xu et al. 2024; Calderon et al. 2019). A range of ecosystem services are also facilitated through the provision of good quality water. For example, clean waterways support a range of healthy biota (such as plants and microorganisms) that are in turn important for nutrient and carbon cycling (Duarte et al. 2005; Flindt et al. 1999). Water quality is an essential variable in any assessment of river health.

Water quality is influenced by a range of natural processes including flow conditions, erosion, photosynthesis/respiration, and surface–groundwater exchange (Hamid et al. 2020; Conant et al. 2019). It is also significantly impacted by human disturbances such as land clearing, streamflow regulation and fertiliser and pesticide use. Poor water quality is often characterised by increased turbidity, high nutrient levels and low dissolved oxygen concentrations (Figure 1). Good water quality is generally characterised by low turbidity, low nutrient levels and higher dissolved oxygen concentrations.

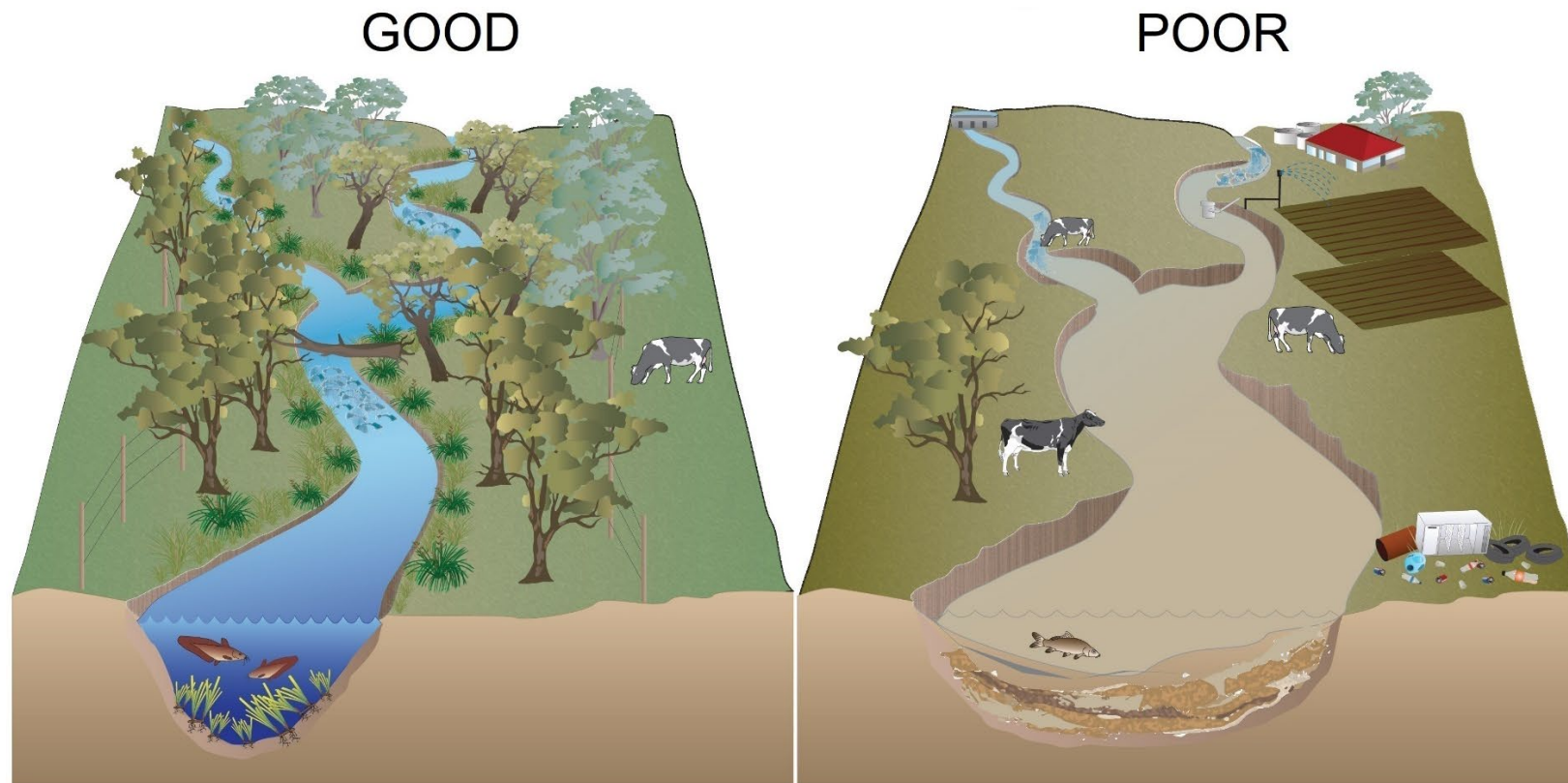


Figure 1 **Good versus poor water quality (Source: DPE 2023a)**

Left: Good water quality, with increased shading, presence of native fish species, an intact riparian zone, and no barriers (dams).

Right: Poor water quality, with decreased shading, absence of native fish species, bank slumping and erosion, and increased nutrients and organic pollution.

4.3 Assessing water quality

Defining ‘good’ water quality can be challenging because it depends on the purpose of the assessment; whether evaluating the water’s ability to support aquatic biodiversity and ecological functions, its suitability for livestock and domestic use, or its safety as drinking water. In environmental water quality monitoring, water sampling is typically compared against guideline values that are developed from sampling relatively unimpacted waterways (ANZECC/ARMCANZ 2000 [referred to as ANZECC 2000]; ANZG 2018). These guidelines are typically different depending on the context of the assessment, bioregion being investigated and the proposed uses of the waterways.

The methods for assessing the Water Quality Index in this report have been developed by adapting the methods used in the *River Condition Index: method report* (DPE 2023a), referred to as the 2023 River Condition Index (RCI). These methods use established water quality guidelines to calculate the number of exceedances of various water quality metrics to establish the index.

For the assessment undertaken in this study final calculations of the Water Quality Index and the overall scoring grades (A to E) remained consistent with the 2023 RCI methodologies. To ensure these consistencies, consultation was undertaken with the RCI development staff in the Department of Climate Change, Energy, the Environment and Water (the department).

Due to the differences in methodologies, comparing the results for the 2023 RCI and 2025 Darling Baaka RCI is not a true indication of changes to water quality over time. Despite the differences between the application of the RCI framework, it is important to understand the differences between the 2023 RCI and the 2025 Darling Baaka RCI presented in this report (see Chapter 9). The metrics used to calculate the 2025 RCI Water Quality Index are summarised in Table 1 and described in the following sections.

4.3.1 Data used to assess the Water Quality Index for the Darling Baaka River

The Water Quality Index in the 2025 Darling Baaka RCI framework uses 42 water quality metrics which are compared to various guideline values (Table 1). Samples were taken at differing frequencies (see section 4.4.1), dependent on the metrics being sampled and the phase of sampling in the project (see Chapter 2 for explanation of sampling phases). For pesticide data to be included in the Water Quality Index calculations, it was necessary that appropriate 95% species protection guideline values exist, and laboratory reporting limits were higher than the default guideline value. If either of these criteria were not met, the pesticide data were excluded from Water Quality Index analysis. In sample analyses prior to September 2024, 12 pesticides met the criteria for incorporation into the Water Quality Index analysis (Table 1). After September 2024, high-resolution LC-MSMS (liquid chromatography with tandem mass spectrometry) with a new detection limit of 0.00001 milligrams per litre (mg/L) was used to analyse 8 pesticides of interest in line with their low guideline values allowing their incorporation into the Water Quality Index calculation (see Table 1 and Table 2). Where the laboratory limit of reporting is higher than default guideline values, the results are

not considered in the Water Quality Index calculation because the resolution of the analysis is not sufficient to identify whether concentrations are above or below guideline values when a below reporting limit result is returned.

Table 1 Metrics used to calculate the Water Quality Index for the 2025 River Condition Index (RCI) assessment

Metric	Contributes to 2025 Darling Baaka RCI	Contributes to project water quality assessment
Physico-chemical¹ • Temperature* • pH • Dissolved oxygen • Electrical conductivity • Turbidity • Fluorescent dissolved organic matter*	Yes/No*	Yes
Nutrients¹ • Total nitrogen • Total phosphorus • Soluble reactive phosphorus • Nitrogen oxides (nitrates and nitrites) • Ammonium	Yes	Yes
Chlorophyll-a²	Yes	Yes
Organic carbon • Total organic carbon • Dissolved organic carbon	No	Yes
Pesticides³ (x 20) (see section 4.3.2 Table 5 for details)	Yes	Yes
Metals³ (x 12) (see section 4.3.2 Table 6 for details)	Yes	Yes
Groundwater quality	No	Yes

Table notes:

* Temperature and fluorescent dissolved organic matter metrics did NOT contribute to the 2025 Darling Baaka Water Quality Index.

Guidelines used in the 2025 Darling Baaka RCI:

1. ANZECC (2000) south central Australian lowland rivers
2. ANZECC (2000) south-east Australian lowland rivers
3. ANZG (2018) 95% species protection guideline value for toxicants in freshwater ecosystems.

Table 2 Comparison of limit of detection between current and new methods for 8 pesticides

Parameter	95% species protection default guideline value (mg/L; ANZG 2018)	Limit of detection prior to September 2024 (mg/L)	Limit of detection post September 2024 (mg/L)
Azinphos methyl	0.00002	<0.0001	<0.00001
Diazinon	0.00001	<0.0001	<0.00001
Dimethoate	0.00015	<0.0001	<0.00001
Endrin	0.00002	<0.0001	<0.00001
Fenitrothion	0.0002	<0.001	<0.00001
Heptachlor	0.00009	<0.0001	<0.00001
Hexachlorobenzene	0.0001	<0.0003	<0.00001
Malathion	0.00005	<0.0001	<0.00001

Sampling for the Darling Baaka River Health Project occurred in 2 major phases; Phase 1 (September 2023 to April 2024) covered a period of moderate river flows across the study area, whereas Phase 2 (April 2024 to March 2025, inclusive) was characterised by higher river flows. Due to the large differences in water flow between sampling phases, only Phase 2 samples were included in the 2025 Darling Baaka RCI, though data from Phase 1 has been presented for comparison. This has been done to remain consistent with other sampling conducted for this report, particularly the biological sampling which occurred at the same time as Phase 2 sampling (see Chapter 2).

A total of 35 surface water sites were sampled monthly for the 12 months of Phase 2, and the data from these 35 sites were incorporated into the Water Quality Index calculation. Results from an additional 6 surface water sites, sampled prior during Phase 1, were incorporated into the broader water quality assessment, bringing the total surface water sampling sites for this project to 41. These data provide good spatial coverage. However, longer term monitoring should be undertaken in variable conditions to gain a full understanding of the system under different climatic and hydrological conditions.

The following sections describe the water quality metrics that have been used to inform the Water Quality Index. Further details on the sampling and methods used for analysis of each metric are given in section 4.4.

Physico-chemical

Temperature

Temperature plays a crucial role in the chemical and biological processes of river systems and is essential for river health. Elevated water temperatures can reduce dissolved oxygen concentrations and accelerate the breakdown of organic matter, increasing the demand for oxygen (biochemical oxygen demand) and impairing the

survival of fish and other species (Dallas and Ross-Gillespie 2015). Colder water can hold more dissolved oxygen, which is vital for aquatic life. Additionally, temperature variations can affect the distribution of sensitive aquatic organisms. Fish, invertebrates and microorganisms are cold-blooded, meaning their body temperature and physiological processes depend on the surrounding water temperature. Warmer temperatures can increase their metabolic rates, requiring more oxygen for survival. In extreme cases, elevated temperatures can lead to thermal stress, reducing reproduction rates, growth, and causing mortality (Kazmi et al. 2022; Heugens et al. 2008). Changes in water temperature can also disrupt seasonal life cycles, such as fish spawning and migration patterns (Corey et al. 2017).

Continuous, long-term monitoring of temperature trends allows for the detection of shifts that may indicate human-induced impacts or climate-related changes in the river system.

pH

The pH of water measures its acidity or alkalinity, and maintaining suitable water pH is a crucial factor for the survival of aquatic life. The pH scale ranges from 0 (zero) to 14, where values below 7 are considered acidic, values above 7 are considered alkaline, and a pH of 7 is neutral. In river systems, extreme pH levels can be harmful to aquatic organisms, particularly during critical life stages such as spawning and early development (Heugens et al. 2008; Baldisserotto 2011).

Additionally, pH affects the solubility of nutrients and metals in water. For instance, at low pH, certain metals like aluminium and iron become more soluble and toxic to aquatic organisms. At high pH, chemicals such as ammonia become more toxic, posing a significant threat to fish and invertebrates (Rendal et al. 2011).

An optimal pH range for most freshwater ecosystems is between 6.5 and 8.5. Deviations from this range may indicate pollution from agricultural runoff, industrial waste, or other sources of contamination (e.g. acid sulfate soils).

Dissolved oxygen

Dissolved oxygen (known as DO) is one of the most important indicators of water quality and river health. It refers to the amount of oxygen available in the water for aquatic organisms to respire. Healthy river systems typically exhibit high levels, which supports a diverse range of species. Dissolved oxygen is essential for the oxidation of organic matter and the respiration of aerobic organisms (Kulkarni 2016). When organic material, such as dead plants/algae and animal waste, enter or build up in a river, microorganisms break it down through a process called aerobic decomposition which consumes oxygen (Kerr et al. 2013). Oxygen in water is naturally replenished through exchange from the atmosphere, due to turbulent water flow which naturally aerates water, as well as by photosynthetic activities of plants and algae. Under natural conditions, the balance between oxygen consumption and replenishment maintains healthy dissolved oxygen levels. However, when there is an influx of organic matter such as sewage or

agricultural runoff, the demand for oxygen increases, which can lead to oxygen depletion (Kerr et al. 2013).

Dissolved oxygen levels below 4 mg/L can lead to hypoxia, stress or mortality in aquatic organisms. When dissolved oxygen levels drop, the shift towards anaerobic conditions (lack of oxygen) can lead to the production of harmful by-products like hydrogen sulfide (H₂S) and methane (CH₄) which further degrades water quality (Shenoy et al. 2021).

Factors such as temperature, flow rate, organic matter decomposition, pollution and photosynthesis all influence dissolved oxygen levels, making it a critical parameter for tracking ecosystem health.

Electrical conductivity

Electrical conductivity (known as EC) is a measure of the dissolved ions (such as salts) within the water. It is a good indicator of the salinity levels of the water, which is an important factor for biota. Freshwater organisms (including both animals and plants) are generally adapted to low-salinity environments. Increased salinity can disrupt their ability to regulate internal water and salt balance, leading to stress or death (Velasco et al. 2018). Water which is impacted by high salinity levels can reduce biodiversity in freshwater ecosystems.

High electrical conductivity levels can often signal the presence of pollutants. Contaminants such as sewage, fertilisers and industrial discharges often increase the concentration of ions in the water resulting in elevated electrical conductivity levels (de Sousa et al. 2014). Electrical conductivity is a cost-effective method to measure water quality and is often used alongside other physico-chemical measurements, such as pH, dissolved oxygen and temperature, to give an indication of water quality.

Turbidity

Turbidity measures the cloudiness or haziness of water caused by suspended particles such as sediment, algae, organic matter and microorganisms. High turbidity can reduce light penetration, affecting photosynthesis in aquatic plants and reducing oxygen production and dissolved oxygen levels as a result (Dunlop et al. 2005). Suspended particles in the water column can also absorb more heat, causing the water temperature to rise, and can act as carriers for contaminants.

High turbidity can arise from natural causes such as erosion during runoff events, or human-induced activities that cause water pollution such as dredging or mining. Clearer water with low turbidity is generally indicative of a healthy river system, while highly turbid water can have negative impacts on both water quality and aquatic life. The effect of turbidity on river ecosystems is highly dependent on the degree and duration of turbidity. While some ecosystems may tolerate periodic increases in turbidity, chronic turbidity can cause long-term damage (Seo and Lee 2008).

Fluorescent dissolved organic matter

Fluorescent dissolved organic matter (known as fDOM) serves as an indicator of dissolved organic matter within the water column. It can help us understand the

contribution of organic matter to the food web, and it can also be used to assess the input of organic matter from the floodplain after rainfall. Organic matter impacts carbon and nutrient cycling and high concentrations can impact water clarity, affecting light availability and the photosynthetic ability of plants and algae. Fluorescent dissolved organic matter is measured using a water quality sonde and can be used to track the changes in water quality over time.

Nutrients

Nitrogen and phosphorus are among the most common nutrients in Australian waterways. While they play a critical role in supporting natural biological growth within ecosystems, excessive concentrations can lead to harmful algal blooms resulting in adverse effects such as elevated algal toxins and low dissolved oxygen levels (Mallin and Cahoon 2020). These nutrients are frequently used in various human activities, such as agriculture and industry, which can lead to their accidental release into waterways.

It is important to monitor nitrogen and phosphorus within waterways to understand the impact of human activities and identify contributing factors. In the Water Quality Index, nutrients concentrations are measured using the following metrics: total nitrogen (TN), total phosphorous (TP), nitrogen oxides (NO_x), ammonium (NH_4^+) and soluble reactive phosphorus (SRP). All of these metrics can be used to investigate different aspects of nutrient loads and their impacts on overall river health. Importantly, dissolved inorganic forms of nutrients, in particular NO_x , NH_4^+ , and SRP, are the most bioavailable forms of nutrients for algae growth.

Chlorophyll-a

Chlorophyll-a is a key water quality indicator. It measures the concentration of photosynthetic pigment found in the water column and can be used to indicate the amount of algae in the water.

Algae are naturally existing primary producers. They form the basis of the food web in many aquatic ecosystems and this influences biodiversity. There are certain situations, including enhanced nutrients and low flows, where algal blooms can form. Algal blooms, particularly some species of cyanobacteria, can form toxins which can impact water quality and render water unfit for drinking, primary contact and for use by stock.

Organic carbon

Carbon is one of the foundational elements for life. It influences various ecological and chemical processes. Carbon plays a major role in the food web, influences pH and nutrient availability, and can alter the mobility of contaminants in the waterway by binding with pollutants. Organic carbon is usually measured in the form of total organic carbon and dissolved organic carbon.

Total organic carbon measures all the organic carbon within the waterway. It can be used to assess contaminants and the impacts of human activities on waterbodies. Dissolved organic carbon measures the bioavailability of carbon, that is the proportion of the total organic carbon that can be used by microbes or consumed by other biota.

Dissolved organic carbon data is used in this study to analyse dissolved oxygen dynamics of the system in relation to the development of poor water quality, oxygen production/consumption associated with primary production, and organic matter decomposition.

Pesticides

Pesticides are chemicals used mainly by the agricultural industry to control or eliminate pests, including insects, weeds, fungi and other unwanted organisms. There are several categories of pesticides, each designed to target specific types of pests. The most common category includes insecticides (such as organophosphates), herbicides (such as glyphosate and atrazine) and fungicides (such as chlorothalonil and mancozeb) (Hassaan and El Nemr 2020). While pesticides play an essential role in agriculture by enhancing crop yields and preventing the spread of diseases, their presence in aquatic ecosystems can pose significant risks.

Pesticides enter rivers through various pathways, including agricultural runoff, groundwater, industrial discharge and atmospheric deposition. Once in the water they can have harmful effects on the health of aquatic life and the overall integrity of river ecosystems (Sánchez-Bayo et al. 2011). Pesticides can degrade and be transformed into different substances, and some can persist in waterways for decades (Jamal et al. 2024; de Araújo et al. 2022; Brodie and Landos 2019).

Pesticides can have diverse toxic effects on aquatic life depending on their concentration, type, and the duration and frequency of exposure. Additionally, pesticide metabolites (degradation products) may pose equal or greater toxic risks than their parent compounds. These toxic effects on fish, invertebrates, amphibians and plants can lead to biodiversity loss, food web disruptions, and long-term water quality degradation (Sánchez-Bayo et al. 2011). Strict regulations often limit pesticide concentrations in water to mitigate these risks.

Metals

Metals, both naturally occurring and those introduced through human activities, are an important component of river water quality monitoring. While certain metals, such as iron (Fe), zinc (Zn) and copper (Cu), are essential in trace amounts for biological functions, many can become toxic at higher concentrations (Gheorghe et al. 2017). Other metals, such as lead (Pb), mercury (Hg) and cadmium (Cd), have no positive biological role and are highly toxic to aquatic ecosystems (Gheorghe et al. 2017).

In the Darling Baaka system, metals enter the rivers primarily through natural weathering of rocks and soil erosion. Human activities such as mining, industrial discharge, agricultural runoff (fertilisers, pesticides, livestock feed), disturbance of acid sulfate soils and urban stormwater can also contribute metals to the system. Metals can exist in various forms: dissolved, particulate or sediment-bound. Dissolved metals are generally the most bioavailable and are potentially toxic through bioaccumulation and biomagnification, which means that top order predators such as large fish, birds and mammals often exhibit the highest metal concentrations (Gheorghe et al. 2017).

Certain metals can have both acute and chronic toxic effects on aquatic ecosystems. Strict regulations are often implemented to limit metal concentrations in surface waters and other water bodies to protect these environments.

Groundwater quality

Rivers and groundwater are part of a connected hydrological system. The health of rivers often reflects the state of the groundwater within the watershed (Rassam et al. 2013). Interactions between surface waters and groundwater are important for water availability, with complicated hydrogeology dictating the direction of water flow, either from the river to the groundwater (that is, a 'losing' section of the river) or the movement of water from aquifers into the river (that is, a 'gaining' section of the river) (Rassam et al. 2013). Groundwater is important in sustaining the baseflow of rivers and providing a water source for riparian vegetation (such as river red gums [*Eucalyptus camaldulensis*]), agriculture and drinking (Hayashi and Rosenberry 2002). Groundwater also has a unique ecosystem that exists entirely within the dark, aquifer waters (Korbel and Hose 2017; see Chapter 6). It is important to monitor groundwater chemistry as this can impact river water quality due to interactions between the surface water and groundwater.

Metrics that are typically measured in groundwater are nutrients, dissolved organic carbon, metals and pesticides. These metrics can be used to understand the quality of the groundwater and can also potentially indicate the impacts of groundwater on rivers. If there are high nutrients or salinity in groundwater this may impact river water quality in locations when groundwater discharges into the river.

The groundwater quality data collected in this study does not contribute to the water quality index score. Rather it is used to assess groundwater health (see Hose et al. 2025, supplementary report).

Additional water quality metrics measured

In addition to the metrics contributing to the Water Quality Index score, a range of further water quality analyses were undertaken (Table 3). While a lack of relevant default guideline values for these additional analyses precludes their inclusion in the calculation of the Index, the data provide important additional information in assessing key water quality stressors in the lower Darling Baaka River.

This data has been collected as part of the Darling Baaka River Health Project but has not been reported in this technical report. Further data manipulation and assessments will be undertaken to establish correlations and causal effects between biotic and abiotic data. The results of these will be published at a later date and could be used to inform management decisions.

Table 3 Additional water quality metrics assessed during this project

Parameter	Description and rationale
Temperature	Water temperature is important as it impacts the habitat of aquatic animals, but it also determines the amount of oxygen that can become dissolved in the water column. This metric is monitored at each site, and by using smart buoys, however it is not specifically part of the RCI framework. Thus, no specific details of the results will be presented as part of this report.
Total suspended solids	Total suspended solids are a measure of the total mass of solid matter suspended in the water column. Although it is related to turbidity, it is a different measurement as turbidity measures how well light can pass through the water, whereas total suspended solids is a quantitative measure of the particles in the water, measured in mg/L.
Sediment	Sediment samples were used to determine pesticide and metal concentrations and their distribution in surface sediment at 15 sites.
Pesticides via passive sampler	Passive samplers are designed to accumulate polar to moderately non-polar pesticides. These samplers were deployed at 9 surface water sites to collect pesticides over a period of approximately 4 weeks (see supplementary report DCCEEW EPS, 2025).

4.3.2 Water quality guidelines used in analyses

Under the RCI framework used in this report, the Water Quality Index metrics are compared to appropriate guideline values. This allows calculation of the frequency and magnitude of guideline value exceedances, which ultimately informed the Index's overall grade.

There is limited national guidance available on conducting water and/or sediment quality assessments for ephemeral surface waters and waterbodies in arid and semi-arid regions of Australia. The majority of runoff in the Darling Baaka River is produced in the relatively wet headwater catchments in the eastern and northern tablelands. However, most of the lower catchment including the project's study area, is semi-arid (250 to 350 mm/year) and arid (<250 mm/year), with an average annual rainfall between 200 and 300 mm/year (see Chapter 1, section 1.5).

The south-east Australia lowland rivers guidelines (ANZECC 2000) were previously used to calculate the RCI for the entire state of New South Wales (DPE 2023a). These guidelines incorporate some sample data from central north-west New South Wales. However, the lack of detailed information on the sampled rivers and methods used limits the confidence in the guideline values' applicability to the Darling Baaka River.

The project's Expert Advisory Panel advised using the default guideline values for south central Australia. These guideline values were developed for low-rainfall regions with extreme fluctuations in water availability and quality (Table 4). The Panel recommended this approach in the absence of site-specific guideline values having been derived.

A major limitation of the ANZECC 2000 default guideline values for south central Australia is the absence of a guideline value for algal biomass (chlorophyll-a concentration). To address this, the south-east Australia chlorophyll-a guideline was applied to incorporate chlorophyll-a data into the Water Quality Index calculation (Table 4). In addition, ANZG (2018) guideline values for 20 common pesticides and 12 dissolved metals have been added to the Water Quality Index calculation (Table 5; Table 6).

Table 4 Water quality parameters and associated guideline values for inclusion in calculation of the Water Quality Index for the 2025 Darling Baaka RCI

Parameter	Guideline value: south-east Australian lowland rivers (ANZECC 2000)	Guideline value: south central Australian lowland rivers (ANZECC 2000)
Total nitrogen	500 µg/L	1,000 µg/L
Total phosphorus	50 µg/L	100 µg/L
Soluble reactive phosphorus	20 µg/L	40 µg/L
Nitrogen oxides (NO _x)	40 µg/L	100 µg/L
Ammonium (NH ₄ ⁺)	20 µg/L	100 µg/L
Turbidity	6 to 50 NTU	1 to 50 NTU
Dissolved oxygen	85% to 110%	90% to 110%
pH	6.5 to 8	6.5 to 9
Electrical conductivity	125 to 2,200 µS/cm	100 to 5,000 µS/cm
Chlorophyll-a	5 µg/L	N/A (5 µg/L) [#]
Pesticides in water		95% species protection guideline values specific to 20 individual pesticides (ANZG 2018; Table 5)
Dissolved metals		95% species protection guideline values specific to 12 individual metals (ANZG 2018; Table 6)

Table notes: µg/L = micrograms per litre; NTU = nephelometric turbidity units; µS/cm = microsiemens per centimetre. [#] In order to incorporate chlorophyll-a data into the Water Quality Index calculation, the south-east Australia chlorophyll-a default guideline value of 5 µg/L has been applied to the data.

Table 5 Pesticides with relevant 95% species protection guideline values incorporated in Water Quality Index calculation

Pesticide	95% species protection default guideline value (mg/L; ANZG 2018)
Atrazine	0.013 mg/L
Diuron	0.0002 mg/L
Glyphosate	0.32 mg/L
Hexazinone*	0.075 mg/L
MCPA	0.0077 mg/L
Methomyl	0.0035 mg/L
Metolachlor	0.00046 mg/L
Molinate	0.0034 mg/L
Picloram	0.087 mg/L
Simazine	0.0032 mg/L
Tebuthiuron	0.0022 mg/L
Trifluralin	0.0044 mg/L
Azinphos methyl^	0.00002 mg/L
Diazinon^	0.00001 mg/L
Dimethoate^	0.00015 mg/L
Endrin^	0.00002 mg/L
Fenitrothion^	0.0002 mg/L
Heptachlor^	0.00009 mg/L
Hexachlorobenzene^	0.0001 mg/L
Malathion^	0.00005 mg/L

Table notes:

* Based on low-reliability trigger level using the assessment factor method (AF = 1,000).

^ After September 2024, these additional 8 pesticides were analysed at higher resolution with reporting limit values below default guideline values, allowing their incorporation into the Water Quality Index calculation (Table 2).

Table 6 **Dissolved metals with relevant 95% species protection guideline values incorporated into Water Quality Index calculation**

Dissolved metal	95% species protection default guideline value (mg/L; ANZG 2018)
Aluminium	0.055 mg/L
Arsenic	0.013 mg/L
Cadmium	0.0002 mg/L
Chromium	0.001 mg/L
Copper	0.0014 mg/L
Lead	0.0034 mg/L
Manganese	1.9 mg/L
Mercury	0.0006 mg/L
Nickel	0.011 mg/L
Total Selenium	0.011 mg/L
Silver	0.00005 mg/L
Zinc	0.008 mg/L

4.4 Methods

Different methods were used to collect data on individual metrics analysed for the Water Quality Index. Data for this study were collected onsite for dissolved oxygen, turbidity, pH, electrical conductivity and temperature using a multi-parameter water quality sonde (section 4.4.2). Other metrics such as nutrients, chlorophyll-a, pesticides and metals were determined by laboratory analysis of water samples.

The sampling design focused on surface water sampling at 35 river sites including 6 smart buoy sites (see section 4.4.2). In addition, 18 groundwater sampling sites were established (see section 4.4.9). However, groundwater samples do not contribute to the Water Quality Index scores. Rather they are an important part of the additional information presented on groundwater health in the supplementary report and in Chapter 6 (see Hose et al. 2025). Additionally, smart buoy data have not been incorporated into the Water Quality Index calculation. Further consideration is required to incorporate smart buoy data into the calculation, particularly in the application of the relative weighting of variables in the overall Water Quality Index.

4.4.1 Surface water sampling design

Phase 1 (September 2023 to April 2024) comprised routine monthly or quarterly sampling of water quality metrics at 20 sites between Wilcannia and Pooncarie. Phase 2 (April 2024 to March 2025) expanded the Phase 1 sampling strategy to align with monitoring required under the RCI framework. Sites were expanded to include 35 river sites located along the lower Darling Baaka River between Wilcannia and Wentworth, including the Great Darling Anabranh. Only data from Phase 2 sampling are used in the calculation of the Water Quality Index (for explanation see section 4.5.1).

The 35 river sites (surface water sampling) were chosen primarily to ensure sampling at a minimum of one site in each sub-catchment. There was no sampling conducted in the Talyawalka Creek catchment due to a lack of flowing water. Sites were also selected based on accessibility (see Chapter 1, section 1.5.3).

The spatial distribution of sampling sites provides a more detailed assessment of the spatial heterogeneity of water quality across the study area during the study period between September 2023 and March 2025. However, this study period is not representative of the full range of variability in hydrological conditions and associated changes in water quality that occur on the lower Darling Baaka River. In a system as climatically and hydrologically variable as the Darling Baaka River, it is critical to extend monitoring over the long term to assess a range of hydrological conditions and to better quantify the range of variability of water quality.

Surface water sampling regimes

A combination of land and boat-based sampling was used to monitor water quality. Sampling evolved over time and is divided into 2 phases (Table 7):

- Phase 1 of the sampling program (September 2023 to April 2024)
- Phase 2 of the sampling program (April 2024 to March 2025).

In addition to the sampling undertaken in this project, earlier high-frequency sampling delivered under a separate program (March 2023 to August 2023) has been collected to provide additional information on water quality. This data, along with smart-buoy data can be used to analyse water chemistry in future programs.

Table 7 **Parameter collection frequency across monitoring phases**

Sample	Earlier high-frequency stages*	Phase 1	Phase 2
Number of sampling sites	20	20	35
General water quality (physico-chemistry, dissolved organic carbon, nutrients)	Weekly	Monthly	Monthly
Pesticides	Weekly	Quarterly	Quarterly
Metals	Weekly	Quarterly	Quarterly
Sediments	None	Ad-hoc	6-monthly

Table Note: * Data not used in this report.

4.4.2 Physico-chemical parameters

Water quality sonde

Physico-chemical water quality parameters were measured using a Xylem EXO2 multi-parameter water quality sonde. The sonde was held at a depth of 0.2 m, with care taken not to disturb underlying sediments. Sensors were wiped prior to measurement to remove any bubbles on the sensor faces. Once variables had stabilised, data were logged at 1-second intervals for at least 1 minute, with readings averaged to yield values for the site. Metrics measured were:

- temperature (°C)
- pH
- dissolved oxygen (% saturation and mg/L)
- specific electrical conductivity (microsiemens per centimetre [$\mu\text{S}/\text{cm}$])
- chlorophyll-a
- turbidity (nephelometric turbidity units [NTU])
- fluorescent dissolved organic matter (relative fluorescent units [RFU]).

The pH sensor was calibrated before each trip and all other sensors were calibrated every 6 months.

Smart buoys

The 6 smart buoys used in this project (Figure 2; Table 8) measured physico-chemical water quality at 4 depths in the water column every 30 minutes and transmitted data to

a web-based dashboard enabling real-time assessment of conditions at the site. The smart buoy sites were located within representative reaches of the river to better understand water quality dynamics throughout the study area. As of March 2025, there were 6 smart buoy sites. Five smart buoys were deployed during the second half of 2023 and early 2024. One of these sites was relocated from the upper Menindee weir pool to Pooncarie in June 2024, and an additional buoy on the Great Darling Anabranch (Woodlands) was added in December 2024.

Table 8 Measurement depth and installation date of each Darling Baaka smart buoy

Site	Barkandji name	Installation date	Depth 1	Depth 2	Depth 3	Depth 4
Wilcannia upstream	Kindji Yupparra	8/12/2023	0.3 m	1.2 m	3.0 m	5.2 m
Lake Wetherell	–	6/12/2023	0.3 m	1.2 m	3.0 m	5.0 m
Menindee weir pool	Baaka Marli	11/10/2023	0.3 m	1.2 m	3.0 m	4.2 m
Pooncarie	Parntu Kira	13/06/2024	0.3 m	1.2 m	3.0 m	4.2 m
Great Darling Anabranch	–	16/06/2024	0.3 m	1.0 m	1.5 m	2.0 m
Woodlands (Great Darling Anabranch)	–	18/12/2024	0.3 m	1.0 m	1.5 m	2.0 m



Figure 2 Darling Baaka River Health Project smart buoy near Menindee Photo credit: A Ferguson DCCEEW

Smart buoy systems comprise a SmartSampler control system coupled to an EXO2 sonde. Samples are pumped every 30 minutes into a flow-through cell containing the sonde sensors. The pump cycle was set at 2 minutes to allow for stabilisation. The flow cell was allowed to drain in between sample times to minimise biofouling of the sensors.

The sonde is maintained monthly as part of the routine sampling program. Data are available to the public in near real time at: [Dashboard – Darling Baaka River Health Program \(tago.run\)](#).

Parameters measured and the corresponding range, resolution and accuracy are summarised in Table 9.

Table 9 Measurement range, resolution and accuracy of the deployed smart buoy sensors

Sensor	Range	Resolution	Accuracy
Conductivity	0 to 100,000 $\mu\text{S/cm}$	1 to 10 $\mu\text{S/cm}$	$\pm 1.0\%$ of reading or 2 $\mu\text{S/cm}$, whichever is greater
Temperature	-5° to 50°C	0.001 $^{\circ}\text{C}$	$\pm 0.2^{\circ}\text{C}$
Dissolved oxygen (%)	0 to 500% air saturation	0.1% air saturation	$\pm 1\%$ of reading or 1% saturation, whichever is greater (0 to 200%) $\pm 5\%$ of reading (200 to 500%)
Dissolved oxygen (mg/l)	0 to 50 mg/L	0.01 mg/L	± 0.1 mg/l or 1% of reading, whichever is greater (0 to 20 mg/l) $\pm 5\%$ of reading (20 to 50 mg/l)
Fluorescent dissolved organic matter	0 to 300 ppb QSU	0.01 ppb QSU	Linearity: $r^2 \geq 0.999$ for 0 to 300 for serial dilution of 300 ppb quinine sulfate solution. Minimum detection limit of 0.1 ppb quinine sulfate equivalents
Total algae (TAL) chlorophyll	0 to 100 RFU or 0 to 400 $\mu\text{g/L}$ chl	0.01 RFU or 0.01 $\mu\text{g/L}$ of pigment	Linearity: $r^2 \geq 0.999$ for rhodamine WQ across full range
Turbidity	0 to 4,000 FNU, NTU	0.1 FNU, NTU	0 to 999 FNU: 0.3 FNU or $\pm 2\%$ of reading, whichever is greater 1,000 to 4,000 FNU: $\pm 5\%$ of reading
Depth (handheld only)	0 to 10, 100 or 250 m	0.001 m	$\pm 0.04\%$ full scale

Table notes: ppb = parts per billion; QSU = quinine sulphate units; FNU = formazin nephelometric units; NTU = nephelometric turbidity units; RFU = relative fluorescent units.

The smart buoys provide long-term continuous data which track water quality variation in response to a range of weather and flow conditions. The high-frequency with which data are collected (every 30 minutes) provides insights into variation due to diurnal cycles in temperature and solar radiation, and biogeochemical processes occurring within the water column. These data offer valuable context to help in the interpretation of grab samples taken as part of the routine monitoring program. The temperature, dissolved oxygen and chlorophyll-a data from multiple depths provide important information on stratification dynamics of the water column. This information leads to an

in-depth understanding of the relationships between water quality, hypoxia and algal blooms, which has particularly important implications for water management.

4.4.3 Nutrients

Water samples for nutrient analysis were collected directly from the river at a depth of 20 cm, using a sample-rinsed syringe, with care taken to avoid surface scum. Samples for dissolved nutrient fractions were filtered immediately through a 0.7- μ m (micrometre) glass fibre pre-filter and a 0.45- μ m cellulose acetate filter (Minisart) into 2 sample-rinsed 30-ml plastic vials. As per sampling protocols, a separate unfiltered sample was collected in a sample-rinsed 30-ml vial for some of the nutrient analyses.

The samples were frozen until delivery to the Australian Laboratory Services within 28 days. Nitrogen oxides, ammonium, soluble reactive phosphorus, total nitrogen, total Kjeldahl nitrogen and total phosphorus (all of these parameters are part of UTN4 method), dissolved total nitrogen (EK262PA method), dissolved total phosphorus (EK267PA method), and dissolved major anions (silicon and sulphur, ED040F method) were analysed using a flow injection analyser.

4.4.4 Chlorophyll-a

Chlorophyll-a concentrations are measured in situ using an EXO2 sonde. However, elevated turbidity levels can interfere with the sensor's optical readings which may reduce measurement accuracy. To ensure data reliability, water samples are collected for laboratory analysis, and these laboratory chlorophyll-a results are used in the Water Quality Index calculations and presented in section 4.5.4.

Surface water chlorophyll-a samples were collected in a plastic 111-mL sample jar directly from the river at a depth of 20 cm, with care taken to avoid surface scum. Samples were kept on ice in the dark until processing on the same day as collection. In the laboratory, samples were filtered onto a 0.7- μ m glass fibre filter paper, which was folded into a Falcon tube, wrapped in foil, and stored in the freezer for further analysis in the Lidcombe laboratory.

Chlorophyll-a concentrations were determined by UV fluorometry following extraction with 99.5% acetone solution using method APHA 10200H (APHA 2012). For sample preparation, 34 mL (~26.86 g) of acetone was added to a 50-mL centrifuge tube with a glass fibre filter. The tube was vortexed, sonicated in an ice bath for 10 minutes, and frozen overnight. For analysis, 1 mL of milli-Q water was added, vortexed, sonicated, and the filter paper was removed and rinsed with acetone. The sample was then centrifuged at 2,300 rpm for 11 minutes at 5 °C. After reaching room temperature, samples were analysed using a Turner fluorometer, calibrated with a stored calibration, and processed. The actual stock solution concentration was determined using the UVProbe software.

4.4.5 Organic carbon

Surface water samples for total and dissolved organic carbon analysis were collected directly from the river at a depth of 20 cm, using a sample-rinsed syringe, with care taken to avoid surface scum. Samples were filtered immediately through a 0.7- μ m glass

fibre pre-filter and a 0.45-µm cellulose acetate filter (Minisart) into an amber glass vial containing 1 mL sulphuric acid. Samples were stored in a portable fridge and/or ice-packed during transportation and then transferred to a fridge at 4 °C. The samples were delivered chilled to Australian Laboratory Services and analysed using EP002 method code.

4.4.6 Pesticides

Surface water samples were collected into amber bottles, taking care not to disturb sediments (if sampling from land). Samples were sent to the Lidcombe laboratory and forwarded to the analytical lab within 7 days.

Pesticides were analysed by the National Measurement Institute until July 2024. After July 2024 pesticides testing was subcontracted to the Environment Protection Science Branch in the Department of Climate Change, Energy, the Environment and Water (the department) until project completion. Samples were processed and analysed using gas chromatography-mass spectrometry (NGCMS_1117 method) and liquid chromatography-mass spectrometry (NR47 method).

Due to samples being analysed in different laboratories, there were variations in the limit of reporting (known as LOR) values across sampling rounds for herbicides and pesticides. The standard approach typically assigns half of the limit of reporting to values reported as less than limit of reporting, accounting for concentrations between zero and the reporting limit. However, inconsistencies in limit of reporting values across sampling rounds made this method impractical. To address this, an alternative approach was adopted. Compounds with detections less than limit of reporting values were excluded before analysis, but detection frequencies were reported for context. This approach improves data reliability and completeness while maintaining standard analytical practices.

4.4.7 Metals

Water samples for total and dissolved metals analysis were collected directly from the river at a depth of 20 cm, using a sample-rinsed syringe, with care taken to avoid surface scum. Samples were filtered immediately through a 0.7-µm glass fibre pre-filter and a 0.45-µm cellulose acetate filter (Minisart) into an acid-rinsed jar containing 5–10% nitric acid. The jars were sealed and transported on ice to Australian Laboratory Services for analysis. Dissolved metals were analysed by ICP-MS (EG020F method code) and dissolved mercury by Flow Injection Mercury System (EG035F method code). Dissolved silver was analysed by ORC-ICPMS (EG094F) in line with the lower guideline value (0.00005 mg/L). Results for dissolved silver analysed by ICP-MS are not considered for the Water Quality Index calculation.

Total and dissolved metal samples were collected during Phase 1 of the sampling (see section 4.5.1), with Phase 2 including total metal concentrations for 12 elements, while dissolved (<0.45 µm filtered) concentrations were measured for 14 elements. To assess ecological risk, dissolved concentrations of metals were screened against ANZG (2018) 95% species protection values due to their complex aquatic chemistry as this fraction is bioavailable to aquatic organisms.

4.4.8 Groundwater sampling

Groundwater samples were collected from 18 bores between 17 and 21 June 2024, and again between the 4 and 9 November 2024. Purged bores were analysed for dissolved oxygen, dissolved organic carbon, electrical conductivity, total nitrogen, nitrogen oxides, ammonium, bicarbonates, total phosphorous, soluble reactive phosphorus, temperature, pH, major ions (calcium, magnesium, bicarbonate, potassium, sodium, chloride, sulfate) and 10 dissolved metals.

All groundwater bores were government-owned and constructed from 50-mm diameter PVC pipe with 1 to 2 m vertical slotted sections located 10 to 32 m below ground level. Wells used for this project were chosen based on their location within the subcatchment and ease of access. Efforts were made to find suitable bores throughout the study area. Several bores planned for inclusion in sampling had either collapsed or had been capped prior to sampling, rendering it impossible to sample at these locations.

Bores were purged a minimum of 3 times the bore volume using a motorised inertia pump (Korbel et al. 2017) prior to sampling. Temperature, electrical conductivity, pH and dissolved oxygen were measured on site using a handheld meter (YSI Pro Plus multimeter, YSI Inc., Ohio USA).

Groundwater samples were pumped directly into appropriate containers for analysis of dissolved oxygen, dissolved organic carbon, total nitrogen, nitrates, ammonium, phosphates, total phosphorous, major ions (calcium, magnesium, potassium, sodium, chloride, sulphates) and 10 dissolved metals. Sterile CSIRO and Australian Laboratory Services sample bottles were used to collect water samples for total nitrogen, total phosphorus, nitrate plus nitrite, ammonium, total organic carbon, dissolved organic carbon, sulphate, ferrous iron, and total and dissolved metals analysis. Samples for dissolved organic carbon and dissolved metals were filtered using a pre-filter (0.7 µm) and a Minisart filter (0.45 µm), with metals collected into acid-rinsed containers. Pesticide samples were collected on both sampling occasions and processed as outlined in section 4.4.6.

Groundwater chemistry data are not included in the calculation of the overall Water Quality Index for the RCI but groundwater chemistry can have great impact on the surface water quality particularly at times of low flow. Therefore, these data are presented in a supplementary report detailing the groundwater health in the region (Hose et al. 2025).

4.4.9 Quality assurance and quality control

The following quality assurance and quality control (QA/QC) measures were used to ensure consistency during the collection, handling, transport, storage and analysis of water samples:

- Pre-sampling calibration checks were performed on all field probes prior to the commencement of sampling trips and recalibration was performed as required
- Consistency in labelling was maintained across all sites and samples (sample type code>sample number>sample date)

- Collection vials were triple-rinsed with sample water to remove low-level residues and prevent contamination, while filtered sample containers were rinsed with filtered sample water
- Samples were collected from the top 30 to 40 cm of the water column
- Images and/or notes were recorded on arrival at each sampling site to support water quality data
- Water samples were stored and maintained as per the conditions described in accordance with the project's QA/QC protocols and handling procedures
- All samples were analysed within the laboratory holding time limits for each analyte, as advised by laboratories
- All water quality data were quality checked by project staff before uploading to a shared drive
- Between sites, reusable equipment was cleaned by rinsing with Milli-Q water.

4.4.10 Overall calculation of the Water Quality Index

Overview and data inputs

Water quality in the lower Darling Baaka River was assessed using the Water Quality Index following the methodology applied in the 2023 RCI (DPE 2023a). The Water Quality Index provides a single summary of water quality conditions by combining the frequency and magnitude of exceedances of relevant guideline values across all metrics and sampling events in Phase 2 only.

While water quality sampling spanned both monitoring phases this report only considers data collected during Phase 2 due to the distinct differences in flow between phases 1 and 2 (see section 4.5.1). This provides consistency with other sampling conducted for this study, particularly the biological sampling which occurred at the same time as Phase 2 sampling.

The Water Quality Index was calculated using the ANZECC (2000) default guideline values for physico-chemical and nutrient data, specific to south central Australian lowland rivers. These guideline values do not include a guideline for chlorophyll-a and so, the south-east Australian guideline value of 5 µg/L was applied to enable its inclusion in the analysis. For pesticides and metals, 95% species protection guideline values from ANZG (2018) were used.

Calculation approach

The Water Quality Index scores were calculated using a modified version of the Canadian Council of Ministers of the Environment method (Lumb et al. 2006), consistent with department's 2023 RCI calculations. Importantly, the Water Quality Index was not calculated separately by metric and averaged. Instead, all individual measurements at each site across all metrics were pooled and assessed collectively. This approach ensures that both the frequency and magnitude of guideline exceedances across the full dataset are captured in the final score. The Water Quality Index was calculated using Equation 1.

$$\text{Equation 1: } WQI = \left(100 - \left(\frac{\sqrt{F1^2 + F2^2}}{1.41421} \right) \right) / 100$$

F1 is the frequency of exceedances, representing how often test results exceed guideline values. F1 was calculated using Equation 2.

$$\text{Equation 2: } F1 = \left(\frac{\text{Number of failed tests}}{\text{Total number of tests}} \right) \times 100$$

F2 is the magnitude of exceedance, measuring the extent to which failed test results exceeded (or fall below) the guideline value. Calculating F2 involves the following steps.

Step 1: Equation 3 was used for parameters where the test value (measured concentration) should not exceed the guideline (for example turbidity, nitrogen, phosphorus, electrical conductivity, upper limits of pH or dissolved oxygen).

$$\text{Equation 3: } \text{Excursion} = \left(\frac{\text{Failed test value } i}{\text{Guideline value}} \right) - 1$$

Step 2: Equation 4 was used for parameters where the test value should not fall below the guideline (for example lower pH or dissolved oxygen limits).

$$\text{Equation 4: } \text{Excursion} = \left(\frac{\text{Guideline value}}{\text{Failed test value } i} \right) - 1$$

The total number of results which do not comply with the target were calculated by summing the *Excursions* and dividing by the number of tests to give the *nse* (normalised sum of excursions), as in Equation 5.

$$\text{Equation 5: } nse = \left(\frac{\sum_{i=1}^n \text{excursion } i}{\text{number of tests}} \right)$$

The *nse* was then scaled to yield an F2 value between 0 and 100 using Equation 6.

$$\text{Equation 6: } F2 = \left(\frac{nse}{[0.01nse + 0.01]} \right)$$

Step 3: A polynomial transformation was undertaken to align with the 0–1 scoring system used in the RCI. The polynomial transformation was applied to the raw Water Quality Index using Equation 7.

$$\text{Equation 7: } \text{Normalised } WQI = (0.7167 \times WQI^2) + 0.1268 \times WQI + 0.073$$

The values were then categorised into a water quality rating for input into the RCI (Table 10). Both pre- and post-normalised index values are presented for comparison. The water quality ratings are not evenly split into categories but rather rely on a subjective process incorporating expert opinion. This results in a larger proportion of scores in the poor to very poor categories than good to very good in recognition of the high proportion of modified or disturbed catchments in New South Wales (DPE 2023a).

Table 10 **Water Quality Index (WQI) scores and corresponding River Condition Index (RCI) water quality grade**

WQI score	Normalised WQI score for RCI calculation	RCI condition grade
0.0 to <0.3	0.0 to <0.2	Very poor
0.3 to <0.6	0.2 to <0.4	Poor
0.6 to <0.8	0.4 to <0.6	Moderate
0.8 to <0.95	0.6 to <0.8	Good
0.95 to 1.0	0.8 to 1.0	Very good

Sensitivity analysis

As the Water Quality Index is calculated using pooled data across all parameter types, a sensitivity analysis was conducted to understand the relative influence of different parameter groups. This involved recalculating the Water Quality Index while sequentially removing one parameter group at a time (for example nutrients, pesticides, chlorophyll-a) and comparing the resulting score to the full dataset score. Graphs showing these comparisons with each panel plotting the recalculated Water Quality Index (excluding one group) against the full index are provided in Appendix A.

Limitations

The integration of contaminants into the index and broader RCI presents challenges due to data availability, ecotoxicological variability and methodological constraints. For instance, metals and pesticides have different mechanisms of toxicity, including acute, chronic and bioaccumulative effects, which are not adequately captured by the current Water Quality Index. Additionally, cumulative toxicity and interactive effects of multiple contaminants are not considered in the RCI framework, which currently evaluates water quality parameters independently. Temporal averaging of metrics may also mask short-term pollution events, reducing sensitivity to acute contamination risks. Addressing these gaps has been recommended for future assessments (see Chapter 9).

4.5 Results and discussion

The following sections provide the results of individual metrics analysed in the Darling Baaka River Health Project. These are summarised into river reach zones (see Chapter 2, Figure 2) for ease of interpretation.

4.5.1 River conditions during the sampling period

This section provides an overview of river flows across the study area during phases 1 and 2 of the sampling program to provide context regarding prevailing conditions during the various sampling components of the study. Two major influences on flows and water quality are considered:

- river inflows from the upper Darling Baaka River basin at Wilcannia
- regulated water releases from the Menindee Lakes Storage Scheme.

Turbidity time series from the smart buoys are used to characterise the influence of various waterbodies across the study area.

Water quality sampling during this study has spanned both monitoring phases. However, due to distinct differences in flow, this report only considers data collected during Phase 2. This has been done to remain consistent with other sampling conducted for this report, as biological, geomorphology and riparian condition sampling was completed in Phase 2 of the project.

Detailed results for nutrients, physico-chemical, metals and pesticides are provided in Appendix B.

Phase 1 (September 2023 to April 2024)

This sampling phase covered a period of moderate river flows (median discharge at Wilcannia 884 megalitres per day [ML/day]) (Figure 3). During this time turbidity was low (<50 NTU).

During early March 2024 there was a brief flow pulse, otherwise known as a fresh, peaking at 4,400 ML/day, owing to heavy rainfall in the upper Darling Baaka catchments. Turbidity levels up to 900 NTU were recorded in the Wilcannia weir pool during the influx of this water and continued to influence the turbidity of the weir pool for weeks (Figure 3) and into the Phase 2 sampling period (which began in April 2024). The interception and storage of this flow in Lake Wetherell and the broader Menindee Lakes Storage Scheme meant that the fresh was unmeasurable downstream of Weir 32 in the month of March 2024 and highlights the influence of river regulation operations on flows in the region (Figure 3).

Flows to the Great Darling Anabranh were not impacted by the March 2024 fresh in the Darling Baaka River. This is due to a complex regulation system whereby flows to the Anabranh are controlled by a combination of releases from Lake Cawndilla and the drainage from various other lakes along the Great Darling Anabranh.

Phase 2 (April 2024 to March 2025)

Phase 2 of the sampling was used to calculate the Water Quality Index scores. Flows during Phase 2 were characterised by higher river flows (median discharge at Wilcannia 1,315 ML/day). Turbidity was still impacted by elevated flows experienced in March 2024 which brought turbid waters down the lower Darling Baaka River during the beginning of this Phase and was high near Wilcannia.

In mid-May 2024, there was an additional high-flow event peaking at 12,643 ML/day (20 May 2024) at the Wilcannia gauge. This high-flow event was characterised by an initial pulse of highly turbid water (770 NTU), followed by a brief second pulse of less turbid water, and finally a sustained flow of highly turbid water (780 NTU). This turbid water reached Lake Wetherell approximately 7 days after arriving at Wilcannia and then flowed into the downstream reaches of the study area (below Menindee Main Weir) via regulated releases from Lake Pamamaroo.

Turbid water dominated Wilcannia, Lake Wetherell and Menindee weir pool regions until the middle of September 2024. The planned release of water in September 2024 (see Figure 3) effectively short-circuited the attenuating effect of the Menindee Lakes Storage Scheme, resulting in a transitory slug of turbid water moving through the Pooncarie North and Pooncarie South zones (sites S15–S23).

This planned release water reached Pooncarie town (site S20) on 10 September 2024 causing a brief increase in turbidity (~450 NTU). Water in the river was gradually diluted by a much less turbid, sustained pulse of moderate flows, with a regulated 5-day release of 4,000 ML/day at weir 32 aimed at diluting a large cyanobacteria bloom near Pooncarie which occurred in late September. The reduction in river inflows between September and December 2024 resulted in decreased turbidity in the lower Darling Baaka River.

The river received a third high-flow pulse at Wilcannia in late December 2024 which peaked at 15,814 ML/day (4 January 2025). This caused a spike in turbidity in the Wilcannia weir pool, which reached Lake Wetherell 7 days later, and was subsequently released downstream to the Menindee weir pool a week after it arrived in Lake Wetherell (Figure 3).

The Great Darling Anabranch had a cease-to-flow event between August and late October 2024. This resulted in flow restriction and the drying out of some river reaches.

The first large sampling campaign for RCI biological metrics (see Chapter 6) occurred during the initial recovery phase following the May 2024 high-flow event (Figure 3). Even though the flows had peaked at Wilcannia, high stream flows and turbidity prevailed throughout the study area during this sampling campaign. Subsequent sampling for RCI water and biological indexes occurred during a phase of diminishing flows and increasing water clarity. These factors need to be accounted for with respect to the biota surveyed (see Chapter 6).

No water quality samples were collected in Talyawalka Creek due to access issues and lack of water flow between April 2024 and March 2025.

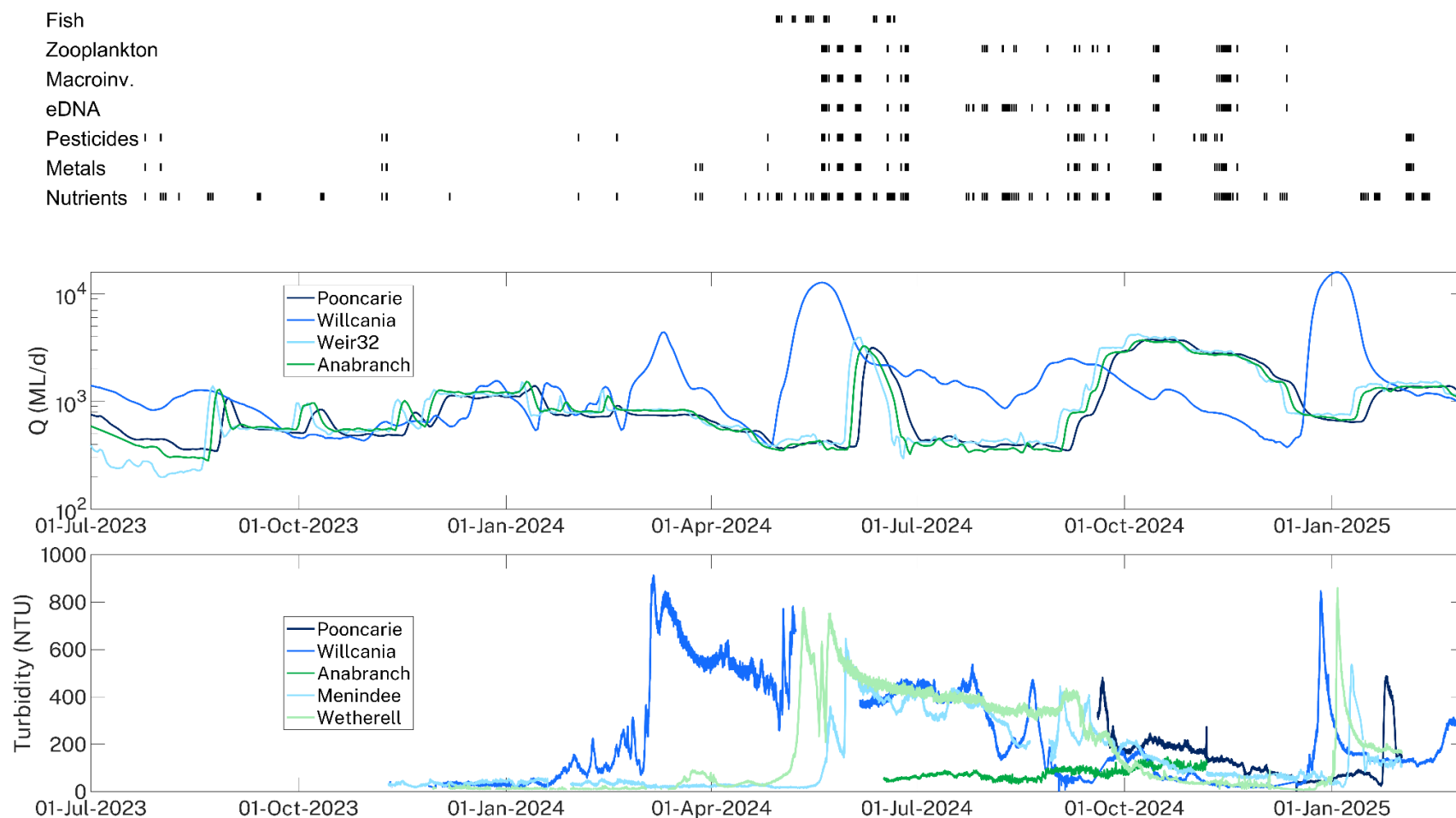


Figure 3 Sampling frequency of different River Condition Index indicators and metrics (top, sampling events indicated by dashes), stream discharge (middle; megalitres per day [ML/day]) and turbidity (bottom; nephelometric turbidity units [NTU]) across the study area during Phase 1 and Phase 2 monitoring periods.

4.5.2 Physico-chemical water quality

pH

pH values were generally high throughout the study area. This is thought to be due to a combination of geology and high rates of primary productivity by algae, which can contribute to increases in pH, balanced by decreases in pH due to organic matter breakdown.

Smart buoy data revealed that significant daytime increases in pH of up to 1 (one) occurred in surface waters, likely due to primary productivity (Figure 4). There were decreases in pH at night and with depth during periods of stratification, presumably due to high rates of heterotrophic respiration below the photic zone.

High-flow inputs from the upper Darling Baaka River catchments had lower pH (~7.2), which influenced pH at sites from Wilcannia to Lake Wetherell (Figure 5). The pH levels increased on the lower Darling Baaka River downstream of Menindee Main Weir and towards Wentworth, however remained (mostly) within the guideline values.

The Great Darling Anabranch sites recorded significantly higher pH than the lower Darling Baaka River. This is most likely reflecting the combined impact of high rates of primary productivity and high pH of inputs from lakes downstream of Packers Weir (site S29). Exceedances of the upper default guideline values occurred primarily at the lower Great Darling Anabranch sites (sites S24–S26).

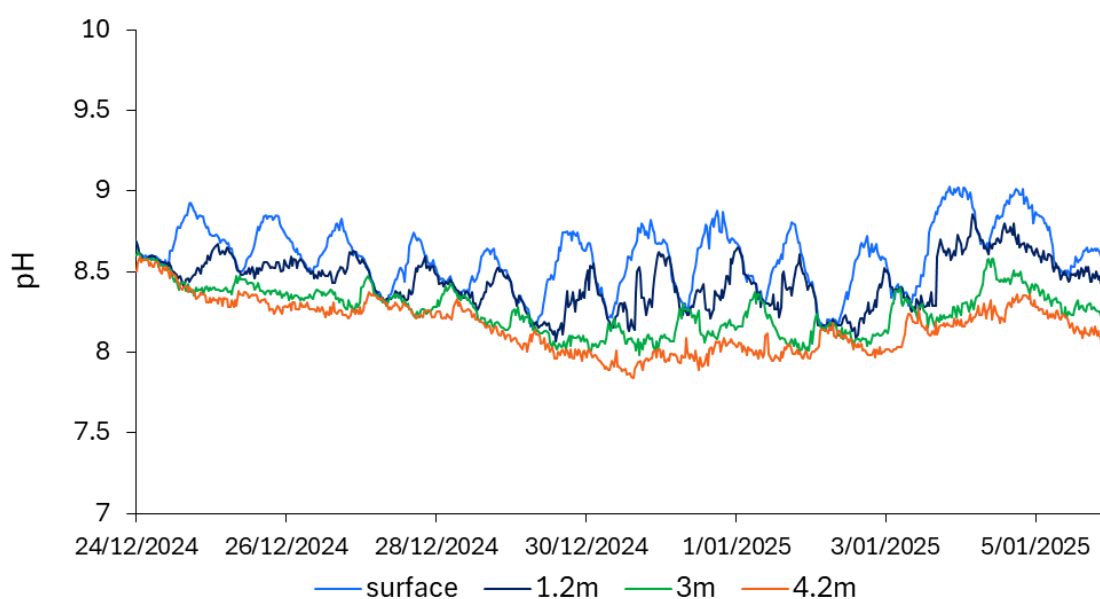


Figure 4 pH at 4 depths in the Menindee weir pool showing diurnal variation in surface water associated with algal productivity (December 2024 to January 2025)

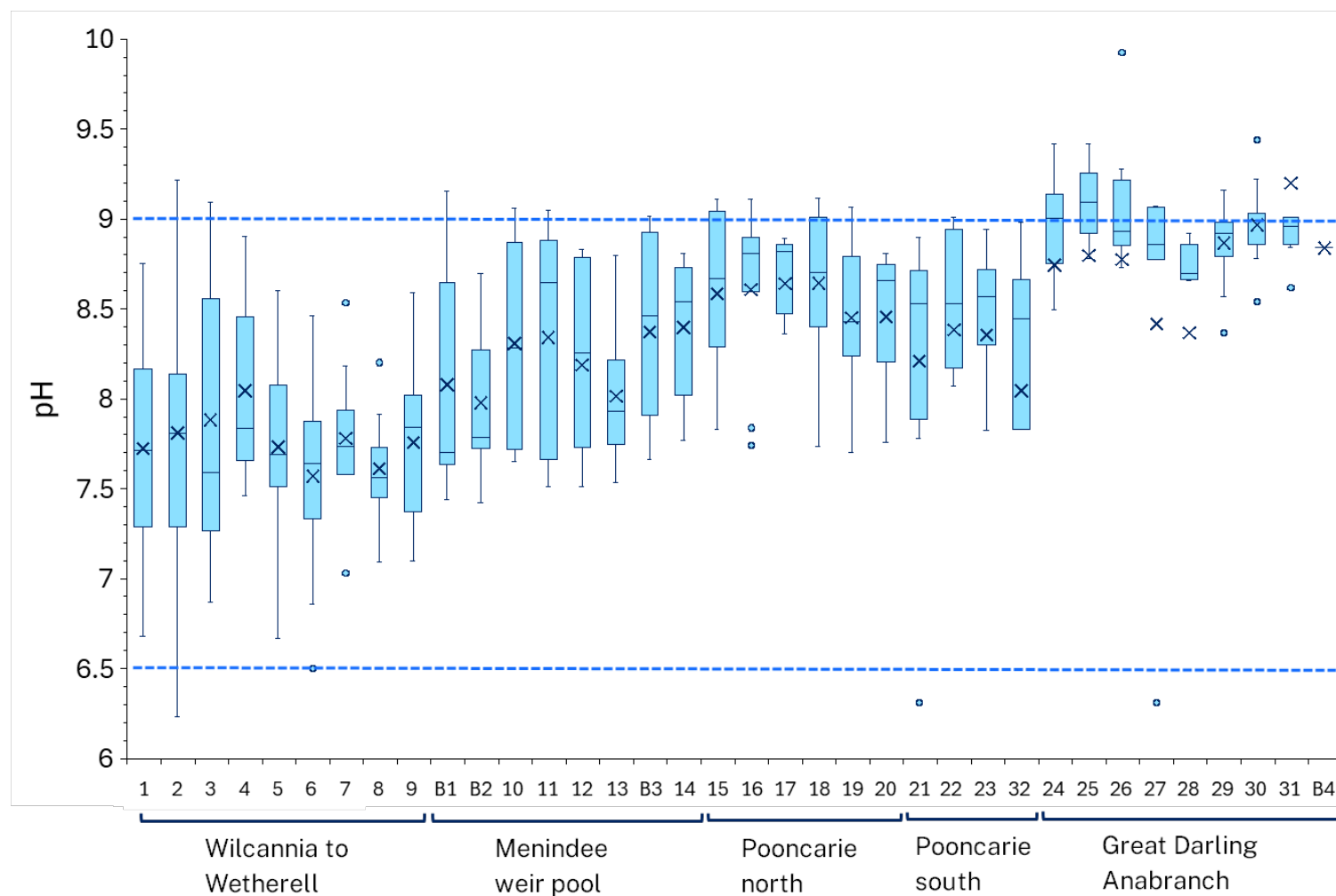


Figure 5 Variation in pH across the study area during the Phase 2 sampling period. The blue dashed lines show the default lower and upper limit guideline values

Dissolved oxygen

Analysis of the dissolved oxygen in the water column used data from both the smart buoys as well as monthly grab samples. Monthly grab samples provide a large spatial range of data (35 sites), whereas the smart buoy data were used to investigate trends over a very fine temporal scale (30 minutes) at 6 locations on the river. Dissolved oxygen is commonly expressed as a concentration (mg/L) as this indicates the actual amount of oxygen available for aquatic organisms, whereas percent values provide details on how close the water is to being fully saturated. As a general guide, native fish and other large aquatic organisms require at least 2 mg/L of dissolved oxygen to survive but may become stressed if levels are below 4 mg/L for prolonged periods (NSW DCCEEW 2025). In this context, low dissolved oxygen concentrations are defined as values falling below the 4 mg/L fish stress threshold and/or below the 2 mg/L fish lethality threshold.

Several sites recorded dissolved oxygen saturation that did not meet the ANZECC 2000 guideline thresholds. Breaches of these guideline values were recorded in all reaches of the river, however, were more frequent and larger in the section of the river near Lake Wetherell (sites S6–S9) and in the region closest to the township of Menindee (sites S12 and S13). These sites recorded very low dissolved oxygen that, on occasions, approached potentially lethal levels (<2 mg/L) for some aquatic biota. In general, the Great Darling Anabranched recorded good to very good dissolved oxygen saturation, and there were limited exceedances of guideline values in these regions.

It should be noted that grab samples were not taken at the same time of the day on all sampling events and this influences concentrations. Smart buoy data indicate that primary productivity and respiration over the diurnal cycle is a major contributor to oxygen in the water column, therefore the sampling time will impact the results. A comparison of smart buoy data and grab samples is provided in Appendix C. Smart buoy data (see below section) are also useful for analysing the long-term trends of dissolved oxygen and understanding responses to hydrological and weather-related drivers and provide detailed information on stratification dynamics within the lower Darling Baaka River.

Monthly grab samples

Dissolved oxygen (DO) from grab samples taken across the study area ranged from 26% to over 200% saturation (median = 93%; Figure 6), equivalent to 2.1 to 28 mg/L (median = 9.0 mg/L; Figure 6). Most dissolved oxygen percent saturation values recorded downstream from Pooncarie North to the Great Darling Anabranched (excluding site S31) were above the ANZECC 2000 low threshold of 80% saturation, which supports healthy aquatic ecosystems.

Notably, several sites in this region recorded supersaturation events exceeding 200%, with an extreme case of 320% saturation observed at site S26 in the Great Darling Anabranched. This is likely indicative of high photosynthetic activity or algal blooms. In contrast, more variable concentrations were observed upstream of Weir 32, with sites S6–S9 consistently below guideline values. Sites within the Menindee weir pool zone, particularly the site closest to Menindee town (site S12), also record dissolved oxygen

values below default guideline values on multiple occasions. Site S9 recorded the lowest observed value of 26% saturation in January 2025. These sub-threshold values in the upstream river reach zones suggest the potential for hypoxic conditions, particularly during periods of low flow or high biochemical oxygen demand. This poses a risk to sensitive aquatic species which require consistently high oxygen levels.

The upstream stretch between Wilcannia and Lake Wetherell (sites S6–S9) recorded frequent dissolved oxygen concentrations below the 4 mg/L fish stress threshold, with sites S8 and S9 (both in Lake Wetherell) displaying dissolved oxygen concentrations approaching the lethality threshold. Several isolated low dissolved oxygen concentrations were recorded between the Menindee Main Weir and Wentworth (Figure 7). These values represent severe hypoxia and present stressful to lethal conditions for aquatic life. These conditions highlight a significant ecological risk during low-oxygen events in this region.

In contrast, sites from Pooncarie North to the Great Darling Anabranch maintained oxygen concentration levels above the stress threshold (4 mg/L). However, one site in the Great Darling Anabranch (site B4) recorded a concentration of 3.8 mg/L, falling below the stress threshold during summer 2025. This further indicates that localised low-oxygen conditions may still be occurring on the Great Darling Anabranch.

Notwithstanding diurnal variation in dissolved oxygen dynamics, the grab samples provide a reasonable indication of spatial variation in the metabolic status of surface waters across the study area (see Figure 6; Figure 7). There were distinct reaches where dissolved oxygen consistently exceeded 100% saturation, indicating net autotrophic metabolism (for example, upstream of Wilcannia weir and the Anabranch; Figure 6; Figure 7). Smart buoy data confirmed that these reaches were characterised by high rates of primary productivity and minimal stratification.

In contrast, there were reaches where dissolved oxygen was consistently below 100% saturation, indicating net heterotrophic metabolism (for example Lake Wetherell, Menindee weir pool; Figure 6). Smart buoy data indicated that while these sites exhibited high rates of primary productivity in surface waters, they were prone to chronic stratification with hypoxic/anoxic water at depth. Turnover of stratified waters due to increased flow and/or atmospheric temperature tended to reduce surface water dissolved oxygen saturation due to mixing with hypoxic bottom water. Dissolved oxygen saturation exceedance of the default guideline value occurred primarily in these reaches during Phase 2 sampling.

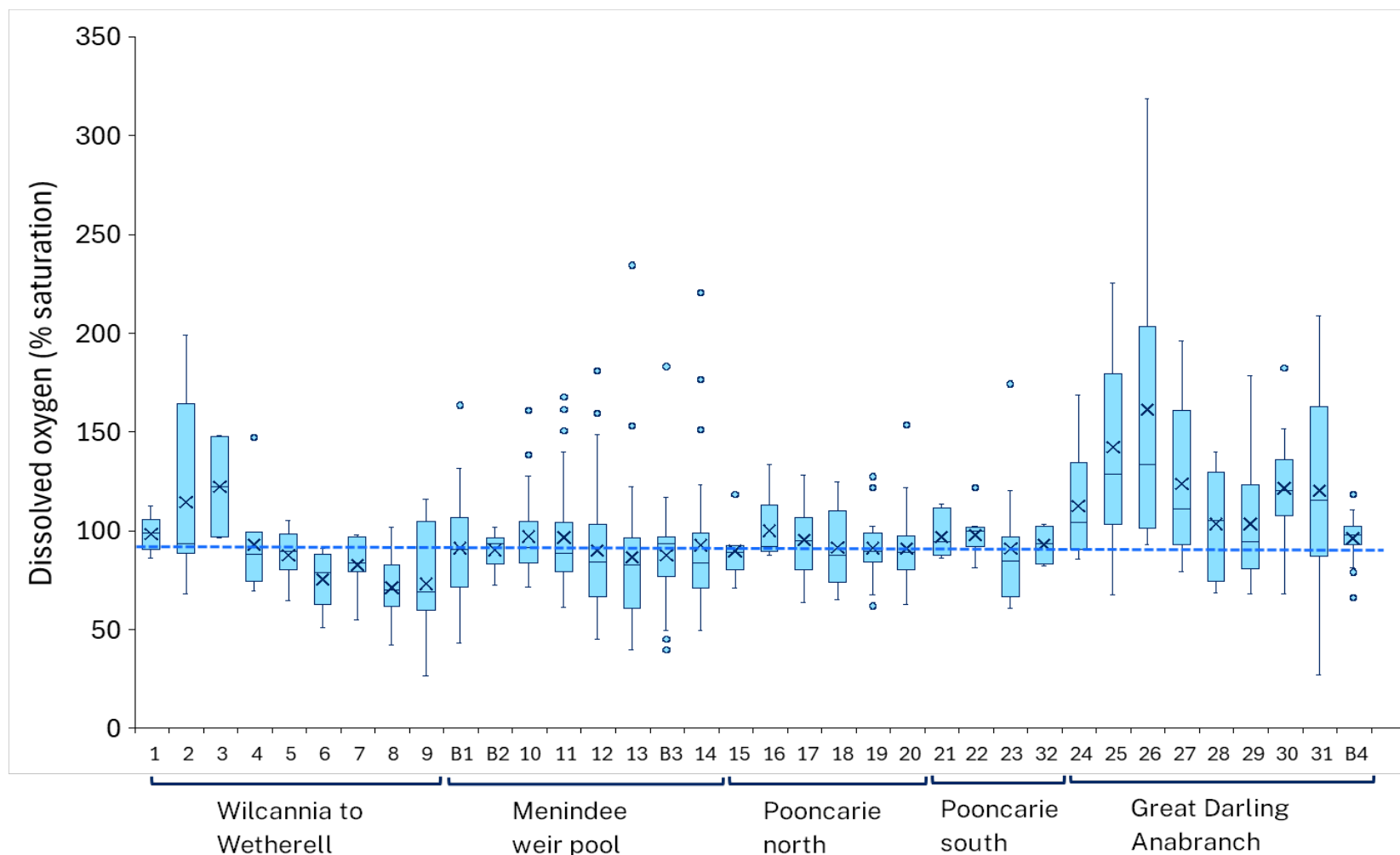


Figure 6 Dissolved oxygen concentrations (% saturation) recorded at each site across the study area during the Phase 2 sampling period. The dashed line shows lower limit guideline value

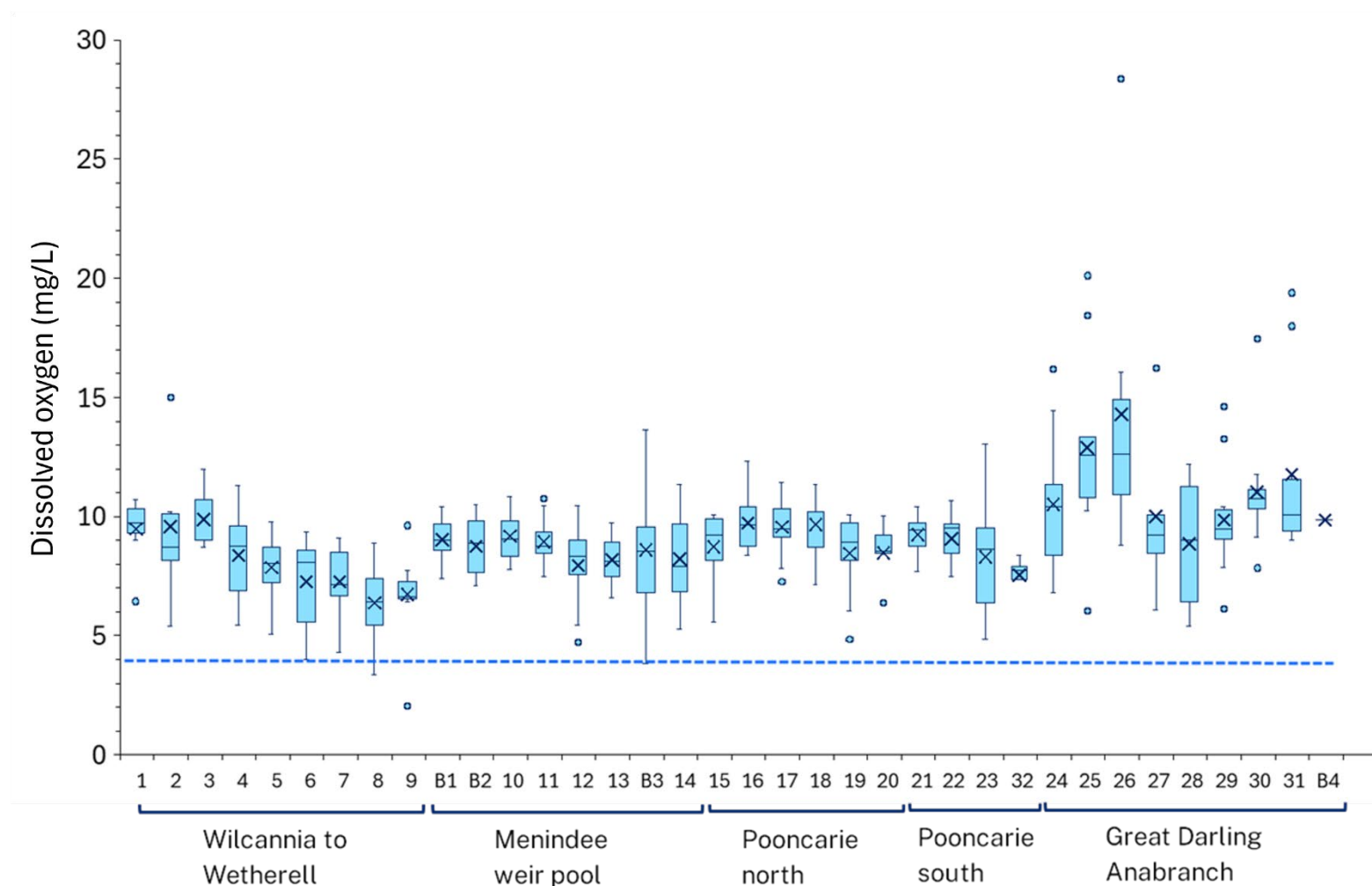


Figure 7 Dissolved oxygen concentrations (milligrams per litre [mg/L]) recorded at each site across the study area during the Phase 2 sampling period. The dashed line shows lower limit considered stressful for aquatic organisms (4 mg/L)

Smart buoy data: effects of microbial processes and stratification patterns

Complementary to grab sampling data, high temporal resolution smart buoy data provide longer-term insights on the cycling of dissolved oxygen within the system. These data revealed large diurnal variation in surface water dissolved oxygen concentrations across the lower Darling Baaka River (Figure 8). During the daytime, primary production by algae produces oxygen (autotrophic metabolism), while oxygen consumed by respiration associated with the microbial community (heterotrophic metabolism) proceeds continuously. The net result of these metabolic processes over the diurnal cycle is an increase in dissolved oxygen during the day (when autotrophic production exceeds heterotrophic consumption) and a decrease in dissolved oxygen during the night and below the depth of light penetration. Combined with increased temperatures during the day, this can result in the stratification of oxygen in the water column (Figure 8A–C), with lower layers of the water often becoming severely depleted in oxygen (Figure 8C).

Stratification and overnight mixing (turnover events) of the water column have significant impacts on dissolved oxygen concentrations with implications for aquatic biota. Smart buoy data show that stratification was generally broken down as nighttime cooling of surface waters was sufficient to cause turnover of the water column and mixing of dissolved oxygen (for example Great Darling Anabranch and Menindee weir pool; Figure 8A and B). Turnover events can mitigate the development of hypoxic conditions through the mixing of super-saturated surface water with oxygen-depleted bottom water. However, in the event of severe and persistent oxygen stratification where bottom water becomes anoxic, turnover can overwhelm oxygenated surface waters resulting in a catastrophic crash in dissolved oxygen (Moritz et al. 2019). Smart buoy data indicate that the degree of stratification tends to become more severe and persistent in deeper reaches with low flow velocities (for example Lake Wetherell; Figure 8C).

Lake Wetherell experienced extended periods of stratification with extremely low oxygen concentrations (<1 mg/L) in deep water (for example late December 2024; Figure 8C). Stratification was less severe in the Menindee weir pool (Figure 8B), however, this site did have periods of persistent stratification observed during the study. Smart buoy data were used in real time to monitor oxygen concentration and potential stratification in the past 12 months to guide water releases aimed at breaking down stratification by increasing flow. Generally, releases greater than ~800-1,000 ML/day at weir 32 appeared to break down stratification in the Menindee weir pool.

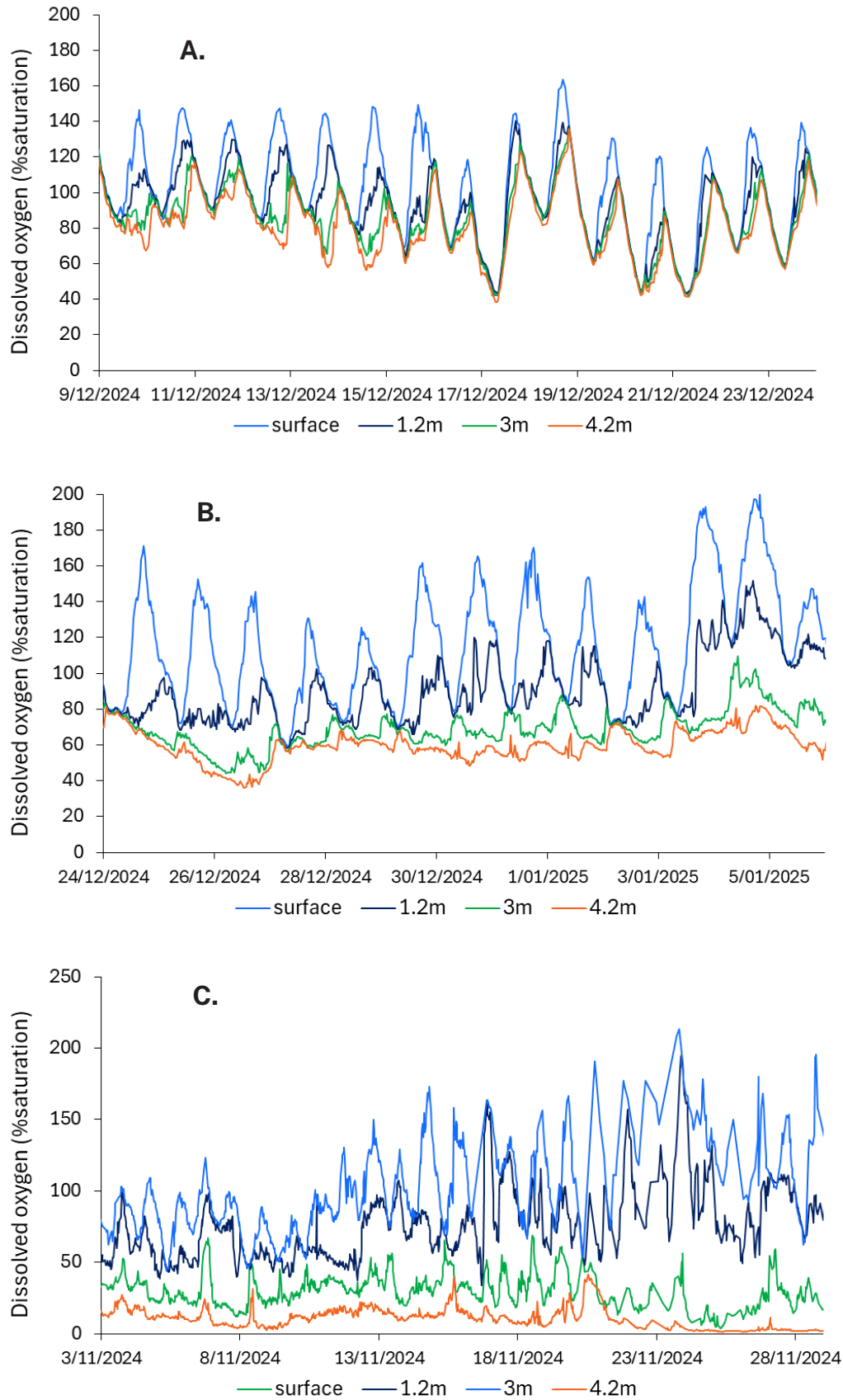


Figure 8 Variation in dissolved oxygen (% saturation) in A) the Great Darling Anabranch; B) Menindee weir pool; and C) Lake Wetherell

Summary of dissolved oxygen results

The current findings show that several reaches within the study area are vulnerable to hypoxic conditions. The areas of most concern are upstream of Weir 32, particularly in upstream reaches in Lake Wetherell approaching Wilcannia. It is in these areas where dissolved oxygen concentrations below 4 mg/L were recorded, raising concerns for aquatic biota during seasonally critical periods such as summer. The smart buoy data confirm some long periods of stratification of the water column in summer periods, where dissolved oxygen in deeper sections was consistently below the fish stress threshold of 4 mg/L (Gehrke 1988).

While not directly linked to acute aquatic mortality, values below 80% saturation are considered suboptimal and may lead to chronic stress, impaired growth, reduced reproductive success, and shifts in aquatic community structure over time (ANZECC 2000). The frequent detection of dissolved oxygen saturation values below 80% in several parts of the system, particularly in the Wilcannia to Lake Wetherell zone, suggests that these areas may not be consistently supporting optimal ecological conditions and may indicate overall poor river health. Chronic exposure to low oxygen levels can alter ecosystem dynamics by favouring more tolerant species, reducing biodiversity, and weakening overall ecosystem resilience.

Thermal stratification and the resulting hypoxic conditions within the weir pools of the lower Darling Baaka River during low flows have been linked to mass fish death events in 2018 and 2019 and contributed to fish deaths in 2023 (DPI 2019; OCSE 2023). The information provided through real-time monitoring of stratification using the smart buoys has seen a significant improvement in the management and timing of water releases in the Menindee Lakes system. Real-time monitoring has informed the regulation of water in order to prevent extended periods of stratification.

Electrical conductivity

Conductivity varied significantly according to river flow (Figure 9), with higher conductivity (800 to 2,000 $\mu\text{S}/\text{cm}$) during the Phase 1 low-flow period, and lower conductivity (<500 $\mu\text{S}/\text{cm}$) associated with high river inflows influencing the river during Phase 2. The large declines in conductivity observed in early 2024 coincided with wet weather events in the upper catchment and subsequent high-flow periods.

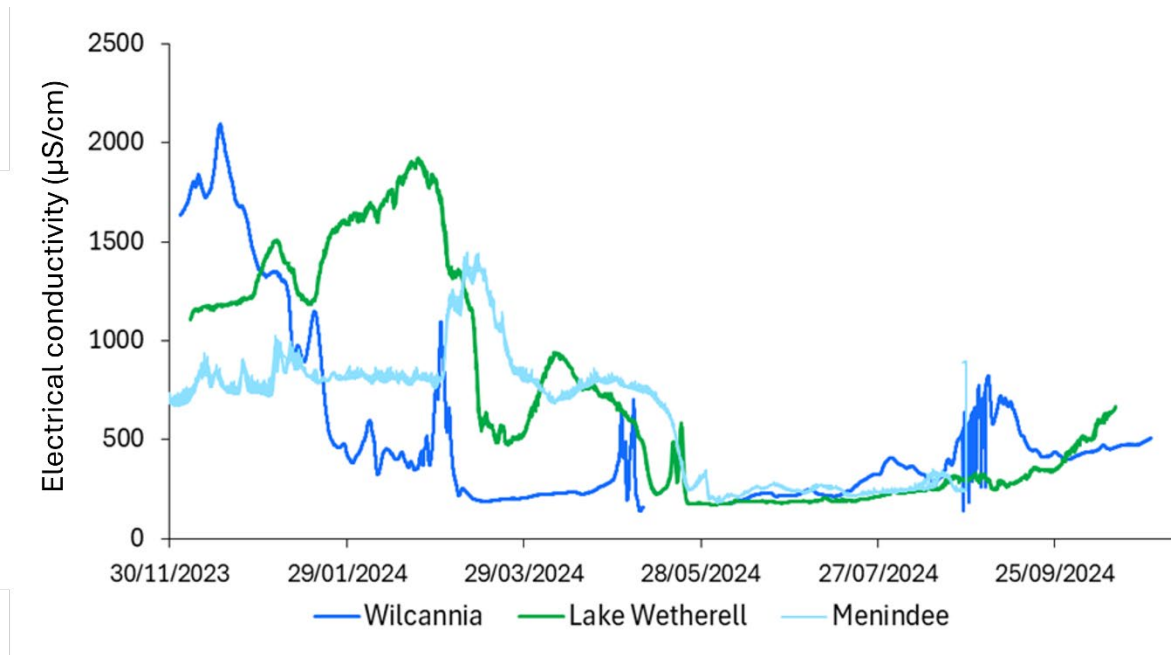


Figure 9 Smart buoy data showing variation in electrical conductivity (microsiemens per centimetre [$\mu\text{S}/\text{cm}$]) associated with a succession of high-flow events between December 2023 and October 2024 at 3 sites

During Phase 2 of sampling, inflows from Lake Menindee tended to have lower conductivity than the main river (Figure 10). Likewise, Lake Cawndilla inflows had low conductivity which influenced the upper reaches of the Anabranch. There were no exceedances of conductivity default guideline values recorded during the study period.

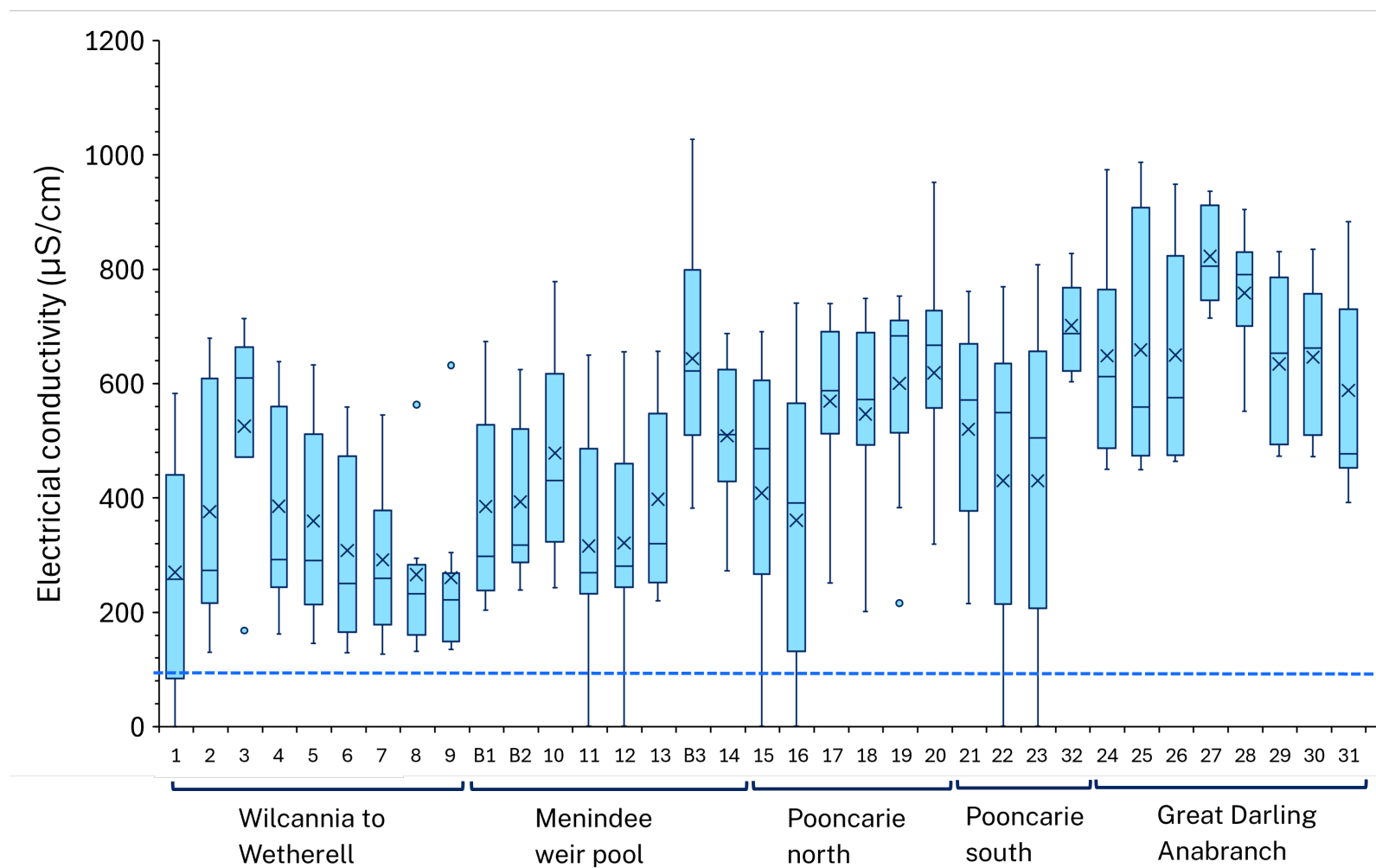


Figure 10 Variation in conductivity (microsiemens per centimetre [$\mu\text{S}/\text{cm}$]) across the study area during the Phase 2 sampling period. The blue dashed line shows the default lower limit guideline value

Turbidity

Turbidity in the study area is influenced by upstream inputs and river regulation activities (see section 4.5.1), primarily the Menindee Lakes Storage Scheme. Typically, this regulation results in the settling of sediments in the lakes before this lower turbidity water is released. However in times of floods, waters flowing into these lakes have high turbidity and sediment may not have time to settle. Turbidity exceeded default guideline values throughout the study area for most of the Phase 2 sampling (Figure 11).

The average turbidity from Wilcannia to Lake Wetherell (sites S1–S9) was extremely high, highlighting the influence of turbid river inflows from the upper Darling Baaka River basin (Figure 3 and Figure 11). Turbidity generally decreased with distance downstream of the Menindee Main Weir. This was mostly due to the partial settling of suspended solids as water passed through Lake Pamamaroo before being released downstream. Further reductions in turbidity downstream of Menindee Creek (site S14) are likely due to low turbidity inflows from Lake Menindee (site B3) and settling throughout the weir pool. Turbidity tended to be lower in the reach downstream of Weir 32 to Pooncarie (sites S15–S20).

Turbidity was relatively low in the upper reach of the Great Darling Anabranh, with increases downstream of Packers Weir likely due to the drainage of turbid waters from the lakes, or in some cases, potentially the disturbance of bottom sediments during releases. There was a progressive decrease in turbidity through the mid to lower reaches of the Great Darling Anabranh zone (sites S28–S24) likely due to settling of suspended material as flow decreased (see section 4.5.1).

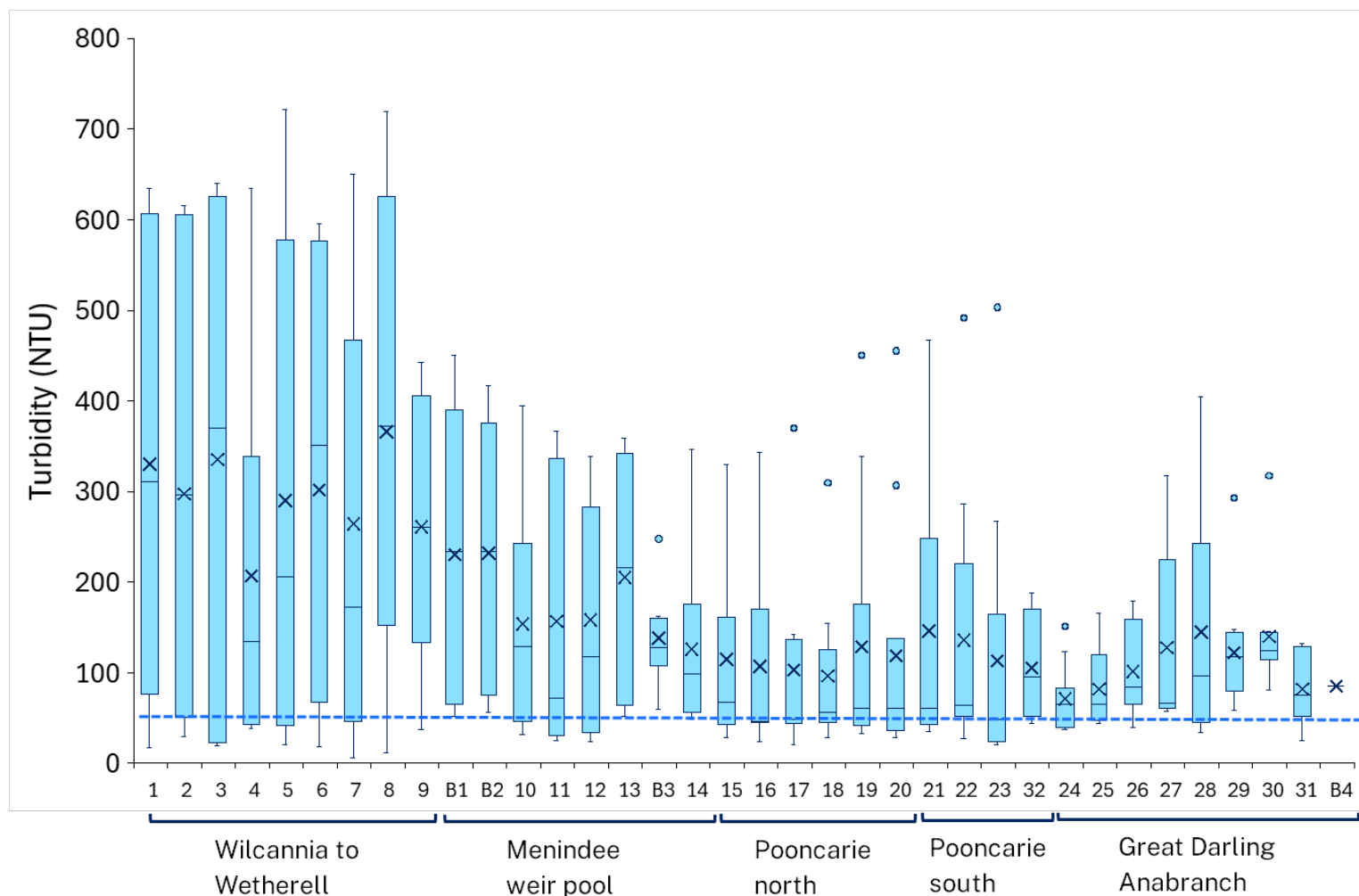


Figure 11 Variation in turbidity (nephelometric turbidity units [NTU]) across the study area during the Phase 2 sampling period. The blue dashed line shows the default upper limit guideline value

4.5.3 Nutrients

Total nitrogen

Total nitrogen concentrations were high across the study area, ranging from 0.54 to 6.6 mg/L. Some sites exceeded the guideline value of 1 mg/L on every sampling occasion (Figure 12). The average nitrogen concentration across the entire study site was 1.5 mg/L, with all sites individually recording averages above the guideline value for total nitrogen. The exceedance of the guideline value has contributed significantly to the overall 2025 Darling Baaka RCI scores for water quality (see section 4.6.1).

Total nitrogen concentrations generally increased from Wilcannia to Wentworth on the lower Darling Baaka River. Sites from Wilcannia to Lake Wetherell (sites S1–S9) had nitrogen concentrations which both exceeded guideline values on some occasions and were below guideline values on others, whereas all sites on the lower Darling Baaka River (below site S18) exceeded guideline values consistently.

Total nitrogen concentrations in the Great Darling Anabranch were, on average, higher than those in the lower Darling Baaka River. Similar trends of increasing total nitrogen concentrations moving downstream were observed in the Great Darling Anabranch zone (Figure 12). All samples taken in the Great Darling Anabranch zone exceeded guideline values.

The inflow sites, where storage water is discharged into the main river, displayed high total nitrogen concentrations (for example 4.6 mg/L at site B3 in June 2024) indicating water being released into the lower Darling Baaka River is enriched with nitrogen. Evidence from Lake Menindee (site B3) shows high nitrogen levels, supporting the hypothesis that lateral inputs from the lakes may be contributing to elevated total nitrogen. As water levels dropped it is suggested that drainage passed through a sediment delta with intense organic matter decomposition causing low dissolved oxygen and high ammonium concentrations. Similar nitrogen-enriching processes are likely occurring in other lakes feeding into the Great Darling Anabranch.

Overall, the elevated total nitrogen concentrations indicate ongoing nutrient pressures which may contribute to eutrophication and periodic dissolved oxygen fluctuations. These conditions suggest a system under significant biogeochemical stress. The frequency and magnitude of exceedances were relatively stable across months, with no clear seasonal decline, suggesting year-round nitrogen loading rather than being limited to specific periods like wet season runoff or agricultural cycles. Larger spikes in concentrations (values >3 mg/L and up to 6.6 mg/L) occurred intermittently between April and June 2024 but were more prevalent in samples collected between September 2024 and February 2025. These months likely correspond to localised events such as inflows, runoff pulses or algal bloom activity, but not necessarily system-wide trends. May and July 2024 showed relatively fewer high-end outliers, but still frequent exceedances of the guideline.

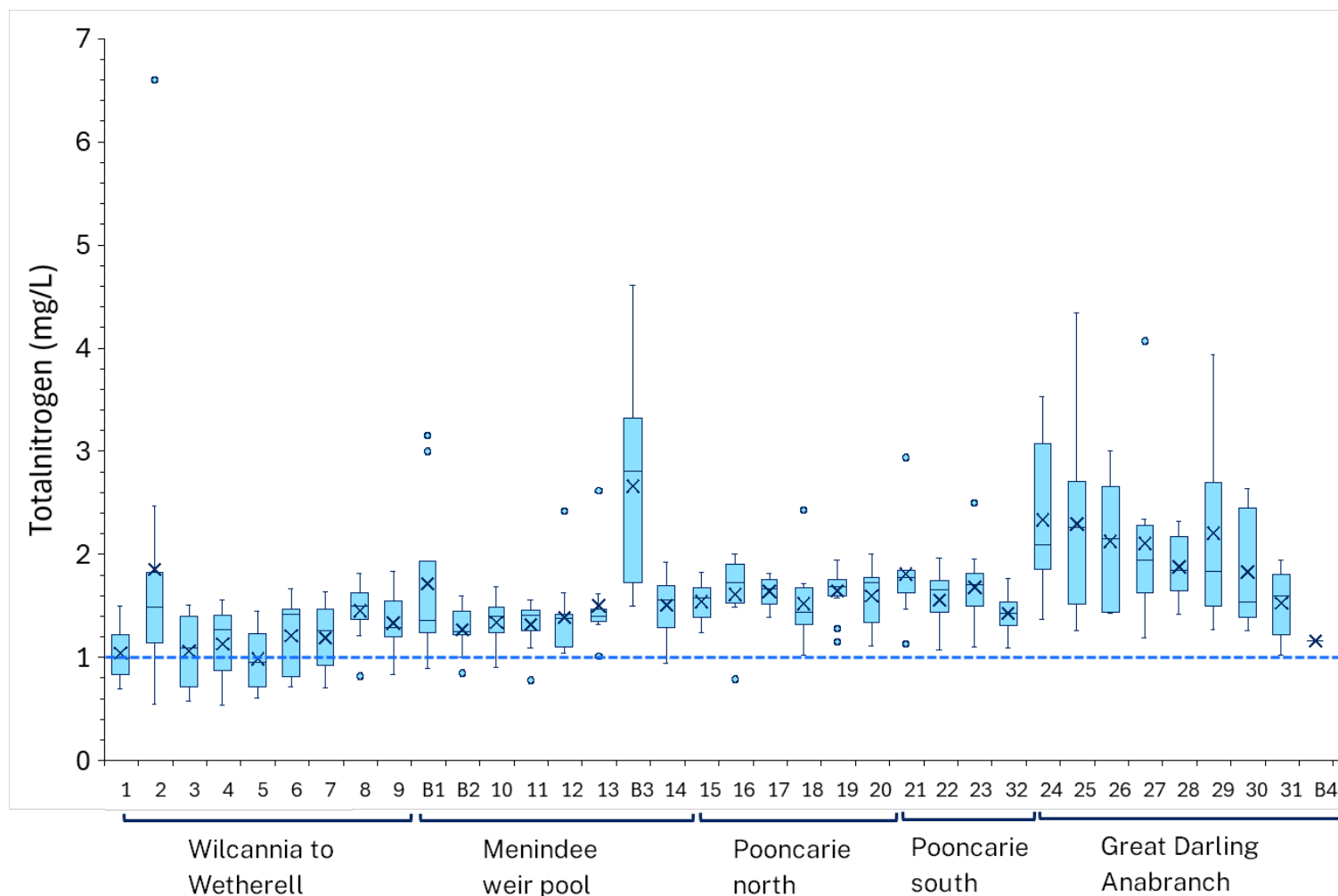


Figure 12 Variation in total nitrogen concentrations (milligrams per litre [mg/L]) across the study area during the Phase 2 sampling period. The blue dashed line shows the default upper limit guideline value

Groundwater seepage may be contributing to the high nitrogen concentrations observed, particularly downstream of Weir 32 and in the Great Darling Anabranch. Groundwater modelling (see Chapter 7) indicates that these regions are receiving water from groundwater sources that are relatively important in this stretch of river, particularly during low-flow periods. Elevated total nitrogen concentrations (>1 mg/L) were recorded in all 5 groundwater bores south of Weir 32, as well as bores on the Great Darling Anabranch and near Wilcannia (see section 4.5.8). The potential contribution of groundwater to overall river health in these regions warrants further investigation.

Elevated total nitrogen concentrations may also be linked to the significant algal blooms recorded in the sampling period. Algal blooms are a precursor to the subsequent mineralisation of nitrogen, the process where microbes convert organic nitrogen from dead algae into inorganic forms. This process can result in increases of total nitrogen in the water column at concentrations that may promote further algal growth, creating a positive feedback loop where nitrogen levels remain elevated. The high total nitrogen concentrations detected in the lower Darling Baaka River and Great Darling Anabranch coincided with increased algal biomass (indicated by chlorophyll-a concentrations; see section 4.5.4, Figure 21). The smart buoy data are suggesting that remineralisation may represent a significant internal source of nitrogen. This hypothesis is further supported by the consistently high dissolved inorganic nitrogen and soluble reactive phosphorus concentrations in bottom waters. This is indicated by a depth analysis study which was only undertaken in Phase 1 sampling, as no bottom water sampling was undertaken during Phase 2 (Figure 13).

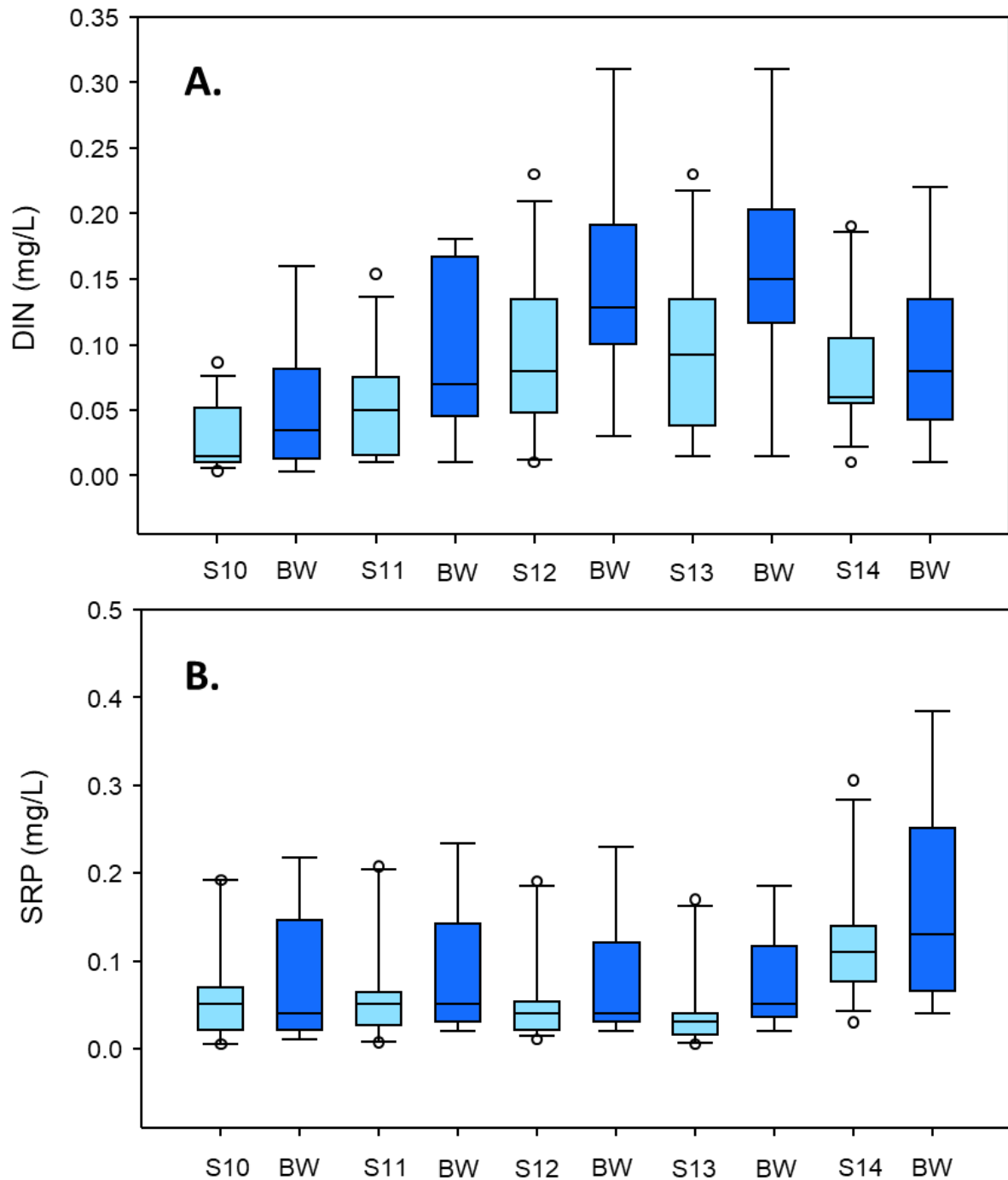


Figure 13 Concentrations of A) dissolved inorganic nitrogen (DIN; milligrams per litre [mg/L]); and B) soluble reactive phosphorus (SRP; milligrams per litre [mg/L]) in surface waters (S) and bottom waters (BW) of the Menindee weir pool during the Phase 1 sampling period. Bottom water samples not collected during Phase 2 sampling period.

Ammonium

Ammonium concentrations were relatively low, ranging from 0.0025 to 1.49 mg/L (median = 0.010 mg/L) and were mostly well below the guideline values of 0.1 mg/L (Figure 14). The exception to this was the Lake Menindee outflow site (site B3) which had the highest concentration of 1.49 mg/L, and site S24 (0.755mg/L) on the lower reaches of the Great Darling Anabranh (Figure 14). Elevated concentrations were also detected at sites S25 (0.31 mg/L), S27 (0.61 and 0.75 mg/L) and S28 (0.14 and 0.38 mg/L). At a pH of ~8, the upper range of these concentrations may exceed the 95% species protection guidelines indicating potential toxicity (ANZG, 2018).

The high ammonium concentrations in water draining from Lake Menindee (site B3) is likely due to the influence of organic matter remineralisation in the channels leading to the outlet (see section 4.5.5). The high concentrations at site S24 in the lower reach of the Great Darling Anabranh are anomalous and may indicate a local pollution source.

The predominantly low ammonium concentrations may be driven by the uptake of ammonium by algae in the river downstream of Weir 32 (sites S15–S23) and in the Great Darling Anabranh. Ammonium is the preferred bioavailable nitrogen source for algae (Lachmann et al. 2019), and it is expected that high rates of productivity will cause a drawdown in ammonium concentrations. Bacterially mediated conversion of ammonium to oxidised nitrogen (nitrification) may further reduce ammonium concentrations, particularly in waters with high dissolved oxygen saturation. Further, the low molar ratios of bioavailable nitrogen:phosphorus (see ‘Nitrogen versus phosphorus limitation’ section) indicated that productivity is most likely nitrogen-limited which would enhance the drawdown on ammonium concentrations, although further investigations are required to confirm this.

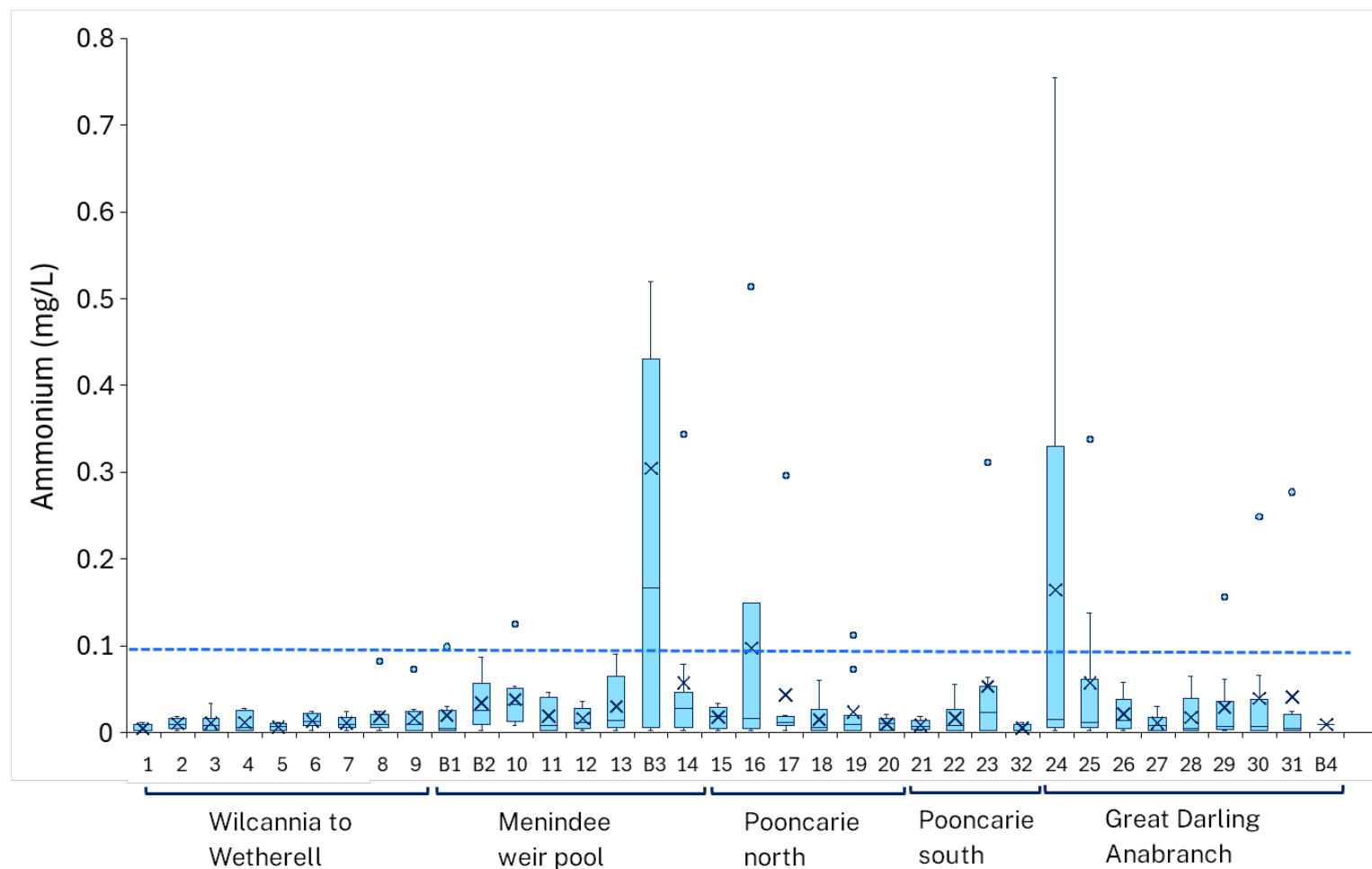


Figure 14 Variation in ammonium concentrations (milligrams per litre [mg/L]) across the study area during the Phase 2 sampling period. The blue dashed line shows the default upper limit guideline value

Note: the y-axis has been limited to 0.8 mg/L to better show spread of data and as such does not show the maximum concentration (1.4 mg/L) recorded at site B3.

Nitrogen oxides

The average oxidised nitrogen concentrations (NO_x) for each site on the lower Darling Baaka River exceeded the guideline value of 0.1 mg/L (Figure 15), and ranged from 0.001 to 1.4 mg/L. The highest nitrogen oxide concentrations were observed in the Menindee weir pool zone (site S12, 1.4 mg/L, June 2024) and Pooncarie South zones (site S23, 1.1 mg/L). Values commonly exceeded 1.0 mg/L in both zones. The origin of the peaks is unknown, but may reflect agricultural inputs, groundwater seepage or oxidation of ammonium under aerobic conditions.

Within the lower Darling Baaka River, the most frequent and elevated exceedances occurred during May to July 2024, where multiple sites recorded nitrogen oxide concentrations over 1.0 mg/L. These high concentrations can be partially explained by high concentrations of nitrogen in the inflows of turbid water to the upstream boundary of the study area (site S1) during high-flow events, and the subsequent nitrification of ammonium moving downstream. It is likely that water from high-flow events contains increased runoff from fertilised agricultural lands upstream of Wilcannia, which contributed to increased nutrients. The reduction in nitrogen oxides in the warmer months (late-spring to summer) may reflect enhanced plant and algae uptake, increased rates of denitrification and greater overall nutrient assimilation and transformation within the system (Figure 16; see discussion above).

In contrast, there were much lower nitrogen oxide concentrations recorded on the Great Darling Anabranch, where the average oxidised nitrogen concentrations for individual sites were below the thresholds. However, there were intermittent exceedances of guideline values at these sites which may indicate system-wide exposure to nitrate/nitrite inputs. It is unclear why oxidised nitrogen concentrations are significantly lower in the Great Darling Anabranch zone.

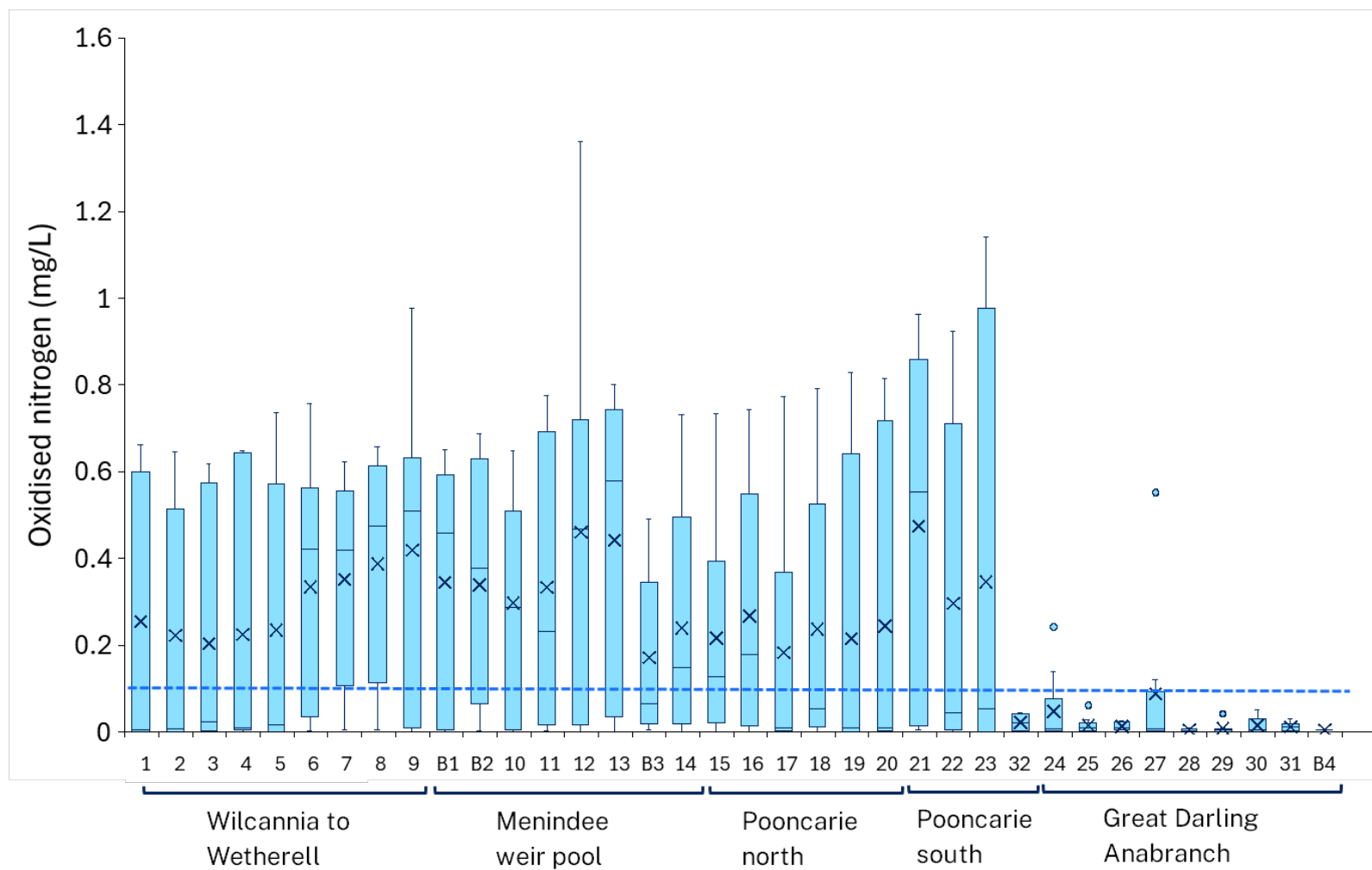


Figure 15 Variation in oxidised nitrogen concentrations (milligrams per litre [mg/L]) across the study area during the Phase 2 sampling period. The blue dashed line shows the default upper limit guideline value

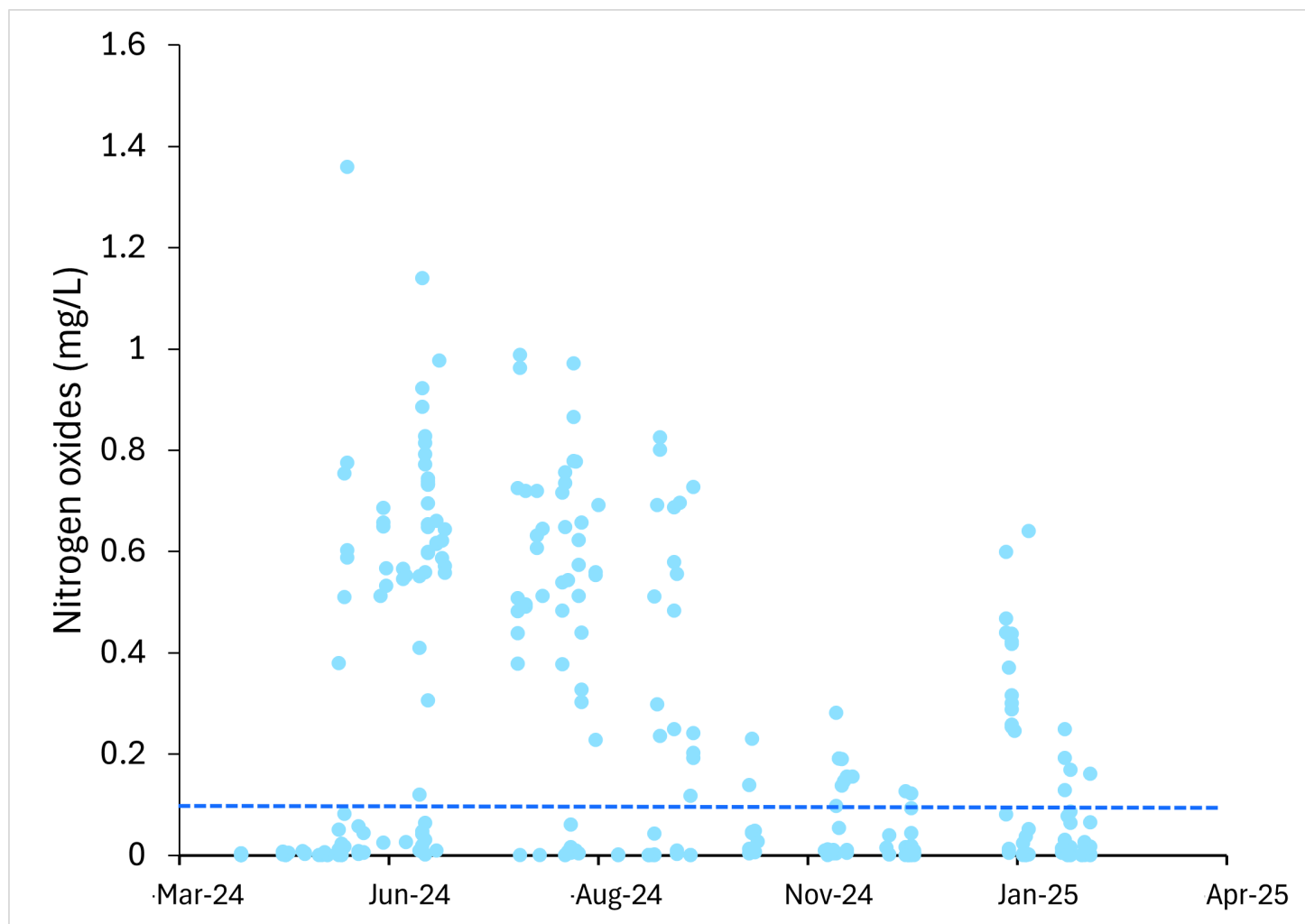


Figure 16 Temporal patterns of oxidised nitrogen concentration (milligrams per litre [mg/L]), for each sample event over the study period.

Total phosphorus

Total phosphorus ranged from 0.063 to 0.823 mg/L and consistently exceeded the ANZECC 2000 guideline value of 0.1 mg/L (Figure 17). These exceedances were observed consistently across all zones, indicating widespread and chronic phosphorus enrichment throughout the system. There were no distinct trends in temporal total phosphorus concentrations across the study period, indicating ongoing high phosphorus loads. This is reflective of a system under stress.

The ongoing exceedances confirm that elevated phosphorus levels are persistent and widespread throughout the year. The exceedance of guideline values contributed significantly to the overall RCI scores for water quality (see section 4.6). High total phosphorus concentrations were also evident in groundwater samples, with concentrations >1 mg/L in several samples. The highest concentration recorded (5.44 mg/L) in the Wilcannia to Lake Wetherell zone (see section 4.5.8). Groundwater may be contributing to elevated total phosphorus concentrations in some zones and should be further investigated.

Other potential causes for high total phosphorus include the mobilisation of phosphorus from sediments and floodplains during floods, particularly in low-oxygen environments. There was a slight increase in concentrations moving downstream from Wilcannia to Lake Wetherell (sites S1–S9) during the study period. This is most likely due to the release of sediment-bound phosphorus in anoxic bottom waters of Lake Wetherell. This mechanism has been observed during experimental sediment core incubations undertaken by Southern Cross University during the study period.

The decomposition of organic matter such as algae is also known to release phosphorus into the water column. This process is enhanced by microbial activity in a similar way to nitrogen mineralisation. A slight increase in total phosphorus in the Pooncarie South zone (sites S21–S23 and S32) coincided with an increase in algal biomass but may also reflect the influence of resuspension of particulate-bound phosphorus from sediments and inputs of groundwaters, which has high total phosphorus in this region. Groundwaters south of weir 32, where modelling indicates the rivers gain water from aquifers, also contained very high total phosphorous levels (up to 5.89 mg/L) and should be further investigated (see section 4.5.8). Levels of phosphorus recorded in this study are indicative of widespread stress and poor river health.

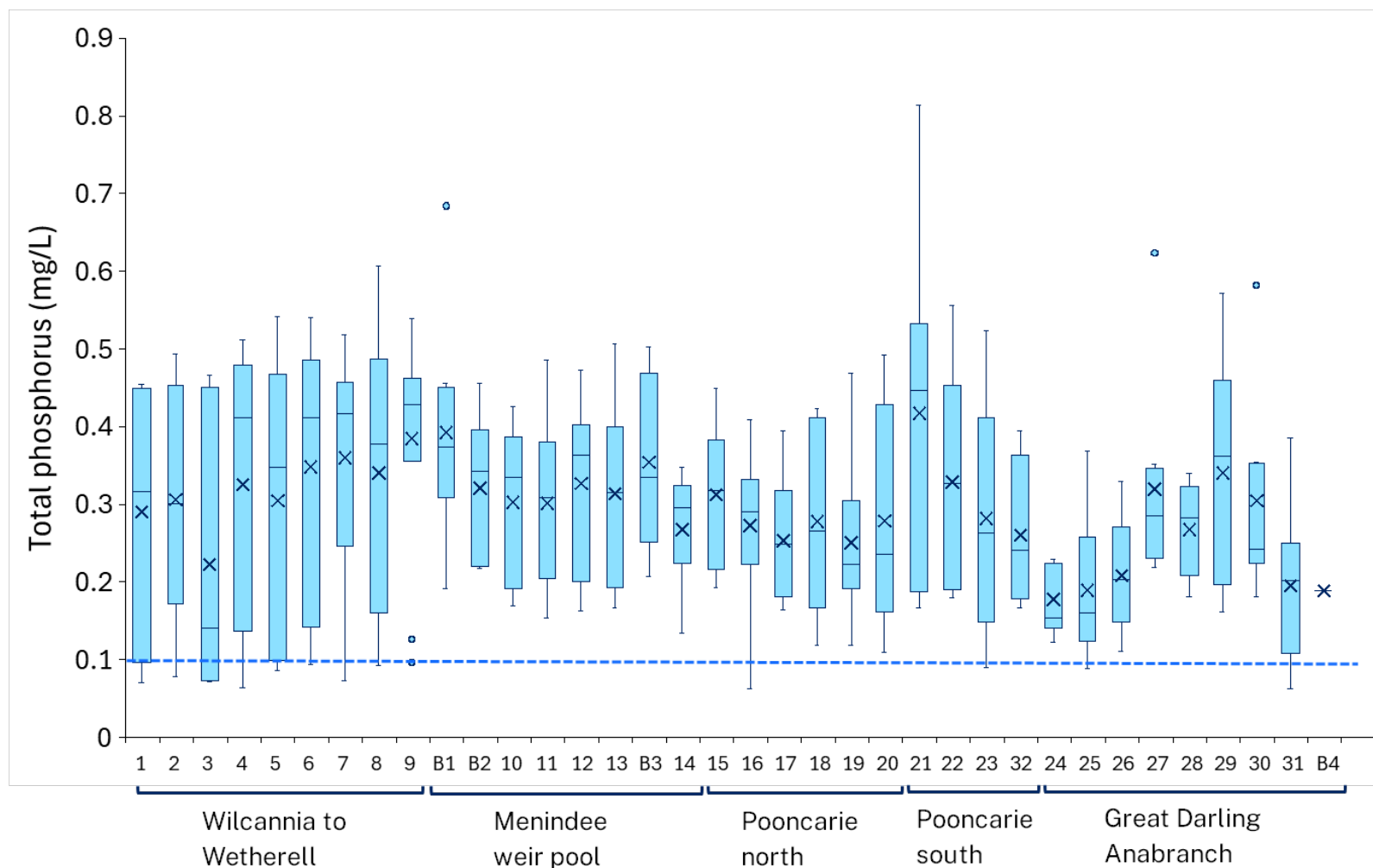


Figure 17 Variation in total phosphorus concentrations (milligrams per litre [mg/L]) across the study area during the Phase 2 sampling period. The blue dashed line shows the default upper limit guideline value

Soluble reactive phosphorus

Soluble reactive phosphorus (SRP) concentrations were elevated in the lower Darling Baaka River, with the majority of samples exceeding the ANZECC 2000 default guideline value of 0.05 mg/L (Figure 18). Concentrations in the study area ranged from 0.002 to 0.614 mg/L, with a median of 0.086 mg/L, highlighting a system-wide enrichment in bioavailable phosphorus. However due to the high turbidity and amount of colloids that would have passed through the 0.4 µm filter, not all of this is likely to be bioavailable (Douglas et al. 1999). Temporally, there were exceedances of the guideline value in every month sampled. However, concentrations of soluble reactive phosphorus tended to be highest between April and June 2024 (Figure 19).

Soluble reactive phosphorus concentrations were highest between Wilcannia and Lake Wetherell (sites S1–S9), where numerous values exceeded 0.2 mg/L, and several spiked above 0.5 mg/L. This pattern suggests substantial internal loading of phosphorus, likely linked to anoxic sediment conditions which facilitate the release of sediment-bound phosphorus and remineralisation of organic matter. These processes are commonly microbially mediated and redox-sensitive, especially during warm, low-flow periods when bottom waters become deoxygenated.

Downstream of Weir 32 to Wentworth (sites S15–23) on the lower Darling Baaka River, soluble reactive phosphorus concentrations generally decrease slightly and are of lower concentration than upstream zones. This likely reflects increased biological uptake by algae, particularly in reaches with greater light penetration and stable flow conditions which support phytoplankton and benthic algal productivity.

Sites on the Great Darling Anabranh contained much lower reactive phosphorus concentrations, with exceedances of guideline values only recorded at sites S29 and S30. The highest value recorded on the Great Darling Anabranh was at site S29, upstream of Packers Weir with a maximum value of 0.161 mg/L (August 2024). This likely indicates a strong algal uptake of phosphorous or limited phosphorus inputs in this zone. The stable, slow-flowing nature of the Great Darling Anabranh likely enhances nutrient assimilation efficiency, resulting in reduced soluble reactive phosphorus availability.

The consistently high soluble reactive phosphorus concentrations in the lower Darling Baaka River indicate that system is susceptible to high algal biomass when other conditions (such as water clarity, flow velocities, temperature, and available nitrogen) are conducive.

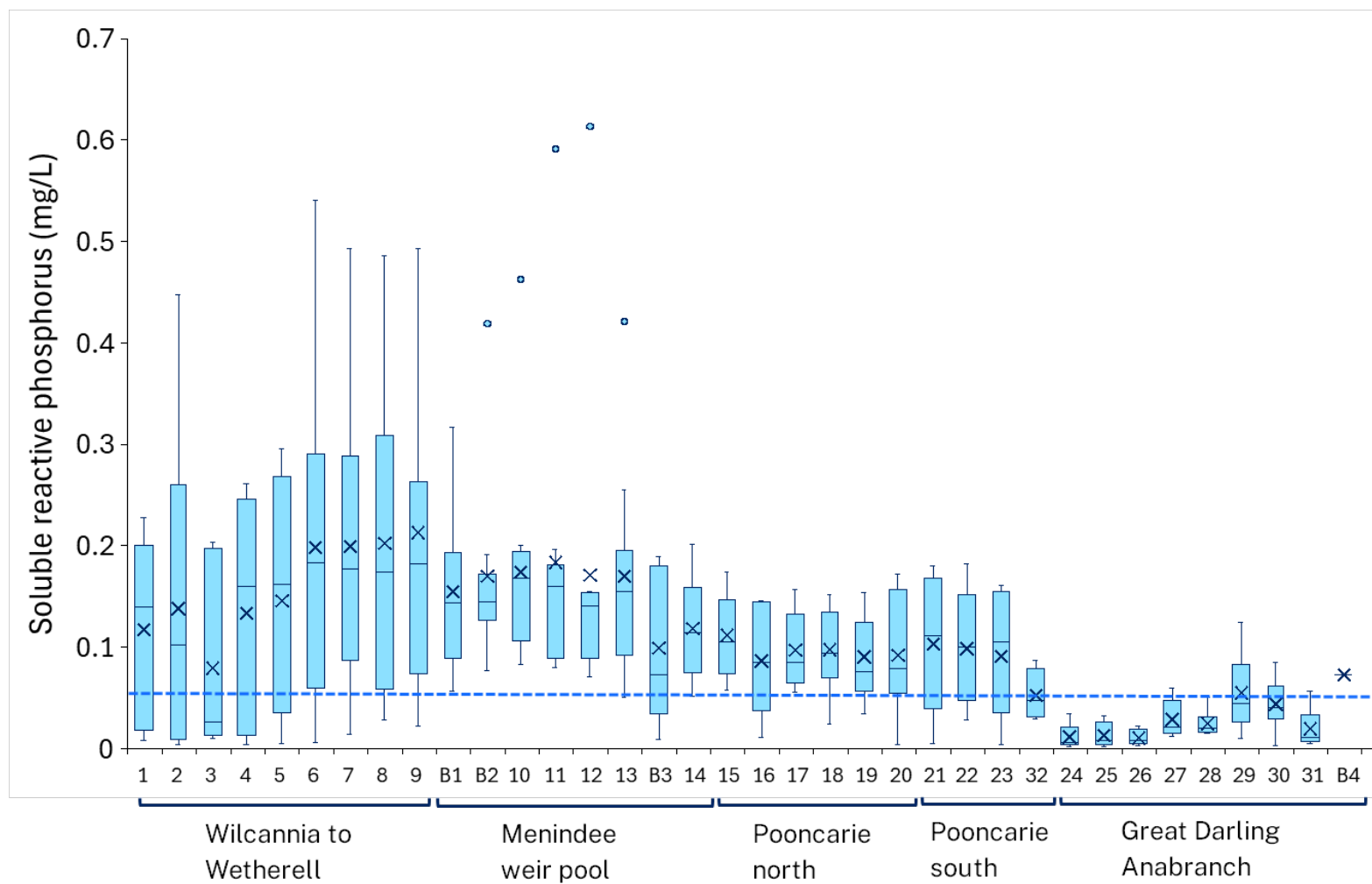


Figure 18 Variation in soluble reactive phosphorus concentrations (milligrams per litre [mg/L]) across the study area during the Phase 2 sampling period. The blue dashed line shows the default upper limit guideline value

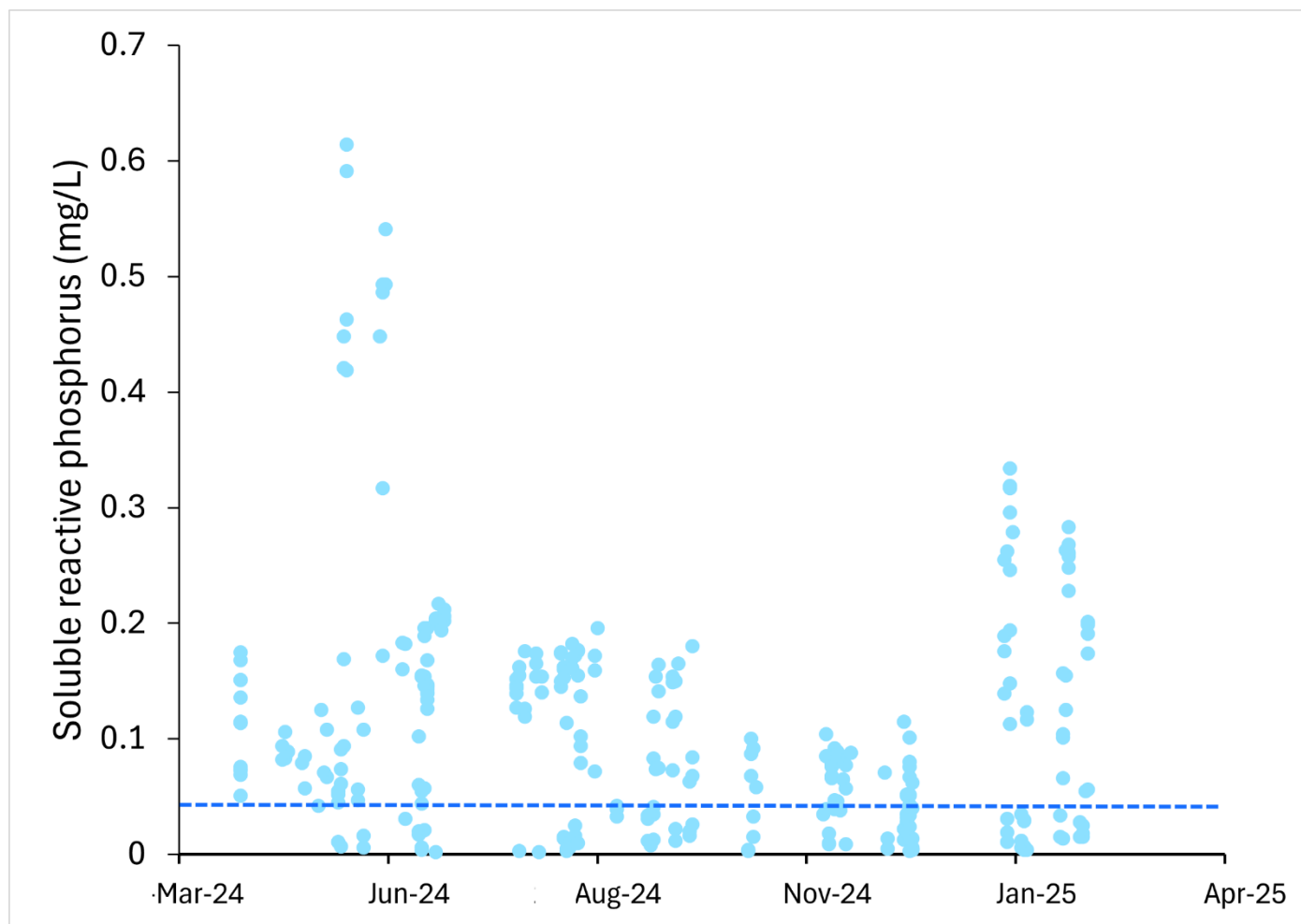


Figure 19 Soluble reactive phosphorus concentration (milligrams per litre [mg/L]) for individual sampling rounds between March 2024 and February 2025. The blue dashed line shows the default upper limit guideline value

Nitrogen versus phosphorus limitation

The molar ratio between bioavailable forms of nitrogen (N) and phosphorus (P) in the water column is a useful metric to assess which macronutrient is limiting the growth of algae. It is universally recognised that aquatic algae require nitrogen and phosphorus at a ratio of 16:1, which is known as the 'Redfield ratio' (Redfield 1934). When the ratio of water column concentrations falls below Redfield, it is likely that nitrogen is the nutrient limiting algae growth. These conditions favour the growth and dominance of diazotrophic cyanobacteria which can supplement their nitrogen requirements by fixing atmospheric nitrogen gas (Facey et al. 2022).

The dissolved inorganic nitrogen:soluble reactive phosphorus (DIN:SRP) molar ratios were overwhelmingly below the Redfield ratio across the study area, primarily due to relatively high concentrations of soluble reactive phosphorus (Figure 20). This is likely a major driver of the observed dominance of cyanobacteria during this study (see Chapter 6 and Seymour et al. 2025 supplementary material). These results contrast with the dominant paradigm of phosphorus as the primary limiting nutrient in freshwater aquatic systems (Dodds and Smith 2016). However, they are in line with recent research which suggests both nitrogen and phosphorus are equally important in some freshwater systems (Elser et al. 2007). Regardless, the consistently high soluble reactive phosphorus concentrations mean that the lower Darling Baaka River is primed to support high algal biomass when other conditions (such as water clarity and flow velocities) are conducive.

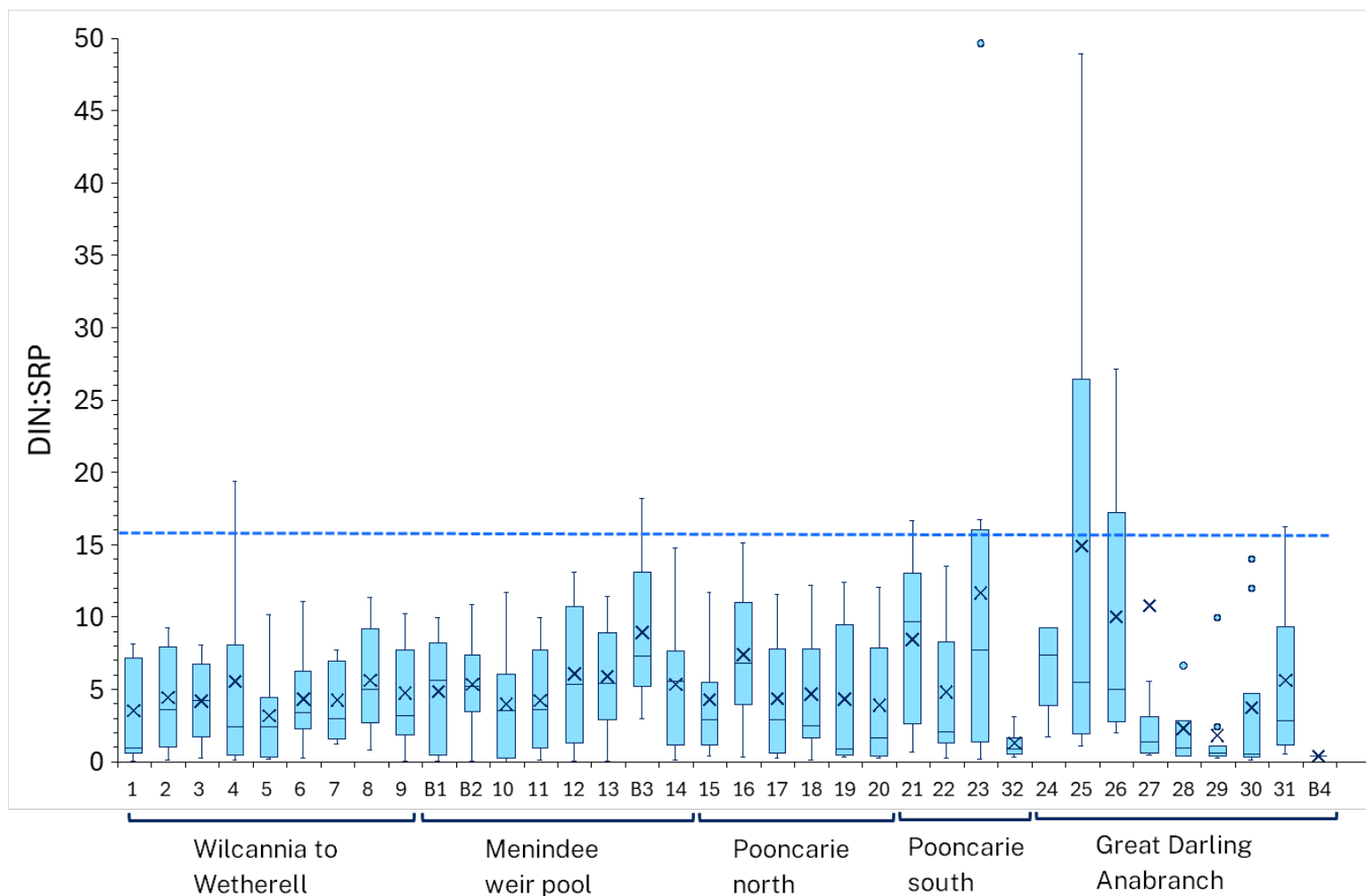


Figure 20 Variation in the molar ratio of bioavailable dissolved inorganic nitrogen (DIN) to soluble reactive phosphorus (SRP) across the study area during the Phase 2 sampling period. The blue dashed line indicates the Redfield ratio (16:1)

4.5.4 Chlorophyll-a

Chlorophyll-a concentrations (an indicator of algal biomass) across the study area were high and exceeded guideline values at all sites for the majority of 2024 and 2025 (Figure 21). In general, chlorophyll-a concentrations displayed an inverse relationship with turbidity and as turbidity decreased (Figure 11) algae concentrations increased (Figure 21). This is also reflected in the progressive increase in chlorophyll-a concentrations towards the lower reach of the Menindee weir pool zone to the Pooncarie North zone (sites S13–20), as well as downstream in the Great Darling Anabranch zone (sites S25–S29). The decreases in turbidity at these sites improves light availability, promoting higher rates of primary productivity and algal growth. Smart buoy data from Lake Wetherell and the Menindee weir pool also show that high turbidity limited primary productivity (as indicated by an increase in dissolved oxygen during the day, Figure 8B and C) to surface waters only.

Several significant algal blooms were noted in the study period, with data from environmental DNA (eDNA) analysis and algae identification providing insights into the species present (see Chapter 6; Seymour et al., 2025; Mitrovic et al., 2025). Notably, in November and December 2024, a significant bloom of *Dolichospermum* occurred in the Wilcannia to Lake Wetherell zone. *Dolichospermum* is known for its role in freshwater cyanobacterial blooms and is notable for producing various toxins, which can cause odour and taste issues in water supply (Li et al. 2016a). This species has previously contributed to several cyanobacteria blooms in the study area (Donnelly et al. 1997; Moritz et al. 2019). Another significant yet smaller bloom of *Prochlorothrix* occurred in the Wilcannia to Lake Wetherell, Pooncarie North and Pooncarie South river reach zones during May 2024, where this organism comprised up to 50% of the cyanobacterial community in these zones. *Prochlorothrix* is not known to be toxic (Ma et al. 2021). Both blooms lead to spikes in chlorophyll-a and are indicative of an ecosystem under stress.

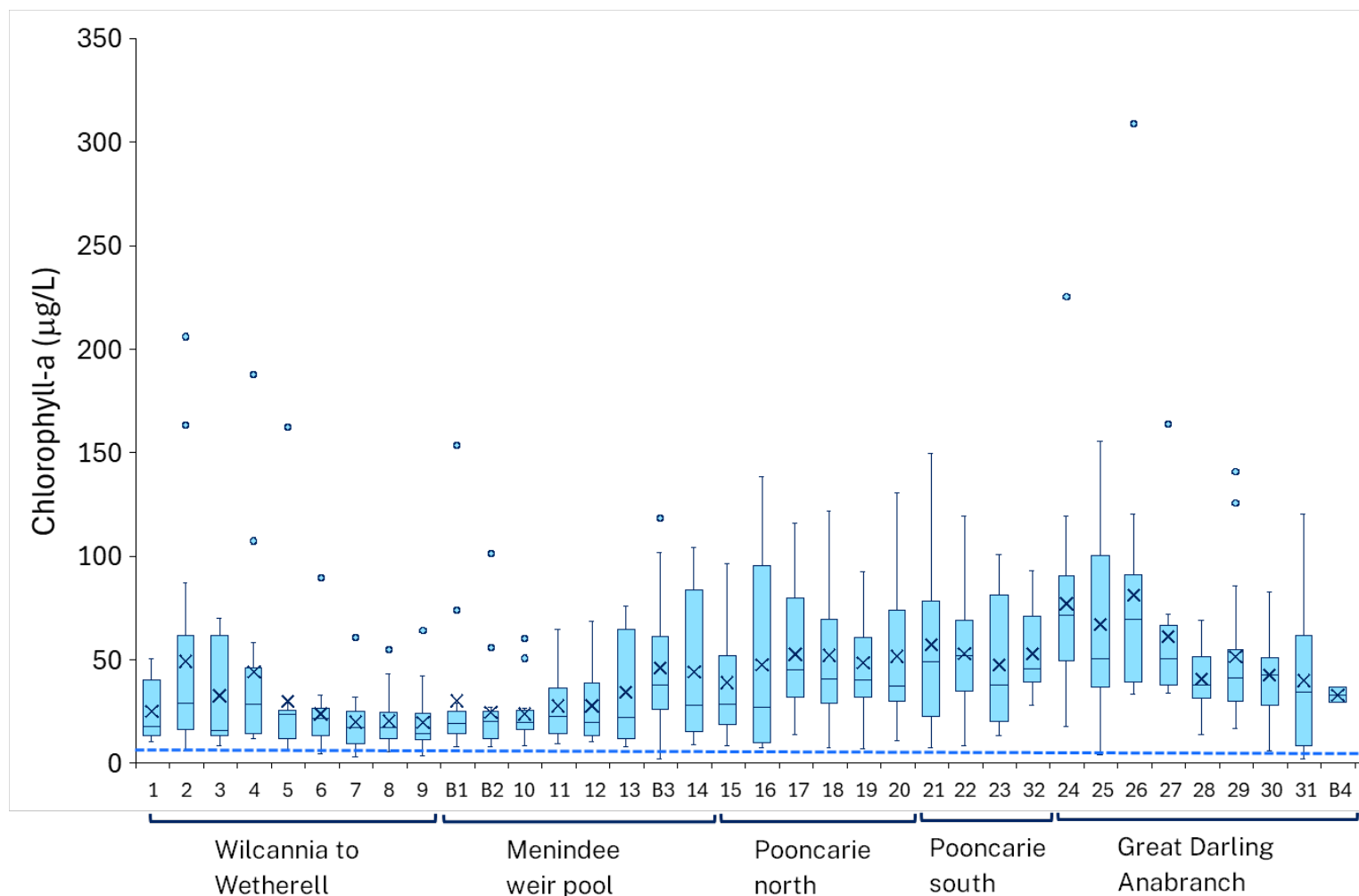


Figure 21 Variation in chlorophyll-a concentrations (micrograms per litre [µg/L]) across the study area during the Phase 2 sampling period. The blue dashed line shows the default upper limit guideline value

4.5.5 Organic carbon

Total organic carbon

The concentrations of total organic carbon detected in the study period were variable across the zones (Figure 22). 'Organics' quantifies all organic materials present in the water column, including both dissolved and particulate forms. This includes a wide range of organic compounds such as humic substances, plant-derived materials, microbial by-products, and proteins. This is also referred to as total organic carbon, accounting for all carbon-containing substances in a sample, regardless of whether they are dissolved or suspended. Total organic carbon provides a broader assessment of organic matter levels in a system and is often used to evaluate water quality, nutrient loading, and potential contamination from natural or anthropogenic sources.

The concentrations of total organic carbon in both the lower Darling Baaka River and the Great Darling Anabranh are elevated (Figure 22) and indicate high algal organic load that may contribute to the depletion of oxygen within the water column. This can lead to hypoxia and create harmful conditions for aquatic biota including fish. The floods which occurred early in 2023 are believed to have contained high concentrations of carbon within floodwaters. This rapid influx of carbon from upstream floodplains is believed to have contributed to the hypoxic blackwater event which led to the fish deaths near Menindee in 2023 (OCSE 2023). The results in this report indicate that organic enrichment in the lower Darling River and the Great Darling Anabranh is still occurring and may be an artifact of a continued wet period.

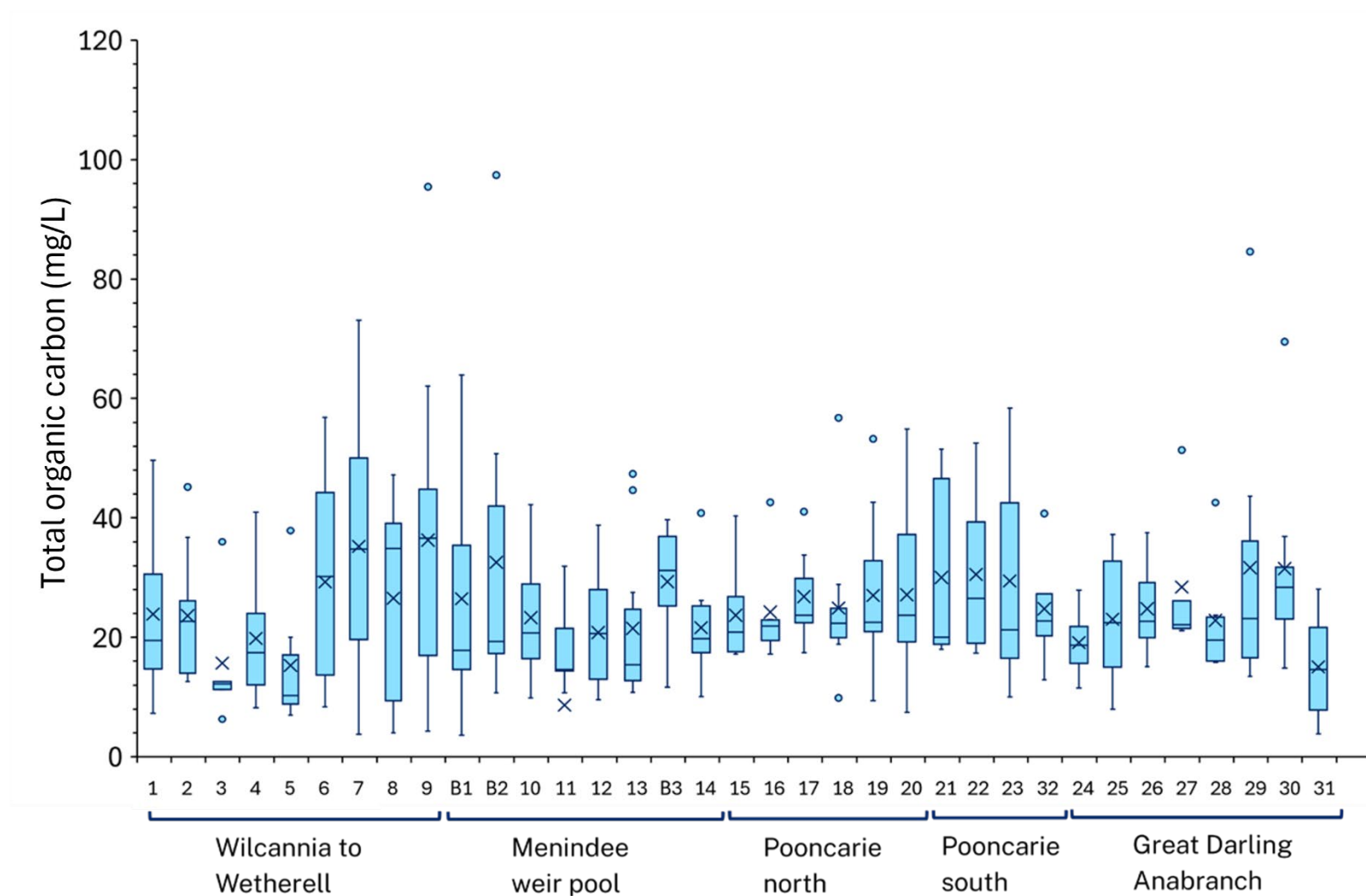


Figure 22 Concentrations of total organic carbon (milligrams per litre [mg/L]) in water samples collected across the study area between April 2024 and February 2025

Dissolved organic carbon

The dissolved organic carbon concentrations in the study period ranged from 6 to 47 mg/L (Figure 23). Concentrations on the lower Darling Baaka River were consistently above 10 mg/L. There were no significant trends temporally or spatially along the River with the exception of site B3 (outlet from Pamamaroo). This site contained significantly higher dissolved organic carbon concentrations than other sites on the lower Darling Baaka River.

The dissolved organic carbon concentrations recorded across the study area, are moderately high when compared to many rivers in south-eastern Australia. Dryland systems, such as those in the study area, typically contain dissolved organic carbon concentrations between 5 and 15 mg/L. However, similar concentrations have been recorded in regulated river systems and weir pools, where organic carbon inputs are relatively consistent.

The most significant concentrations of dissolved organic carbon occurred in the Great Darling Anabranh, where median concentrations were above 15 mg/L, and some samples exceeded 30 mg/L. Dissolved organic carbon was low in upstream sites but increased significantly downstream. This may suggest organic breakdown of algal biomass and enhanced dissolved organic contributions due to floodplain interactions.

Dissolved organic carbon concentrations in groundwater bores along the Great Darling Anabranh also displayed signs of elevated concentrations, with bore GW0087616 recording a concentration of 53 mg/L (see section 4.5.8 and Hose et al. 2025 supplementary material). It is unclear whether the high levels of dissolved organic carbon within groundwater are contributing to elevated levels in the Great Darling Anabranh. The elevated dissolved organic carbon concentrations in groundwaters may indicate stronger organic matter inputs such as floodplain interactions, decomposition of vegetation or increased microbial activity.

Dissolved organic carbon plays a critical role in aquatic ecosystems, influencing microbial activity, chemical interactions and nutrient cycling. Unlike total organic carbon, which provides a comprehensive measure of total organic matter, dissolved organic carbon specifically reflects the portion that is readily available for biological and chemical processes in waterbodies. High dissolved organic carbon in rivers has been linked to hypoxia, as microbes deplete oxygen from the water column in the process of breaking down carbon sources. High dissolved organic carbon concentrations can also impact nutrient cycling, potentially causing excessive nutrients which can then promote algal blooms. The patterns of dissolved organic carbon and total organic carbon indicate different organic matter sources and transformations along the system, with total organic carbon being more influenced by physical inputs and dissolved organic carbon reflecting biogeochemical processes.

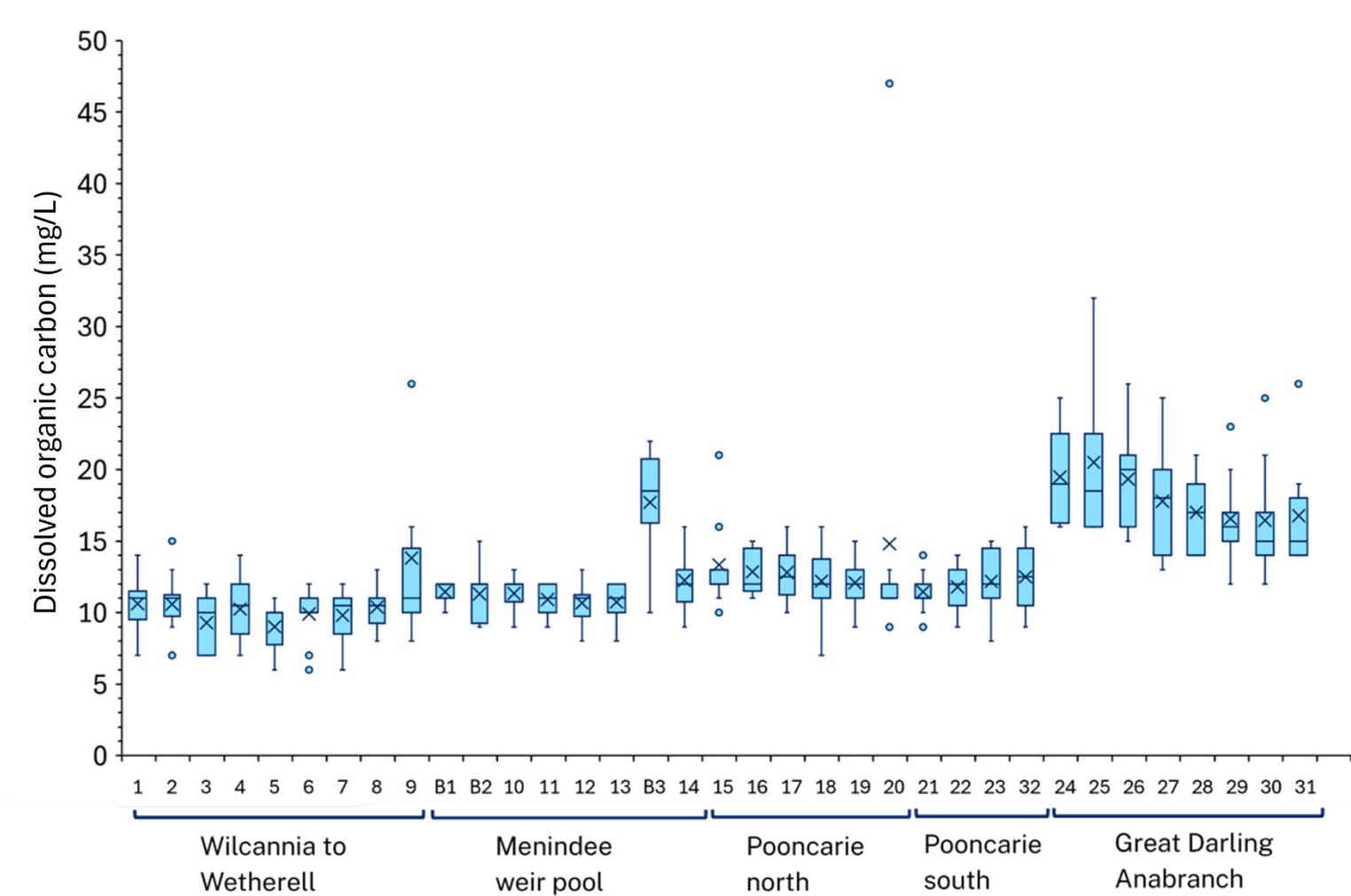


Figure 23 Concentrations of dissolved organic carbon (milligrams per litre [mg/L]) in water samples collected across the study area between April 2024 and February 2025

4.5.6 Pesticides

This section provides the results from grab samples from 15 surface water sites on the river taken between April 2024 and February 2025. These data were used in the 2025 Darling Baaka RCI calculations. The pesticides listed in Table 5 were incorporated into the Water Quality Index analysis, with some other pesticide results discussed below. An additional study investigated pesticides in sediment and used passive samplers to detect pesticides in the water column (see DCCEEW EPS 2025, supplementary report). Please note that the supplementary report (DCCEEW EPS 2025) only presents data collected between October 2024 and February 2025.

Organochlorine pesticides

All concentrations of organochlorine pesticides were below laboratory reporting limits (limits of reporting). Organochlorine pesticides are persistent organic pollutants known for their toxicity and potential for bioaccumulation. This has led to their ban or restriction under the 2001 Stockholm Convention. Water samples were analysed for aldrin, BHC isomers, chlordane isomers, dieldrin, endosulfan, endrin, hexachlorobenzene, heptachlor, oxychlordane, and dichlorodiphenyltrichloroethane (DDT) derivatives. Although in many cases the detection limits exceeded the 95% species protection level, ecologically significant concentrations in the water column are unlikely due to their hydrophobic nature and long-standing restrictions.

Fungicides

Twenty-four fungicidal chemicals were analysed. Of these chemicals, only tebuconazole was detected. This chemical was detected in several samples, but all concentrations were low and below respective guideline values and indicative guideline values.

Tebuconazole concentrations ranged between less than limit of reporting to 0.073 µg/L. While no ANZG (2018) default guideline values currently exist, these concentrations are well below the United States EPA chronic freshwater aquatic life benchmark (120 µg/L).

Herbicides

Forty herbicide compounds were measured in the collected water samples. Among this group only atrazine, diuron, metolachlor, simazine and hexazinone were detected in samples above the respective laboratory reporting limits.

Atrazine concentrations ranged from less than limit of reporting to 0.00033 mg/L, well below the ANZG (2018) 95% species protection guideline of 0.013 mg/L, indicating low ecological risk (Figure 24). Concentrations appear to be relatively stable in the upstream zone (Wilcannia to Lake Wetherell), but greater variation and higher maximum concentrations were detected downstream. Atrazine is a widely used herbicide, and concentrations are likely influenced by localised agricultural inputs, runoff or sediment resuspension. While all detections remained below guideline values, additional monitoring is recommended to assess seasonal fluctuations and episodic contamination from agricultural or rainfall-driven runoff based on the increased variability downstream.

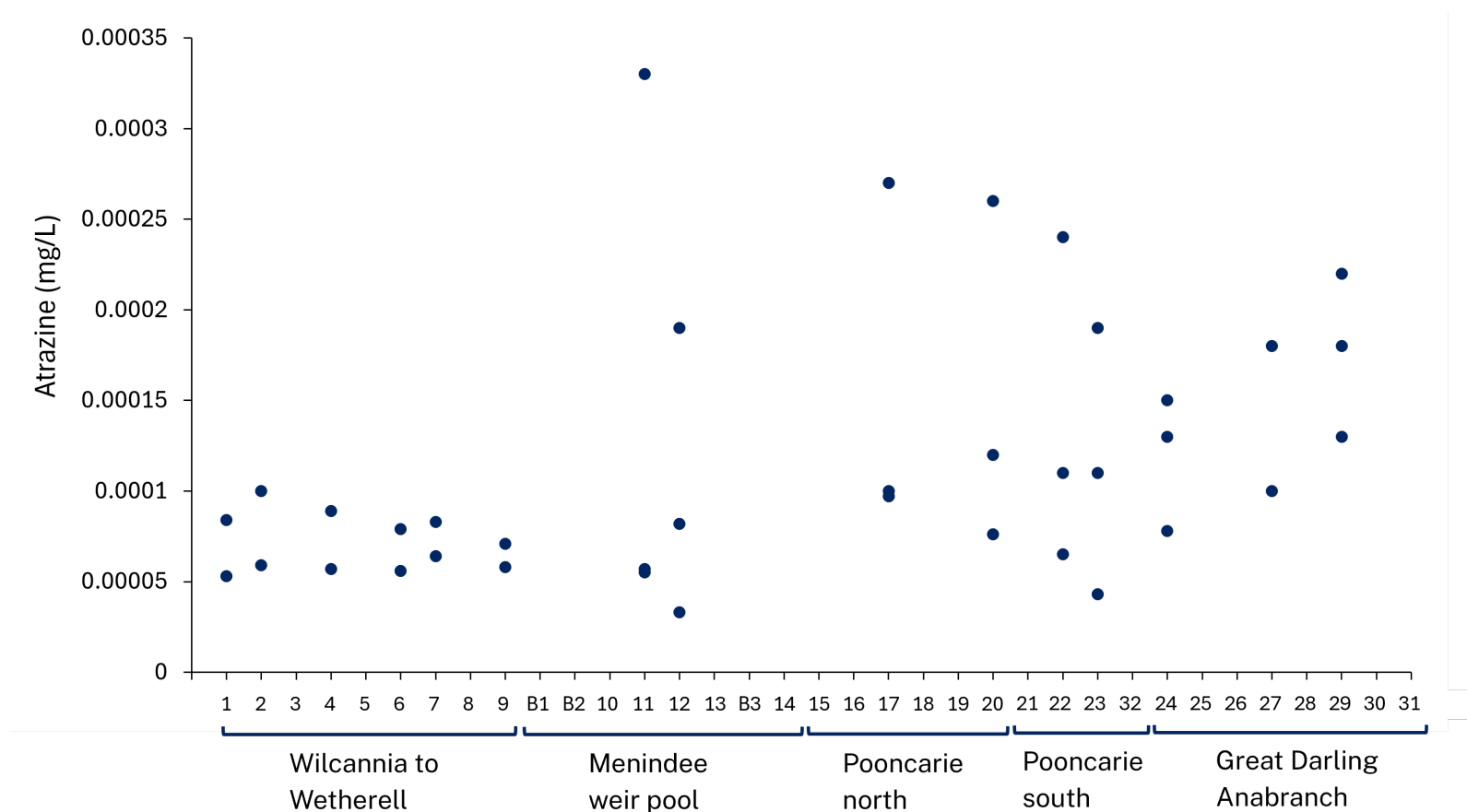


Figure 24 Concentrations of atrazine (milligrams per litre [mg/L]) in water samples collected between April 2024 and February 2025. Note samples returning values below laboratory limits of reporting are not presented in this graph (guideline value = 0.013mg/L ANZG (2018))

Diuron was detected in 25% of samples, with the concentration of these compounds ranging from below the limit of reporting to 0.00042 mg/L (Figure 25). There were 5 exceedances of the ANZG (2018) 95% species protection default guideline value (0.0002 mg/L), all occurring in the Wilcannia and Lake Wetherell zone during February 2025. Concentrations of diuron downstream of site S10 and on the Great Darling Anabranch were low or below laboratory reporting limits.

Metolachlor was detected in 29% of samples collected, with concentrations ranging from less than the limit of reporting to 0.84 µg/L (Figure 26). There were 3 detections in May 2024 between Wilcannia and Menindee weir pool which exceeded the ANZG (2018) 95% species protection default guideline value of 0.00046 mg/L. In February 2025, one exceedance of Metolachlor occurred at S9 and a detection at the guideline value occurred at S7 (Figure 26). Like diuron and tebuconazole, concentrations of metolachlor were highest in the upstream zones but declined downstream, with no detections recorded in the Great Darling Anabranch.

Simazine was detected in 33% of samples, the maximum concentration recorded was 0.00016 mg/L which is well below the ANZG (2018) guideline of 0.0032 mg/L (Figure 27). No clear spatial or temporal patterns were observed.

Hexazinone concentrations ranged between less than limit of reporting to 0.014 µg/L and did not exceed ANZG (2018) low-reliability trigger value of 0.075 mg/L. There were no clear spatial trends for hexazinone, suggesting limited sources, rapid degradation, or dilution that minimises ecological risk.

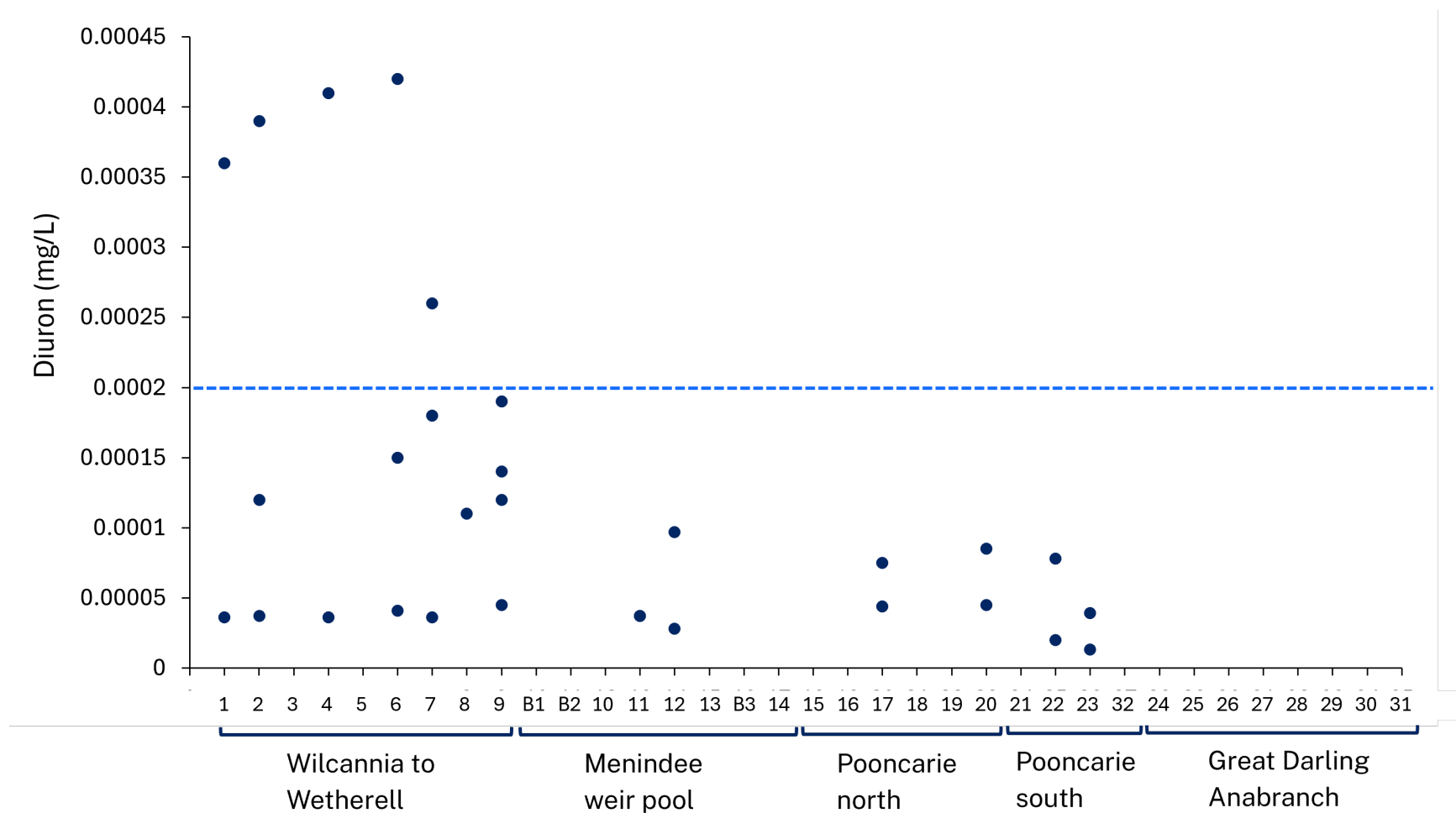


Figure 25 Concentrations of diuron (milligrams per litre [mg/L]) in water samples collected between April 2024 and February 2025. Blue dashed line represents the 95% species protection value (0.0002 mg/L) for diuron in freshwaters. Note: samples returning values below laboratory limits of reporting are not presented in this graph

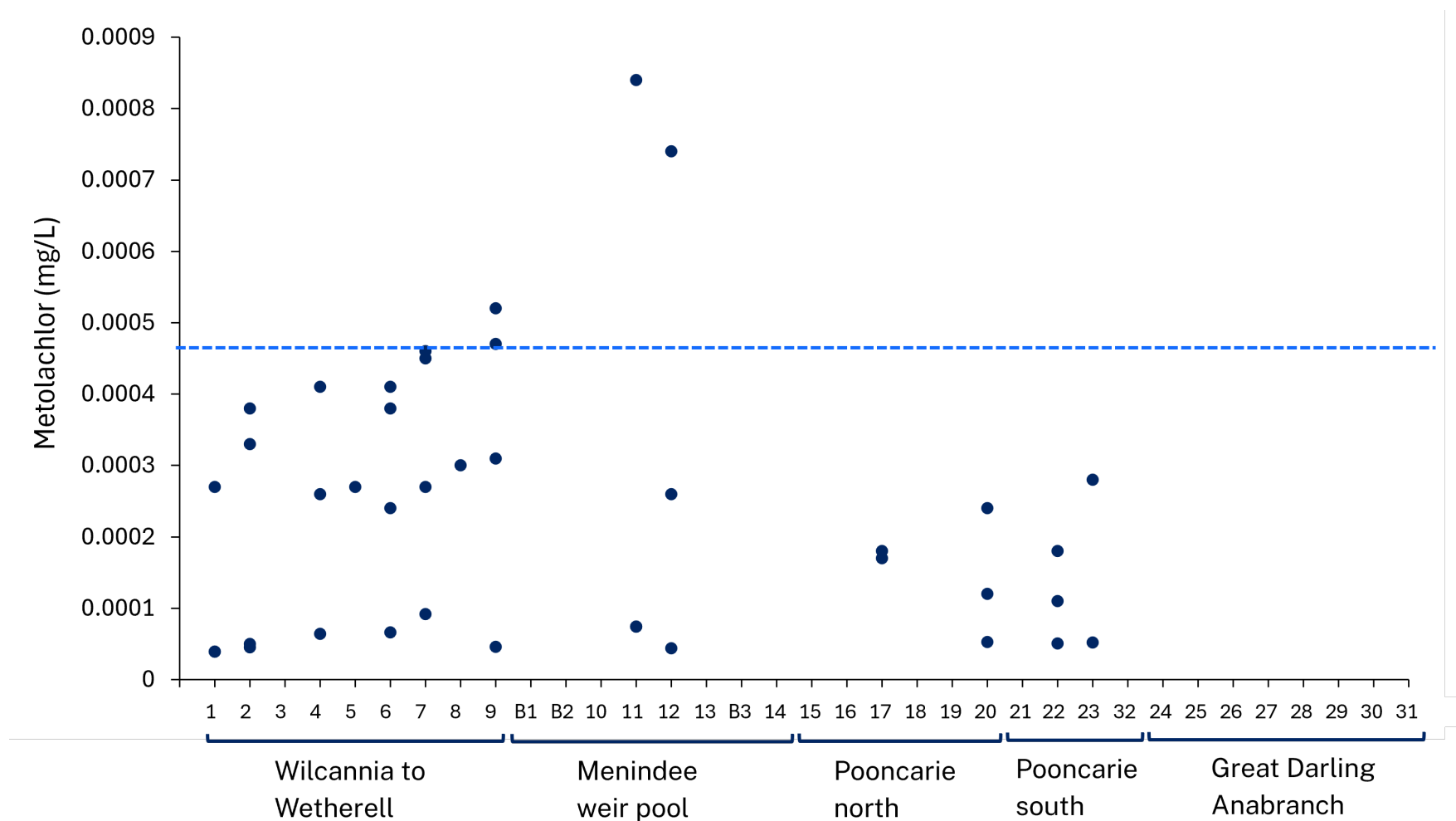


Figure 26 Concentrations of metolachlor (milligrams per litre [mg/L]) in water samples collected between April 2024 and February 2025. Blue dashed line represents the 95% species protection value (0.00046 mg/L) for metolachlor in freshwaters. Note: samples returning values below laboratory limits of reporting are not presented in this graph

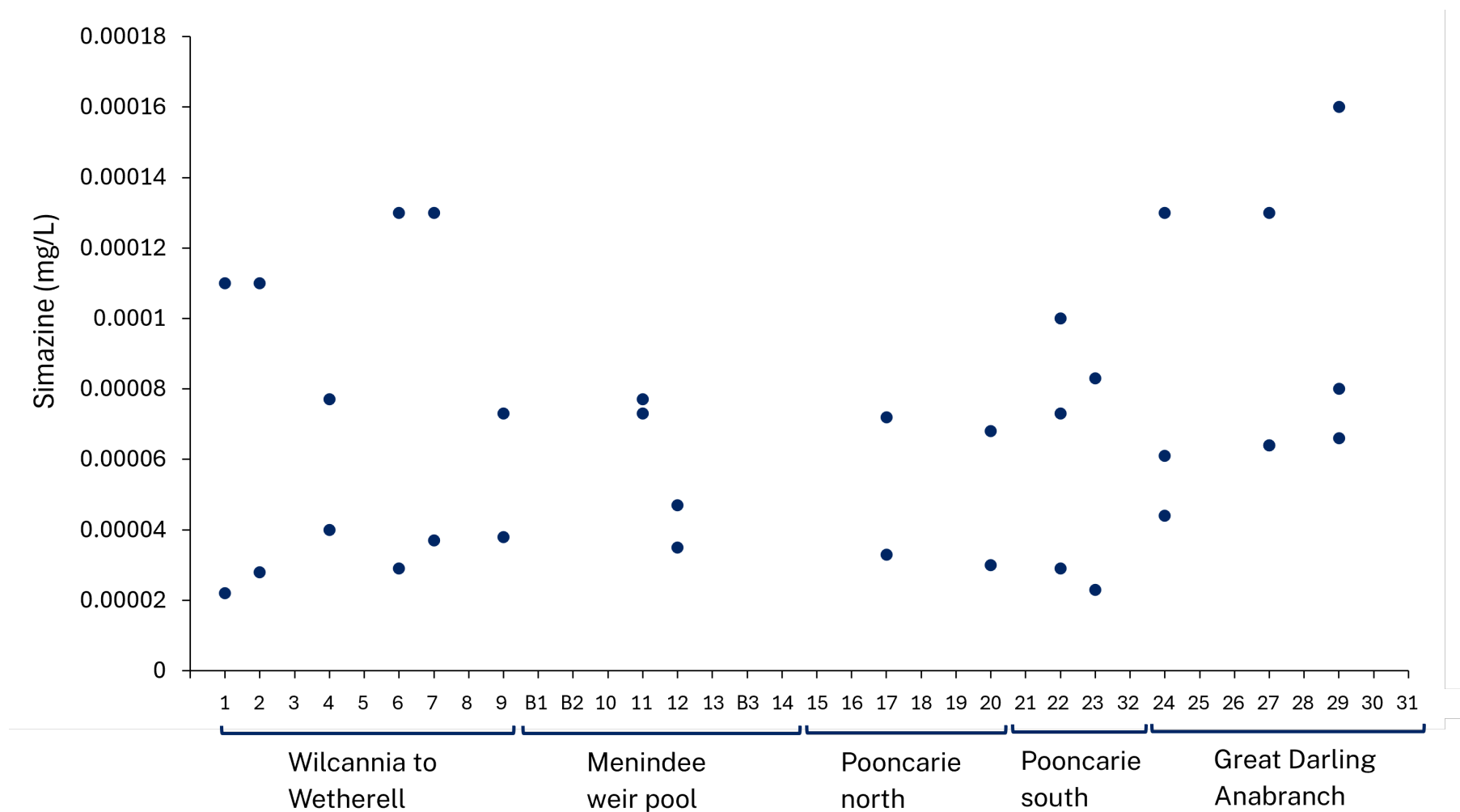


Figure 27 Concentrations of simazine (milligrams per litre [mg/L]) in water samples collected between April 2024 and February 2025. Note: samples returning values below laboratory limits of reporting are not presented in this graph

Summary of pesticides results

Concentrations of pesticides and herbicides (such as diuron and metolachlor) were higher in the Wilcannia to Lake Wetherell zone than other zones in the study area. This is likely to be associated with inflows from the upper Darling Baaka basin rather than direct source influences, however no source attribution was conducted as part of this program. In contrast, reaches downstream of Weir 32 had higher concentrations of atrazine and simazine. This may be associated with 'older' water displaced downstream by upstream inflows, and/or local source-based inputs such as agricultural runoff. There was no evidence that groundwater was contributing to agrochemicals in the region (see section 4.5.8).

The behaviour and interactions of the detected pesticides can be influenced by other environmental conditions. Elevated pH and dissolved organic carbon concentrations can reduce the freely dissolved fraction of these compounds through increased solubility and binding to organic matter, often lowering acute toxicity but prolonging environmental persistence (Qui et al. 2009; Gao et al. 1998, 2012; Spark and Swift 2002; Katagi 2016; Gennari et al. 1998; Takeshita et al. 2019). Some chemicals, like diuron and hexazinone, remain bioavailable and toxic to primary producers even at low concentrations, highlighting the potential for synergistic effects under these co-occurring stressors. Furthermore, high turbidity can further facilitate the transport of particle-bound contaminants and limit light availability, thereby stressing photosynthetic organisms and altering ecosystem dynamics (Li et al. 2022; Fuchte et al. 2022; Kontchou 2024; Knauer et al. 2016; Saeedi et al. 2013; Abbt-Braun et al. 1996). For more information on pesticides, including the results of passive sampling methods, see supplementary report DCCEEW EPS (2025).

4.5.7 Metals

Metal concentrations were highest in the Wilcannia to Lake Wetherell zone. This is likely due to influences of the Menindee Main Weir which impounds water, promoting settling of sediment. This trend suggests that Lake Wetherell is acting as a sink for metals, regulating their accumulation and release downstream. The low detection (less than limits of reporting or less than guideline values) of other metals further emphasises the effects of weirs and barrage systems, indicating their influence extends beyond water flow to metal retention.

Concentrations of selenium, mercury and cadmium were below the lower detection limit of the analysis performed in this project. Concentrations of arsenic, chromium, cobalt, lead, manganese and nickel were all below the 95% guideline values for protection of aquatic ecosystems, except for one sample where chromium levels exceeded guideline values in Lake Wetherell (June 2024). It is unclear if this is an anomaly and warrants further investigation.

Aluminium, copper and zinc were detected above guideline values and are known to persist in more labile and potentially bioavailable forms under the observed environmental conditions. At a pH range of 8–9, typical of the sampled waters, copper and zinc may exhibit reduced binding to dissolved organic carbon, increasing their

mobility and bioavailability. Aluminium, while often less bioavailable near neutral pH, can become more soluble at higher pH or under varying redox and complexation conditions (Stumm and Morgan 1996; Linnik et al. 2018).

Only the metals exceeding ANZG (2018) criteria are discussed in detail below, as they contributed most significantly to the Water Quality Index values compared to other contaminants of potential concern.

Aluminium

The highest concentrations (1.5 mg/L) of dissolved Aluminium were detected at site S2 near Wilcannia (Figure 28). Three sites (S2, S6 and S7) recorded concentrations above the guideline value of 0.055 mg/L. Given the alkaline pH (8–9) and high concentrations of fluorescent dissolved organic matter detected across the sites, aluminium speciation is likely dominated by aluminate ion (Al(OH)_4^-), particulate aluminium hydroxide ($\text{Al(OH)}_3(\text{s})$), and organic-complexed aluminium species. High levels of dissolved aluminium can pose a threat to fish and invertebrates, particularly when there is either low or high pH conditions. There was no evidence that the aluminium concentrations were contributing to fish health issues in the study area.

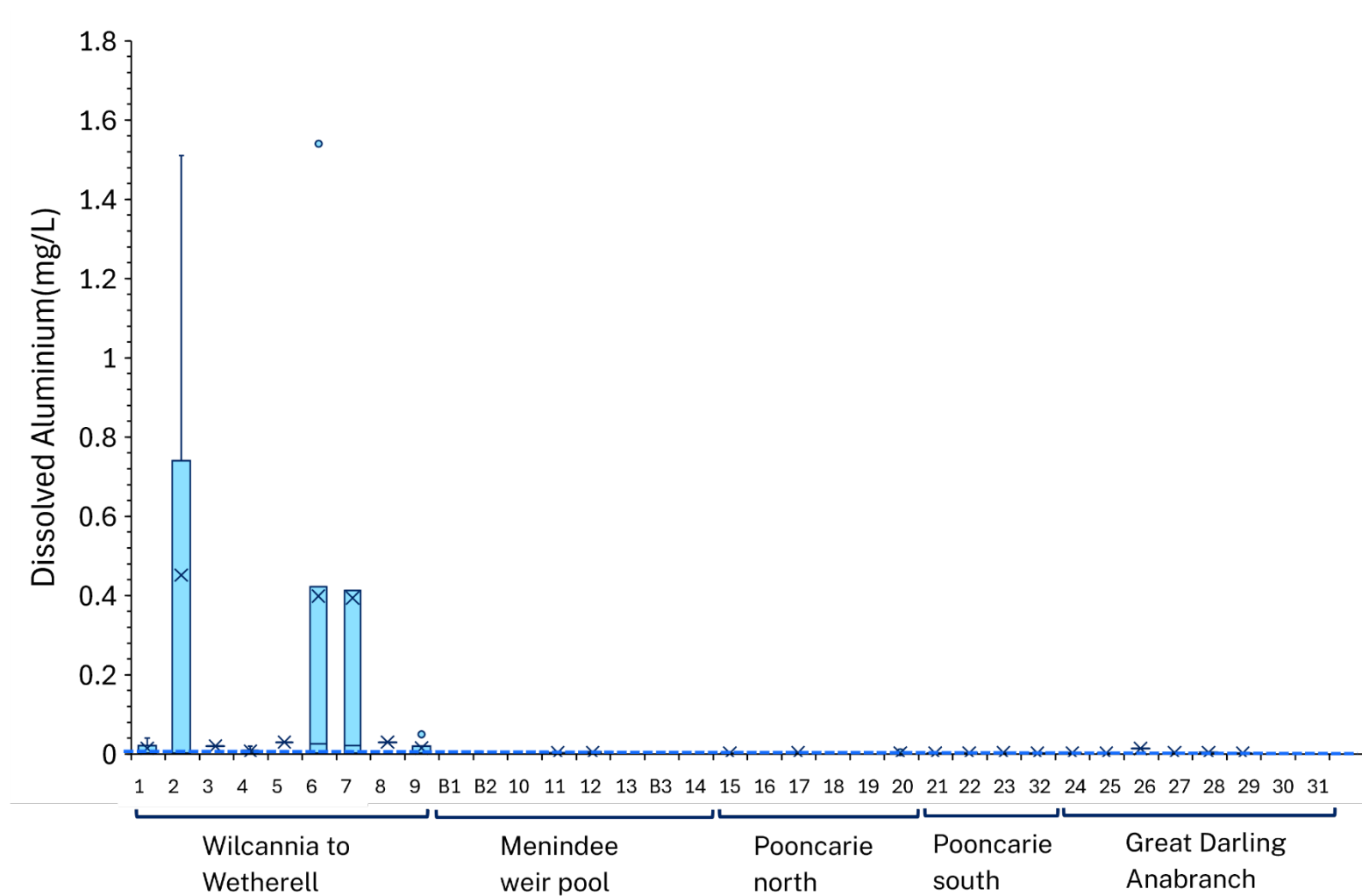


Figure 28 Concentrations of dissolved aluminium (milligrams per litre [mg/L]) in water samples collected between April 2024 and February 2025. Blue dashed line represents the 95% species protection value (0.055 mg/L) for aluminium in freshwaters

Copper

Exceedances of guideline values for dissolved copper (0.0014 mg/L) were recorded across all zones in the study area (Figure 29), with concentrations ranging from <0.001 mg/L to 0.006 mg/L. Dissolved copper concentrations were highest in the Wilcannia to Lake Wetherell zone (sites S1–S9), with site S7 having the highest concentration. Copper can leach into waterways from agricultural activities during heavy rainfall. It may also leach naturally from surrounding geology and may be bound to sediments being released under various pH and oxygen conditions. Elevated copper levels can be toxic to aquatic biota and may disrupt nutrient cycling within the environment.

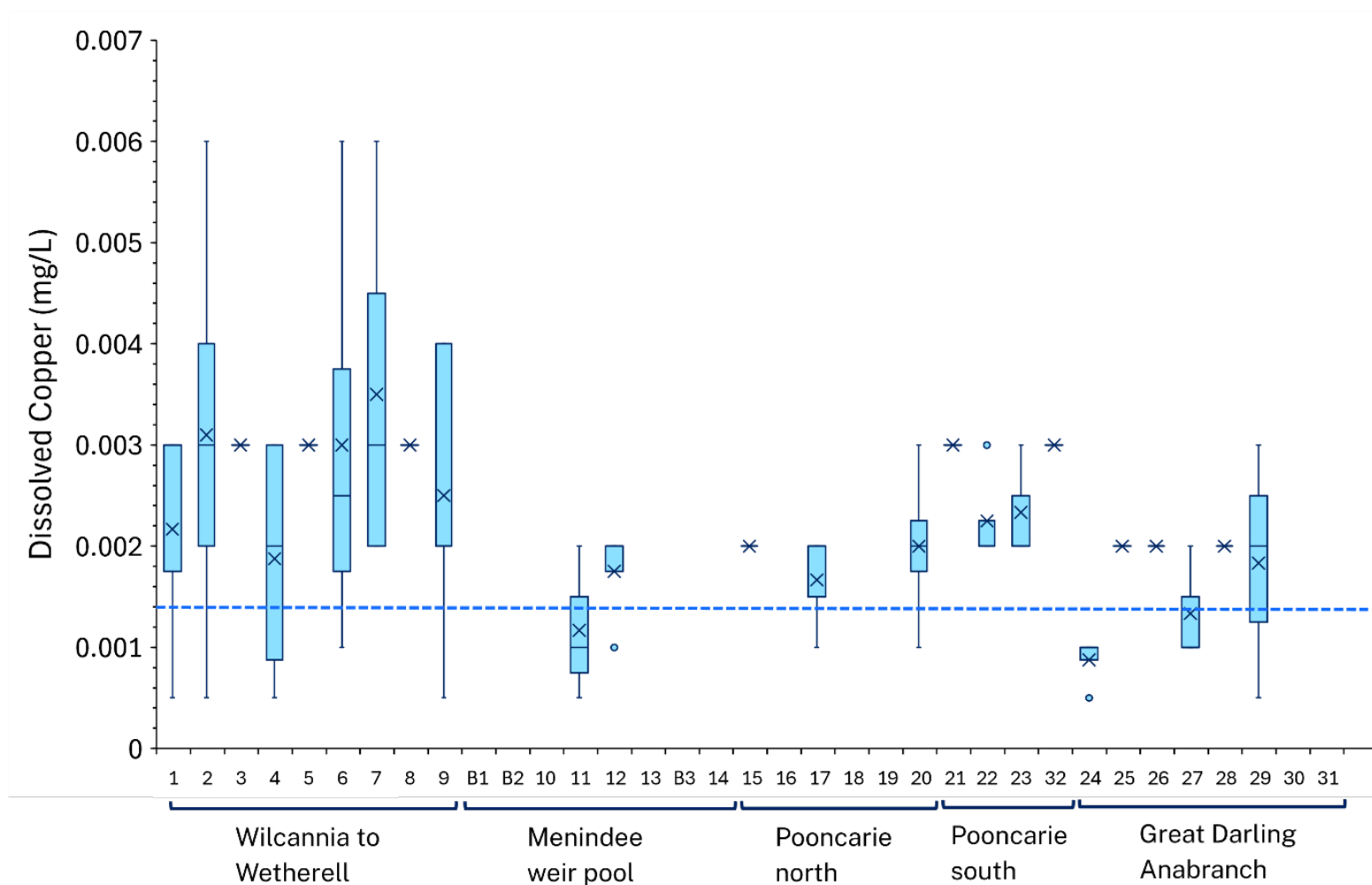


Figure 29 Concentrations of dissolved copper (milligrams per litre [mg/L]) in water samples collected between April 2024 to February 2025. Blue dotted line represents the 95% species protection value (0.0014 mg/L) for copper in freshwaters

Zinc

Dissolved zinc concentrations were detected across all sites, ranging between 0.0025 to 0.15 mg/L (Figure 30). As with both aluminium and copper, the highest concentrations of dissolved zinc were observed in sites in the Wilcannia to Lake Wetherell zone (sites S1–S9), where maximum concentrations ranged between 0.031 and 0.153 mg/L (Figure 30).

Zinc is present naturally in the Earth's crust and can enter the waterway through erosion and from underlying geological formations. It can also be present in runoff from agriculture and industry. It appears that Lake Wetherell may be acting as a sink for metals, regulating their accumulation and release downstream.

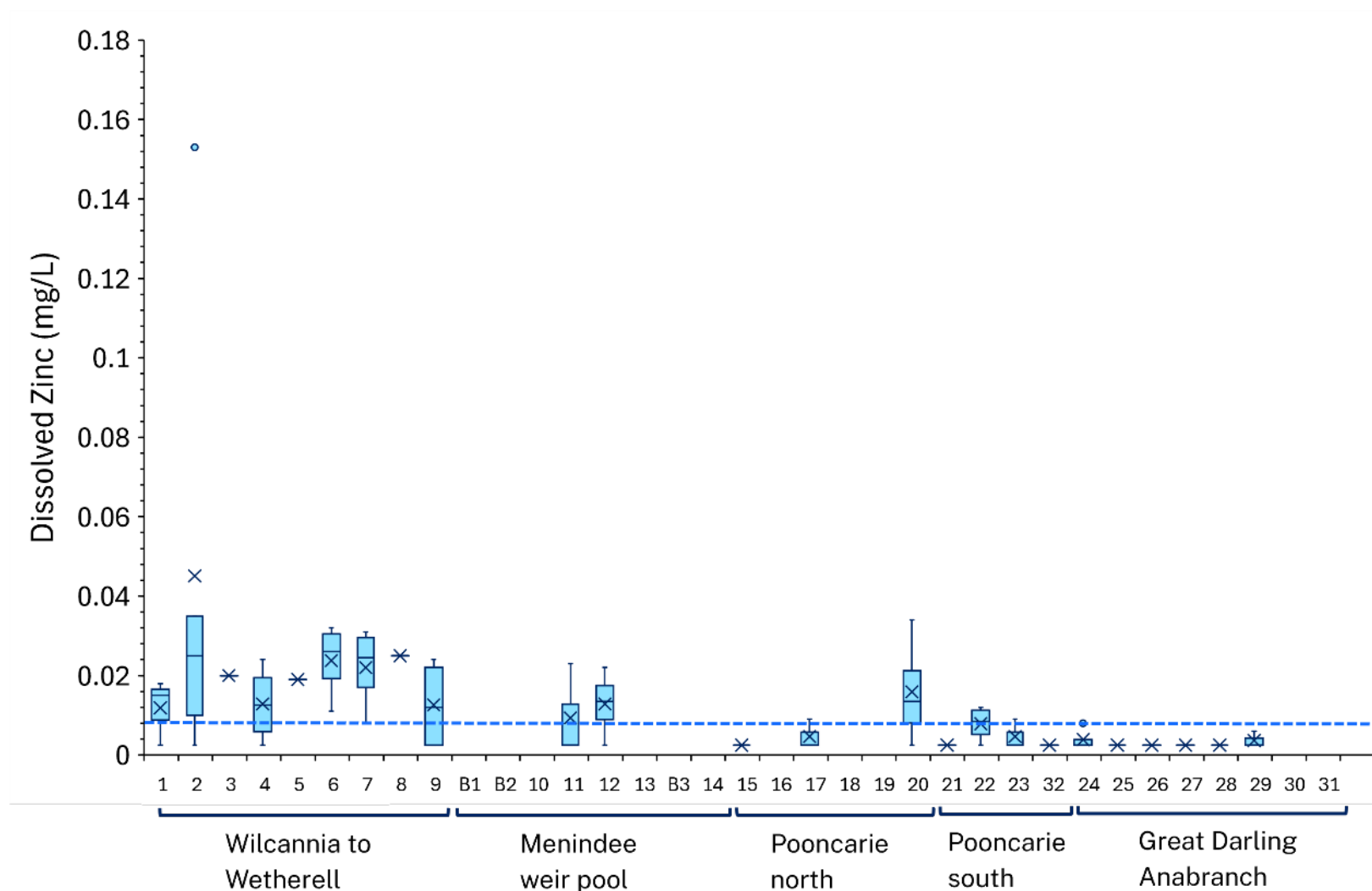


Figure 30 Concentrations of dissolved zinc (milligrams per litre [mg/L]) in water samples collected between April 2024 and February 2025. Blue dotted line represents the 95% species protection value (0.008 mg/L) for zinc in freshwaters

4.5.8 Groundwater quality

Results of groundwater quality chemistry are provided in Table 11. Groundwater chemistry indicated generally good water quality, although nutrient levels were very high in a number of groundwater bores, particularly those downstream of Weir 32 and on the Great Darling Anabranch. Results indicate the pH values in bores are typical of groundwater environments. One bore on the Great Darling Anabranch close to the Murray confluence had elevated electrical conductivity indicating highly saline waters ($>47,000 \mu\text{S/cm}$). This may indicate a natural salinity gradient and needs further investigation. There were bores on the Wilcannia floodplain (site GW087802) and near Lake Wetherell which displayed elevated levels of manganese (up to 7.56 mg/L) and iron (up to 27.0 mg/L).

Total nitrogen concentrations in groundwater ranged between below detection limit (0.1 mg/L) and 3.8 mg/L and total phosphorus concentrations ranged from 0.23 to 5.89 mg/L . There were several instances where surface water nutrient guideline values for protection of aquatic ecosystems for nitrogen, phosphorous and reactive phosphorous were exceeded. While these guidelines do not apply to groundwaters, it is evident that groundwaters in the region are displaying high nutrient concentrations. Median total phosphorous concentration across the study area was 0.2 mg/L , with very high concentrations ($>5 \text{ mg/L}$) present near Lake Wetherell (site GW036813) and in the lower Darling Baaka River downstream of Pooncarie (site GW0088209). The Lower Darling Baaka subcatchment (1512) had several sites with high soluble reactive phosphorous concentration ($>0.5 \text{ mg/L}$). High levels of phosphorus and nitrogen in groundwater are of concern, particularly in the regions where groundwater modelling indicates that the river is receiving significant flows from groundwater sources (see Chapter 7).

Pesticides (as per grab samples presented in this report) were not detected above the relevant lower detection limits in groundwater samples except for GW40797 (Tandou Creek, Great Darling Anabranch). At this site, atrazine was detected at a concentration of $0.42 \mu\text{g/L}$, which was higher than the concentrations in the surrounding river sites. The concentration detected was below the guideline value for atrazine in freshwater, ($13 \mu\text{g/L}$; ANZG, 2018a). Detailed water quality data are provided in the supplementary reports Hose et al. (2025) and DCCEE EPS (2025).

Table 11 Groundwater data from sites across the Darling Baaka River Health project study area

Subcatchment name (number)	Site	Sample time	Nitrate (mg/L)	TN (mg/L)	TP (mg/L)	SRP (mg/L)	DOC (mg/L)	EC (µS/cm)
Wilcannia Downstream (3249)	36806	Jun-24	<0.01	3.2	2.20	0.04	4	607
		Nov-24	<0.01	<0.5	0.97	0.06	13	2,182
Lake Wetherell (1483)	36813	Jun-24	0.07	0.5	0.34	0.13	3	1,233
		Nov-24	0.03	<0.5	5.44	0.13	2	1,656
Wilcannia Downstream (3249)	36836	Jun-24	<0.01	0.4	0.37	0.31	<1	800
		Nov-24	<0.01	0.1	0.34	0.29	1	1,008
Downstream Pooncarie (1475)	40366	Jun-24	0.02	1.2	1.93	0.14	7	480.5
		Nov-24	<0.01	0.3	0.47	0.16	7	580
Downstream Pooncarie (1475)	40371	Jun-24	<0.01	0.5	1.29	0.40	40	749
		Nov-24	<0.01	0.9	1.19	0.11	6	795
Cawndilla (1477)	40797	Jun-24	0.19	1.2	0.38	0.27	11	356
		Nov-24	<0.01	3.4	1.45	1.13	8	2,060
Cawndilla (1477)	40805	Jun-24	<0.01	2.6	1.26	0.02	20	492
		Nov-24	<0.01	1.8	0.82	0.02	13	625
Lower Anabranh (1521)	87616	Jun-24	0.08	3.1	2.81	0.04	2	47,632
		Nov-24	<0.01	1.0	0.32	<0.01	53	55,484
Lower Darling (1512)	87746	Jun-24	0.02	0.8	0.88	0.84	5	509
		Nov-24	<0.10	3.4	1.22	0.82	16	966

Subcatchment name (number)	Site	Sample time	Nitrate (mg/L)	TN (mg/L)	TP (mg/L)	SRP (mg/L)	DOC (mg/L)	EC (µS/cm)
Lake Wetherell (1483)	87788	Jun-24	0.40	0.8	0.14	0.04	2	4,990
		Nov-24	0.11	<0.5	1.16	<0.01	24	8,980
Wilcannia Downstream (3249)	87794	Jun-24	<0.01	1.0	0.62	0.02	3	624
		Nov-24	0.60	2.0	0.25	<0.01	37	927
Wilcannia Downstream (3249)	87796	Jun-24	<0.01	1.1	1.45	<0.01	5	976
		Nov-24	<0.01	<0.5	0.75	<0.01	10	1,302
Lake Wetherell (1483)	87802	Jun-24	<0.01	0.6	0.24	<0.01	6	4,045
		Nov-24	<0.01	0.6	0.23	<0.01	5	4,887
Anabranh North Lakes (1474)	88077	Jun-24	0.04	0.5	0.74	0.48	3	643
Lower Anabranh (1521)	88090	Jun-24	0.02	3.6	3.26	0.06	8	2310
		Nov-24	0.28	0.9	0.40	0.08	22	2,587
Downstream Pooncarie (1475)	88209	Jun-24	<0.01	3.8	5.89	0.61	3	2,966
		Nov-24	<0.01	0.5	0.91	0.72	8	3,700
Upstream Pooncarie (1484)	88323	Jun-24	<0.01	3.1	1.48	0.03	6	741
		Nov-24	<0.01	<0.5	1.40	0.18	11	903
Lake Woytchugga (3254)	40892-1	Jun-24	0.03	0.9	0.60	<0.01	5	596
		Nov-24	<0.01	1.0	0.56	0.02	12	944

Table notes: TN = total nitrogen; TP = total phosphorus; SRP = soluble reactive phosphorus; DOC = dissolved organic carbon; EC = electrical conductivity; mg/L = milligrams per litre; µS/cm = microsiemens per centimetre.

4.6 Overall Water Quality Index

4.6.1 Water Quality Index scores

Poor water quality was recorded in the majority of the subcatchments between April 2024 and March 2025 (Table 12). The main factors contributing to poor Water Quality Index scores were chlorophyll-a, nutrients and turbidity. In our analysis, four subcatchments with flowing water were not sampled (subcatchments 1507, 1481, 1516 and 1522), in these cases water quality condition was averages from the results of the adjacent upstream subcatchment. Subcatchments with either no flow or no water (mainly in the Talyawalka Creek region) were not allocated a Water Quality Index score.

The only lower Darling Baaka River subcatchment that received a moderate RCI water quality grade (between 0.4 and 0.6 in the Water Quality Index) was the northernmost subcatchment of Lower Paroo. In the Great Darling Anabranh, the subcatchments of Lower Redbank Creek, Anabranh North, and Anabranh Offtake received water quality grades of moderate. In these subcatchments, moderate grades were reflected in other RCI indicator scores (see Chapter 6 Biodiversity condition and Chapter 7 Landscape disturbance).

Chlorophyll-a consistently exceeded default guideline values across all sites in the study area and every site received a ‘very poor’ grade for chlorophyll-a. This contributed significantly to the low overarching Water Quality Index grades (Table 12). Chlorophyll-a concentrations in the lower Darling Baaka River and the Great Darling Anabranh displayed an inverse relationship with turbidity. Chlorophyll-a and nutrient concentrations are intrinsically linked due to the nutrient requirements for algal growth as well as the mineralisation of nutrients from dead algae through biological processes. Several significant algal blooms occurred in the lower Darling Baaka River and on the Great Darling Anabranh during the study period, with toxin-producing cyanobacteria recorded in high concentrations at several sites. Detailed results for chlorophyll-a and algae are presented in section 4.5.4 and in Mitrovic et al. (2025; supplementary report).

Nutrients also proved to be a major driver of poor water quality conditions throughout the study area. The metrics for nutrients, including total nitrogen, total phosphorous, soluble reactive phosphorous, ammonium and nitrogen oxides, indicates excessive nutrient loads within both the lower Darling Baaka River and the Great Darling Anabranh. Elevated total and oxidised nitrogen concentrations indicate a high level of nutrient enrichment which could contribute to increased algal growth and associated oxygen fluctuations. Persistent exceedances of the guideline values for total nitrogen and phosphorus, both temporally and spatially, indicate chronic nutrient enrichment in both the lower Darling Baaka River and the Great Darling Anabranh. Groundwater seepage downstream of Weir 32 and within the Great Darling Anabranh may be contributing to the high nutrient loadings observed, with modelling indicating groundwater is relatively important within this stretch of river particularly during low-flow periods (see Chapter 7). Elevated nutrient levels indicate ongoing pressures, including eutrophication and periodic dissolved oxygen fluctuations, and suggest a system under significant biogeochemical stress.

Turbidity was also found to be a major driver of the poor Water Quality Index grades throughout the study area. Turbidity exceeded guideline values across the study area and was graded as very poor for all sites above Weir 32. Sites on the lower Darling Baaka River downstream of Weir 32 to Wentworth received poor grades. Sites within the Great Darling Anabranh zone received poor or very poor grades for turbidity. It is likely that high turbidity in the study area is, in part, a function of the fine sediment composition of the lakes and river. However, it is also likely related to elevated sediment inputs from local sources (such as alluvial gullies, see Chapter 3), inflows from the upper Darling Baaka River after rain events (Table 12) and increased sediment loads in tributaries throughout the catchment.

The Water Quality Index scores for **dissolved oxygen** saturation were variable across the study area, with the lowest scores in zones prone to stratification and persistent hypoxia at depth (Wilcannia to Wetherell and Menindee weir pool zones). There were low dissolved oxygen scores recorded in association with high algal biomass in the Pooncarie North and Pooncarie South zones. However, the Great Darling Anabranh had mostly good to very good scores for dissolved oxygen, indicating better oxygen conditions and less stratification. This study has highlighted the complex interactions between water regulation, oxygen concentrations and negative impacts of high nutrient concentrations and algal biomass.

There were far fewer exceedances of guideline values for **metals and pesticides** than other metrics. The Water Quality Index scores for metals (0.76 to 0.98) and pesticides (0.98 to 1) were much higher than scores for other water quality indices, indicating a relatively minor influence on the health of the river ecosystem. All sites were graded as very good in terms of pesticides. However, 4 sites between Wilcannia and Lake Wetherell were graded as poor for metals because the guideline values for dissolved aluminium, zinc and copper were exceeded.

4.6.2 Drivers of Water Quality Index grades

The Water Quality Index scores and resulting grades (very poor to very good; Figure 31) calculated during this study were strongly influenced by the hydrological conditions that prevailed during sampling. The succession of high-flow events at the beginning of the Phase 2 sampling period influenced turbidity and nutrient concentrations for an extended period, while flow regulation associated with the operation of the Menindee Lakes Storage Scheme influenced downstream water quality dynamics (see section 4.5.1). The fluctuation of water dynamics and flow are a natural part of the system, but the natural regime has been significantly impacted by water regulation activities (see Chapter 7). The combination of inflow events and flow regulation contribute to the recorded fluctuations in water chemistry which highlights the need for monitoring over multiple years to capture a more robust indication of variation over time.

Water regulation activities and highly turbid inflows from the upper Darling Baaka River system had a major impact on the water quality within the lower Darling Baaka River. Turbid, high flow events were a primary driver of water quality in the river, particularly in the Wilcannia to Lake Wetherell zone where turbidity spiked after upstream wet

weather events. The diversion of water via Lake Pamamaroo allows settling of suspended sediments in the lake, which can reduce the turbidity of water that is subsequently released to the Menindee weir pool. However, in the event of water being released from Lake Wetherell to Lake Pamamaroo while simultaneously being released to the Menindee weir pool from Lake Pamamaroo, the attenuating effect of the lakes on turbidity is short-circuited resulting in the transmission of highly turbid water as far downstream as the Pooncarie south zone. Such impacts on turbidity due to releases demonstrate the role water regulation can play in determining water quality.

Water regulation, and in particular controlled releases, also tends to decouple the different zones from the impacts of natural river flows. For example, the retention of high flows arriving from the upper Darling basin in early May 2024 in the Menindee Lakes Storage Scheme meant that flows downstream to Pooncarie and Wentworth were diminished (see Figure 3). This promoted conditions for the development of a large cyanobacteria bloom downstream of Pooncarie during May 2024, with high chlorophyll-*a* concentrations measured in this reach having a significant impact on Water Quality Index scores. A planned release was subsequently made in late May 2024 with the aim of flushing the cyanobacteria downstream. This example highlights the role of river flow (natural or human-induced) on the water quality and biological function of the lower Darling Baaka River (Mitrovic et al. 2011).

In addition to hydrological drivers, fluctuations in turbidity and dissolved oxygen are also believed to influence the cycling of nutrients and metals within the system. Periods of hypoxia, particularly in deeper reaches such as Lake Wetherell and the Menindee weir pool, can promote redox-driven release of phosphorus, ammonium and metals (for example iron, manganese, aluminium) from sediments. These anoxic conditions facilitate the breakdown of organic matter and enhance the remineralisation of organic-bound nutrients, resulting in increased solubility and mobility of certain metals and nutrients. This process can act as a significant internal source of nutrients, particularly during periods of low flow when stratification persists. Similarly, high turbidity can limit algal uptake of nutrients due to light limitation, while also serving as a vector for the transport of particulate-bound phosphorus and metals. Conversely, reductions in turbidity downstream of Weir 32 and in the lower Great Darling Anabranh facilitated greater light availability, which can enhance algal growth and nutrient uptake but may also lead to further dissolved oxygen depletion during biomass decay. The interaction between flow, turbidity, dissolved oxygen and biogeochemical processes therefore plays a critical role in mediating internal nutrient and metal fluxes, influencing water quality beyond direct external inputs alone.

Table 12 **Summary of Water Quality Index (WQI) metrics for each site and subcatchment with overall River Condition Index (RCI) subcatchment score and grade (2 decimal places)**

Sub-catchment name	Sub-catchment no.	Site	Chlorophyll-a (lab)	Dissolved oxygen (%)	Metals	Nutrients	Pesticides	pH	Electrical conductivity	Turbidity	Site score	RCI score	RCI grade
Darling Baaka River subcatchments													
Lower Paroo	3411	1	0.09	0.71	0.60	0.32	0.92	0.92	0.92	0.11	0.45	0.45	Moderate
Lake Woytchugga	3254	2	0.08	0.66	0.35	0.25	0.92	0.62	0.92	0.12	0.32	0.33	Poor
		3	0.08	0.92	0.60	0.39	0.92	0.74	0.92	0.18	0.35		
Wilcannia Downstream	3249	4	0.08	0.40	0.65	0.28	0.92	0.92	0.92	0.18	0.42	0.36	Poor
		5	0.08	0.40	0.40	0.30	0.92	0.92	0.92	0.15	0.32		
		6	0.11	0.22	0.38	0.22	0.92	0.92	0.92	0.10	0.37		
		7	0.12	0.31	0.38	0.21	0.92	0.92	0.92	0.15	0.38		
		8	0.10	0.22	0.39	0.20	0.92	0.92	0.92	0.10	0.27		
Lake Wetherell	1483	B1	0.08	0.45	–	0.19	–	0.78	0.92	0.09	0.21	0.25	Poor
		B2	0.09	0.66	–	0.19	–	0.92	0.92	0.09	0.23		
		B3	0.09	0.33	–	0.17	–	0.80	0.92	0.11	0.20		
		9	0.12	0.24	0.62	0.19	0.89	0.92	0.92	0.10	0.25		
		10	0.09	0.71	–	0.18	–	0.81	0.92	0.17	0.25		
		11	0.09	0.45	0.77	0.19	0.89	0.81	0.92	0.16	0.37		
		12	0.09	0.30	0.71	0.18	0.90	0.92	0.92	0.14	0.35		
		13	0.08	0.37	–	0.18	–	0.92	0.92	0.10	0.19		
		14	0.08	0.45	–	0.22	–	0.92	0.92	0.10	0.22		

Sub-catchment name	Sub-catchment no.	Site	Chlorophyll -a (lab)	Dissolved oxygen (%)	Metals	Nutrients	Pesticides	pH	Electrical conductivity	Turbidity	Site score	RCI score	RCI grade
Downstream Weir 32	1518	16	0.08	0.77	–	0.24	–	0.77	0.92	0.25	0.27	0.27	Poor
Lower Yampoola Creek	1515	17	0.08	0.92	0.75	0.22	0.92	0.92	0.92	0.29	0.40	0.38	Poor
Cuthero Creek	1514	18	0.08	0.69	–	0.24	–	0.66	0.92	0.29	0.25	0.25	Poor
Upstream Pooncarie	1484	19	0.08	0.52	–	0.24	–	0.81	0.92	0.22	0.24	0.32	Poor
		20	0.08	0.42	0.70	0.25	0.92	0.92	0.92	0.19	0.38		
Downstream Pooncarie	1475	21	0.08	0.63	0.81	0.19	–	0.81	0.92	0.22	0.25	0.32	Poor
		22	0.08	0.69	0.71	0.23	0.92	0.69	0.92	0.13	0.37		
Palinyewah	1504	32	0.08	0.46	0.81	0.39	–	0.66	0.92	0.21	0.32	0.32	Poor
Lower Darling	1512	23	0.08	0.38	0.73	0.23	0.92	0.81	0.92	0.26	0.36	0.36	Poor
Murray–Darling Confluence	1507	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0.36*	Poor*
Great Darling Anabranch subcatchments													
Cawndilla	1477	15	0.08	0.40	0.81	0.22	–	0.69	0.92	0.21	0.28	0.31	Poor
		30	0.08	0.92	–	0.35	–	0.56	0.92	0.11	0.29		
		31	0.10	0.92	–	0.46	–	0.54	0.92	0.21	0.36		
Coonalhugga Creek	1481	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0.31*	Poor*

Sub-catchment name	Sub-catchment no.	Site	Chlorophyll -a (lab)	Dissolved oxygen (%)	Metals	Nutrients	Pesticides	pH	Electrical conductivity	Turbidity	Site score	RCI score	RCI grade
Lower Redbank Creek	1476	29	0.08	0.80	0.86	0.31	0.92	0.66	0.92	0.12	0.42	0.42	Moderate
Anabranh Offtake	1516	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0.42*	Moderate*
Anabranh North Lakes	1474	28	0.08	0.58	0.81	0.42	–	0.74	0.92	0.20	0.39	0.39	Poor
Popio	1522	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0.39*	Poor*
Anabranh North	1473	27	0.08	0.71	0.89	0.34	0.92	0.39	0.92	0.12	0.46	0.46	Moderate
Warrawenia Lake	1467	26	0.08	0.92	0.81	0.45	–	0.46	0.92	0.16	0.31	0.31	Poor
Lower Anabranh	1521	24	0.08	0.69	0.86	0.35	0.92	0.36	0.92	0.31	0.42	0.38	Poor
		25	0.08	0.80	0.81	0.43	–	0.34	0.92	0.28	0.31		
Talyawalka Creek subcatchments													
All sub-catchments			n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d

Table note: * indicates overall Water Quality Index score and grade was estimated using the subcatchment condition in adjacent upstream subcatchment. n.d.= no data available for these metrics as there was no flow during the sampling period.

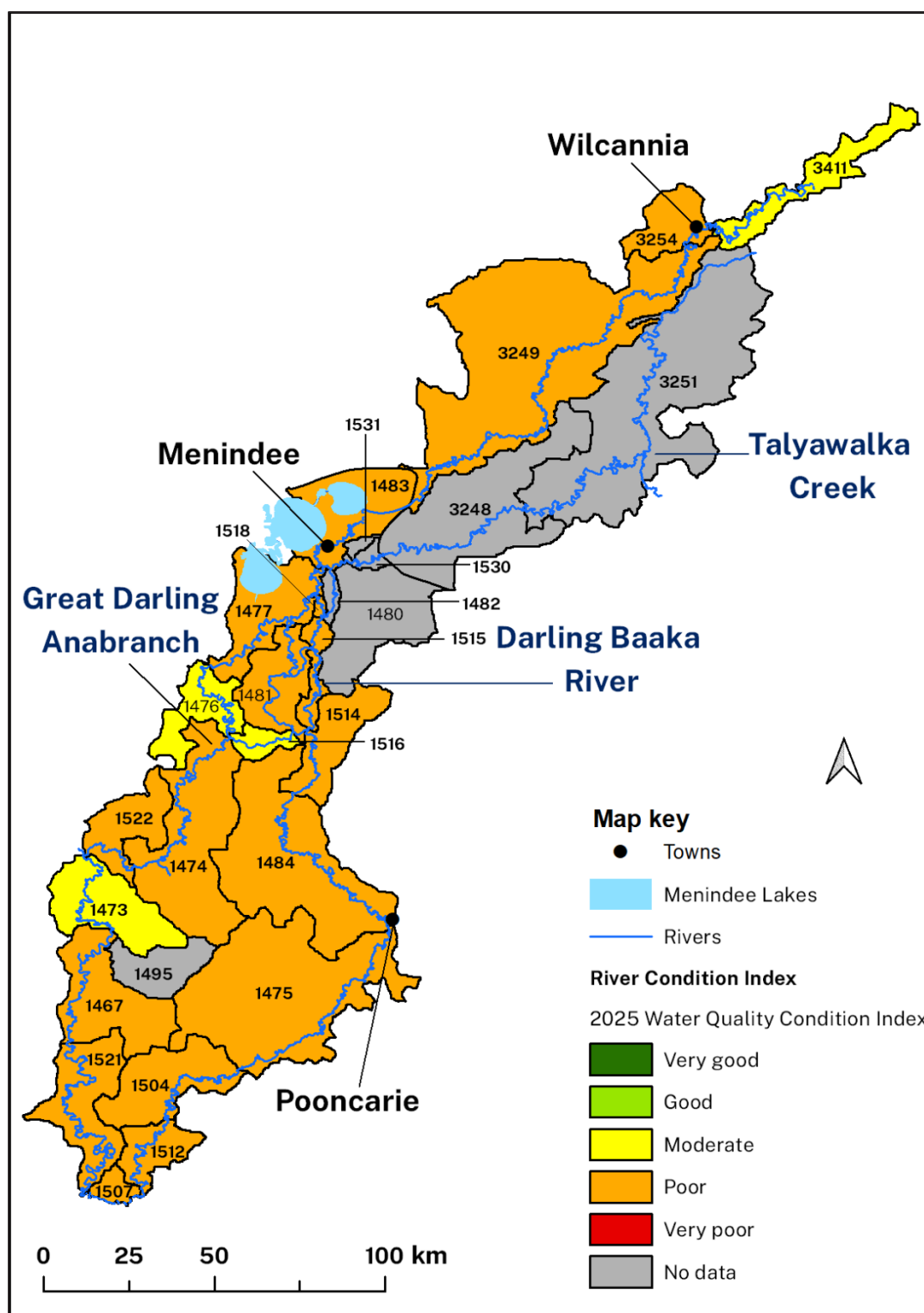


Figure 31 The 2025 Water Quality Condition Index grades for the lower Darling Baaka. Numbers refer to subcatchments (see Table 12). The grades for subcatchments 1481, 1507, 1516, 1522 is an average of the sites in the adjacent upstream catchment

4.7 Conclusion

Overall, the results show poor water quality in the majority of the lower Darling Baaka River system. The Water Quality Index scores are the result of a complex interplay of natural and regulated flows, catchment inputs and local environmental conditions in the lower Darling Baaka River and the Great Darling Anabranch. High nutrient concentrations and turbidity have emerged as the most significant and widespread stressors, with associated chlorophyll-a concentrations exceeding guideline values in all sections of the river.

The high nutrient concentrations within the system aid excessive algae growth and impact dissolved oxygen levels. This negatively impacts ecosystem functioning in various ways including altering the base of food chains, degrading physico-chemical conditions and promoting harmful algal blooms. High nutrient concentrations also have the potential to make ecosystems more susceptible to the impacts of other chemicals, further exacerbating ecosystem degradation and risks to aquatic species.

The study highlights the role of water regulation in downstream water quality, particularly through altered flow regimes, residence times and stratification. Given that water quality variability is driven by both natural flow events and regulation, long-term monitoring across a range of hydrological conditions is essential to better understand water quality dynamics, manage risks to river health, and support informed decision-making for the regulation of the lower Darling Baaka River and the Great Darling Anabranch. This is demonstrated by the smart-buoy network, which provided data to aid management of flow during this study period. It is important to note that moderate to high flows were experienced during the study period, and findings here cannot be extrapolated to low flow periods. Further monitoring is required to better characterise the interactions between hydrology, river regulation, and internal biogeochemical processes that influence water quality during low flow periods.

Appendix A: Sensitivity analyses graphs

The 1:1 line in these plots indicates no change; points below the line indicate that excluding the group improves the WQI score, while points above the line indicate that excluding the group reduces the WQI score. The sensitivity analysis indicated:

- Chlorophyll-a and nutrients exert the strongest downward influence on Water Quality Index scores, due to the high magnitude of exceedances (high F2 values).
- Pesticide parameters exert a modest upward pull, as exceedances are relatively infrequent and minor.

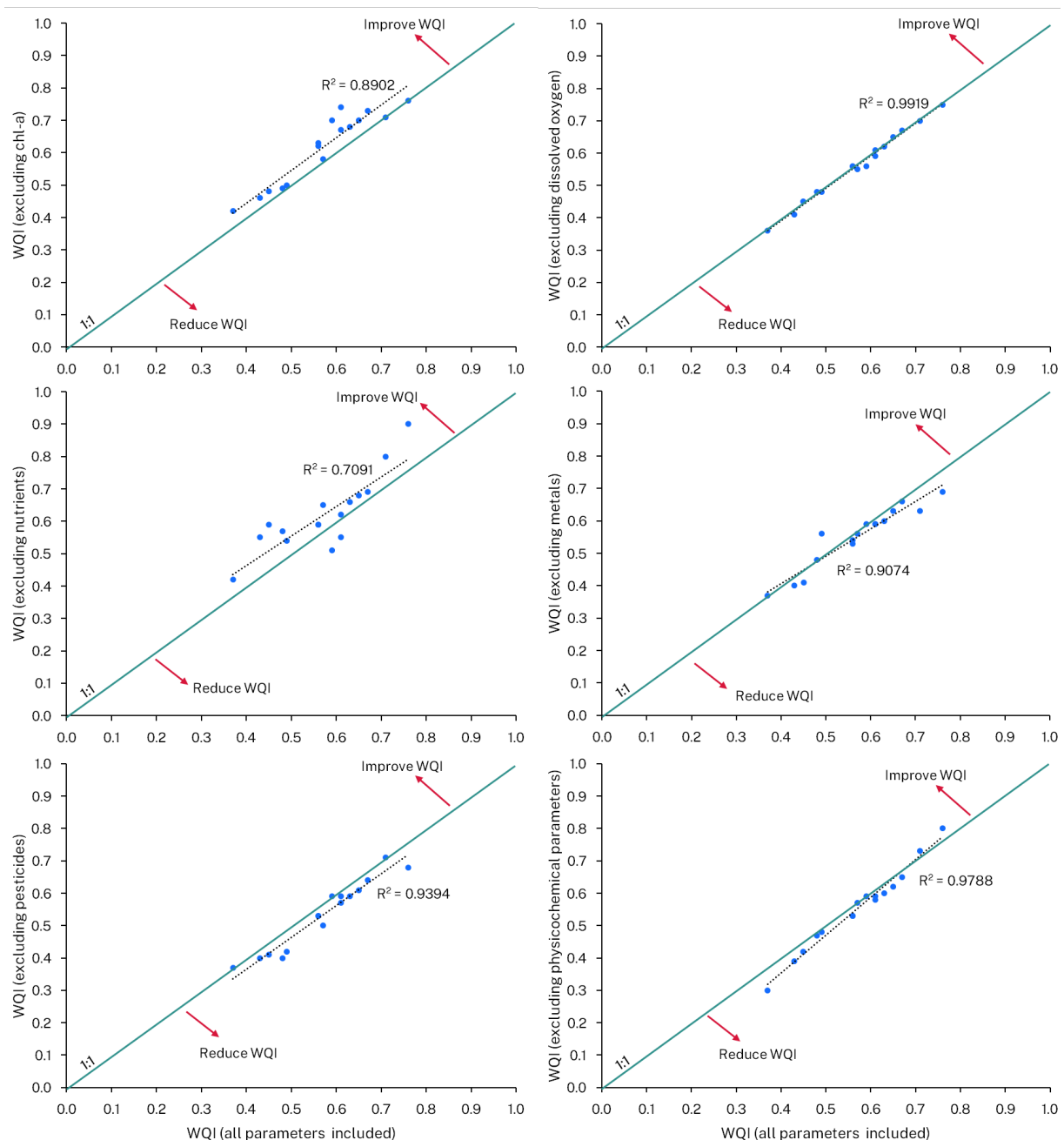


Figure 32 Sensitivity analysis graphs for Water Quality Index metrics

Appendix B: Summary results water quality parameters

Table 13 **Nutrients summary results (samples taken between April 2024 and March 2025)**

	Total nitrogen (mg/L)			Total phosphorus (mg/L)			Soluble reactive phosphorus (mg/L)			Oxidised nitrogen (mg/L)			Ammonium (mg/L)		
Site	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
S01	1.04	1.50	0.70	0.29	0.45	0.07	0.12	0.23	0.01	0.25	0.66	0.00	0.00	0.01	0.00
S02	1.86	6.60	0.55	0.31	0.49	0.08	0.14	0.45	0.00	0.22	0.65	0.00	0.01	0.02	0.00
S03	1.06	1.51	0.58	0.22	0.47	0.07	0.08	0.20	0.01	0.20	0.62	0.00	0.01	0.03	0.00
S04	1.13	1.56	0.54	0.33	0.51	0.06	0.13	0.26	0.00	0.22	0.65	0.00	0.01	0.03	0.00
S05	0.99	1.45	0.61	0.30	0.54	0.09	0.15	0.30	0.01	0.24	0.74	0.00	0.01	0.01	0.00
S06	1.21	1.67	0.72	0.35	0.54	0.09	0.20	0.54	0.01	0.33	0.76	0.00	0.01	0.02	0.00
S07	1.19	1.64	0.71	0.36	0.52	0.07	0.20	0.49	0.01	0.35	0.62	0.00	0.01	0.02	0.00
S08	1.46	1.82	0.82	0.34	0.61	0.09	0.20	0.49	0.03	0.39	0.66	0.00	0.02	0.08	0.00
S09	1.34	1.84	0.83	0.38	0.54	0.10	0.21	0.49	0.02	0.42	0.98	0.00	0.02	0.07	0.00
S10	1.33	1.69	0.90	0.32	0.43	0.17	0.17	0.46	0.08	0.33	0.65	0.00	0.04	0.13	0.01
S11	1.32	1.56	0.78	0.30	0.49	0.15	0.18	0.59	0.08	0.33	0.78	0.00	0.02	0.05	0.00
S12	1.39	2.42	1.04	0.33	0.47	0.16	0.17	0.61	0.07	0.46	1.36	0.00	0.02	0.04	0.00
S13	1.50	2.62	1.01	0.31	0.51	0.17	0.17	0.42	0.05	0.44	0.80	0.00	0.03	0.09	0.00
S14	1.51	1.92	0.94	0.27	0.35	0.13	0.12	0.20	0.05	0.24	0.73	0.00	0.06	0.34	0.00
S15	1.54	1.83	1.24	0.31	0.45	0.19	0.11	0.17	0.06	0.22	0.73	0.00	0.02	0.03	0.00
S16	1.61	2.00	0.79	0.27	0.41	0.06	0.09	0.15	0.01	0.27	0.74	0.00	0.10	0.51	0.00
S17	1.64	1.82	1.39	0.25	0.40	0.16	0.10	0.16	0.06	0.18	0.77	0.00	0.04	0.30	0.00

	Total nitrogen (mg/L)			Total phosphorus (mg/L)			Soluble reactive phosphorus (mg/L)			Oxidised nitrogen (mg/L)			Ammonium (mg/L)		
Site	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
S18	1.52	2.43	1.02	0.28	0.42	0.12	0.10	0.15	0.02	0.24	0.79	0.00	0.02	0.06	0.00
S19	1.65	1.94	1.15	0.25	0.47	0.12	0.09	0.15	0.03	0.22	0.83	0.00	0.02	0.11	0.00
S20	1.60	2.00	1.11	0.28	0.49	0.11	0.09	0.17	0.00	0.24	0.82	0.00	0.01	0.02	0.00
S21	1.81	2.94	1.13	0.42	0.81	0.17	0.10	0.18	0.01	0.47	0.96	0.00	0.01	0.02	0.00
S22	1.56	1.96	1.07	0.33	0.56	0.18	0.10	0.18	0.03	0.30	0.92	0.00	0.02	0.06	0.00
S23	1.68	2.50	1.10	0.28	0.52	0.09	0.09	0.16	0.00	0.35	1.14	0.00	0.05	0.31	0.00
S24	2.34	3.53	1.37	0.18	0.23	0.12	0.01	0.03	0.00	0.05	0.24	0.00	0.16	0.76	0.00
S25	2.30	4.34	1.26	0.19	0.37	0.09	0.01	0.03	0.00	0.01	0.06	0.00	0.06	0.34	0.00
S26	2.13	3.00	1.43	0.21	0.33	0.11	0.01	0.02	0.00	0.01	0.03	0.00	0.02	0.06	0.00
S27	2.11	4.07	1.19	0.32	0.62	0.22	0.03	0.06	0.01	0.09	0.55	0.00	0.01	0.03	0.00
S28	1.88	2.32	1.42	0.27	0.34	0.18	0.02	0.05	0.02	0.00	0.01	0.00	0.02	0.07	0.00
S29	2.21	3.94	1.27	0.34	0.57	0.16	0.05	0.13	0.01	0.01	0.04	0.00	0.03	0.16	0.00
S30	1.83	2.64	1.26	0.30	0.58	0.18	0.04	0.09	0.00	0.01	0.05	0.00	0.04	0.25	0.00
S31	1.53	1.94	1.02	0.20	0.39	0.06	0.02	0.06	0.01	0.01	0.03	0.00	0.04	0.28	0.00
S32	1.43	1.77	1.09	0.26	0.39	0.17	0.05	0.09	0.03	0.02	0.04	0.00	0.00	0.01	0.00
B1	1.72	3.15	0.89	0.39	0.68	0.19	0.15	0.32	0.06	0.34	0.65	0.00	0.02	0.10	0.00
B2	1.27	1.60	0.85	0.32	0.46	0.22	0.17	0.42	0.08	0.34	0.69	0.00	0.03	0.09	0.00
B3	2.66	4.61	1.50	0.35	0.50	0.21	0.10	0.19	0.01	0.17	0.49	0.01	0.30	1.49	0.00
B4	1.16	1.16	1.16	0.19	0.19	0.19	0.07	0.07	0.07	0.00	0.00	0.00	0.01	0.01	0.01

Table 14 Physico-chemical summary results (samples taken April 2024 and March 2025)

Site	Chlorophyll-a (ug/L)			Turbidity (NTU)			pH			Electrical conductivity (µS/cm)			Dissolved oxygen (% saturation)		
	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
S01	29.96	50.73	10.42	296.86	634.00	17.35	7.78	8.75	6.68	353.37	640.79	168.00	98.38	112.56	86.27
S02	68.61	206.12	6.07	266.13	616.00	29.26	7.85	9.22	6.23	352.40	746.62	166.90	114.48	199.10	68.34
S03	43.15	70.06	8.57	286.86	640.00	19.00	7.93	9.09	6.87	416.99	718.00	168.00	122.27	148.26	96.20
S04	64.79	187.57	12.09	206.95	635.00	37.99	8.05	8.90	7.46	374.65	657.95	163.00	93.01	147.14	69.80
S05	44.58	162.35	9.52	254.74	722.00	20.33	7.76	8.60	6.67	320.05	583.92	138.00	87.60	105.06	64.72
S06	27.03	89.67	4.72	272.80	582.00	18.09	7.60	8.46	6.50	289.00	526.07	145.00	75.52	91.17	50.97
S07	21.90	60.65	3.33	221.60	638.00	6.21	7.77	8.53	7.03	261.38	519.60	132.00	82.88	97.89	54.99
S08	19.25	54.81	5.45	322.12	631.00	11.58	7.60	8.20	7.09	237.67	547.61	103.00	71.40	101.64	42.33
S09	20.16	64.21	3.66	467.62	1231.00	37.56	7.69	8.59	7.10	252.33	636.41	173.00	73.24	115.86	26.44
S10	26.16	60.18	8.39	175.76	394.38	31.31	8.19	9.06	7.65	528.15	855.10	319.70	100.85	120.80	84.55
S11	33.16	64.77	9.59	181.89	367.06	24.67	8.22	9.05	7.51	515.04	860.00	289.37	98.00	139.99	75.60
S12	33.06	68.43	10.43	181.66	338.37	23.97	8.07	8.80	7.51	516.77	922.00	319.13	84.63	137.09	62.30
S13	40.03	75.99	8.21	205.34	358.80	51.55	8.01	8.79	7.53	439.26	668.06	252.17	89.11	122.30	75.35
S14	49.22	101.68	8.80	132.11	346.10	48.61	8.37	8.81	7.77	591.35	836.00	358.30	92.74	150.94	67.76
S15	39.67	95.53	8.74	128.64	329.92	28.22	8.48	9.11	7.83	593.01	776.00	356.10	89.89	118.44	70.92
S16	50.65	119.99	7.76	124.44	343.20	24.26	8.53	9.11	7.74	658.85	827.00	353.40	103.23	133.75	88.70
S17	59.99	92.97	15.45	108.68	370.12	20.08	8.62	8.89	7.84	704.95	851.63	333.40	100.57	121.30	91.90
S18	64.68	121.80	7.65	100.98	309.90	28.69	8.61	9.11	7.73	699.26	850.00	366.28	100.16	124.78	76.50
S19	60.93	117.39	7.21	143.66	450.54	33.38	8.39	9.07	7.70	662.71	882.00	292.60	91.07	121.88	61.98

	Chlorophyll-a (ug/L)			Turbidity (NTU)			pH			Electrical conductivity (µS/cm)			Dissolved oxygen (% saturation)		
Site	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
S20	61.70	130.70	11.19	124.17	455.29	28.61	8.43	8.81	7.76	677.82	894.77	294.60	92.90	119.36	76.59
S21	68.20	149.57	7.33	146.12	467.26	34.76	8.21	8.90	6.31	634.74	876.00	293.90	96.95	113.64	86.11
S22	62.84	119.60	8.51	155.15	492.00	27.55	8.26	9.01	6.31	628.58	850.00	294.50	97.08	121.95	81.51
S23	55.38	100.76	13.60	127.75	503.35	20.80	8.29	8.94	6.30	646.13	913.00	258.60	96.95	174.36	61.30
S24	71.87	119.21	38.33	71.15	150.90	37.29	8.75	9.42	6.31	696.65	885.32	600.09	112.49	168.64	85.51
S25	70.50	155.47	13.12	81.73	165.28	44.16	8.80	9.42	6.31	710.14	954.60	594.74	142.38	225.26	67.52
S26	74.87	120.46	35.83	101.59	179.17	39.09	8.77	9.93	6.30	697.61	883.89	594.20	161.47	318.55	92.90
S27	74.15	163.90	38.02	127.61	317.06	56.95	8.42	9.07	6.31	799.37	872.51	716.40	123.74	196.19	79.17
S28	42.94	69.22	14.12	144.89	404.47	34.47	8.37	8.92	6.32	769.42	856.32	652.12	103.53	139.95	68.82
S29	58.95	140.72	29.51	122.31	293.32	58.44	8.87	9.16	8.37	646.63	797.44	548.00	114.34	145.86	70.86
S30	48.60	82.89	6.27	140.03	317.35	80.92	8.97	9.44	8.54	665.66	818.13	544.00	126.61	182.25	91.47
S31	44.47	120.58	2.36	82.19	132.20	24.91	9.20	10.45	8.62	596.49	821.14	456.11	143.73	208.91	110.50
S32	67.99	92.82	46.25	105.59	188.53	43.95	8.05	8.98	6.31	687.83	769.63	588.37	93.11	103.10	82.08
B1	40.83	153.56	8.00	230.34	450.52	51.43	8.08	9.16	7.44	417.57	648.24	266.40	98.72	131.79	73.82
B2	30.38	101.25	8.16	231.94	416.92	56.87	7.98	8.70	7.42	440.64	634.04	296.91	91.91	99.38	74.25
B3	56.50	118.49	2.04	138.26	247.74	60.07	8.37	9.02	7.66	703.98	959.52	336.76	95.36	183.12	49.40
B4	36.63	36.63	36.63	85.36	85.36	85.36	8.84	8.84	8.84	582.00	582.00	582.00	103.70	103.70	103.70

Table 15 **Metals analysis result summary for samples collected between April 2024 and March 2025 (dissolved aluminium, dissolved arsenic, dissolved cadmium)**

Site	Dissolved aluminium (mg/L)			Dissolved arsenic (mg/L)			Dissolved cadmium (mg/L)		
	Average	Max	Min	Average	Max	Min	Average	Max	Min
S01	0.015000	0.040000	BLOR	0.002667	0.005000	0.001000	BLOR	BLOR	BLOR
S02	0.451500	1.510000	BLOR	0.002300	0.006000	0.000500	BLOR	BLOR	BLOR
S03	0.020000	0.020000	0.020000	0.002000	0.002000	0.002000	BLOR	BLOR	BLOR
S04	0.007750	0.020000	BLOR	0.002750	0.007000	0.001000	BLOR	BLOR	BLOR
S05	0.030000	0.030000	0.030000	0.002000	0.002000	0.002000	BLOR	BLOR	BLOR
S06	0.398750	1.540000	BLOR	0.002750	0.005000	0.002000	BLOR	BLOR	BLOR
S07	0.393750	1.530000	BLOR	0.002750	0.005000	0.002000	BLOR	BLOR	BLOR
S08	0.030000	0.030000	0.030000	0.002000	0.002000	0.002000	BLOR	BLOR	BLOR
S09	0.015500	0.050000	BLOR	0.002600	0.005000	0.002000	BLOR	BLOR	BLOR
S11	0.003333	0.005000	BLOR	0.002333	0.003000	0.002000	BLOR	BLOR	BLOR
S12	0.004250	0.007000	BLOR	0.002750	0.004000	0.002000	BLOR	BLOR	BLOR
S15	0.002500	0.002500	BLOR	0.004000	0.004000	0.004000	BLOR	BLOR	BLOR
S17	0.003333	0.005000	BLOR	0.004333	0.005000	0.004000	BLOR	BLOR	BLOR
S20	0.003125	0.005000	BLOR	0.003250	0.004000	0.002000	BLOR	BLOR	BLOR
S21	0.002500	0.002500	BLOR	0.004000	0.004000	0.004000	BLOR	BLOR	BLOR
S22	0.003125	0.005000	BLOR	0.003750	0.004000	0.003000	BLOR	BLOR	BLOR
S23	0.003333	0.005000	BLOR	0.003333	0.005000	0.002000	BLOR	BLOR	BLOR
S24	0.003125	0.005000	BLOR	0.004750	0.010000	0.003000	BLOR	BLOR	BLOR
S25	0.002500	0.002500	BLOR	0.009000	0.009000	0.009000	BLOR	BLOR	BLOR

Site	Dissolved aluminium (mg/L)			Dissolved arsenic (mg/L)			Dissolved cadmium (mg/L)		
	Average	Max	Min	Average	Max	Min	Average	Max	Min
S26	0.014000	0.014000	0.014000	0.009000	0.009000	0.009000	BLOR	BLOR	BLOR
S27	0.003333	0.005000	BLOR	0.007000	0.010000	0.004000	BLOR	BLOR	BLOR
S28	0.003750	0.005000	BLOR	0.005000	0.005000	0.005000	BLOR	BLOR	BLOR
S29	0.002500	0.002500	BLOR	0.006667	0.008000	0.005000	BLOR	BLOR	BLOR
S32	0.002500	0.002500	BLOR	0.005000	0.005000	0.005000	BLOR	BLOR	BLOR

Table note: BLOR = below limit of reporting

Table 16 **Metals analysis result summary for samples collected between April 2024 and March 2025 (dissolved chromium, dissolved cobalt, dissolved copper)**

Site	Dissolved chromium (mg/L)			Dissolved cobalt (mg/L)			Dissolved copper (mg/L)		
	Average	Max	Min	Average	Max	Min	Average	Max	Min
S01	0.000667	0.001000	BLOR	0.000233	BLOR	0.000100	0.002167	0.003000	0.000500
S02	BLOR	BLOR	BLOR	0.000370	0.001000	BLOR	0.003100	0.006000	0.000500
S03	BLOR	BLOR	BLOR	0.000500	BLOR	BLOR	0.003000	0.003000	0.003000
S04	BLOR	BLOR	BLOR	0.000188	BLOR	BLOR	0.001875	0.003000	0.000500
S05	BLOR	BLOR	BLOR	0.000500	BLOR	BLOR	0.003000	0.003000	0.003000
S06	0.000625	0.001000	BLOR	0.000325	BLOR	0.000100	0.003000	0.006000	0.001000
S07	BLOR	BLOR	BLOR	0.000350	BLOR	0.000200	0.003500	0.006000	0.002000
S08	BLOR	BLOR	BLOR	0.000500	BLOR	BLOR	0.003000	0.003000	0.003000
S09	0.090000	0.448000	BLOR	0.000270	BLOR	BLOR	0.002500	0.004000	0.000500
S11	BLOR	BLOR	BLOR	0.000250	BLOR	BLOR	0.001167	0.002000	0.000500
S12	BLOR	BLOR	BLOR	0.000213	BLOR	BLOR	0.001750	0.002000	0.001000
S15	BLOR	BLOR	BLOR	0.000200	0.000200	0.000200	0.002000	0.002000	0.002000
S17	BLOR	BLOR	BLOR	0.000300	BLOR	0.000200	0.001667	0.002000	0.001000
S20	BLOR	BLOR	BLOR	0.000213	BLOR	BLOR	0.002000	0.003000	0.001000
S21	BLOR	BLOR	BLOR	0.000200	0.000200	0.000200	0.003000	0.003000	0.003000
S22	BLOR	BLOR	BLOR	0.000225	BLOR	0.000100	0.002250	0.003000	0.002000
S23	BLOR	BLOR	BLOR	0.000300	BLOR	0.000200	0.002333	0.003000	0.002000
S24	BLOR	BLOR	BLOR	0.000450	0.000800	0.000200	0.000875	0.001000	0.000500
S25	BLOR	BLOR	BLOR	0.000800	0.000800	0.000800	0.002000	0.002000	0.002000

Site	Dissolved chromium (mg/L)			Dissolved cobalt (mg/L)			Dissolved copper (mg/L)		
	Average	Max	Min	Average	Max	Min	Average	Max	Min
S26	BLOR	BLOR	BLOR	0.000800	0.000800	0.000800	0.002000	0.002000	0.002000
S27	BLOR	BLOR	BLOR	0.000500	0.000600	0.000400	0.001333	0.002000	0.001000
S28	BLOR	BLOR	BLOR	0.000350	BLOR	0.000200	0.002000	0.002000	0.002000
S29	BLOR	BLOR	BLOR	0.000300	0.000400	0.000200	0.001833	0.003000	0.000500
S32	BLOR	BLOR	BLOR	0.000200	0.000200	0.000200	0.003000	0.003000	0.003000

Table note: BLOR = below limit of reporting

Table 17 **Metals analysis result summary for samples collected between April 2024 and March 2025 (dissolved lead, dissolved manganese, dissolved mercury)**

Site	Dissolved lead (mg/L)			Dissolved manganese (mg/L)			Dissolved mercury (mg/L)		
	Average	Max	Min	Average	Max	Min	Average	Max	Min
S01	BLOR	BLOR	BLOR	0.001383	0.002000	0.000250	BLOR	BLOR	BLOR
S02	0.000900	0.002000	BLOR	0.028960	0.095000	0.000250	BLOR	BLOR	BLOR
S03	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S04	BLOR	BLOR	BLOR	0.001288	0.003800	0.000250	BLOR	BLOR	BLOR
S05	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S06	0.000625	0.001000	BLOR	0.011875	0.037000	0.001000	BLOR	BLOR	BLOR
S07	0.000625	0.001000	BLOR	0.016150	0.040000	BLOR	BLOR	BLOR	BLOR
S08	BLOR	BLOR	BLOR	0.001000	0.001000	0.001000	BLOR	BLOR	BLOR
S09	BLOR	BLOR	BLOR	0.001240	0.002500	0.000600	BLOR	BLOR	BLOR
S11	BLOR	BLOR	BLOR	0.000450	0.000600	0.000250	BLOR	BLOR	BLOR
S12	BLOR	BLOR	BLOR	0.000850	0.001300	BLOR	BLOR	BLOR	BLOR
S15	BLOR	BLOR	BLOR	0.000250	0.000250	0.000250	BLOR	BLOR	BLOR
S17	BLOR	BLOR	BLOR	0.000450	0.000600	0.000250	BLOR	BLOR	BLOR
S20	BLOR	BLOR	BLOR	0.001013	0.002000	0.000250	BLOR	BLOR	BLOR
S21	BLOR	BLOR	BLOR	0.000250	0.000250	0.000250	BLOR	BLOR	BLOR
S22	BLOR	BLOR	BLOR	0.000512	0.000700	0.000250	BLOR	BLOR	BLOR
S23	BLOR	BLOR	BLOR	0.001333	0.003000	BLOR	BLOR	BLOR	BLOR
S24	BLOR	BLOR	BLOR	0.005450	0.009900	BLOR	BLOR	BLOR	BLOR

Site	Dissolved lead (mg/L)			Dissolved manganese (mg/L)			Dissolved mercury (mg/L)		
	Average	Max	Min	Average	Max	Min	Average	Max	Min
S25	BLOR	BLOR	BLOR	0.003300	0.003300	0.003300	BLOR	BLOR	BLOR
S26	BLOR	BLOR	BLOR	0.001500	0.001500	0.001500	BLOR	BLOR	BLOR
S27	BLOR	BLOR	BLOR	0.001433	0.002000	BLOR	BLOR	BLOR	BLOR
S28	BLOR	BLOR	BLOR	0.000600	0.000700	BLOR	BLOR	BLOR	BLOR
S29	BLOR	BLOR	BLOR	0.007250	0.020600	0.000250	BLOR	BLOR	BLOR
S32	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR

Table note: BLOR = below limit of reporting

Table 18 **Metals analysis result summary for samples collected between April 2024 and March 2025 (dissolved nickel, dissolved silver, dissolved zinc)**

Site	Dissolved nickel (mg/L)			Dissolved silver (mg/L)			Dissolved zinc (mg/L)		
	Average	Max	Min	Average	Max	Min	Average	Max	Min
S01	0.002333	BLOR	0.001000	BLOR	BLOR	BLOR	0.011833	0.018000	BLOR
S02	0.002800	0.005000	0.001000	BLOR	BLOR	BLOR	0.045100	0.153000	BLOR
S03	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	0.020000	0.020000	0.020000
S04	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	0.012875	0.024000	BLOR
S05	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	0.019000	0.019000	0.019000
S06	0.002750	0.004000	BLOR	BLOR	BLOR	BLOR	0.023750	0.032000	0.011000
S07	0.003250	0.004000	BLOR	BLOR	BLOR	BLOR	0.022000	0.031000	0.008000
S08	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	0.025000	0.025000	0.025000
S09	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	0.012600	0.024000	BLOR
S11	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	0.009333	0.023000	BLOR
S12	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	0.012875	0.022000	BLOR
S15	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S17	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	0.004667	0.009000	BLOR
S20	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	0.015875	0.034000	BLOR
S21	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S22	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	0.007875	0.012000	BLOR
S23	0.001667	BLOR	0.001000	BLOR	BLOR	BLOR	0.004667	0.009000	BLOR
S24	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	0.003875	0.008000	BLOR
S25	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR

Site	Dissolved nickel (mg/L)			Dissolved silver (mg/L)			Dissolved zinc (mg/L)		
	Average	Max	Min	Average	Max	Min	Average	Max	Min
S26	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S27	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S28	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S29	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	0.003667	0.006000	BLOR
S32	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR

Table note: BLOR = below limit of reporting

Table 19 Pesticides analysis result summary for samples collected between April 2024 and March 2025 (2,4,5-T, 2,4-D, Aldrin, Alpha-Endosulfan)

	2,4,5-T (mg/L)			2,4-D (mg/L)			Aldrin (mg/L)			Alpha-Endosulfan (mg/L)		
Site	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
S01	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S02	0.000875	0.002000	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S03	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S04	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S05	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S06	0.000875	0.002000	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S07	0.000875	0.002000	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S08	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S09	0.000875	0.002000	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S11	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S12	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S17	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S20	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S22	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S23	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S24	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S27	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S29	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR

Table note: BLOR = below limit of reporting

Table 20 Pesticides analysis result summary for samples collected between April 2024 and March 2025 (Atrazine, Azinphos methyl, Azinphos methyl_HR, Carbofuran)

	Atrazine (mg/L)			Azinphos methyl (mg/L)			Azinphos methyl_HR (mg/L)			Carbofuran (mg/L)		
Site	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
S01	0.000062	0.000084	0.000050	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S02	0.000065	0.000100	0.000050	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S03	0.000050	0.000050	0.000050	BLOR	BLOR	BLOR	-	-	-	-	-	-
S04	0.000065	0.000089	0.000050	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S05	0.000050	0.000050	0.000050	BLOR	BLOR	BLOR	-	-	-	-	-	-
S06	0.000059	0.000079	0.000050	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S07	0.000062	0.000083	0.000050	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S08	0.000050	0.000050	0.000050	BLOR	BLOR	BLOR	-	-	-	-	-	-
S09	0.000057	0.000071	0.000050	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S11	0.000147	0.000330	0.000055	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S12	0.000102	0.000190	0.000033	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S17	0.000156	0.000270	0.000097	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S20	0.000152	0.000260	0.000076	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S22	0.000138	0.000240	0.000065	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S23	0.000114	0.000190	0.000043	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S24	0.000119	0.000150	0.000078	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S27	0.000073	0.000180	0.000005	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S29	0.000177	0.000220	0.000130	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR

Table note: BLOR = below limit of reporting

Table 21 Pesticides analysis result summary for samples collected between April 2024 and March 2025 (Chlorpyrifos, Deltamethrin, Diazinon, Diazonon_HR)

	Chlorpyrifos (mg/L)			Deltamethrin (mg/L)			Diazinon (mg/L)			Diazonon_HR (mg/L)		
Site	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
S01	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S02	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S03	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	-	-	-
S04	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S05	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	-	-	-
S06	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S07	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S08	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	-	-	-
S09	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S11	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S12	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S17	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S20	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S22	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S23	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S24	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S27	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S29	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR

Table note: BLOR = below limit of reporting

Table 22 Pesticides analysis result summary for samples collected between April 2024 and March 2025 (Dicofol, Dieldrin, Dimethoate, Dimethoate_HR)

	Dicofol (mg/L)			Dieldrin (mg/L)			Dimethoate (mg/L)			Dimethoate_HR (mg/L)		
Site	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
S01	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S02	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S03	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	–	–	–
S04	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S05	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	–	–	–
S06	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S07	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S08	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	–	–	–
S09	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S11	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S12	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S17	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S20	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S22	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S23	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S24	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S27	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S29	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR

Table note: BLOR = below limit of reporting

Table 23 Pesticides analysis result summary for samples collected between April 2024 and March 2025 (Diruon, Endrin, Endrin_HR, Fenitrrthion)

	Diuron (mg/L)			Endrin (mg/L)			Endrin_HR (mg/L)			Fenitrothion (mg/L)		
Site	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
S01	0.000149	0.000360	0.000036	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S02	0.000149	0.000390	0.000037	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S03	0.000050	0.000050	0.000050	BLOR	BLOR	BLOR	–	–	–	BLOR	BLOR	BLOR
S04	0.000165	0.000410	0.000036	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S05	0.000050	0.000050	0.000050	BLOR	BLOR	BLOR	–	–	–	BLOR	BLOR	BLOR
S06	0.000165	0.000420	0.000041	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S07	0.000132	0.000260	0.000036	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S08	0.000110	0.000110	0.000110	BLOR	BLOR	BLOR	–	–	–	BLOR	BLOR	BLOR
S09	0.000124	0.000190	0.000045	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S11	0.000041	0.000050	0.000037	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S12	0.000058	0.000097	0.000028	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S17	0.000056	0.000075	0.000044	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S20	0.000060	0.000085	0.000045	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S22	0.000049	0.000078	0.000020	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S23	0.000034	0.000050	0.000013	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S24	0.000020	0.000050	0.000005	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S27	0.000016	0.000050	0.000005	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S29	0.000020	0.000050	0.000005	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR

Table note: BLOR = below limit of reporting

Table 24 Pesticides analysis result summary for samples collected between April 2024 and March 2025 (Fenitrothion_HR, Fipronil, gamma-BHC(Lindane), Glyphosate)

	Fenitrothion_HR (mg/L)			Fipronil (mg/L)			gamma-BHC(Lindane) (mg/L)			Glyphosate (mg/L)		
Site	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
S01	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S02	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S03	-	-	-	-	-	-	BLOR	BLOR	BLOR	-	-	-
S04	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S05	-	-	-	-	-	-	BLOR	BLOR	BLOR	-	-	-
S06	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	-	-	-
S07	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	-	-	-
S08	-	-	-	-	-	-	BLOR	BLOR	BLOR	-	-	-
S09	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S11	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S12	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S17	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	-	-	-
S20	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S22	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S23	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	-	-	-
S24	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S27	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	-	-	-
S29	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR

Table note: BLOR = below limit of reporting

Table 25 Pesticides analysis result summary for samples collected between April 2024 and March 2025 (HCB, HCB_HR, Heptachlor, Heptachlor_HR)

	HCB (mg/L)			HCB_HR (mg/L)			Heptachlor (mg/L)			Heptachlor_HR (mg/L)		
Site	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
S01	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S02	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S03	BLOR	BLOR	BLOR	–	–	–	BLOR	BLOR	BLOR	–	–	–
S04	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S05	BLOR	BLOR	BLOR	–	–	–	BLOR	BLOR	BLOR	–	–	–
S06	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S07	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S08	BLOR	BLOR	BLOR	–	–	–	BLOR	BLOR	BLOR	–	–	–
S09	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S11	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S12	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S17	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S20	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S22	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S23	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S24	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S27	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S29	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR

Table note: BLOR = below limit of reporting

Table 26 Pesticides analysis result summary for samples collected between April 2024 and March 2025 (Malathion, Malathion_HR, MCPA, Methomyl)

	Malathion (mg/L)			Malathion_HR (mg/L)			MCPA (mg/L)			Methomyl (mg/L)		
Site	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
S01	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S02	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S03	BLOR	BLOR	BLOR	-	-	-	BLOR	BLOR	BLOR	-	-	-
S04	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S05	BLOR	BLOR	BLOR	-	-	-	BLOR	BLOR	BLOR	-	-	-
S06	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S07	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S08	BLOR	BLOR	BLOR	-	-	-	BLOR	BLOR	BLOR	-	-	-
S09	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S11	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S12	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S17	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S20	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S22	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S23	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S24	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S27	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S29	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR

Table note: BLOR = below limit of reporting

Table 27 Pesticides analysis result summary for samples collected between April 2024 and March 2025 (Methoxychlor, Metolachlor, Molinate, Picloram)

Methoxychlor (mg/L)				Metolachlor (mg/L)			Molinate (mg/L)			Picloram (mg/L)		
Site	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
S01	BLOR	BLOR	BLOR	0.000120	0.000270	0.000039	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S02	BLOR	BLOR	BLOR	0.000201	0.000380	0.000045	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S03	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S04	BLOR	BLOR	BLOR	0.000245	0.000410	0.000064	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S05	BLOR	BLOR	BLOR	0.000270	0.000270	0.000270	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S06	BLOR	BLOR	BLOR	0.000274	0.000410	0.000066	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S07	BLOR	BLOR	BLOR	0.000318	0.000460	0.000092	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S08	BLOR	BLOR	BLOR	0.000300	0.000300	0.000300	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S09	BLOR	BLOR	BLOR	0.000337	0.000520	0.000046	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S11	BLOR	BLOR	BLOR	0.000329	0.000840	0.000074	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S12	BLOR	BLOR	BLOR	0.000348	0.000740	0.000044	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S17	BLOR	BLOR	BLOR	0.000133	0.000180	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S20	BLOR	BLOR	BLOR	0.000138	0.000240	0.000053	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S22	BLOR	BLOR	BLOR	0.000114	0.000180	0.000051	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S23	BLOR	BLOR	BLOR	0.000127	0.000280	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S24	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S27	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S29	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR

Table note: BLOR = below limit of reporting

Table 28 Pesticides analysis result summary for samples collected between April 2024 and March 2025 (Simazine, Tebuthiuron, Temephos, Trifluralin)

	Simazine (mg/L)			Tebuthiuron (mg/L)			Temephos (mg/L)			Trifluralin (mg/L)		
Site	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
S01	0.000061	0.000110	0.000022	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S02	0.000059	0.000110	0.000028	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S03	0.000050	0.000050	0.000050	BLOR	BLOR	BLOR	–	–	–	BLOR	BLOR	BLOR
S04	0.000056	0.000077	0.000040	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S05	0.000050	0.000050	0.000050	BLOR	BLOR	BLOR	–	–	–	BLOR	BLOR	BLOR
S06	0.000065	0.000130	0.000029	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S07	0.000067	0.000130	0.000037	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S08	0.000050	0.000050	0.000050	BLOR	BLOR	BLOR	–	–	–	BLOR	BLOR	BLOR
S09	0.000053	0.000073	0.000038	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S11	0.000067	0.000077	0.000050	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S12	0.000044	0.000050	0.000035	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S17	0.000052	0.000072	0.000033	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S20	0.000049	0.000068	0.000030	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S22	0.000067	0.000100	0.000029	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S23	0.000052	0.000083	0.000023	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S24	0.000078	0.000130	0.000044	BLOR	BLOR	BLOR	0.000750	BLOR	BLOR	BLOR	BLOR	BLOR
S27	0.000077	0.000130	0.000050	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR
S29	0.000102	0.000160	0.000066	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR	BLOR

Table note: BLOR = below limit of reporting

Appendix C: Comparison of smart buoy and grab sample data

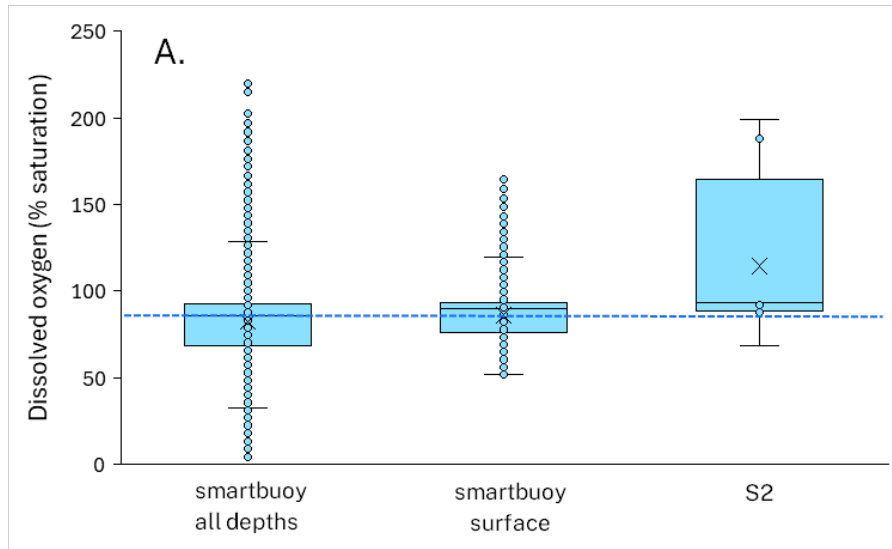


Figure 33 Comparison of smart buoy and grab sample data for Wilcannia

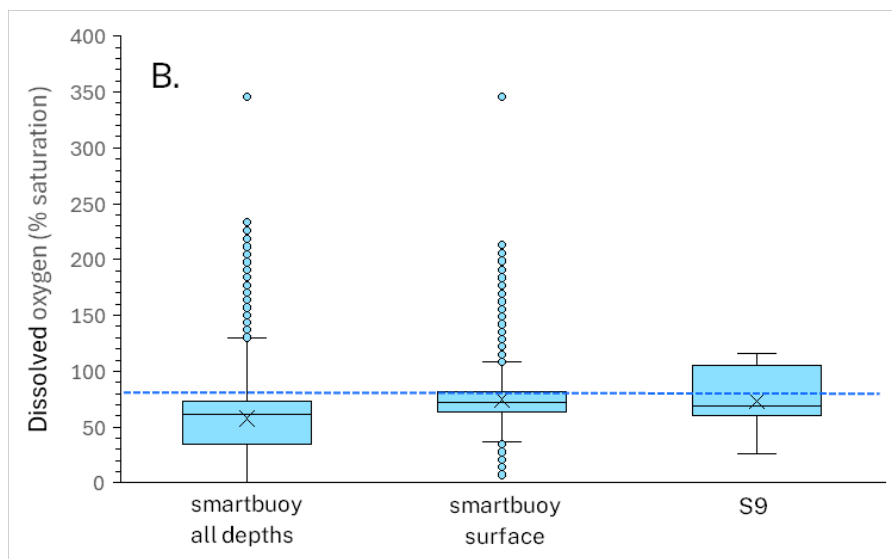


Figure 34 Comparison of smart buoy and grab sample data for Lake Wetherell

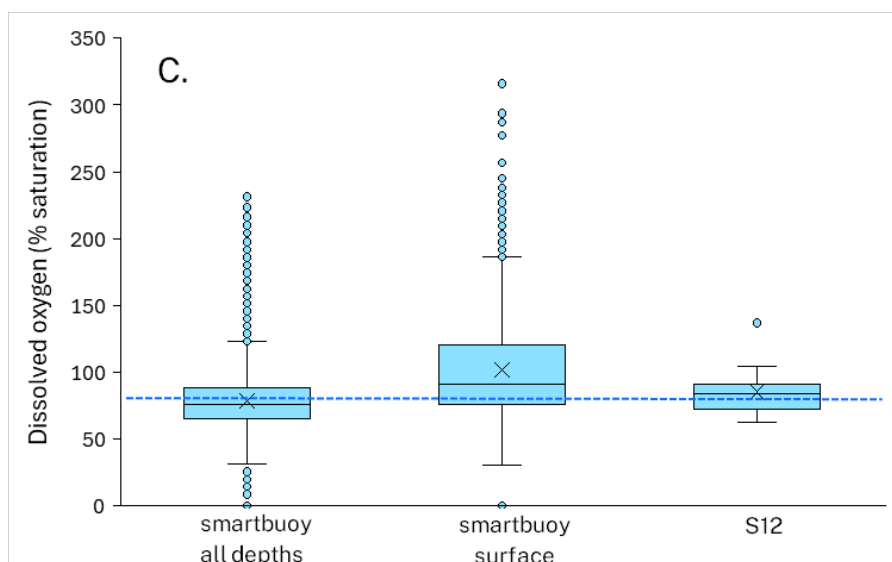


Figure 35 Comparison of smart buoy and grab sample data for Menindee weir pool

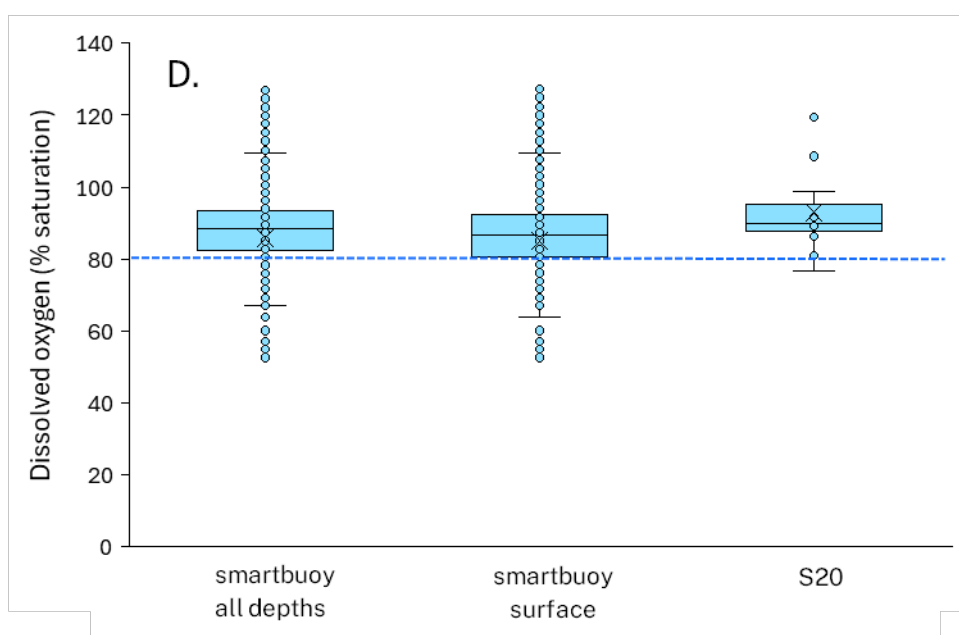


Figure 36 Comparison of smart buoy and grab sample data for Poongcarie

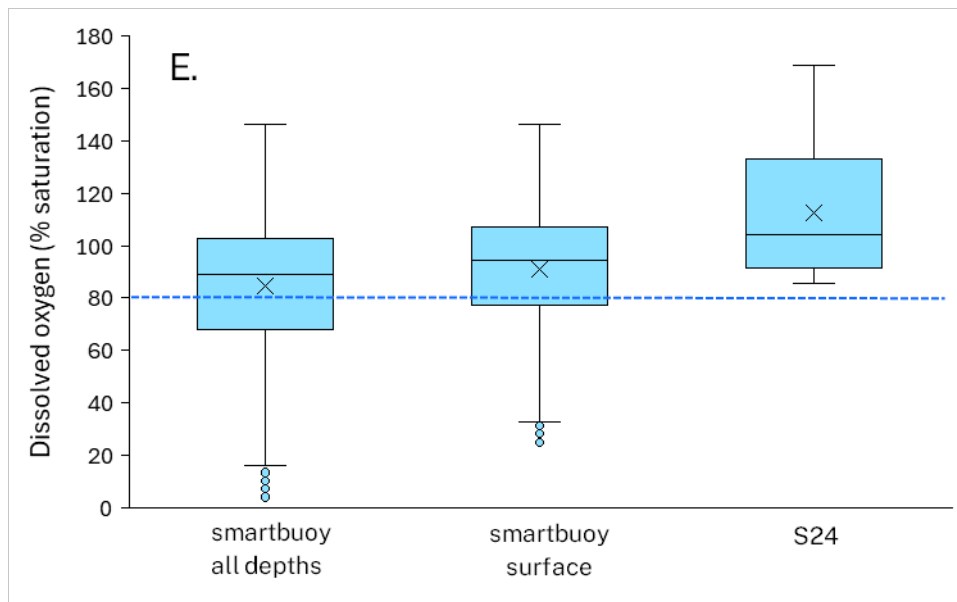


Figure 37 Comparison of smart buoy and grab sample data for lower Anabranh