Wambuul / Macquarie-Castlereagh valley annual surface water quality report: 2022–2023

Key Points

- Flow during July 2022 to June 2023 was characterised by heavy rain falling across much of the catchment. This rain resulted in several large flow events throughout the catchment.
- The heavy rains led to substantial increases in water storage levels.
- Flooding was the main driver of water quality in the Wambuul / Macquarie-Castlereagh catchment. Ten sites returned a lower water quality index score in 2022–2023 compared to 2021–2022. The water quality index indicated that of the 15 sites in the catchment, 5 were rated as moderate and 10 as poor.
- Macquarie River at Baroona (closest monitoring site to Narromine) had a 95th percentile electrical conductivity of 924 µS/cm, which is lower than the Basin Plan agriculture and irrigation salinity target of 957 µS/cm. The Castlereagh River median and Bogan River 80th percentile electrical conductivity exceeded the End-of-Valley salinity targets.
- Red alert warnings for blue-green algae occurred mostly over the summer months for Windamere dam, Burrendong dam and sites further downstream along the Wambuul / Macquarie River. The Bogan River at Nyngan Weir Pool was on red alert from March until June 2023.

The water quality data used in this report is collected on a monthly frequency at 15 sites in the Wambuul / Macquarie-Castlereagh valley for the State Water Quality Assessment and Monitoring Program. The program is responsible for collecting, analysing and reporting the ambient water quality condition of rivers in NSW. This annual report summarises the surface water quality data collected in the Wambuul / Macquarie-Castlereagh Valley from July 2022 to June 2023. The location of monitoring sites is shown in Figure 1.

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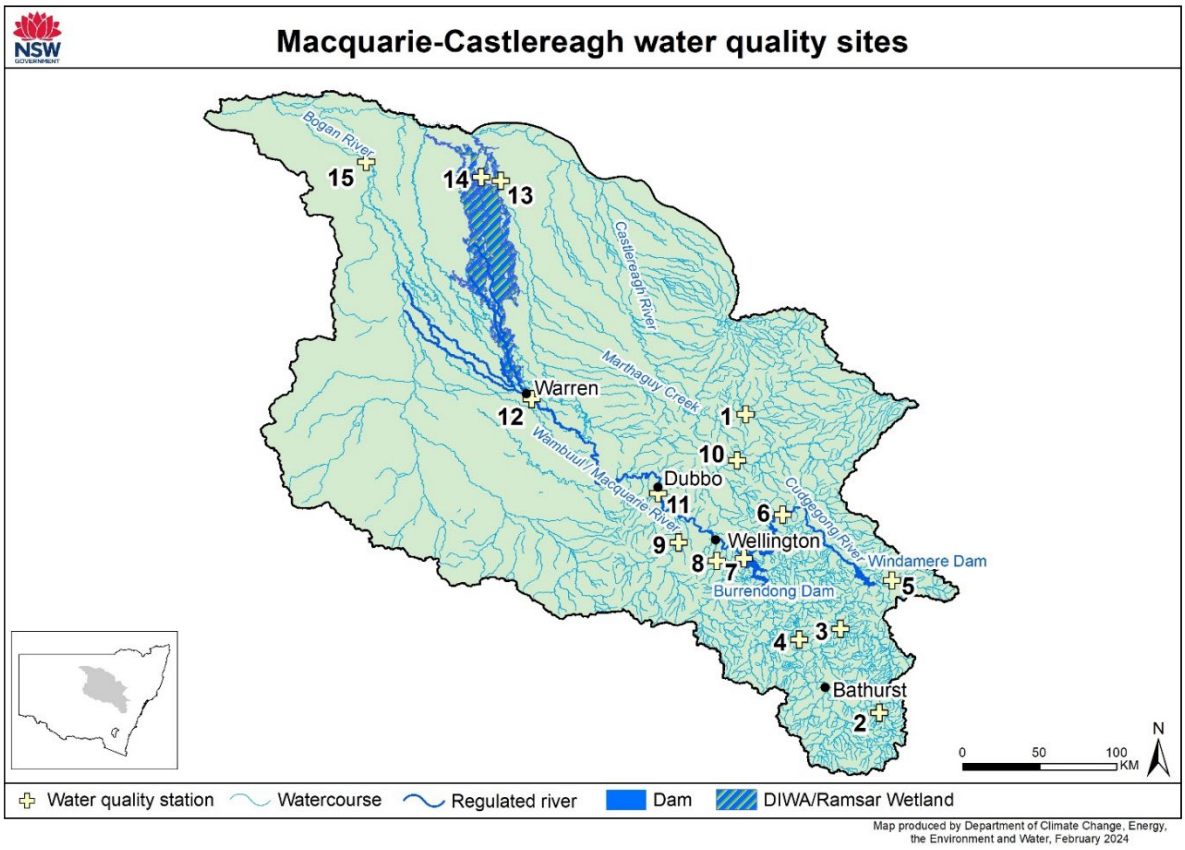

Figure 1: Location of routine water quality monitoring sites in the Wambuul / Macquarie-Castlereagh valley

Table 1: Site information for each monitoring site in the Wambuul / Macquarie-Castlereagh catchment. Refer to Figure 1 and site numbers for location of each site.

Site number	Site name	Water Quality Zone	Station number
1	Castlereagh River at Mendooran	Castlereagh - Talbragar uplands	420004
2	Fish River at Hazelgrove	Wambuul / Macquarie montane	42110171
3	Turon River at Bathurst Point	Wambuul / Macquarie - Cudgegong unregulated uplands	42110170
4	Wambuul / Macquarie River at Bruinbun	Wambuul / Macquarie - Cudgegong unregulated uplands	421025
5	Cudgegong River at Rylstone	Wambuul / Macquarie - Cudgegong unregulated uplands	421038
6	Cudgegong River at Yamble Bridge	Wambuul / Macquarie regulated uplands	421019
7	Wambuul / Macquarie River downstream Burrendong Dam	Wambuul / Macquarie regulated uplands	421077
8	Bell River at Newrea	Wambuul / Macquarie unregulated tributaries uplands	421018
9	Little River at Arthurville	Wambuul / Macquarie unregulated tributaries uplands	421176
10	Talbragar River at Elong	Castlereagh - Talbragar uplands	421042
11	Wambuul / Macquarie River at Molong Rail Bridge	Wambuul / Macquarie regulated uplands	42110101
12	Wambuul / Macquarie River at Warren Weir	Wambuul / Macquarie regulated uplands	421004
13	Marthaguy Creek at Carinda	Wambuul / Macquarie lowlands	421011
14	Wambuul / Macquarie River at Bells Bridge	Wambuul / Macquarie lowlands	421012
15	Bogan River at Gongolgon	Wambuul / Macquarie lowlands	421023

Catchment description

The Wambuul / Macquarie–Castlereagh catchment covers more than 75,000 km^2 in the State's central west. The area comprises of three major river networks that flow north-west to the Barwon River: the Castlereagh, Wambuul / Macquarie and Bogan Rivers.

The Castlereagh River is approximately 549 km in length and rises in rugged terrain in the Warrumbungle Range at an elevation of approximately 850 m. The Castlereagh River flows through Timor Dam on its way to joining the Wambuul / Macquarie River downstream of the Wambuul / Macquarie Marshes.

The Wambuul / Macquarie River is approximately 960 km in length. It is formed by the joining of the Campbells and Fish Rivers, which drain a high plateau area centred near Oberon with a general elevation of 900 to 1,000 m above sea level. The river flows northward through steep gorge country in the Hill End area and is impounded by Burrendong Dam upstream of Wellington. The Cudgegong River rises in the sandstone tableland country east of Rylstone. It is impounded by Windamere Dam upstream of Mudgee, and then flows through Mudgee before flowing into Burrendong Dam. Downstream of Burrendong Dam, the Wambuul / Macquarie River continues to flow in a northwest direction through Wellington and Dubbo and is joined by 3 major tributaries; the Talbragar, Bell and Little rivers. At Narromine the Wambuul / Macquarie River takes a dramatic turn to the north and commences a complex system of anabranches and effluent creeks that connect the Wambuul / Macquarie, Darling and Bogan Rivers. The Wambuul / Macquarie Marshes are located toward the end of the catchment and comprise a meandering network of effluent channels and anabranches with shallow swamps, lagoons and floodplains. The Wambuul / Macquarie Marshes are Ramsar-listed and are one of the largest semi-permanent wetland systems and colonial waterbird breeding sites in inland Australia. The Wambuul / Macquarie River emerges from the wetlands before joining the Castlereagh River and then flowing into the Barwon River near Brewarrina.

The Bogan River is approximately 590 km in length. It rises in the Harvey Ranges between Parkes and Peak Hill and flows northwest through a broad, flat landscape through Nyngan to join the Darling River near Bourke. Major streams of the lower valley include the Albert Priest Canal (artificial), and Gunningbar and Duck Creeks, which deliver regulated flows from the Wambuul / Macquarie River to the lower Bogan River.

Land use in the Wambuul / Macquarie-Castlereagh is largely grazing in the upper and lower sections of the catchment with increased cultivation through the mid-catchment downstream of Dubbo and Gilgandra.

Catchment conditions during 2022–2023

Flow during 2022–2023 was characterised by heavy rain falling from August to November 2022 across much of the catchment (Figure 2A). For all of 2022 Burrendong Dam was well over 100% capacity, dropping to around 100% by late February 2023 where it remained for the rest of the year (Figure 2B). From July to October 2022 Windamere Dam increased from 60 to 100% capacity where it also remained for the rest of the year. Discharge in the Wambuul / Macquarie River increased with heavy rainfall leading to large flood events peaking at over 60,000 ML/day at Yarracoona in early December 2022 (Figure 2C). Discharge was also high (> 40,000 ML/day) at Carinda in November 2022 and consistently high (>10,000 ML/day) at Warren Weir from July until late December 2022. Discharge was consistently low in 2023, rarely exceeding 1,000 ML/day at Yarracoona and consistently below 100 ML/day at Carinda from February 2023 onwards. Two periods of cease to flow conditions (discharge less than 1 ML/day) occurred on the Wambuul / Macquarie River at Carinda from 17/3/23–10/4/23 and 4/5/23–30/6/23.

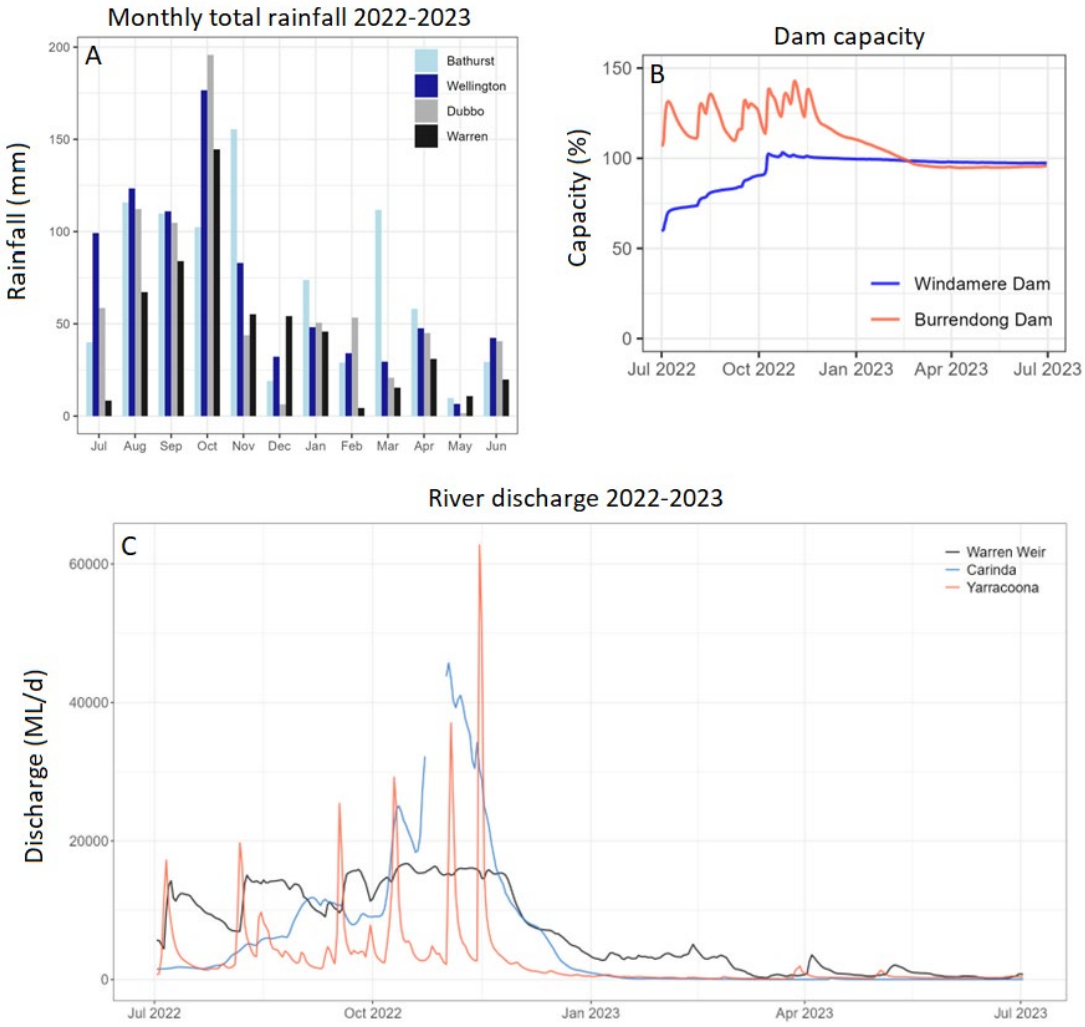

Figure 2: Catchment conditions for selected stations in the Wambuul / Macquarie catchment from July 2022 to June 2023 for A: Monthly total rainfall (mm) B: Dam capacity (%) and C: River discharge (ML/day).

Water quality for water dependent ecosystems

NSW uses a Water Quality Index (WaQI) as a tool to communicate complex and technical water quality data in a simple and consistent way. The WaQI score was calculated for each monitoring site using total nitrogen, total phosphorus, turbidity, pH, dissolved oxygen and electrical conductivity. The index compares the monthly water quality results against a set of predetermined water quality targets to calculate a score between 1 and 100. A score of 100 represents a site in pristine condition, while a score of one is a very highly degraded site. This value can then be categorised to rate the general water quality at a monitoring site. The results from the WaQI are summarised in Figure 3. Sites where there has been a change of less than 5 points in WaQI score, have been identified with

horizontal arrows. Arrows pointing up or down indicate the score has increased/decreased by more than 5 points.

The water quality index category ratings in the Wambuul / Macquarie-Castlereagh Valley declined in 2022–2023 for 4 of the 15 sites compared to 2021–2022.

- Turon River at Bathurst Point and Wambuul / Macquarie River at Bells Bridge (Carinda) declined from good to moderate.
- Wambuul / Macquarie River downstream Burrendong Dam and Little River at Arthurville declined from moderate to poor.
- For the remaining sites in Table 1, the ratings stayed the same as the previous year, which was mostly poor.

Overall, in 2022–2023, five sites were rated as moderate, and 10 sites rated as poor due to high turbidity and nutrient concentrations caused by heavy rainfall and high flows.

Seven sites showed minimal change in water quality index score between 2021–2022 and 2022–2023.

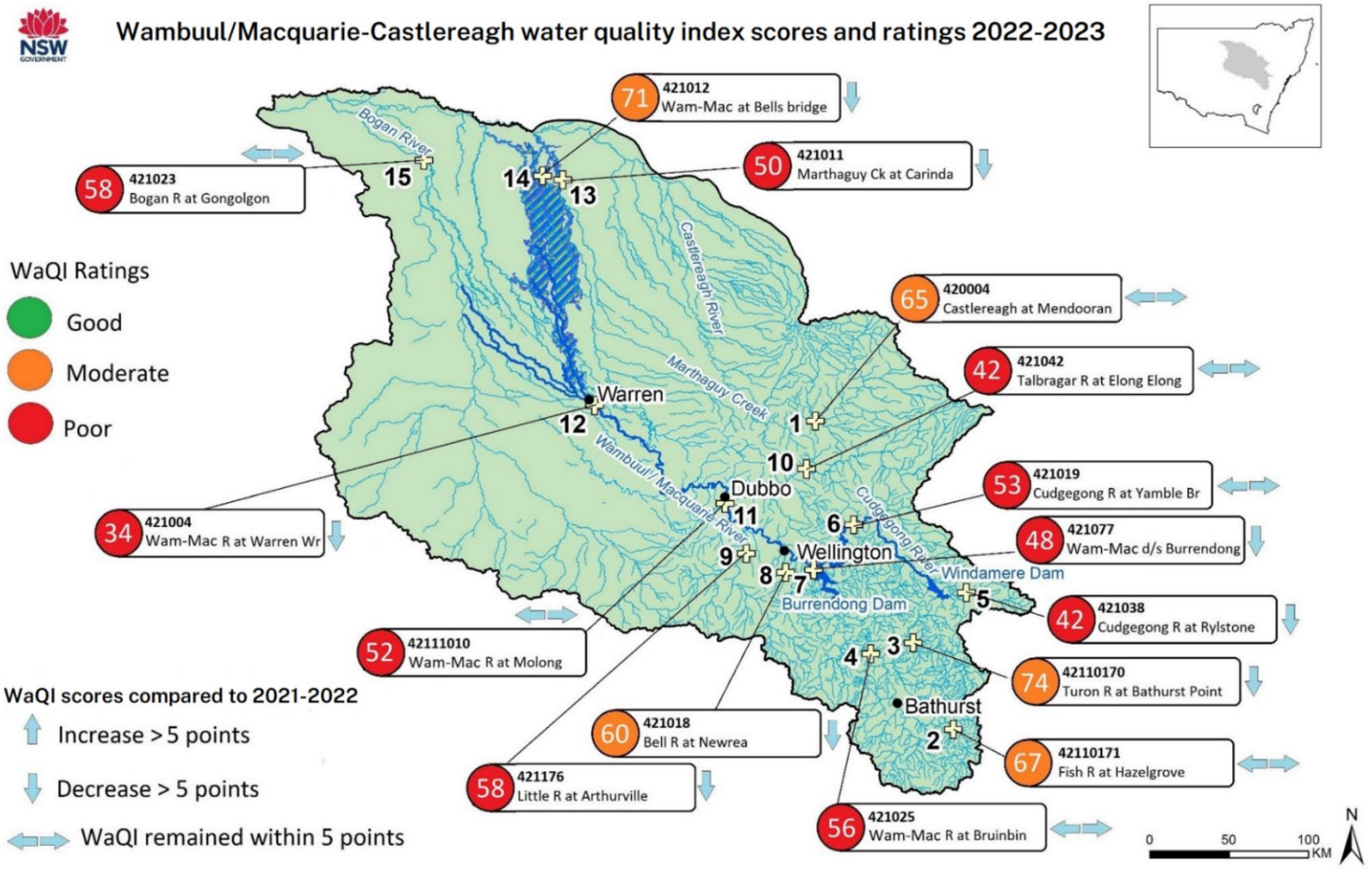

Figure 3: Water quality index scores and ratings for the Wambuul / Macquarie-Castlereagh valley

There is a general trend of increasing turbidity and nutrient concentrations down the catchment reflecting the impact of the cumulative effects of land use, soil disturbance and human activity on water quality. The highest turbidity and total phosphorus results were in Talbragar River at Elong and Marthaguy Creek at Carinda and the highest total nitrogen in Marthaguy Creek at Carinda and Bogan River at Gongolgon. Turbidity and nutrient concentrations in the Wambuul / Macquarie River at Bells Bridge are much lower than the adjacent Marthaguy Creek. This may have been due to the filtering benefits of the water flowing through the Wambuul / Macquarie Marshes.

The pH fluctuated markedly between catchments in response to localised influences.

The lowest dissolved oxygen readings were in the lower catchment, where high turbidity reduces light penetration, reducing aquatic plant growth and higher water temperature reduces the solubility of oxygen in the water column. In addition, major flooding resulted in the flushing of organic matter off the lowland Castlereagh and Wambuul / Macquarie floodplains and into waterways. The rapid breakdown of this material by bacteria caused dissolved oxygen levels to decline below the 4 mg/L critical level for fish health in January 2023.

There were also high dissolved oxygen (super saturated) results in the Little River and Bogan River at Gongolgon which can indicate excessive algal growth or a blue-green algal bloom.

The Castlereagh, Talbragar, Bell and Little rivers had the highest median electrical conductivity. The elevated electrical conductivity is caused by localised areas of high salinity in these unregulated catchments. Similarly, salinity in the area around Goolma can cause high readings in the Cudgegong River at Yamble Bridge. The electrical conductivity at other sites is low and would not impact water users.

Summary statistics for the key water quality parameters at each monitoring site in the Wambuul / Macquarie-Castlereagh valley have been displayed as box plots (Figure 4). The box plots show the annual 25th, 50th and 75th percentile values, with error bars indicating the 10th and 90th percentile values for each site.

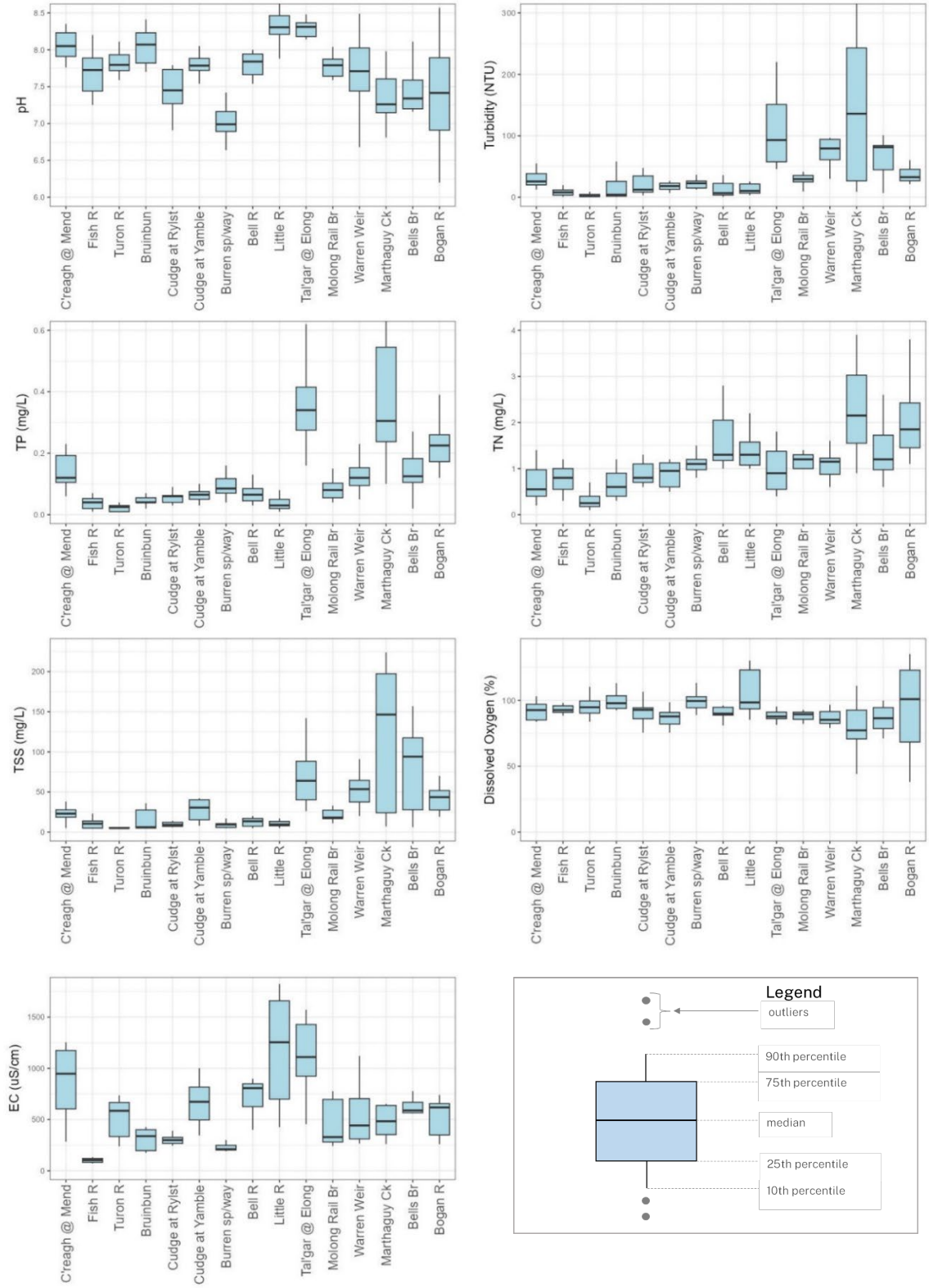

Figure 4: Water quality data by site, moving upstream to downstream from left to right. The water quality parameters shown are pH, Turbidity, Total phosphorus (TP), Total nitrogen (TN), Total suspended solids (TSS), Dissolved oxygen, and electrical conductivity (EC).

Irrigation and salinity

There are 16 continuous electrical conductivity monitoring sites in the Wambuul / Macquarie-Castlereagh valley. Selected sites plotted in Figure 5 show that heavy rainfall and high flows kept electrical conductivity low throughout 2022 to 2023.

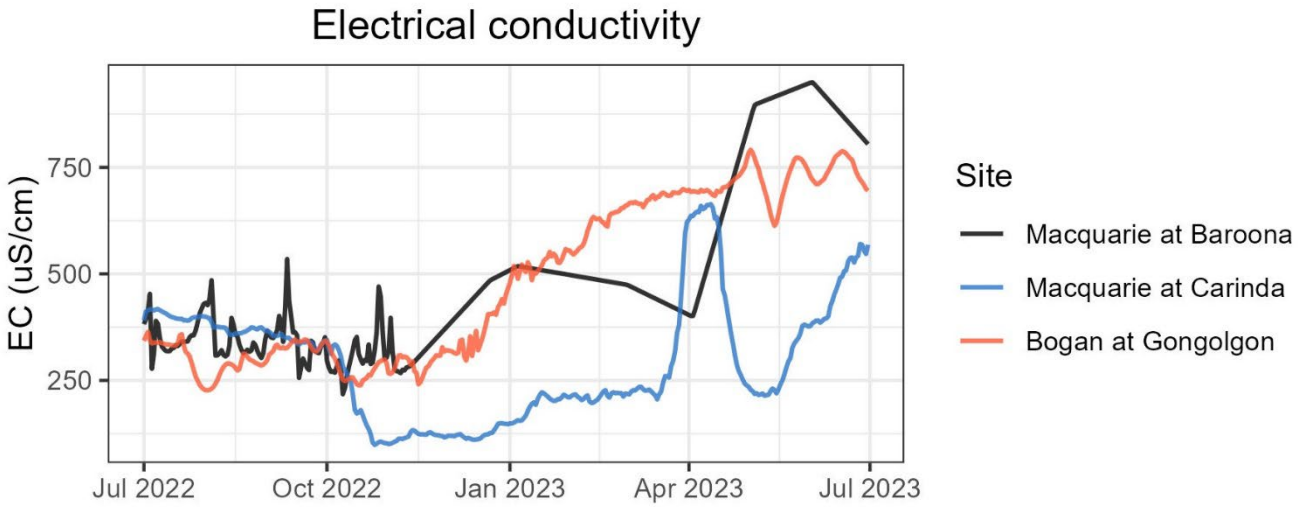

Figure 5: Electrical conductivity (µS/cm) at selected sites in the Wambuul / Macquarie-Castlereagh valley

The Narromine Irrigation Board of Management is the only irrigation infrastructure operator in the Wambuul / Macquarie valley. Water is diverted to the irrigation area from the Wambuul / Macquarie River at Narromine. Wambuul / Macquarie River at Baroona (closest monitoring site to Narromine) had a 95th percentile electrical conductivity of 924 µS/cm, which is lower than the Basin Plan agriculture and irrigation salinity target of 957 µS/cm.

There are 3 Basin Salinity Management Strategy End-of-Valley salinity target sites in the Wambuul / Macquarie-Castlereagh catchments:

- Castlereagh River at Gungalman Bridge
- Wambuul / Macquarie River at Bells Bridge (Carinda)
- Bogan River at Gongolgon.

Table 2 compares the electrical conductivity results to the target values (target values in brackets).

The median electrical conductivity in Castlereagh River at Gungalman Bridge and the 80th percentile in the Bogan River at Gongolgon did not meet the respective Basin Salinity Management Strategy

End-of-Valley salinity targets. High flows transported very high salt loads that exceeded targets in all three river systems.

Table 2: End-of-Valley salinity results for Castlereagh, Wambuul / Macquarie and Bogan valleys (targets in brackets)

Assessment site	Median electrical conductivity (µS/cm)	80 percentile electrical conductivity (µS/cm)	Salt load (t/year)
Castlereagh River at Gungalman Bridge	**766** (368)	917 (N/A)	**328,282** (8,910)
Wambuul / Macquarie River at Bells Bridge	239 (504)	371 (744)	**201,039** (25,760)
Bogan River at Gongolgon	451 (456)	**694** (581)	**245,999** (34,830)

* values in red indicate readings have exceeded the salinity target

Recreation

Exposure to blue-green algae (cyanobacteria) through ingestion, inhalation or contact during recreational use of water can impact human health. A colour alert scale is used with a green alert warning indicating low numbers of blue-green algae but requiring monitoring, an amber alert warning being a heightened level of alert with increased sampling and surveillance, and a red alert warning being a state of action where waters are unsuitable for recreational use. For more information about blue-green algae and algal alerts see the WaterNSW algae web page (Algae - WaterNSW).

Table 3 indicates the distribution of algal alerts for recreational use during 2022 to 2023. Blue-green algae blooms have historically been a major issue in Windamere and Burrendong dams during the summer period due to low flows and warmer temperatures. Due to heavy rainfall events delivering nutrients such as nitrogen and phosphorus, Windamere and Burrendong dams still received red alerts starting from July 2022 and for most of the summer months, as did sites further downstream along the Wambuul / Macquarie River. The Bogan River at Nyngan Weir Pool was on red alert from March until June 2023.

Table 3: Distribution of algal alert levels in Wambuul / Macquarie-Castlereagh valley July 2022 to June 2023

	Jul					Aug					Sep					Oct					Nov					Dec					Jan					Feb					Mar					Apr					May					Jun				
Windamere Dam	1	1	1	*	*	*	*	*	*	*	*	3	3	3	3	3	2	2	1	1	*	2	2	3	3	3	3	3	3	3	3	3	3	3	2	2	2	*	1	1	1	1	1	1	1	1	1	*	*	*	*	*	*	*	*
Burrendong Dam	3	3	3	3	*	*	1	*	*	*	*	*	*	*	*	1	1	1	1	1	1	1	1	1	2	2	2	3	3	3	3	3	3	3	2	2	2	2	2	2	2	1	1	1	2	2	2	2	2	2	2	2	2	2	2
Burrendong Downstream (Macquarie River)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	1	1	1	3	1	1	1	1	1	1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	1	1	1	*	*	*	*	*	*
Wambuul/Macquarie River at Dubbo	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	1	2	2	3	3	3	3	3	3	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Wambuul/Macquarie River at u/s Wellington	1	1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	1	1	3	3	3	3	3	3	2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	1	1	1	1	1	*	*	*	*	*
Wambuul/Macquarie River at Ponto Road Geurie	*	1	1	1	1	2	2	2	2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	1	1	3	3	3	3	3	3	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Bogan River at Nyngan Weir Pool	1	1	1	1	1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	1	1	*	*	*	*	*	*	*	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Key: * = Nil/Low alert; 1 = green alert; 2 = amber alert; 3 = red alert

Extreme water quality events

Spring 2022 was the wettest spring on record (since 1900) for New South Wales. In October, heavy rainfall led to widespread flooding in the Murray–Darling Basin, impacting many towns in inland New South Wales (Figure 6 - BoM, 2023). Flooding occurred in all catchments across the Northern Basin. The heavy rains led to substantial increases in water storage levels, with many storages spilling. With flooding on this scale came an increased risk of hypoxic blackwater events.

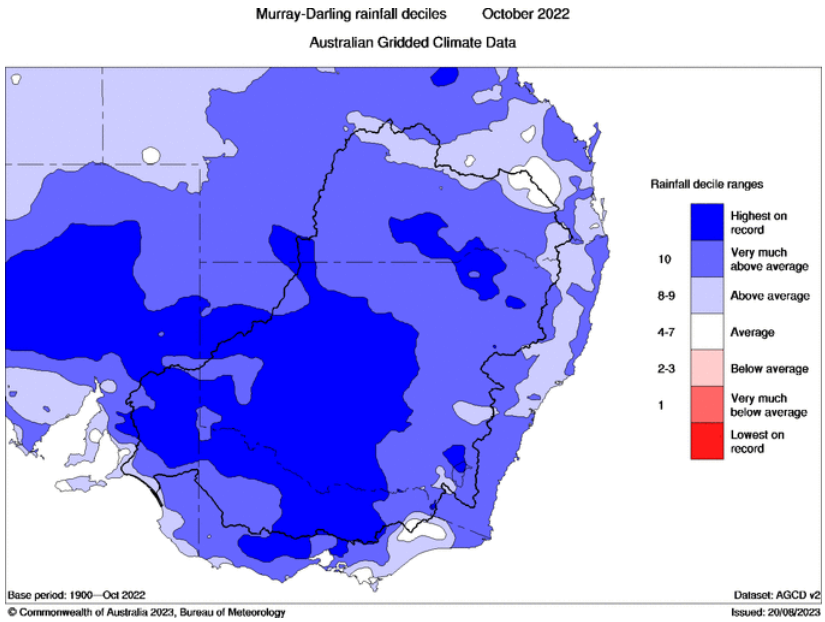

Figure 6: Murray Darling rainfall deciles for October 2022. (Source: BoM).

Widespread flooding in the Castlereagh, Wambuul / Macquarie and Bogan valleys washed organic material into creeks and waterways, resulting in lower oxygen levels in the lower catchment (Figure 7).

Figure 7: Flood debris across the Macquarie, downstream of Warren February 2023. (Picture: Bron Powell/ABC news)

NSW Fisheries investigated several fish death reports for 1 July 2022 to 30 June 2023. These reports are listed on the Department of Primary Industries website.

From 12 to 17 November 2022, approximately 40 to 50 dead Golden Perch were reported in the Cudgegong River below Windamere Dam spillway. The suspected cause was fish being stranded below the spillway.

In December 2022, thousands of dead fish were reported in the Bogan River near Nyngan. Species affected included carp, goldfish, gambusia (Mosquito fish) and yabbies. The suspected cause was a mixture of some fish becoming stranded and others being affected by deteriorating water quality due to a drop in dissolved oxygen. Yabbies were also observed walking upstream towards Nyngan Dam Weir.

In January 2023, two fish death reports were investigated. The first was at Reddenville Break, near Gin Gin on 19 January. Tens of dead fish were reported. Species affected included Murray Cod and carp. The suspected cause was a drop in dissolved oxygen.

The second fish death report occurred at Ellengerah Creek near Warren on 22 January. Ten to 100 dead Murray Cod were reported. The suspected cause was attributed to critically low dissolved oxygen. The regulator at the top of the creek was closed and a combination of no flow conditions with hot weather, generated critically low dissolved oxygen.

Summary

The quality of the water in a river or stream reflects underlying climate and geology and the multiple activities and land uses occurring in a catchment area. Numerous factors contribute to the observed results.

In 2022 to 2023, flooding was the key driver for water quality. Increased runoff carries high volumes of sediment and attached nutrients into waterways resulting in 10 of 15 water quality monitoring sites being rated as poor.

In contrast, the high flows in 2022 maintained electrical conductivity below target values. However, following the heavy rainfall and recharge of shallow groundwater during the flooding events, salts stored in the geology and soils of some catchments were mobilised, leading to increased electrical conductivity during 2023. Over the coming years this could lead to continued high electrical conductivity in some catchments.

The flood flows resulted in a hypoxic blackwater event in the lower Castlereagh and Wambuul / Macquarie catchment which contributed to low oxygen levels in the Barwon and Darling rivers. The widespread flooding resulted in fish deaths from hypoxic blackwater in these valleys, as was experienced in some other catchments across NSW.

For more detailed information about water quality issues in the Wambuul / Macquarie-Castlereagh catchment see the Wambuul / Macquarie-Castlereagh surface water quality technical report (https://www.industry.nsw.gov.au/__data/assets/pdf_file/0010/305758/Water-quality-technical-report-for-the-Macquarie-Castlereagh-surface-water-resource-plan-area-SW11.pdf).

Long-term water quality trends

Water quality data from 2012–2013 until 2022–2023 has been analysed to show long-term trends in the Wambuul / Macquarie River. Figure 8 shows data for each site over the 10-year period. The Fish, Turon, Bell and Bogan Rivers and the Wambuul / Macquarie at Burrendong spillway had the highest median WaQI scores of 75 or higher. Seven sites recorded a median WaQI score below 60, constituting a rating of poor. The Turon River had the highest median WaQI score over the 10-year period while the Talbragar at Elong had the lowest with all scores below 50 since 2012–2013.

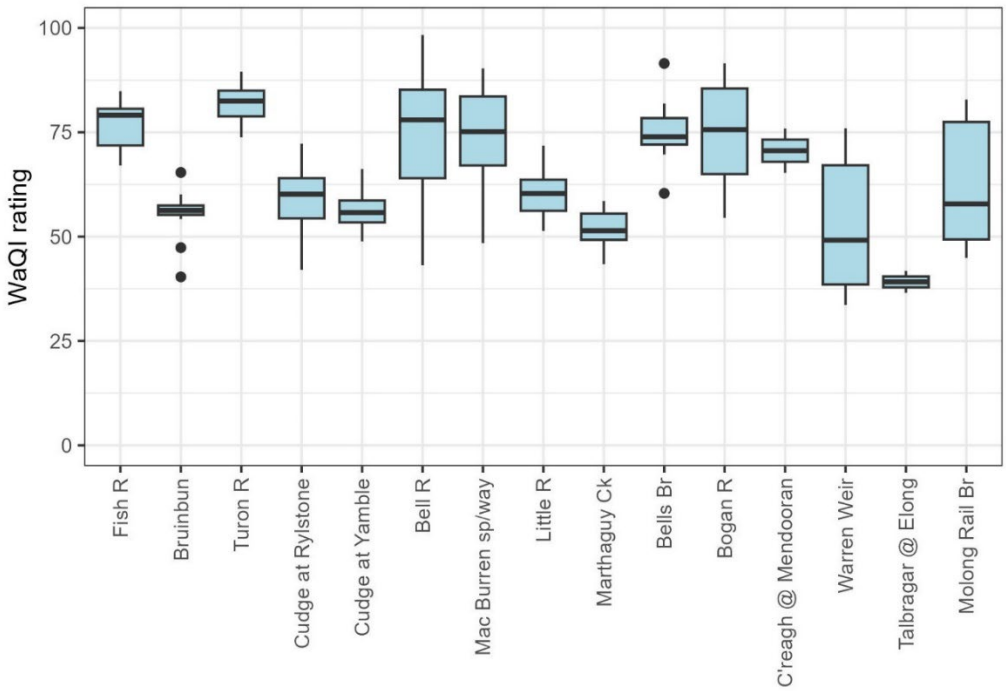

Figure 8: Boxplots showing long-term WaQI scores (2012–2013 to 2022–2023) for all sites in the Wambuul / Macquarie River

The number of sites with ratings of good, poor and moderate has changed considerably from 2012–2013 to 2022–2023 (Figure 9). The number of sites with a good (>80) rating has consistently declined with five sites rated as good in 2012–2013 and zero in 2022–2023. In contrast, the number of sites with a poor rating has consistently increased with two sites rated as poor in 2012–2013 and 10 sites rated as poor in 2022–2023. The number of sites rated as moderate has been relatively stable over time, with four sites rated as poor in 2012–2013 and five sites in 2022–23, the number of moderate rated sites peaked in 2018 before poor ratings increased due to drought and then several years of flooding.

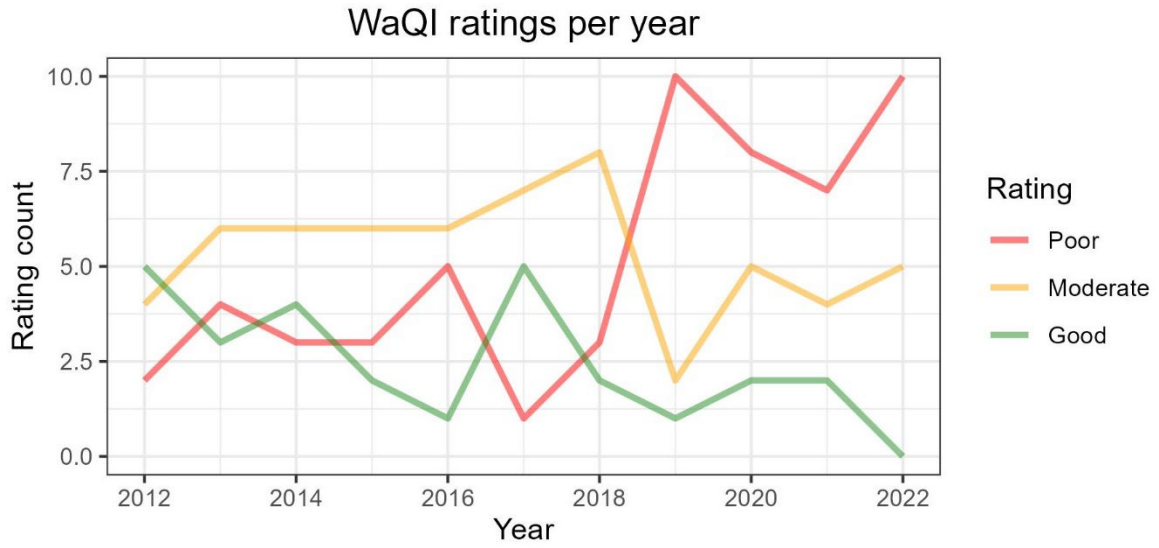

Figure 9: Number of sites with ratings of good, moderate or poor over time on the Wambuul / Macquarie River

References and further information

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Fish kills in NSW: https://www.dpi.nsw.gov.au/fishing/habitat/threats/fish-kills

MDBA regional fact sheet: https://www.mdba.gov.au/sites/default/files/pubs/regional-fact-sheet-macquarie-castlereagh.pdf

MDBA water management: https://www.mdba.gov.au/water-management/catchments/macquarie-castlereagh

NSW DPE water for the environment: https://www.environment.nsw.gov.au/topics/water/water-for-the-environment/macquarie

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