



WATER QUALITY REPORT

Mid Richmond River – Annual Progress Report, January 2023
Prepared by Southern Cross University

Executive Summary

It has been known for decades that the artificially enhanced drainage of the Richmond River floodplain (and associated floodgates) is a significant contributor to the water quality issues affecting the lower Richmond River, in particular, blackwater events and acidic discharges containing metal contaminants.

The data collected by the telemetered logger network during the wet 2021-22 period presents a sobering reality of the lower River's response to wet conditions. The ~1,500,000 measurements of fundamental water quality parameters that have been collected across the eight monitoring sites since March 2021 reveals:

- There is considerable spatial and temporal variability in blackwater generation across the floodplain
 - The ability to predict this variability is currently unachievable
 - Our understanding of the capacity of the river to assimilate the blackwater before its affects become catastrophic is unknown
 - The relative contribution of the different floodplain areas to river deoxygenation under any particular flood event is also unknown
- The discharge of low oxygen waters from the floodplain is not limited to large blackwater events associated with flooding, but can occur more frequently and after smaller rain events
- Chronic acidic discharges from the drained floodplain soils follows most rain events – not just after floods
- Beyond the “visible impacts” of blackwater and acid discharges, i.e. fish kills, the ecological and biogeochemical impacts to the river are largely unknown

As such, Rous County Council (RCC) face a considerable challenge in reducing the environmental impact of the enhanced floodplain drainage, particularly the floodgated drainage systems they manage. Recent assessments have concluded that broad-scale changes in land and water management (and as a consequence, land use change) across the floodplains is necessary. Such changes are beyond RCC and needs to be driven by the appropriate authority.

This project, which is a collaborative project between RCC, NSW Governments Department of Planning and Environment (DPE) and Southern Cross University (SCU), has significantly enhanced our understating of the water quality issues facing the Richmond River. However, funding for the project ends in early 2025. In lieu of this, and given a considerable investment into the flood damaged loggers is expected in the coming months, a longer-term plan for the continuation of the initiative including the maintenance of the network and the reporting is recommended.

1. Project Background

As part of a collaborative project between Rous County Council, NSE Department of Planning, Industry and Environment, and Southern Cross University, a network of real-time water quality loggers has been installed throughout the mid and lower Richmond River catchment. The project was commissioned in February 2021.

2. Report Aims and Objectives

The aim of this Annual Progress Report is to present and discuss the data collected to December 1st 2022, specifically:

- A climatological overview of 2022 (Section 4)
- The major blackwater event that occurred in March 2022, including insights into the evolution of blackwater across the floodplain (Section 5)
- The chronic discharges of acidic and low oxygen water from the floodplain due to the artificially enhanced drainage (Section 6)
- Site specific water quality data including comparison with ANZECC guidelines (Section 7)



Figure 1 Location of the eight water quality loggers (yellow text).



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3. Project Methodology

The water quality loggers are located at eight sites throughout the lower Richmond River and its key tributaries as shown in Figure 1.

Detailed descriptions of the Project's methodology are outlined in the 2022 Annual Report.

Briefly, the loggers measure the following fundamental water quality parameters at either 30 min or 60 min intervals:

- Water temperature ($^{\circ}\text{C}$)
- Dissolved Oxygen (DO) reported as concentration (mg L^{-1}) and percentage saturation (% sat)
- Conductivity (mS cm^{-1}) and salinity (ppt)
- pH
- Turbidity (NTU) which is a measure of water clarity
- Chromophoric dissolved organic matter (CDOM; $\text{QSE } \mu\text{g L}^{-1}$) which a measure of dissolved organic carbon¹
- Chlorophyll a (Chl a; $\mu\text{g L}^{-1}$) which is a proxy of algal biomass¹

The data is transmitted after every measurement to a publicly available [Dashboard](#) that is linked to the [Rous County Council Website](#).

Southern Cross University is responsible for logger maintenance and data QA/QC.



Figure 2 Rous County Council Flood Mitigation Operators installing a logger housing at the Tuckean Upstream site (left) and SCU staff at the Rocky Mouth Creek site following logger installation (right).

¹ Woodburn and Wardell only



3.1. Flood damage

Unfortunately, loggers at four of the monitoring sites were damaged beyond repair following the record flood in March 2022: Rocky Mouth Creek, Woodburn, Tuckean Upstream and Tuckean Downstream. A variety of temporary loggers sourced from DPE, SCU and RCC were deployed at some of these sites when the loggers were available for use. Considerable time and money were required to deploy and maintain the temporary loggers including the purchasing of new materials for temporary installations and more frequent visits due to calibration requirements. The loggers were deployed for much of 2022 to capture the flood recovery with the data collected from the temporary loggers incorporated in Section 7.



Figure 3 Photos of flood damaged loggers

After a lengthy insurance claim, replacement loggers plan to be installed mid-2023 by SCU. The new loggers feature an improved design that aims to improve serviceability and reduce maintenance time. Given this considerable investment, a longer-term plan for the continuation of the initiative is recommended as funding for the collaborative project ends in early 2025.



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4. Climate – 2022

Climatological data for Lismore² and Ballina for the 12-month period ending December 31st 2022 along with long-term monthly averages are presented in Figure 4.

2022 was an extremely wet year. Lismore received ~2300 mm of rain, which was nearly double its long-term average of ~1200 mm. Ballina received ~2900mm, of rainfall, approximately 1000 mm more than its long-term average of ~1900 mm.

Similarly to 2021, La Niña continued to be the major climate driver throughout 2022. A double-dip La Niña event was declared in November 2021 and persisted until June 2022. During this period, Lismore recorded three flood events:

- 25th February: 7.21m (moderate)
- 28th February: 14.4m (major); highest since records began in 1890 exceeding the previous record flood level by over two metres (12.27 metres in February 1954).
- 30th March: 11.4m (major); ranked as the 6th highest on record

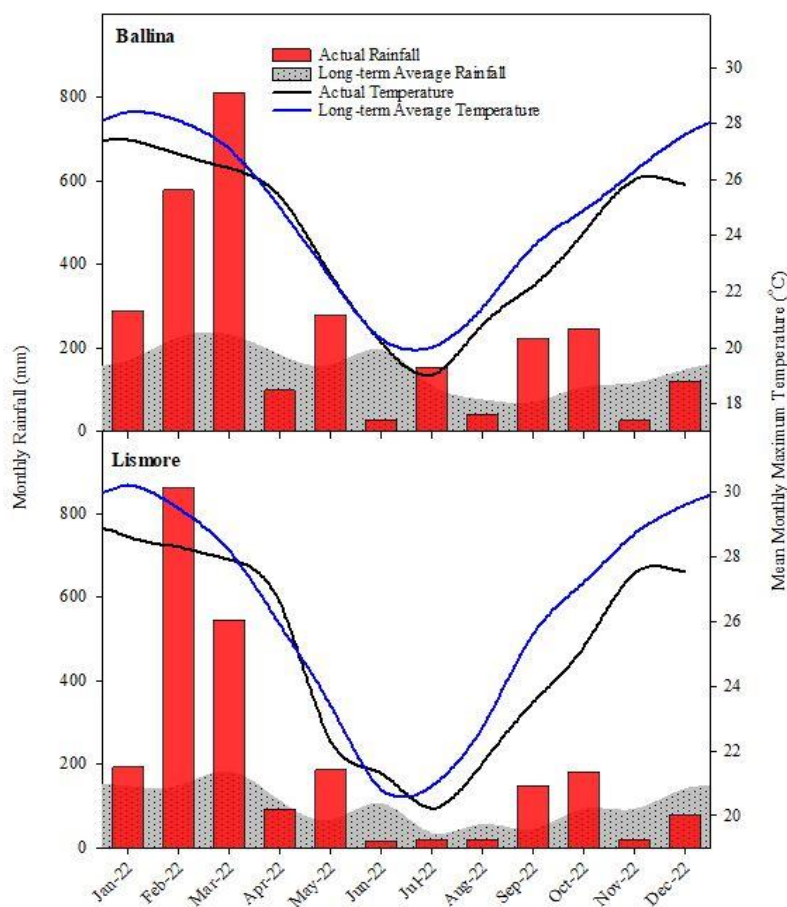


Figure 4 Total monthly rainfall for Lismore and Ballina along with long-term monthly averages. Source www.bom.gov.au.

² Lismore rainfall and temperature data sourced from the Tuncester (January to June) and Casino (from March to June), respectively due to reporting issues related to floods.





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The record-breaking flood resulted from an intense rain event that delivered over 1000 mm of rainfall at five of the Bureau of Meteorology's (BOM) monitoring sites for the 3-day period ending 9am 1 March (BOM, 2022). This extreme rain event occurred on the back of high antecedent soils moisture levels and water storage levels due to two years of La Niña conditions.

A 3rd La Niña commenced in September 2022, which is only the fourth time three consecutive La Niña events have occurred since 1900 with the others being 1954–57, 1973–76, and 1998–2001 (BOM, 2023). Lismore recorded its 4th flood event for 2022 on the 24th October (6.64m; minor).

Since this collaborative project was commissioned in February 2021, the region has experienced above-average rainfall including an unprecedented extreme weather event. The following sections present the reality of the lower Rivers response when subject to these conditions.



Figure 5 Broadwater and surrounds following record flooding in 2022
Source: Richmond Valley Council.



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5. 2022 Blackwater Event

A large [blackwater](#) event occurred following the record-breaking flood in February 2022. The event deoxygenated ~55 km of the lower Richmond River from Bungawalbin to Ballina resulting in mass fish kills. This section summarises the evolution of the blackwater event based on data collected by the logger network. For a more detailed account of the fish kill, refer to the “[Post-flood water quality and fish kill assessment, Richmond River February-May 2022](#)” prepared by DPE.

Figure 6 presents water level, DO and turbidity data from the Bungawalbin, Woodburn and Wardell loggers as well as data from Coraki. The floodplain-river hydraulic gradient is also presented - this is the difference in elevation in m AHD between the water levels on the floodplain and in the river (calculated as the difference between Bungawalbin and Woodburn water levels).

For this event, there appeared to be a sequence of distinct phases linked to the timing of water level changes across the floodplain and in the river (i.e. the floodplain-river hydraulic gradient) that lead to the large hypoxic blackwater event that resulted in mass fish mortality. The key phases were:

- During the moderate flood that occurred on the 25th February, low-lying areas of the floodplain (i.e. backswamps below 2 m AHD) became inundated prior to the major flood event (refer phase “A” in Figure 6).
- Following the flood peak (refer phase “C” in Figure 6) the first phase of floodplain drainage occurred (refer phase “D₁” in Figure 6). During this initial decanting, blackwater discharges over the natural levees.
 - **Blackwater discharging at Bungawalbin is already low in DO (~30 %sat)**
- As river levels dropped below ~4.3 m AHD at Woodburn, which is the approximate maximum height of the natural levees (Wong et al., 2011) the second phase of floodplain drainage followed (refer phase “D₂” in Figure 6). During this phase, large volumes of blackwater discharge to the main channel via the constructed drains that dissect the natural levees. At the same time, the residence time of water in the river begins to increase as tidal signals reappears at Wardell.
 - **The relative volume of blackwater (which is now hypoxic at Bungawalbin i.e. ~20 %sat) increases and the rivers ability to assimilate this blackwater decreases**
- The final stage of floodplain drainage occurred when water levels at Woodburn dropped below ~2.5 m AHD (refer phase “E” in Figure 6). Blackwater from the low-lying backswamps, which were inundated for up to 15 days, drain to the main river channel
 - **By this time anoxic blackwater has overwhelmed ~50 km of the river from Bungawalbin to Ballina resulting in mass kills (refer Figure 7)**



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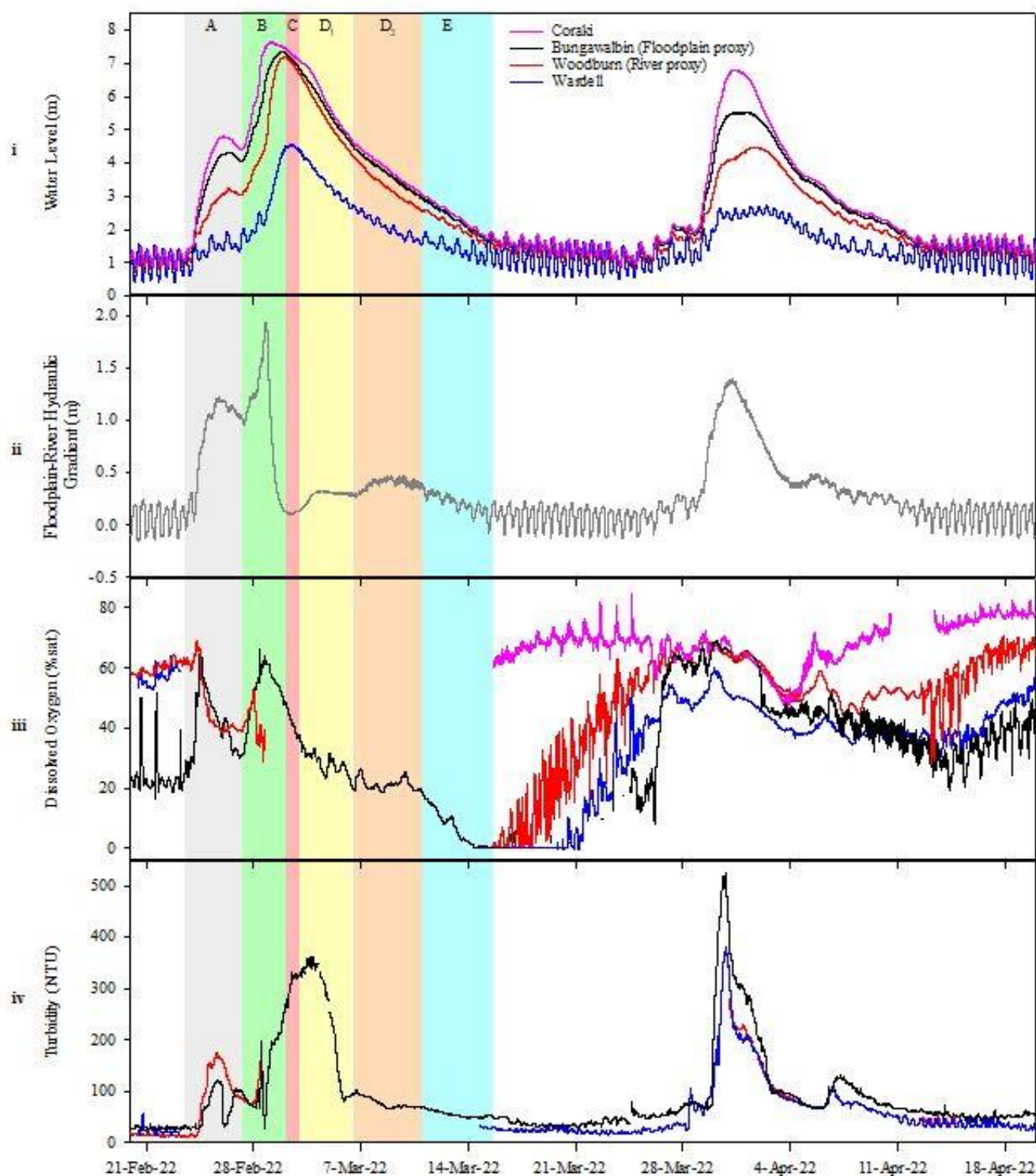


Figure 6 **i** Water level data; **ii** Floodplain-River Hydraulic Gradient; **iii** Dissolved Oxygen; **iv** Turbidity. **A** Pre-flood; **B** Rising stage; **C** Flood peak; **D₁** Stage 1 of floodplain drainage; **D₂** Stage 2 of floodplain drainage; **E** Backswamps drain.

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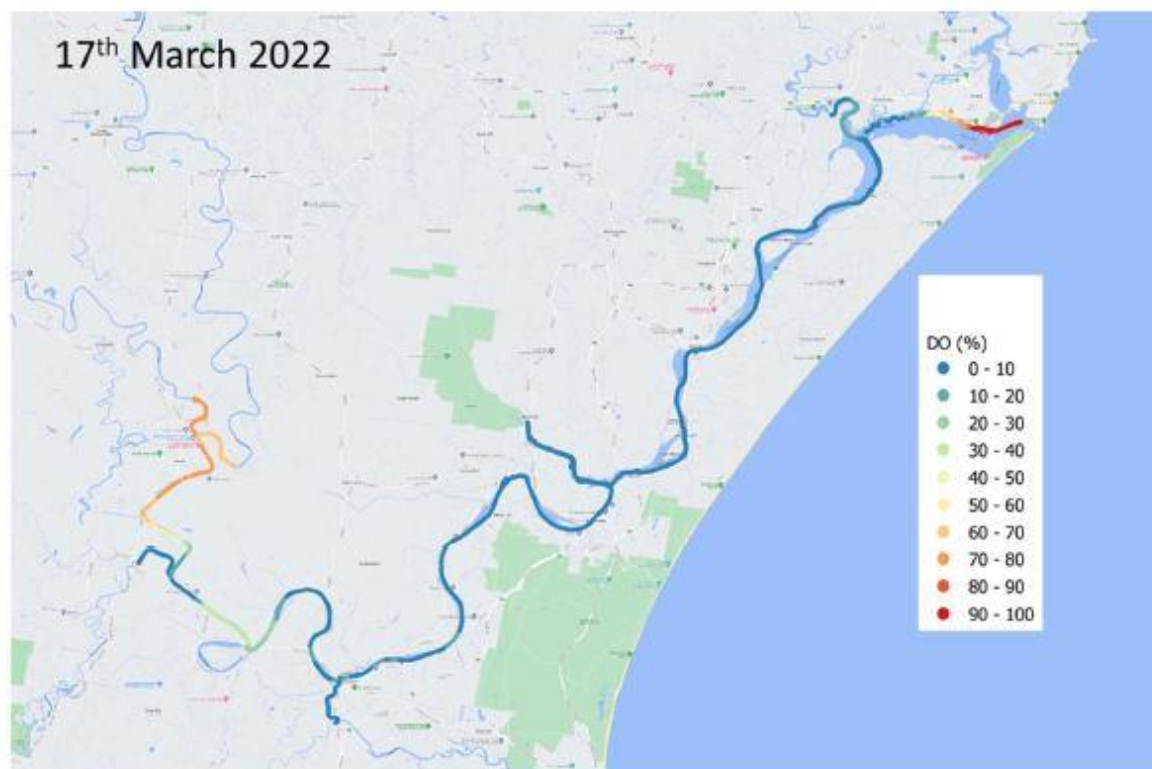
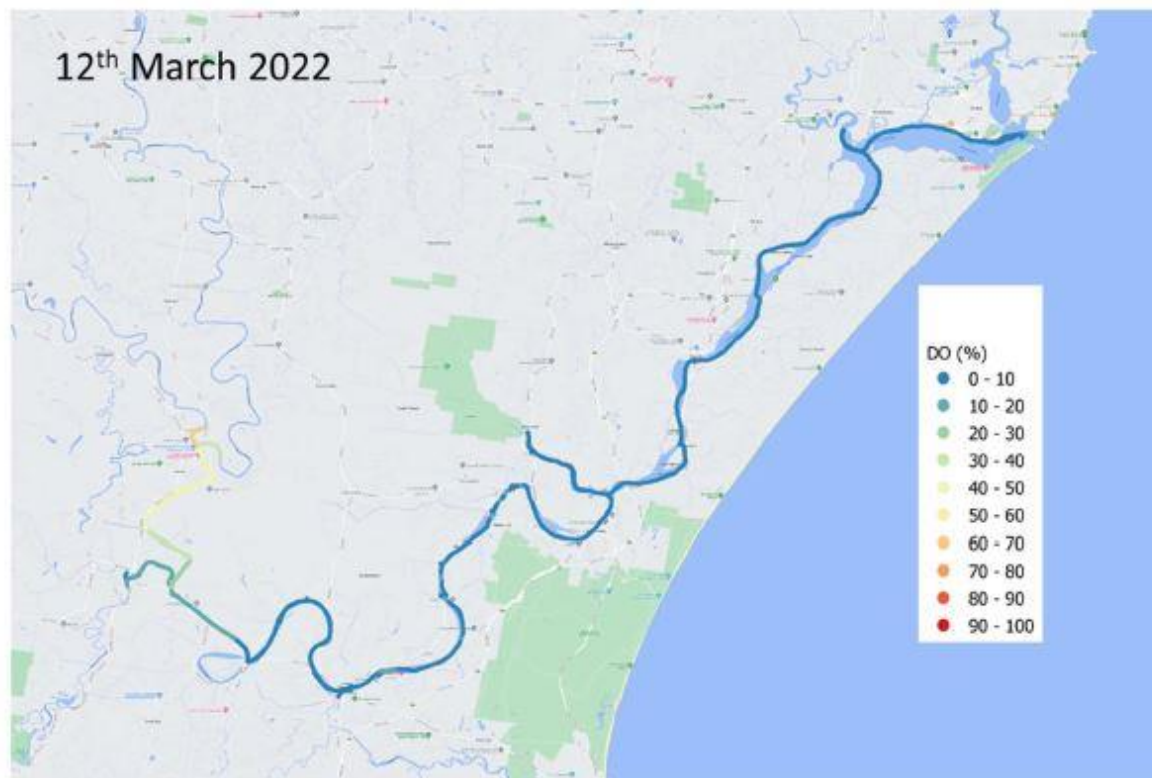


Figure 7 DO in the Richmond River following the major flood in March 2022.



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Whilst anoxic blackwater was not observed discharging from Bungawalbin until the 14th March, flood monitoring revealed the river was anoxic from Bungawalbin to Ballina from at least the 12th March with anoxic blackwaters emanating from West Coraki drain, Rocky Mouth Creek, Dungarubba Drain, and the Tuckean Swamp, all areas of the floodplain that contain vast areas of low-lying backswamps. The anoxia persisted in the river at Woodburn until the 16th March and at Wardell until the 21st March before DO levels slowly increased to ~60 %sat over the proceeding two-week period (for comparative purposes, the ANZECC guideline values for DO are 80-110 %sat). The data suggests that there is spatial and temporal variability in blackwater generation across the floodplain. The variability is likely linked to subcatchment specific hydrology (e.g. residence time of water) as well as vegetation cover and decomposition rates, however our ability to model and predict the effect of such factors for a given flood event requires further research. Furthermore, the capacity of the river to assimilate the blackwater before its effects become catastrophic is not understood either, nor is the relative contribution of the different backswamp areas to river deoxygenation. Such knowledge would inform future mitigation activities and should be the aim of future research efforts.

The logger data supports what has been known for decades – that backswamps are significant hotspots for the generation of anoxic waters and their drainage, which occurs during the latter stages of flood recession when the assimilative capacity of the river is lowest, can lead to mass fish kill events (Eyre et al., 2006; Johnston et al., 2003; Slavich, 2001). Unfortunately, the current land-use practices on these coastal floodplains has enhanced the frequency and magnitude of blackwater discharges (Eyre et al., 2006; Johnston et al., 2003; Wong et al., 2011; Wong et al., 2010). Whilst the mitigation strategies employed across the floodplain over the past two decades are commendable, they have failed to reduce the blackwater threat at the scale required (Harrison et al., 2022). This was the 87th documented fish kill event to have occurred throughout the Richmond River since 1970, with blackwater the likely significant contributor to most (Harrison et al., 2022). The likelihood of similar blackwater events is expected to increase into the future due to the prediction of more extreme weather events and rises in sea level attributed to a warming climate (Wong et al., 2018; Wong et al., 2011). As such, managing blackwater formation and discharge to improve the health and integrity of the Richmond River is a considerable challenge. Broad-scale changes in land and water management across the floodplains is necessary (Harrison et al., 2022) and needs to be driven by the appropriate authority.



Figure 8 Blackwater discharging from Rocky Mouth Creek after flooding in 2020. Source: RCC.



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6. Enhanced Floodplain-River Connectivity: Chronic Environmental Impacts?

The natural drainage patterns of the Richmond River floodplain have been significantly altered by the installation of over 400,000 km of constructed drains and numerous tidal gates since the mid to late 19th century (Tulau, 1999). These modifications serve to allow the efficient drainage of the floodplain down to the low tide level in the adjacent reach of the main river to allow year-round agriculture. Unfortunately, these human modifications of the floodplain have unintentionally enhanced the frequency and severity of blackwater events as described in Section 5. Another significant environmental impact attributed to the enhanced drainage of the floodplain is acidic discharges associated with the flushing of oxidized acid sulfate soils (ASS). These acidic discharges contain metal contaminants and have also led to fish kills. Similarly to blackwater, the occurrence of the acid discharges has been well documented for over 20 years and the mitigation initiatives employed during this time have not been sufficient to reduce the threat at the scale required to improve water quality (Harrison et al., 2022). In the event of a flood, it is well known that once the blackwater threat passes, the acid threat begins. That is, once the surface waters have drained off the floodplain during the flood recession (which is when the threat of blackwater exists), groundwater begins to drain from the floodplain soils and the threat of acidic discharges arises.

The high-resolution measurements that have been captured by the logger network (i.e. every 30-60 mins) since March 2021 present the sobering reality of the lower River's response to wet conditions. The data reveals chronic acidic discharges from the drained floodplain soils following many rain events – not just after floods. The monitoring also reveals that the discharge of low oxygen waters from the floodplain is not limited to large blackwater events associated with flooding, but can occur more frequently and after smaller rain events. Whilst the “visible impacts” of blackwater and acid discharges can be obvious following flood events (i.e. fish kills) the ecological impacts would likely extend down the entire aquatic food chain, yet the degree to which this occurs is largely unknown. Neither is the impact of the chronic discharges that can occur following wet periods. The following section of this report discusses the prevalence of these events for each monitoring site.



Figure 9 Acid discharges from Tuckean Downstream at Baggotville Barrage. Left: Iron stained water, pH ~3.2, 5/8/22. Right: Shifting to blue-green water due to high levels of aluminum, pH ~3.5, 17/8/22.



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7. Water Quality Results

7.1. Overview of results and comparison with ANZECC

Over 1,500,000 measurements of water quality have been logged across the sites since March 2021. Figure 10 presents box and whisker plots for key water quality parameters for each site. The ANZECC default guideline range is included in both figures and is based on the upper and lower trigger values for slightly disturbed Lowland Rivers and Estuaries in south-east Australia. The ANZECC Guidelines are the only relevant indicator values to benchmark water quality. Table 1 presents the proportion of data points that do not meet the ANZECC guidelines at each site.

Key observations include:

- The water quality discharging from the floodplain is generally very poor, characterised by acidic, low-oxygenated waters:
 - DO was lower than ANZECC guidelines ~100% of the time at Bungawalbin, Rocky Mouth Creek³ and the Tuckean³, and 90% of the time at North Creek (Upstream)
 - ⇒ **DO concentrations in waters discharging from the floodplain is, on average, only ~50 %sat**
 - pH was lower than ANZECC guidelines ~100% of the time at Tuckean³, and North Creek (Upstream), 90% of the time at Rocky Mouth Creek³ and 50% of the time at Bungawalbin
 - ⇒ **On average, the pH of waters discharging from the floodplain is very acidic**
 - **4.5 at the Tuckean³**
 - **5.1 at Rocky Mouth Creek³**
 - **5.5 at North Creek (Upstream)**
- In the River, DO data suggests a decrease in water quality between Woodburn³ and Wardell
 - DO was lower than ANZECC guidelines ~66% of the time at Woodburn³ but ~85% of time at Wardell
 - ⇒ **On average, DO was ~74 %sat at Woodburn³ versus ~64 %sat at Wardell**
 - ⇒ **Drivers either instream processes or floodplain inputs with the Tuckean the major point source but also drains at [Dungarubba](#) and [Kilgin](#)**
 - pH was below ANZECC guidelines ~45% of the time at Woodburn³, ~37% of time at Wardell and 58% of the time at North Creek Downstream
 - ⇒ On average pH of ~7 was observed at Woodburn³ and Wardell and 6.7 at North Creek Downstream (ANZECC Guideline is 7)
 - Tidal processes provide buffering capacity for acidic floodplain discharges at Wardell and to a lesser extent at North Creek Downstream

³ Rocky Mouth Creek, Woodburn, Tuckean Upstream logger were damaged in the March flood. Data to March 2022 only.



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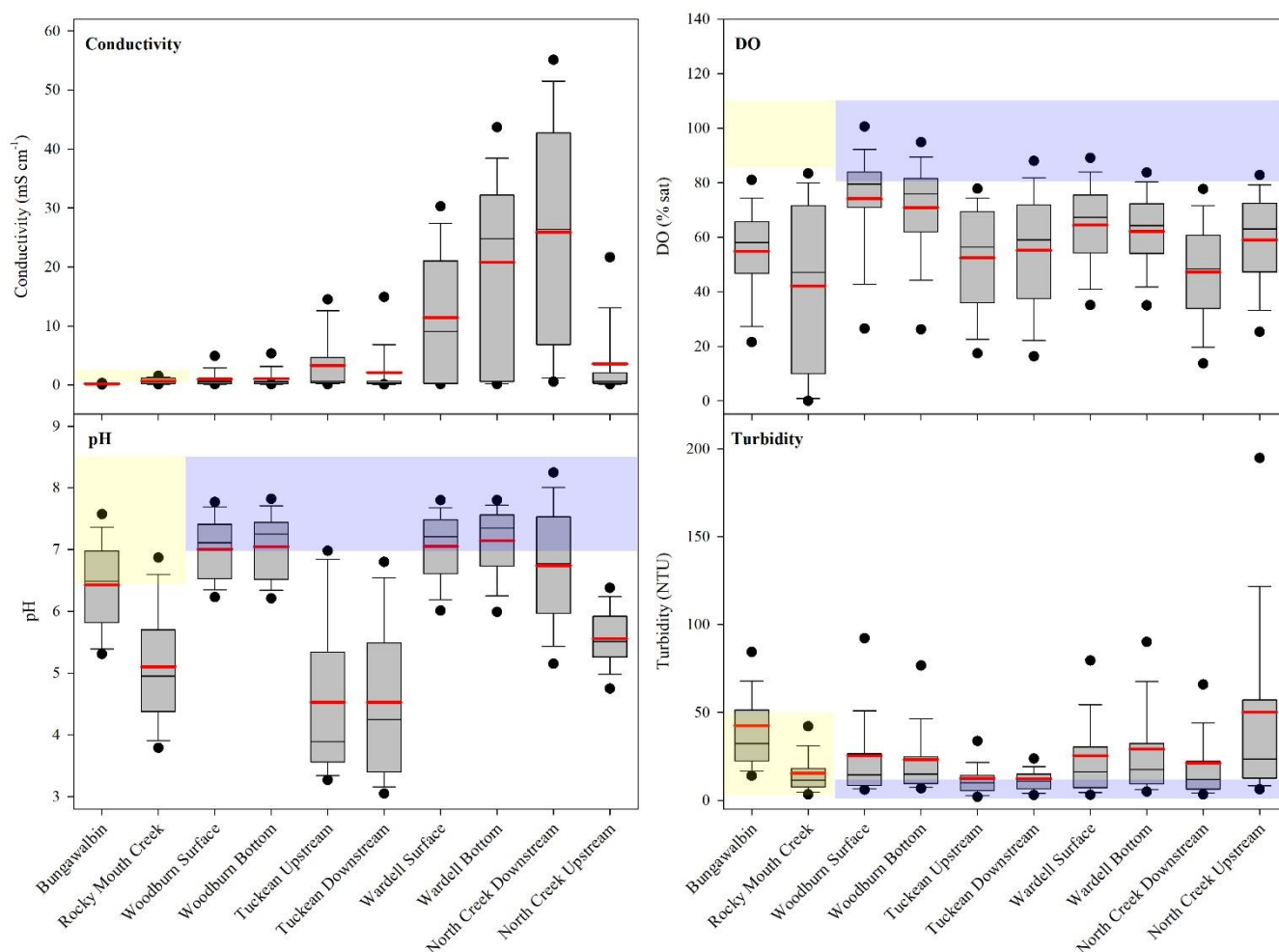


Figure 10 Box and whisker plots for EC, DO, pH and Turbidity for each site showing mean value (red line), median, 25th/75th percentiles (grey box), 10th/90th percentiles (whisker caps) and 5th/95th percentiles (black circles). The shaded areas represent the ANZECC guideline ranges for slightly disturbed Lowland Rivers (yellow) and Estuaries (blue) in south-east Australia.



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Table 1 Percentage of samples that did not meet ANZECC guidelines for dissolved oxygen, pH and turbidity at each site (the ANZECC guideline range for Estuaries is shown in *italics* for each parameter).

	Percentage of samples that do not meet ANZECC guidelines		
	Dissolved Oxygen (80-110 % sat)	pH (7-8.5)	Turbidity (0.5-10 NTU)
Bungawalbin	98% ^a	53% ^b	12% ^c
Rocky Mouth Creek	97%	85% ^b	20% ^c
Woodburn Surface	59%	37%	59%
Woodburn Bottom	73%	32%	67%
Tuckean Upstream	98%	96%	49%
Tuckean Downstream	89%	98%	54%
Wardell Surface	84%	34%	39%
Wardell Bottom	90%	17%	50%
North Creek Upstream	91%	100%	72%
North Creek Downstream	96%	17%	74%
^a ANZECC guideline range 85-110 %sat ^b ANZECC guideline range 6.5-8.5 ^c ANZECC guideline range 6-50 NTU			



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7.2. Times-series results

The following Sections present the time-series data for selected water quality parameters for each site. ANZECC guideline ranges have been included along with daily rainfall. Bungawalbin, Rocky Mouth Creek, Wardell and Woodburn also include water level data sourced from Manly Hydraulics Laboratory.

7.2.1. Bungawalbin

Bungawalbin commenced logging data on the 29th April 2021 and was not damaged during the March 2022 flood.

Timeseries data is presented in Figure 11.

The Bungawalbin logger captures water draining Bungawalbin Creek and [Sandy Creek](#) – a known acid and blackwater hotspot.

Key observations from Bungawalbin:

- Water quality measured by the logger is influenced from waters discharging from the floodplain (lower in DO and pH) and better-quality upstream water (higher in DO and pH) transiting downstream and shunting up into Bungawalbin Creek during the flood tides
- DO has averaged 55 %sat which is driven by low DO following rainfall
 - Water discharging from the catchment was largely hypoxic (DO < 30 % sat) during the wet summer/autumn (December 2021 through to May 2022) and then again following the onset of wet conditions in October 2022
 - ⇒ The spikes in DO is the upstream water
 - Anoxic waters occurred following the March 2022 flood and were <10%sat during December 2021
 - During dry periods DO can reach ANZECC Guideline values e.g. August 2021
- pH has averaged 6.4
 - Acidic floodplain discharges of 4.5 to 5.5 occur during wet periods and continue in the weeks to months after as soils drain
 - During dry periods pH can approach ANZECC Guideline values e.g. winter and spring in 2021
 - ⇒ Rainfall after these periods flushes acid from floodplain soils e.g. July and October 2021
- Turbidity is generally outside of ANZECC guideline values during rain events and immediately after



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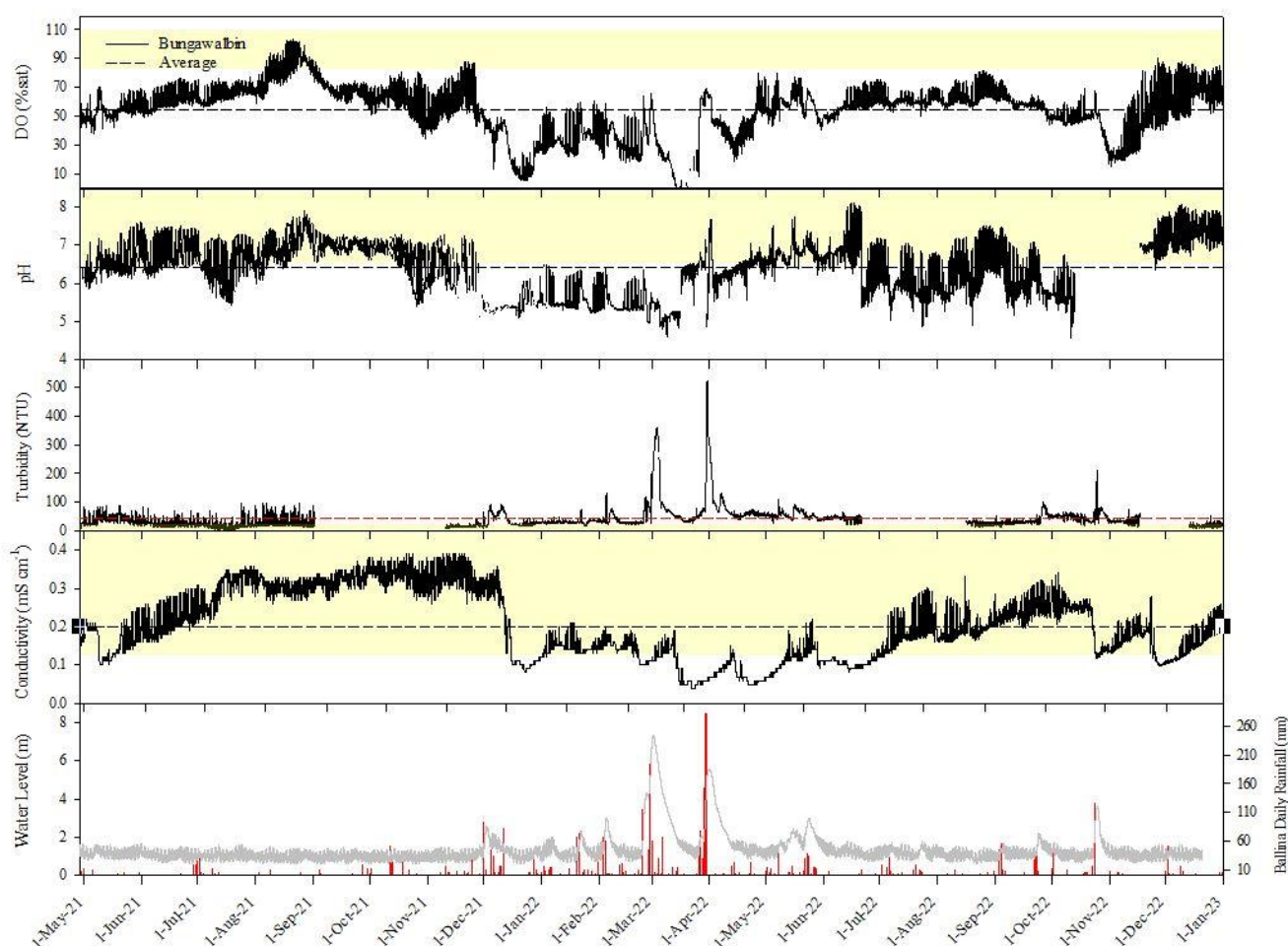


Figure 11 DO, pH, turbidity and conductivity at Bungawalbin. Yellow shaded area represents the ANZECC guideline range for slightly disturbed Lowland Rivers in south-east Australia.



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7.2.2. Rocky Mouth Creek

Rocky Mouth Creek commenced logging data on the 3rd March but was damaged during the March 2022 flood. Temporary loggers have been deployed briefly in the interim. Unfortunately, RCC's logger was vandalised beyond repair late in 2022 and monitoring data was lost.

Timeseries data is presented in Figure 13.

[Rocky Mouth Creek](#) is a known acid and blackwater hotspot.

Key observations from Rocky Mouth Creek:

- DO and pH averaged 43% sat and 5.1, respectively
 - Anoxic waters routinely discharge following rain e.g. March through May 2021, and December 21 through to May 2022
 - pH routinely drops to <4
 - ⇒ Figure 12 shows blue-green water that routinely occurs at Rocky Mouth Creek and driven by high levels of aluminium that causes particles in the water to clump together and fall to the bottom creating the clear, blue-green water
- DO and pH can approach ANZECC Guidelines but only during extended dry periods when tidal waters intrude
 - This occurred only 3% of the time for DO and 15% of the time for pH
- Turbidity is only outside of ANZECC guideline values during rain events and immediately after



Figure 12 Blue-green water at Rocky Mouth Creek, pH ~ 3.6, DO ~90 %sat on the 17/8/22.



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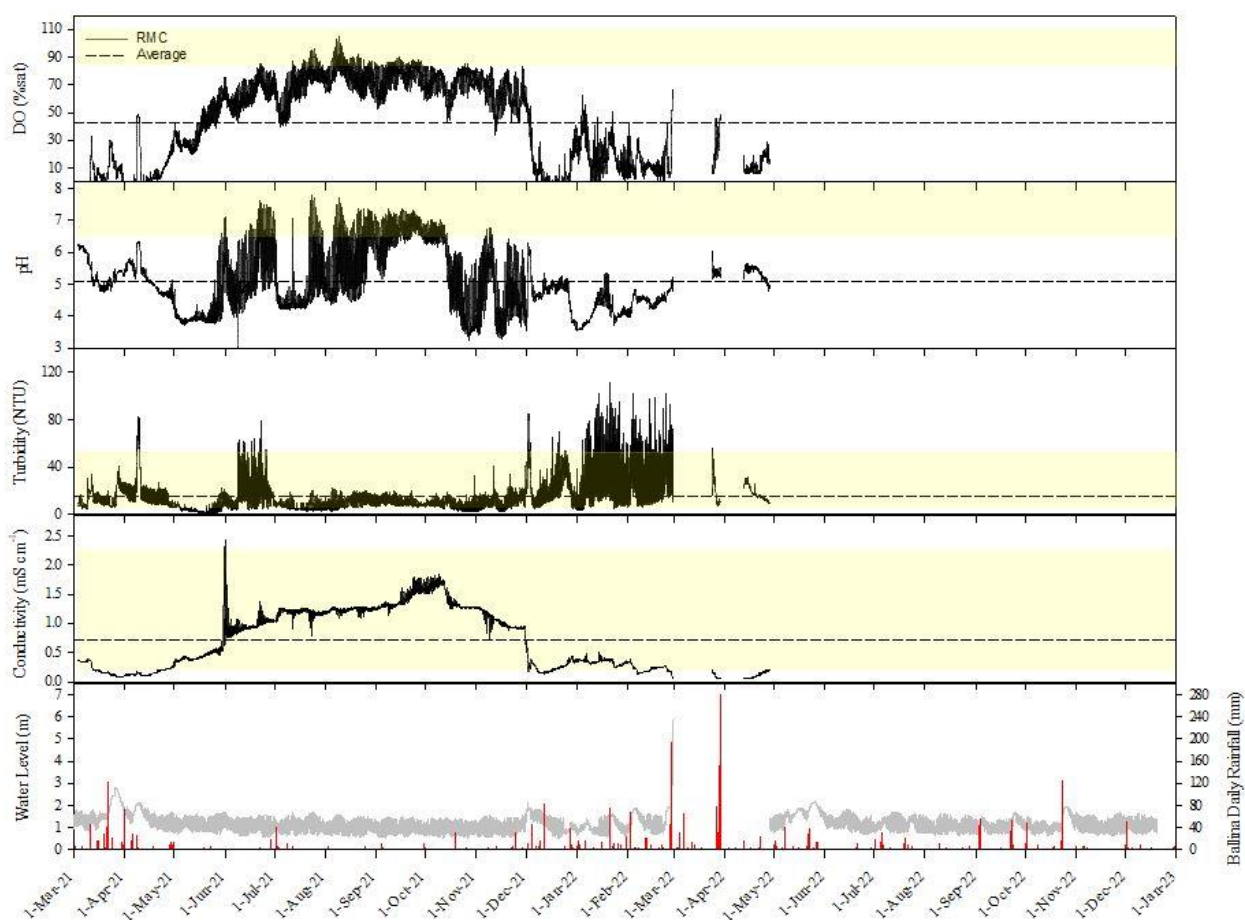


Figure 13 EC, DO, pH, turbidity and water temperature at Rocky Mouth Creek. Yellow shaded area represents the ANZECC guideline range for slightly disturbed Lowland Rivers in south-east Australia.



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7.2.3. Woodburn

Woodburn commenced data logging from 28th July 2021 but was damaged during the March 2022 flood. Temporary loggers were deployed but unfortunately the loggers were lost during the October 2022 flood including the data from August 2022 onwards.

Timeseries data is presented in Figure 14 and Figure 15.

Key observations include:

- Floodplain discharges heavily influence water quality during wet periods
 - Fresh water dominated the water column from mid-November onwards when La Nina re-established
 - ⇒ Hypoxic waters (DO < 30%sat) occurred in December 2021
 - ⇒ Anoxic blackwater event in March 2022 and pH levels dropped considerably towards the end of November 2021 and remained below ANZECC guidelines until June 2022
 - ⇒ pH ranged from 5.9 to 7.0 during this time
- Brackish tidal water dominated the water column during the dry period (August through October 2021)
 - DO was within ANZECC guidelines during this time except the first few weeks of August when waters were super-saturated (>110 %sat) in DO suggesting high primary productivity at that time
 - pH was also within ANZECC guidelines during this period
 - Rainfall in October resulted in a fresh water column for a few weeks but DO and pH still remained within ANZECC
 - Turbidity driven by tidal activity with values generally outside of the guidelines
- Turbidity levels spiked immediately with the onset of rain in December and late January



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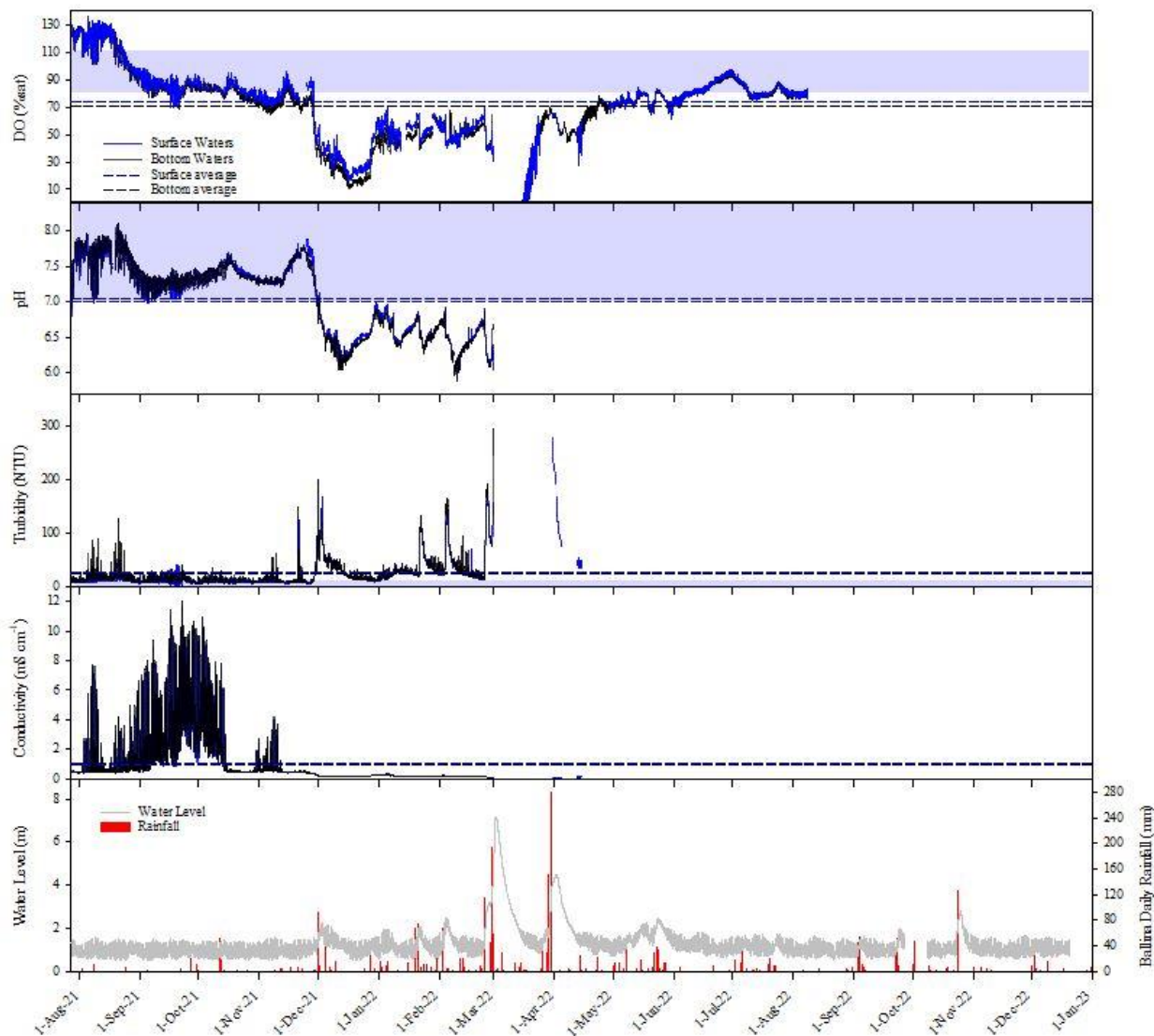


Figure 14 EC, DO, pH and Turbidity at Woodburn. Blue shaded area represents the ANZECC guideline range for slightly disturbed Estuaries in south-east Australia.



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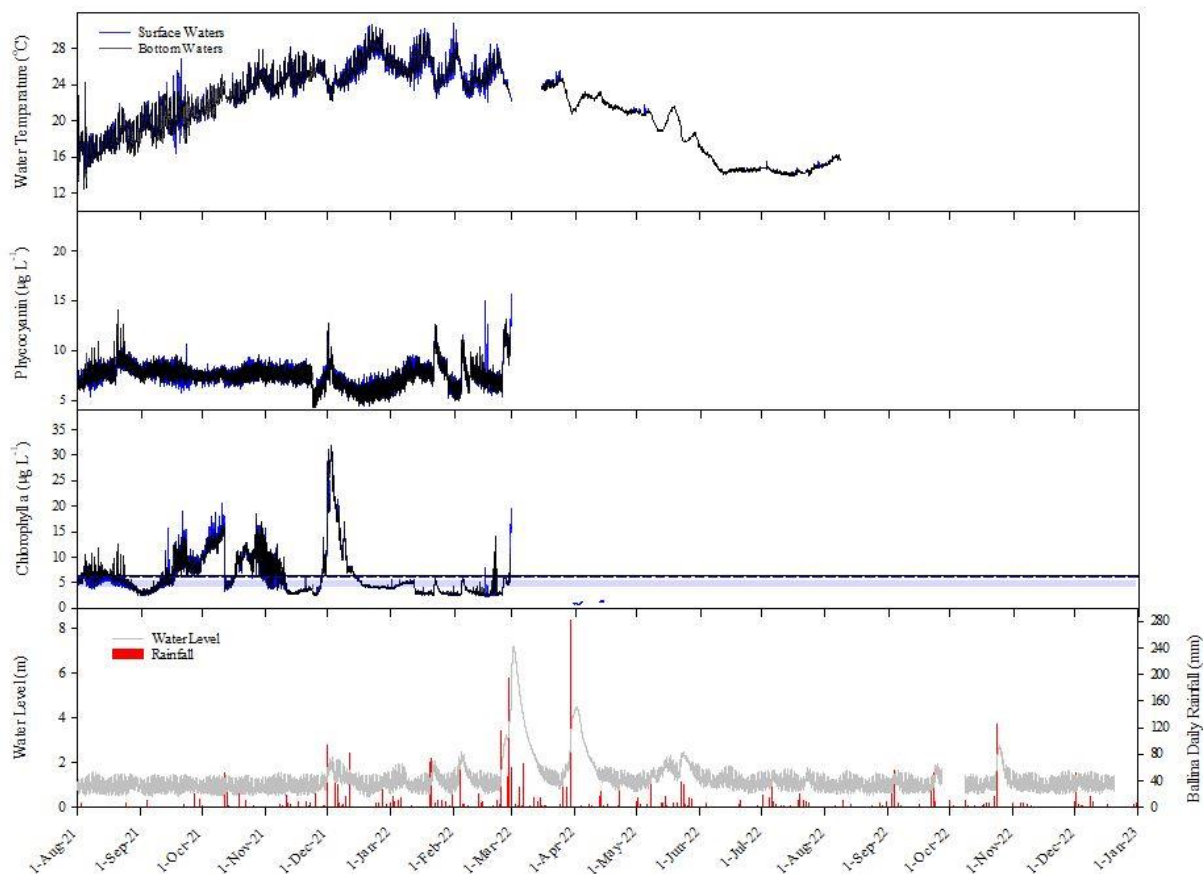


Figure 15 Water temperature, Phycocyanin, and Chlorophyll a at Woodburn. Blue shaded area represents the ANZECC guideline range for slightly disturbed Estuaries in south-east Australia.



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7.2.4. Tuckean Downstream and Upstream

Tuckean Downstream and Upstream commenced logging on the 3rd and the 11th March, respectively. Both loggers were destroyed in the March 2022 flood with a temporary logger deployed at Tuckean Downstream site.

Timeseries data is presented in Figure 16.

The [Tuckean](#) is a known acid and blackwater hotspot.

Key observations from the Tuckean sites:

- Water discharging from the Tuckean are, on average, very acidic (i.e. pH 4.5) and low in DO (i.e. ~50 %sat)
- The trends at the Tuckean are similar to those observed at Rocky Mouth Creek
 - Wet conditions = acidic discharges (refer Figure 9) and low DO
 - ⇒ pH routinely drops to the low 3s
 - ⇒ Waters routinely hypoxic (DO < 30%)
 - ⇒ Anoxic water observed on three occasions – March, April and September 2022
 - DO and pH only within ANZECC guidelines during dry periods when tidal waters intrude the drain
 - ⇒ This was only 2% of the time at the Upstream site and 10% of the time at the Downstream site for DO
 - ⇒ < 3% of the time for pH
- Turbidity is generally outside of ANZECC guideline values during following rainfall



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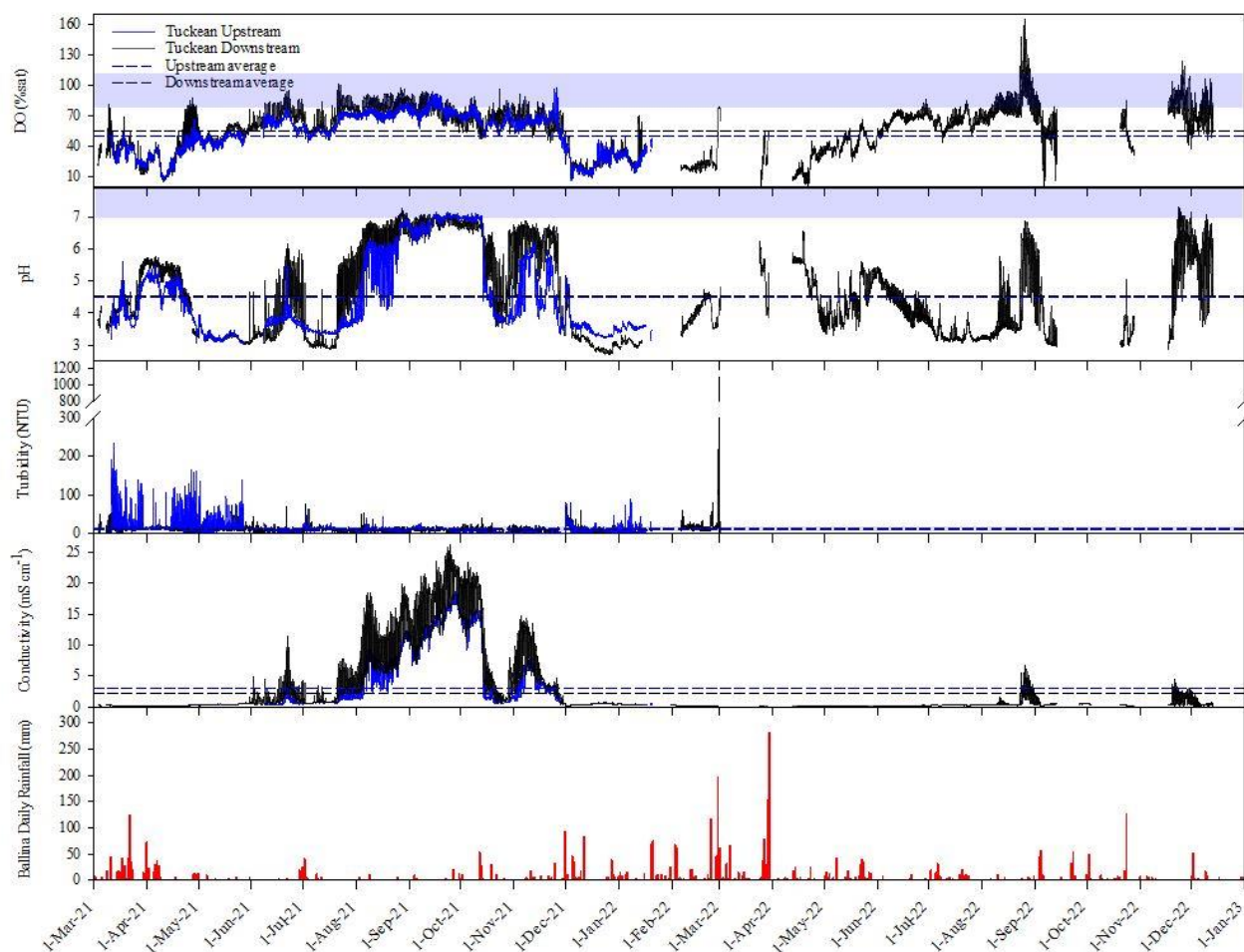


Figure 16 EC, DO, pH, turbidity and water temperature at the Tuckean sites. Blue shaded area represents the ANZECC guideline range for slightly disturbed Estuaries in south-east Australia.



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7.2.5. Wardell

The sentinel Wardell logger commenced transmission of data on the 30th March 2021. The logger was damaged during the March 2022 flood but was able to be quickly reinstated.

The timeseries data is presented in Figure 17 and Figure 18.

Key observations include:

- Floodplain discharges heavily influence water quality during wet periods
 - The river is routinely flushed fresh during the wet periods
 - ⇒ DO and pH drop considerably as the poor water upstream discharges from the system
 - ➔ DO dropped to ~10 % sat in April and December 2021 and 30% in October and November 2022
 - ➔ Anoxic during the major blackwater event
 - ➔ pH of ~ 5.6 occurred following floods in March and October 2022
- During the dry period DO and pH are relatively stable (e.g. June through November)
 - pH is generally within ANZECC guidelines during this time
 - The ~ 15% of the time DO is within ANZECC guidelines occurs during dry periods
- Stratification of surface and bottom waters can display a spring-neap tidal trend with stratification becoming more pronounced during neap tides – this trend was most prevalent during the dry period (May to September)
- Turbidity values increase to levels well above ANZECC guidelines following rain



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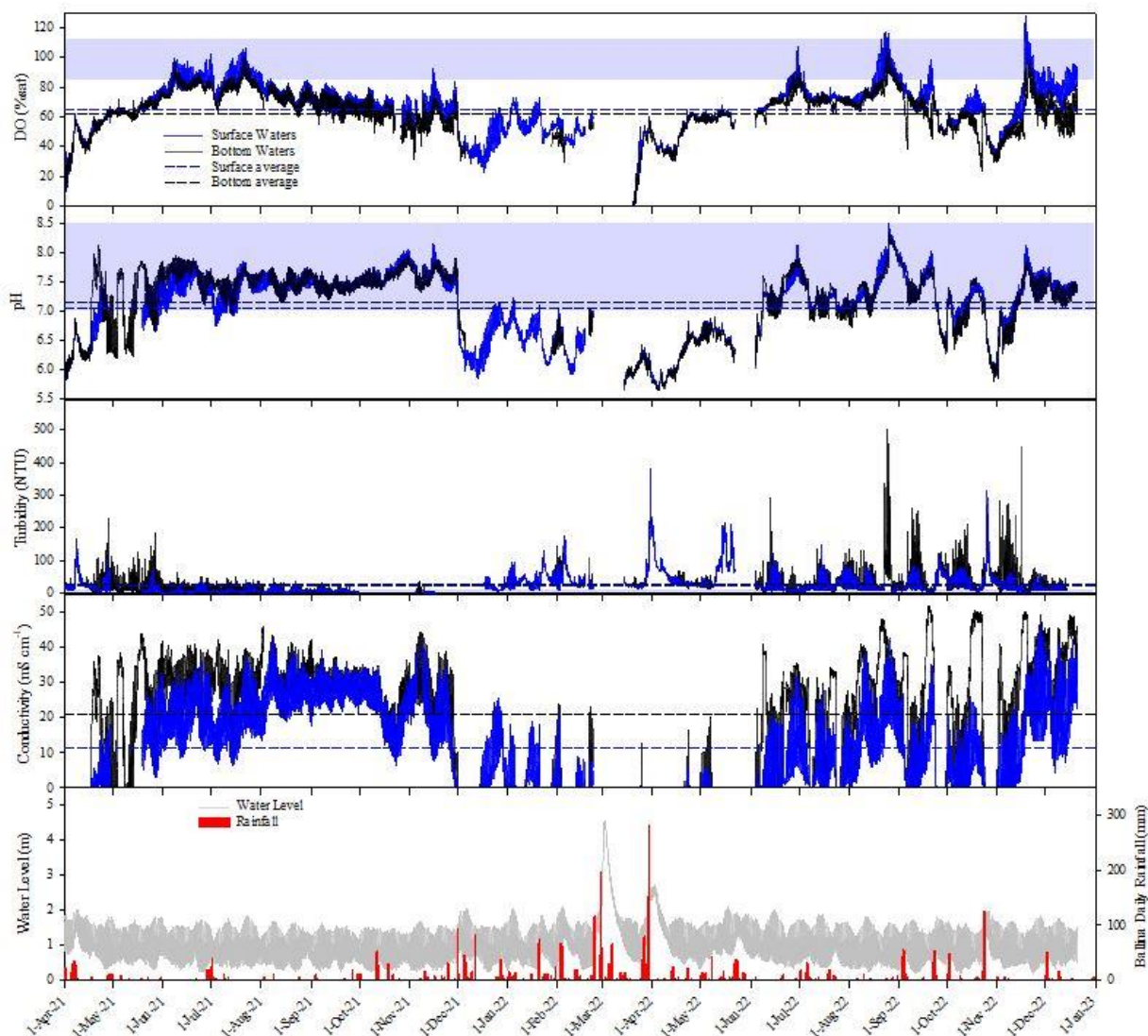


Figure 17 EC, DO, pH and Turbidity at Wardell. Blue shaded area represents the ANZECC guideline range for slightly disturbed Estuaries in south-east Australia.



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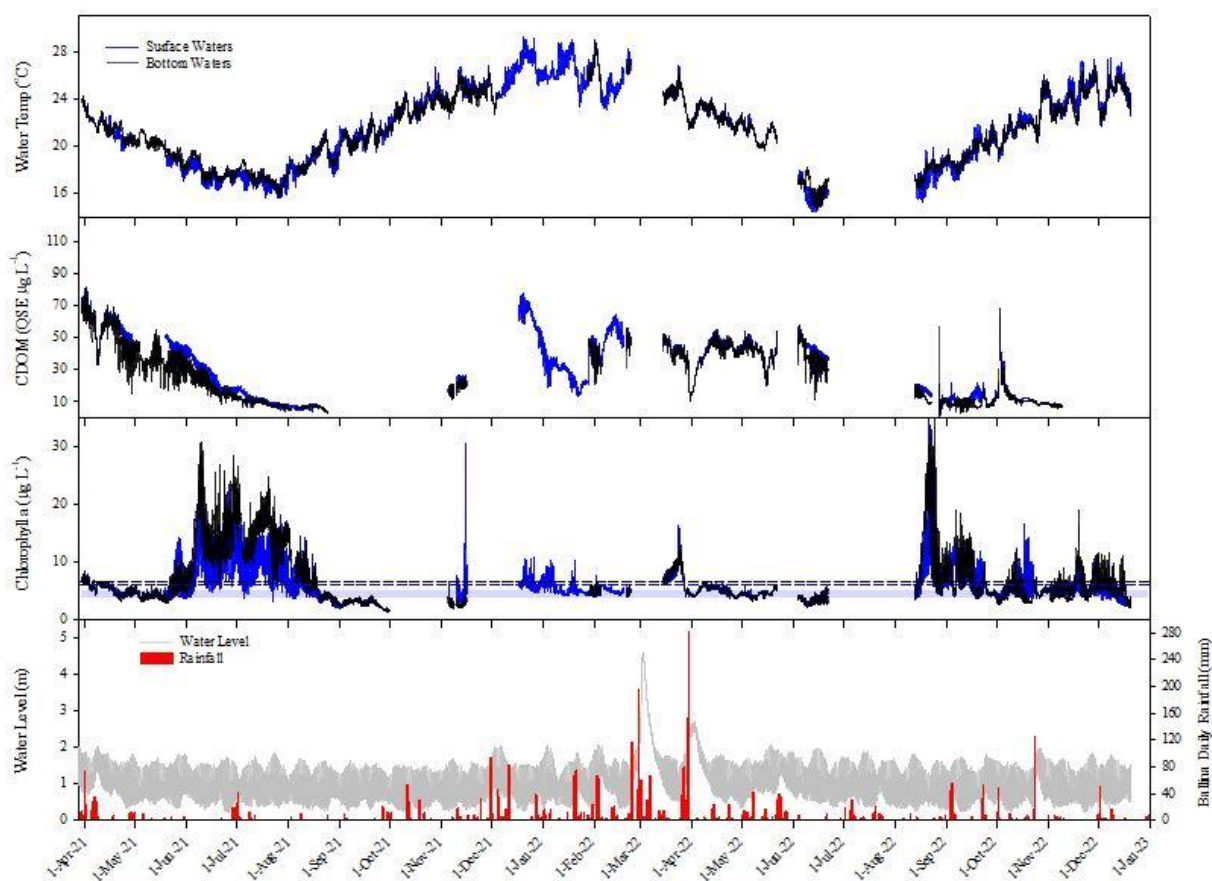


Figure 18 Water temperature, CDOM, and Chlorophyll a at Wardell. Blue shaded area represents the ANZECC guideline range for slightly disturbed Estuaries in south-east Australia.



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7.2.6. North Creek Upstream and Downstream

North Creek Upstream and Downstream sites commenced logging on the 8th March and the 28th April, respectively.

Timeseries data is presented in Figure 19 and the average values of water quality data are presented in Table 2.

Key observations from the North Creek sites:

- Like all other monitoring sites, rainfall results in poor water quality
 - Water are routinely hypoxic (DO <30%sat) at both sites with anoxic waters occurring at the Upstream site after considerable rain events
- DO, on average, is higher at the Upstream (59 %sat) versus Downstream (47 %sat)
 - Suggests consumption of DO and/or inputs of low DO water between the sites (potential influence from the Nature Reserve)
 - Both sites were only within ANZECC guidelines <10% of the time which occurred during dry periods
- pH is much lower, on average, at the Upstream site (5.6) compared to the Downstream site (6.7)
 - pH is below ANZECC 100% of the time at the Upstream site, routinely dropping to low 4s following rain and can remain depressed (<5.5) for weeks as acidic water drains the floodplain
 - Downstream site is buffered by marine waters, thus within ANZECC guideline ~40% of the time
 - ⇒ pH dropped to 3.8 in October 2022 which is lower than the lowest value observed at the Upstream site (4.1)
 - Acid discharges occur between the sites
- Turbidity levels increase in response to rainfall and fluctuate with tides

Table 2 Average values for water quality parameters for the monitoring period at the North Creek Upstream and Downstream sites

	North Creek Upstream	North Creek Downstream
Conductivity (mS cm ⁻¹)	6.0	36.3
DO (% sat)	56.6	45.1
pH	5.6	7.7
Turbidity (NTU)	20.7	31.9
Salinity (PSU)	4.1	27.8



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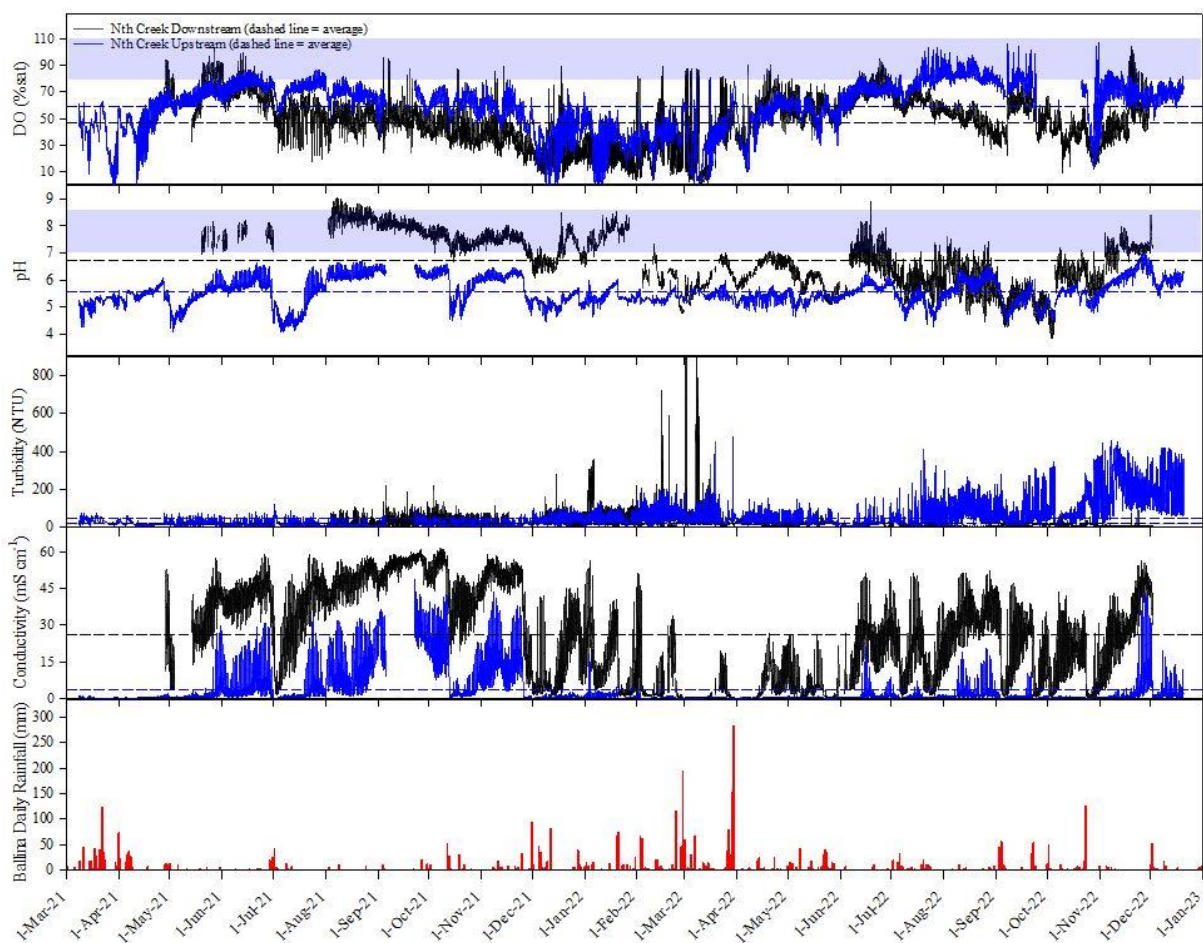


Figure 19 EC, DO, pH, turbidity and water temperature at the North Creek sites. Blue shaded area represents the ANZECC guideline range for slightly disturbed Estuaries in south-east Australia.



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8. Conclusions and Recommendations

It has been known for decades that the artificially enhanced drainage of the Richmond River floodplain is a significant contributor to the water quality issues affecting the lower Richmond River, in particular, blackwater events and acidic discharges containing metal contaminants. The data collected by the logger network during the wet 2021-22 period presents a sobering reality of the lower River's resilience to wet conditions. The data reveals:

- There is considerable spatial and temporal variability in blackwater generation across the floodplain
 - Our understanding of how the mechanisms driving such variability interact, and how much blackwater is generated for a given event are not known
 - Neither is the capacity of the river to assimilate the blackwater before its affects become catastrophic
 - Nor is the relative contribution of the different floodplain areas to river deoxygenation for a given event
- The discharge of low oxygen waters from the floodplain is not limited to large blackwater events associated with flooding, but can occur more frequently and after smaller rain events
- Chronic acidic discharges from the drained floodplain soils following rain events – not just after floods
- Beyond the “visible impacts” of blackwater and acid discharges, i.e. fish kills, the ecological impacts to the entire aquatic food chain is largely unknown

As such, improving the health and integrity of the Richmond River is a considerable challenge for RCC. Recent assessments have concluded that broad-scale changes in land and water management across the floodplains is necessary. Such changes are beyond RCC and needs to be driven by the appropriate authority, being the NSW Government.

This collaborative project has enhanced our understating of the water quality issues facing the Richmond River, however, funding for this collaborative project ends in early 2025. In lieu of this, and given a considerable investment into the flood damaged loggers is expected in the coming months, a longer-term plan for continuation of the initiative including the reporting and maintenance of the network is recommended.



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