Annual Water Quality Monitoring Report

2020-21

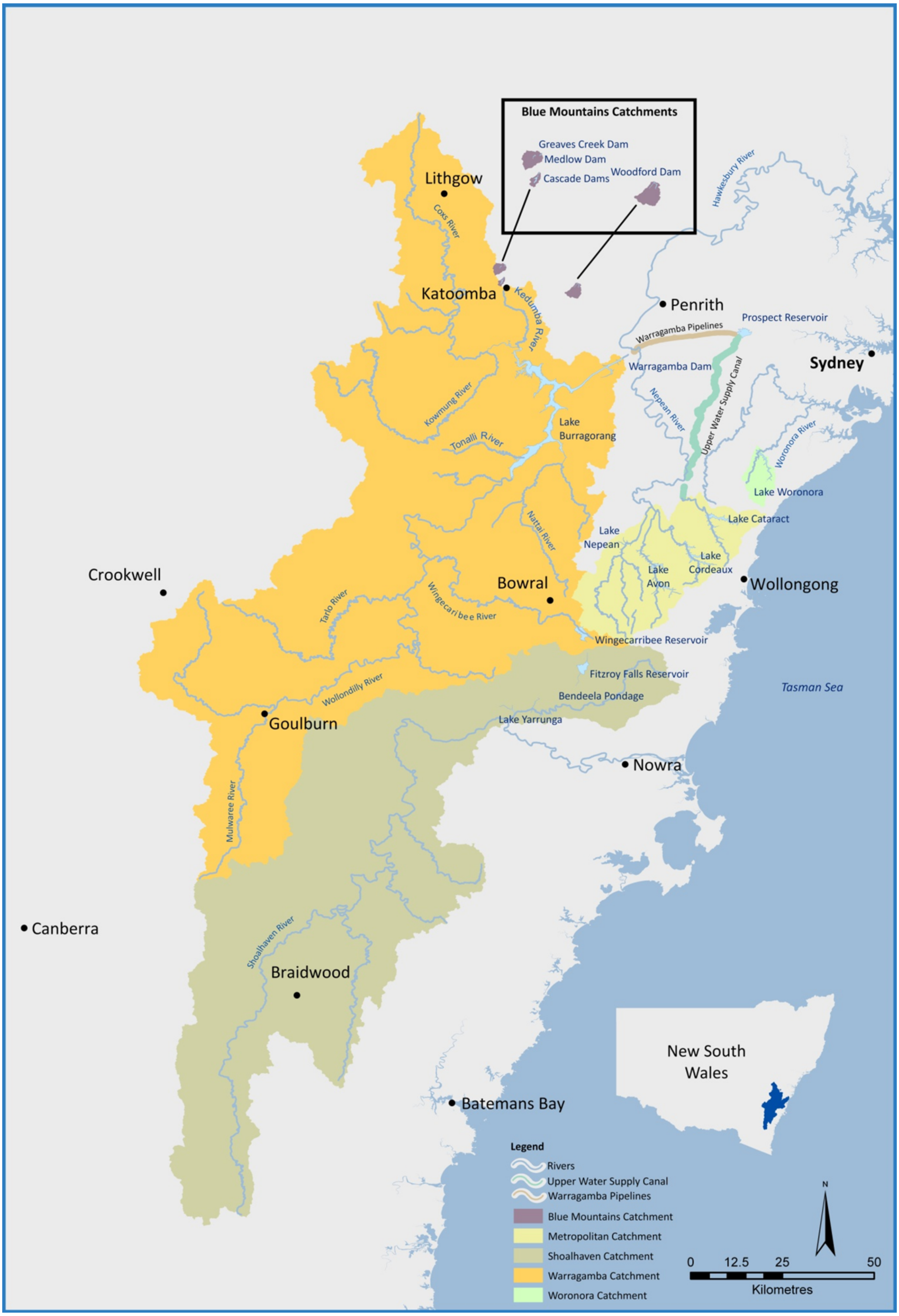

Figure 0.1: Sydney catchment area

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Executive Summary

WaterNSW's Water Monitoring Program Manual (WMP) for the Sydney catchment area details the comprehensive monitoring activities covering catchments, lakes, intakes to water filtration plants, picnic areas and downstream river sites. The WMP has been developed in collaboration with NSW Health, Sydney Water and other wholesale customers. The program incorporates locations, frequency and benchmarks or guideline values for more than 200 water quality characteristics. The WMP includes routine and event monitoring employing field sampling, laboratory testing and telemetered 'real-time' data collection from in-situ instruments. Monitoring provides timely water quality data and information to inform water quality risks, operational decisions and verification of water quality to demonstrate compliance.

This report describes the results of the water quality monitoring undertaken by WaterNSW during 2020-21. The report is prepared to meet WaterNSW's statutory obligations and supports the implementation of WaterNSW Water Quality Management System, providing invaluable information for the assessment water quality changes and early identification of potential trends that can adversely impact water quality. This allows WaterNSW to proactively develop mitigation strategies, required for the protection of our water sources. In addition, it provides stakeholders, students, researchers and the general public with water quality information for waters managed by WaterNSW in the greater Sydney catchment area.

Highlights

The 2020-21 reporting period commenced with a total storage volume of 81% on 1 July 2020. The high storage volume was due to heavy rainfall and resulting inflows in February 2020. Subsequent inflow events in August 2020 and March 2021 further increased storage volume and resulted in spills at most storages with total storage volume sitting at 96% on 30 June 2021.

Storage and catchment sample sites were more accessible than in the previous year which experienced catchment closures due to bushfire and rainfall events. Some sites were not sampled due to dry conditions, catchment closures or access issues due to dam spills.

Guided by its Water Quality Management System, WaterNSW successfully delivered agreed quantities of high quality water to customers in full compliance with the Australian Drinking Water Guidelines (ADWG) for health-related characteristics.

A combination of extended drought, widespread bushfire in the Warragamba catchment followed by major rain events in 2020 and 2021 resulted in some of the most challenging water quality conditions since 1998. Despite these significant challenges, through proactive modelling, monitoring and source selection, WaterNSW continued to deliver best available source water to our customers to ensure safety of the water supply was not compromised.

Water supplied to **water filtration plants** achieved near full compliance with site specific standards in raw water supply agreements. Exceptions were minor, occurring in the Warragamba, Shoalhaven and Blue Mountains systems and were managed in accordance with the Water Quality Incident Response Protocol.

WaterNSW continued to manage **picnic area supply** sites in accordance with the Quality Assurance Plans developed in line with NSW Private Water Supply Guidelines. Results from routine monitoring were similar to previous years with low chlorine residuals in picnic area end taps due to chlorine decay and high residence time in the reticulation. The efficacy of chlorine disinfection was demonstrated with consistent high residuals achieved at the dosing plants, high chlorine contact times and the absence of *E. coli* and indicator bacteria in the supplies.

Consistent with recent years, nutrients and chlorophyll *a* often exceeded ANZECC benchmarks in catchment sites with significant agricultural or urban development, particularly within the Warragamba and Shoalhaven systems. Slight improvements in the Warragamba catchment and storage indicate early recover signs from 2020 bushfires and floods.

Water quality in 2020-21 achieved
98.35% conformance with Raw Water Supply Agreements and
100% conformance with Australian Drinking Water Guidelines

Monitoring **downstream** of WaterNSW storages is part of the requirements of the Water Licences and Approvals package administered by Department of Planning, Industry and Environment. In the Nepean River system water quality continues to be poorer moving downstream due to catchment influences. Chlorophyll *a* was similar to the upstream storages with decreases observed in the Wingecarribee River and increases in the Shoalhaven River.

WaterNSW successfully managed one major water quality incident as triggered by and in accordance with our Water Quality Incident Response Protocol:

- March 2021 intense rainfall event

Investigative monitoring was limited to scour releases from Lake Medlow in the Blue Mountains system. Monitoring carried out informed operational aspects in management of storage level, identified water quality risks, and further monitoring to be undertaken downstream in Lake Greaves following large scour releases from Lake Medlow.

The annual **Macroinvertebrate Monitoring Program** scored 77 routine sites against the AUSRIVAS band grades. Of the 77 sites, 43 received a lower AUSRIVAS value while 34 recorded higher values, indicating an overall a slight decline compared to the previous year; however, changes were not always large enough to cause a AUSRIVAS band grade change at each site.

A trend analysis was conducted for selected analytes and sites for the period from 2011 to 2021. The analysis was generally consistent with results from 2009-2019 and did not identify any significant negative trends impacting on water quality supplied for treatment.

1 Introduction

WaterNSW is a state-owned corporation whose responsibilities include, inter-alia, supplying water in compliance with appropriate standards of quality (Section 6(1)(b), Water NSW Act 2014) in the Sydney catchment area. WaterNSW undertakes extensive monitoring within its catchments, lakes and raw water supply system and in rivers downstream of storages to meet this objective.

WaterNSW's Water Monitoring Program Manual (WMP) sets out the location, frequency and analytes monitored for the Sydney catchment area and the regional area (WaterNSW, 2017). Specific and health-related characteristics are determined in consultation with our major customers and the program is developed to the satisfaction of NSW Health. Monitoring for operations and planning helps WaterNSW understand the threats to water quality throughout the supply system, including rivers, lakes and the delivery system. This information aids the selection of the best source water for our customers and the environment.

Data collected through the WMP is used to:

- provide early detection of possible contaminants to protect the health of consumers
- assist in proactive operational decisions
- ensure that the raw water delivered to wholesale customers meets agreed standards and can be treated to meet the Australian Drinking Water Guidelines
- identify and target possible contamination sources in the catchments and storages
- prioritise monitoring to inform water quality risks and remedial actions
- identify emerging water quality issues and address them in forward configurational planning

WaterNSW's compliance monitoring activities are governed by the following key drivers:

- Operating Licence and Reporting Manual granted by the Governor of NSW and administered by Independent Pricing and Regulatory Tribunal (IPART)
- Water Licences and Approvals package granted by the Water Administration Ministerial Corporation and administered by Department of Planning Industry and Environment (DPIE – Water Division)
- Raw water supply agreements between WaterNSW and its wholesale customers
- Australian Drinking Water Guidelines
- NSW Private Water Supply Guidelines and Public Health Act 2010
- ANZECC benchmarks

This report describes the results of water quality monitoring undertaken by WaterNSW in the Sydney catchment area between 1 July 2020 and 30 June 2021 under the WMP. The report is a requirement of the Reporting Manual of the Operating Licence (2017-2022). The report also provides the community with information on water quality.

More specifically this report includes:

- a summary of the WMP, including objectives and applicable guidelines
- a summary of the results of the routine, event and investigative monitoring
- analysis of system performance relative to the criteria where relevant water quality or catchment health benchmarks are available
- information on the integrity of the data reported
- details of research activities
- summary of water quality incidents and actions taken to resolve, eliminate or mitigate the effect of those incidents, especially to protect public health during the incident
- an analysis of trends in water quality over the previous 10 years for selected sites and analytes.

2 Overview of the Sydney catchment area water supply network

WaterNSW collects water from river catchments to the south and west of Sydney and stores it in lakes and reservoirs to supply more than five million people in the Greater Sydney region.

It is transported via a network of rivers, lakes, pipes and canals to water filtration plants, where it is treated for consumers in Sydney, Illawarra, Shoalhaven, Goulburn, Blue Mountains and the Southern Highlands. Water is also released from storages as environmental flows to maintain the health of the downstream river systems.

The catchments cover an area of approximately 16,000 square kilometres, extending from the headwaters of the Coxs River north of Lithgow, south to the source of the Shoalhaven River near Cooma, and from Woronora in the east to the Wollondilly River near Crookwell in the west (Figure 0.1). Raw water is collected from the river systems of five major catchments:

- Warragamba (including Prospect)
- Upper Nepean
- Woronora
- Shoalhaven
- Blue Mountains, including supplementary flows from the Fish River system.

The transfer routes for water around the system and approximate number of people supplied by that part of the system are shown in the water supply system schematic (Figure 2.1).

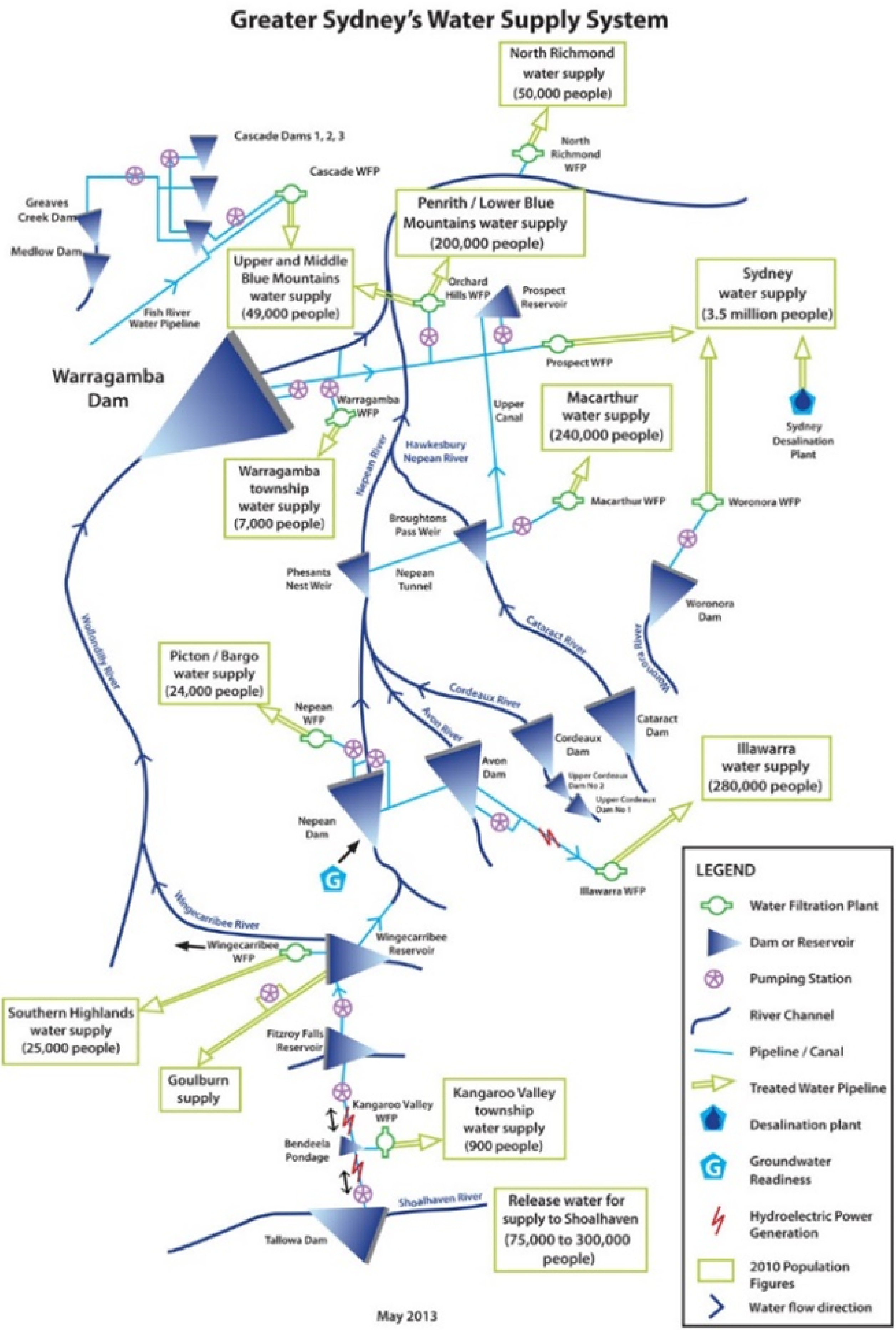

Figure 2.1: Schematic of the water supply system

3 Sydney catchment area water monitoring program

The Water Monitoring Program Manual (WMP) consists of operational, verification and investigative monitoring. The WMP covers catchments, storages, inlets to water filtration plants, picnic taps, transfer canals and pipelines, as well as rivers downstream of water supply dams and weirs. Monitoring includes physical, chemical, biological, radiological, hydrological and meteorological parameters through on-line instruments, field sampling and laboratory analysis. A key feature of the WMP is an agreed list of water quality characteristics. The list contains:

- those characteristics that cannot be managed by conventional treatment and for which Australian Drinking Water Guidelines (ADWG) must be met; and,
- those characteristics for which ADWG exist but are not applicable to raw water, where WaterNSW must endeavour to supply raw water so that it can be treated to meet the ADWG.

WaterNSW is subject to a range of statutory requirements and standards set by regulatory agencies. WaterNSW is also benchmarked against other raw water suppliers to maintain best practice service standards.

The principal documents that outline requirements on WaterNSW with respect to water monitoring are listed below.

- Water NSW Act 2014.
- Operating Licence (Part 2), Water NSW Act 2014 (Division 4)
- Water Licences and Approvals Package under Water Management Act 2000
- Memorandum of Understanding between NSW Health and WaterNSW (2016) (Parts 5-8)
- Raw Water Supply Arrangements
- Water Quality Incident Response Protocol
- Private Water Supply Guidelines and Public Health Act 2010
- Water Act 2007 (Commonwealth)

The WMP specifies the requirements for water sample collection and analysis. It describes sampling locations and frequencies, and the parameters to be analysed. Additional samples are collected and analysed for quality assurance and quality control (QA/QC) purposes. The QA/QC program provides confidence in the data collected.

The collection and analysis of routine and QA/QC water samples is performed by WaterNSW monitoring staff and external service providers. Service contracts include requirements for quality assurance practices in the monitoring, sampling, testing and reporting processes. A chain of custody system allows individual samples to be tracked from field collection, through laboratory analysis, to the transfer of results to WaterNSW's database. Further details of the QA/QC monitoring for 2020-21 are included in Section 5.1.

4 Applicable guidelines and benchmarks

WaterNSW has adopted nationally recognised standards and guidelines for a range of water quality characteristics in each part of the water supply network. Different guidelines and standards apply to each part of the supply cycle as water passes from catchment waterways into lakes and then into the delivery network or downstream rivers.

4.1 Australian Drinking Water Guidelines (ADWG)

The Australian Drinking Water Guidelines (NHMRC, 2011 and later revisions) apply to any water intended for drinking, irrespective of the source or where it is consumed. The ADWG framework for managing drinking water quality advocates risk management and preventive measures at all barriers from catchment to consumer.

For water quality characteristics that have been specified as 'health related', including metals, pesticides and synthetic organic compounds (Table 4.1a-b), raw water must conform to the ADWG. As conventional water treatment methods are not designed to remove these compounds from raw water, it is preferable to avoid them in the raw water supply through catchment and storage management practices. Drinking water supply at picnic areas is managed in accordance with the ADWG.

Routine monitoring of radionuclides is performed at water filtration plants by screening for gross alpha and gross beta activity concentrations. Testing for individual radionuclides is performed in the case of a positive gross alpha or gross beta result. Gross alpha and gross beta screening is now carried out three-yearly in accordance with ADWG. Gross alpha and gross beta screening was clear in 2019-20 and will next be conducted in 2022-23.

4.2 Raw water supply agreements

WaterNSW has established terms and conditions of supply with wholesale customers to ensure treated water is not harmful to consumers' health. WaterNSW maintains raw water supply agreements with Sydney Water, Wingecarribee Shire Council, Goulburn Mulwaree Council and Shoalhaven City Council. Raw water supplied for treatment is required to conform to site-specific standards specified in raw water supply agreements (Table 4.2). These standards are based on the treatment capabilities of the plants and the natural characteristics of the catchment. This ensures that raw water can be treated to meet ADWG requirements.

Table 4.1a: Health-related water quality characteristics: Synthetic Organics, Radiological and Pesticide Characteristics

	SPECIFIC WATER CHARACTERISTIC	DRIVER	ADWG (2011) Health Guideline
SYNTHETIC ORGANICS - RADIOLOGICAL - PESTICIDES	**Synthetic Organic Compounds**	Operating Licence[1]	
	Benzene		0.001 mg/L
	Vinyl chloride		0.0003 mg/L
	Pesticides		
	2,4-D (2,4-Dichlorophenoxyacetic acid)		0.03 mg/L
	Atrazine		0.02 mg/L
	Chlorfenvinphos		0.002 mg/L
	Chlorpyrifos		0.01 mg/L
	Diuron		0.02 mg/L
	Flupropanate		0.009 mg/L
	Glyphosate		1.0 mg/L
	Hexazinone		0.4 mg/L
	MCPA (2-methyl-4-clorophenoxyacetic acid)		0.04 mg/L
	Picloram		0.3 mg/L
	Simazine		0.02 mg/L
	Triclopyr		0.02 mg/L
	Radiological	ADWG recommends screening level test for radiological parameters	
	Gross alpha		0.5 Bq/L
	Gross beta		0.5 Bq/L

1 Section shaded yellow contains health related water quality characteristics. These characteristics must not exceed Australian Drinking Water Guidelines (NHMRC, 2011) in raw water supplied as treatment may not remove them. Minimising these in raw water effectively minimises risk to consumers.

Table 4.1b Health-related and aesthetic Water Quality Characteristics: (Physical, Chemical, Biological and Organic)

	SPECIFIC WATER CHARACTERISTIC	DRIVER	Guideline
PHYSICAL - CHEMICAL - BIOLOGICAL - ORGANIC	Arsenic Barium Beryllium Boron Iodide Manganese Mercury Molybdenum Selenium Silver Tin	ADWG (2011)[1] Health Guideline	0.01mg/L 2 mg/L 0.06mg/L 4 mg/L 0.5 mg/L 0.5 mg/L 0.001 mg/L 0.05 mg/L 0.01 mg/L 0.1 mg/L N/A
	Antimony Cadmium Chromium (Cr^{VI}) Copper Fluoride Lead Nickel Nitrate Nitrite	ADWG (2011)[2] Health Guideline (NSW Private Water Supply Guidelines, 2016)	0.003 mg/L 0.002 mg/L 0.05 mg/L 2 mg/L 1.5 mg/L 0.01 mg/L 0.02 mg/L 50 mg/L 3 mg/L
	E. coli Enterococci *C. perfringens* *Cryptosporidium* *Giardia* Toxin producing cyanobacteria Toxicity Total cyanobacteria biovolume	ADWG (2011) Operating Licence[3]	Seek advice from NSW Health
	Algae (ASU) Alkalinity Aluminium Hardness Iron Manganese Odour pH True colour Turbidity	Water Supply Agreements	Refer to Water Supply Agreements
	Total cyanobacteria biovolume Total toxin producing cyanobacteria Toxicity Enterococci	Water Licences and Approvals Package (WLAP)[4]	Refer to *Guidelines for Managing Risks in Recreational Water* (NHMRC 2008)

1 Section shaded **yellow** contains health related water quality characteristics – these characteristics must not exceed Australian Drinking Water Guidelines (NHMRC, 2011) in treated waters or in raw water supplied as treatment may not remove them. Minimising these in raw water effectively minimises risk to consumers.

2 Section shaded **orange** contains health related water quality characteristics for private water supplies – these characteristics must not exceed Australian Drinking Water Guidelines (NHMRC, 2011) in treated waters.

3 Section shaded **blue** contains characteristics for which drinking water guidelines exist but these are not applicable for raw water. However, WaterNSW must endeavour to supply the best quality raw water available so that it can be treated to meet Australian Drinking Water Guidelines.

4 Section shaded **green** contains characteristics which apply for recreational waters and releases.

Table 4.2: Raw water supply agreements – Site specific standards

<table>
<tr><th colspan="2" rowspan="2"></th><th>Turbidity</th><th>True Colour @400 nm</th><th>Iron</th><th>Manganese</th><th>Aluminium</th><th>Hardness</th><th>Alkalinity</th><th>pH</th><th>Odour</th><th>Algae</th></tr>
<tr><th>NTU</th><th>CU</th><th>mg/L</th><th>mg/L</th><th>mg/L</th><th>mg/L as CaCO3</th><th>mg/L as CaCO3</th><th>pH units</th><th>Rating</th><th>ASU</th></tr>
<tr><td colspan="2">Prospect WFP</td><td rowspan="3">40</td><td rowspan="3">60</td><td rowspan="3">3.50</td><td rowspan="3">1.40</td><td rowspan="3">2.6</td><td rowspan="3">25 – 70</td><td rowspan="3">15 - 60</td><td rowspan="11">NA</td><td rowspan="7">NA</td><td>1000(i)</td></tr>
<tr><td colspan="2">Warragamba WFP</td><td rowspan="2">2000</td></tr>
<tr><td colspan="2">Orchard Hills WFP</td></tr>
<tr><td rowspan="4">Macarthur WFP Based on Demand (ML/day)</td><td>185 - <265</td><td>10</td><td rowspan="4">40</td><td>0.60</td><td>0.20</td><td>0.40</td><td>6 – 30</td><td rowspan="4">15</td><td rowspan="2">100(ii)</td></tr>
<tr><td>125 - <185</td><td>25</td><td>0.80</td><td>0.25</td><td>0.50</td><td rowspan="3">6 – 32.20</td></tr>
<tr><td>80 - <125</td><td>50</td><td>1.10</td><td>0.30</td><td>0.75</td><td rowspan="2">500(ii)</td></tr>
<tr><td><80</td><td>60</td><td>1.30</td><td>0.35</td><td>0.95</td></tr>
<tr><td colspan="2">Illawarra WFP</td><td rowspan="2">10</td><td>50</td><td>1.1</td><td>0.4</td><td>1.4</td><td>30</td><td>10</td><td rowspan="2">Not objectionable</td><td rowspan="2">5000</td></tr>
<tr><td colspan="2">Woronora WFP</td><td>70</td><td>1</td><td>0.1</td><td>0.4</td><td>2 – 30</td><td>15</td></tr>
<tr><td colspan="2">Nepean WFP</td><td>150</td><td rowspan="2">60</td><td>5.0</td><td>1.5</td><td>1.0</td><td>2 – 35</td><td>0.5 – 25</td><td rowspan="5">NA</td><td rowspan="2">2000</td></tr>
<tr><td colspan="2">Cascade WFP</td><td>15</td><td>3.0</td><td>0.3</td><td>0.2</td><td>40</td><td>30</td></tr>
<tr><td colspan="2">Kangaroo Valley WFP</td><td>20</td><td rowspan="3">70</td><td rowspan="3">1.1</td><td>0.4</td><td rowspan="3">NA</td><td rowspan="3">36.5</td><td>29</td><td rowspan="3">6.5 – 8.5</td><td rowspan="3">5000</td></tr>
<tr><td colspan="2">Wingecarribee WFP</td><td rowspan="2">40</td><td rowspan="2">NA</td><td rowspan="2">35</td></tr>
<tr><td colspan="2">Goulburn Mulwaree</td></tr>
</table>

(i) Maximum for Prospect WFP is 1000 ASU, except if turbidity is greater than 10 NTU or true colour is greater than 30 CU, then the algae maximum will be 500 ASU.

(ii) Algal limits for Macarthur WFP (average of 3 samples): 500 ASU small individual cells (<10 µm) of filamentous or colonial species, typically *Chlorella*, *Dolichospermum*, *Monodus* and *Melosira*; or 100 ASU large (>10 µm) cells, branching species, and/or gelatinous species, typically *Asterionella*, *Taballaria*, *Fragillaria*, *Synedra*, *Cyclotella*, *Dinobryan*, *Elakatothrix*, and *Volvox*.

(iii) Upper limits are shown for analytes where ranges are not provided.

4.3 ANZECC 2000

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000) (ANZECC, 2000) provide a guide for setting water quality objectives required to sustain current or likely future environmental values for natural and semi-natural water resources in Australia and New Zealand. Water quality in WaterNSW Sydney catchment area waterways are compared against relevant sections of the ANZECC Guidelines.

Benchmarks for storages

Benchmarks for storages are derived from the guidelines for freshwater lakes and reservoirs (ANZECC, 2000) for the 95-99 percent level of species protection (Table 4.3). Site specific benchmarks are to be developed for temperature and conductivity, and as such are not included in the table below.

Table 4.3: Water quality benchmarks for storages

Analyte	Units	Benchmark range
pH	pH units	6.5 - 8.0
Chlorophyll *a*	µg/L	< 5
Dissolved oxygen	% sat	90 – 110
Total nitrogen	mg/L	< 0.35
Oxidised nitrogen	mg/L	< 0.01
Ammoniacal nitrogen	mg/L	< 0.01
Total phosphorus	mg/L	< 0.01
Filterable reactive phosphorus	mg/L	< 0.005
Turbidity	NTU	< 20.0
Total manganese	mg/L	< 1.9
Total aluminium	mg/L	< 0.055

Benchmarks for catchments

WaterNSW benchmarks water quality in metropolitan catchment streams against the ANZECC (2000) guideline ranges for upland rivers (Table 4.4).

Table 4.4: Water quality benchmarks for catchment streams

Analyte	Units	Benchmark range
pH	pH units	6.5 – 8.0
Chlorophyll *a*	µg/L	< 5
Dissolved oxygen	% sat	90 – 110
Total nitrogen	mg/L	< 0.25
Ammoniacal nitrogen	mg/L	< 0.013
Oxidised nitrogen	mg/L	< 0.015
Total phosphorus	mg/L	< 0.02
Filterable reactive phosphorus	mg/L	< 0.015
Turbidity	NTU	< 25
Total aluminium	mg/L	< 0.055
Total manganese	mg/L	< 1.9
Conductivity	mS/cm	< 0.35

4.4 Benchmarks for recreational areas

To minimise risks to public health, WaterNSW manages recreational exposure risk by benchmarking water quality against the Guidelines for Managing Risks in Recreational Waters (NHMRC, 2008) (Table 4.5).

Table 4.5: Water quality benchmarks for recreation areas

Analyte	Units	Primary Contact		Secondary Contact
		Minor Alert Threshold	Major Alert Threshold	Alert Threshold
Enterococci	cfu/100mL	40	200	200
Microcystis aeruginosa	cells/mL	5,000	50,000	50,000
Toxic cyanobacteria biovolume	mm^3/L	0.4	4	4
Total cyanobacteria biovolume	mm^3/L	-	10	10
Algal toxins (microcystin variants)	µg/L	NA	10	10

4.5 Benchmarks for downstream rivers

Benchmarks for water quality downstream of WaterNSW's dams and weirs are derived from ANZECC lowland rivers ecosystem types (Table 4.6).

Table 4.6: Water quality benchmarks downstream of storages

Analyte	Units	Benchmark range
pH	pH units	6.5 - 8.5
Chlorophyll *a*	µg/L	< 5
Dissolved oxygen	% sat	85 – 110
Total nitrogen	mg/L	< 0.5
Total phosphorus	mg/L	< 0.05
Turbidity	NTU	< 50

4.6 Benchmarks for picnic area supplies

Benchmarks for the picnic area supplies are based on ADWG (2011) threshold ranges, where relevant (Table 4.7). Some benchmarks are prompts for action, such as chlorophyll *a*, which triggers algal monitoring in the picnic area supply.

Table 4.7: Water quality guidelines for specific parameters at picnic areas

Analyte	Units	Threshold
Free chlorine residual	mg/L	> 0.5
pH	pH units	6.5 - 8.5
Turbidity	NTU	< 5
Total iron	mg/L	< 0.3
Total aluminium	mg/L	< 0.2
Total manganese	mg/L	< 0.1
E. coli	orgs/100 mL	Should not be detected
Algal toxins (microcystin variants)	µg/L	< 1.3
Chlorophyll *a*	µg/L	< 5
Potentially toxin producing algal cells	cells/mL	< 6,500[(i)]

(i) See cyanobacteria benchmarks in Table 4.8

4.7 Benchmarks for cyanobacteria

WaterNSW routinely monitors levels of algae in major storages to provide early warning of possible bloom conditions and to ensure that raw water supplied to customers can be treated to meet drinking water guidelines. Algal monitoring is also conducted to avoid contaminating downstream waterways through environmental releases or transfers.

While the ADWG stipulate cyanobacteria guidelines and alert levels for drinking water, WaterNSW applies those guidelines to the raw water supplied for treatment in Greater Sydney. At Lake Yarrunga and Fitzroy Falls Reservoir, the only WaterNSW storages in the Sydney catchment area with recreational access, the National Health and Medical Research Council Recreational Waters Guidelines (NHMRC, 2008) for catchments and lakes are applied (Table 4.8). The raw water and picnic areas benchmarks are from the ADWG.

Table 4.8: Cyanobacteria benchmarks throughout Sydney catchment area

Analyte		Units	Threshold
Catchment and lake sites(i)			
Cells	*Microcystis aeruginosa*	cells/mL	50,000
Toxicity	Microcystin variants	µg/L	10
Biovolume	Total cyanobacteria	mm^3/L	4
Raw water and picnic area water supplies(ii)			
Cells	*Microcystis aeruginosa*	cells/mL	6,500
	Raphidiopsis raciborskii	cells/mL	15,000
	Dolichospermum circinale	cells/mL	20,000
Toxicity	Microcystin variants	µg/L	1.3
	Cylindrospermopsin	µg/L	1.0
	Saxitoxin	µg/L	3.0
Biovolume	Potentially microcystin-producing species	mm^3/L	0.6
	Potentially cylindrospermopsin-producing species	mm^3/L	0.6
	Potentially saxitoxin-producing species	mm^3/L	5

(i) National Health and Medical Research Council Guidelines for Managing Risks in Recreational Water 2008.

(ii) These triggers are based on cell counts, toxin concentration and biovolume ADWG 2011 specify actions in response to various alert level ranges for *Microcystis aeruginosa, Dolichospermum circinale* and *Raphidiopsis raciborskii*, and the consolidated biovolumes of the species known to produce microcystin, saxitoxins and cylindrospermopsin toxins.

4.8 Benchmarks for *Cryptosporidium* and *Giardia*

The ADWG do not contain guideline values for *Cryptosporidium* and *Giardia* in raw or treated drinking water. However, ADWG (2011) recommends a multi-barrier approach to minimise the risks of these pathogens. Investigative testing is encouraged in response to events that could increase the risk of contamination. WaterNSW implements additional monitoring during high-risk events. *Cryptosporidium* and *Giardia* monitoring in the catchments is undertaken to provide early warning to enable optimal configuration of the raw water supply system in the event of high concentrations of protozoan pathogens within the storages. Catchment monitoring also contributes to the understanding of sources which can then improve the robustness of risk assessments and catchment actions.

5 Routine monitoring

Water quality monitoring was conducted as per the Water Monitoring Program. Samples were collected from catchment streams, lakes and delivery sites and analysed by National Association of Testing Authorities (NATA) accredited laboratories. Online instruments were used to supplement this monitoring. This report summarises the results of routine monitoring compared against appropriate guidelines or benchmarks.

Data from routine samples was extracted from the WaterNSW water quality database. Storage data was filtered so that surface samples were used. Routine data was compared to the relevant guideline, standards and benchmark value for each analyte. The number of guideline exceedances was calculated as a percentage of the total compliance samples taken in the reporting year. The appendices provide summary statistics for all samples collected on each routine sampling occasion.

Compliance was 100% with the ADWG and 98.35% with Raw Water Supply Agreements. Overall, the water quality monitoring of the reservoirs in the declared catchment areas indicated good water quality apart from impacts associated with the February 2020 inflow event following bushfires in some catchments, and subsequent inflow events in August 2020 and March 2021. The impacts of the recent inflow events were managed by adjusting the supply system configuration (e.g., offtake depth changes and source selection) and raw supply to water treatment plants was not adversely impacted.

5.1 Quality Assurance and Quality Control

The WaterNSW quality assurance and quality control (QA/QC) program ensures the sampling and analysis process is accurate and representative. Specific QA/QC samples are collected and analysed to provide confidence that errors are controlled in the sampling and analysis process. Field collected QA/QC samples include field duplicates and field blanks. Trip blanks are also prepared at the laboratory and taken on designated sampling trips. 5.2% of the number of routine samples were taken for QA/QC purposes in 2020-21 to ensure the validity and accuracy of the WaterNSW's water quality data. This was well above the effort on QA/QC recommended by ISO 5667.

In addition to WaterNSW QA/QC samples, WaterNSW's analytical service providers have management systems that require them to maintain their own internal QA/QC program. These systems are accredited with the NATA and aligns with ISO17025. The analytical service providers conduct internal quality control analysis per each batch of samples including matrix spikes, internal and inter-laboratory duplicates, blanks, replicate analysis and inter-laboratory proficiency trials. The service provider QA/QC specialists analyse conformance with specified standards of accuracy and precision defined by WaterNSW to identify any contamination, outliers or errors (either random or systemic).

Trip blanks

A total of 94 trip blanks were taken in 2020–21 across the Sydney catchment area. Twelve trip blanks detected at least one analyte, representing a 12.7% anomaly rate per sample. Anomalous detections included total aluminium (1), dissolved organic carbon (3), oxidised nitrogen (2), turbidity (1) and odour (6). All detections were low and, when compared to acceptable analytical error per standard method for each analyte, represented a very low bias relative to the method error.

Field blanks

A total of 119 field blanks were taken in 2020–21. Thirty six field blanks returned positive results, equating to an anomaly rate of 22.7%. The detections were generally low level and represented minor contamination in the sampling process. Analytes detected most frequently within the positive blank samples were dissolved organic carbon (15), oxidised nitrogen (7), odour (5), and total organic carbon (4). Recurring organic carbon samples showing a field blank detection, while consistently of a low level, reflects a minor bias in results and is factored into interpretation by water quality advisors. Odour, being an interpretative analysis, is expected to show a bias towards a positive result and this bias is also considered in interpretation. One sample showed elevated contamination (turbidity 103NTU) and warranted further investigation. The turbidity result was due to a data input error where a decimal place was excluded from reporting. For other detections, due to the ultra-trace levels of reporting for these analytes, intermittent anomalies are to be expected, the levels of detection did not impact operational decision making.

Duplicates

Duplicate samples can identify any contamination or procedural errors in all elements of sampling and analysis. The samples are used as a pass/fail performance metric. Duplicate results are assessed on the acceptable performance criteria determined by WaterNSW and the respective laboratory. If the variation of the sample is outside the performance criteria the duplicate is reanalysed. During 2020–21, 232 duplicate samples were collected for which 128 samples showed significant percentage variation (>50%) in at least one of the analyses. Within these 128 samples, 58 analyses showed variation that warranted further investigation. The majority of these samples showed variation only when measured at low ranges or where analyses that are known to have significant sample to sample variability (such as cyanobacterial and algal counts and derivations from these counts). Only a small number of analyses showed unacceptable sample variation and they included Enterococci (1), total nitrogen (1) and kjeldahl nitrogen (1). No duplicate pair showed variation of a magnitude to which WaterNSW would not accept the result or the variation would impact operational decision making.

5.2 Warragamba system

Sampling sites in the Warragamba system (including Prospect Reservoir) are shown in Figure 5.1 below.

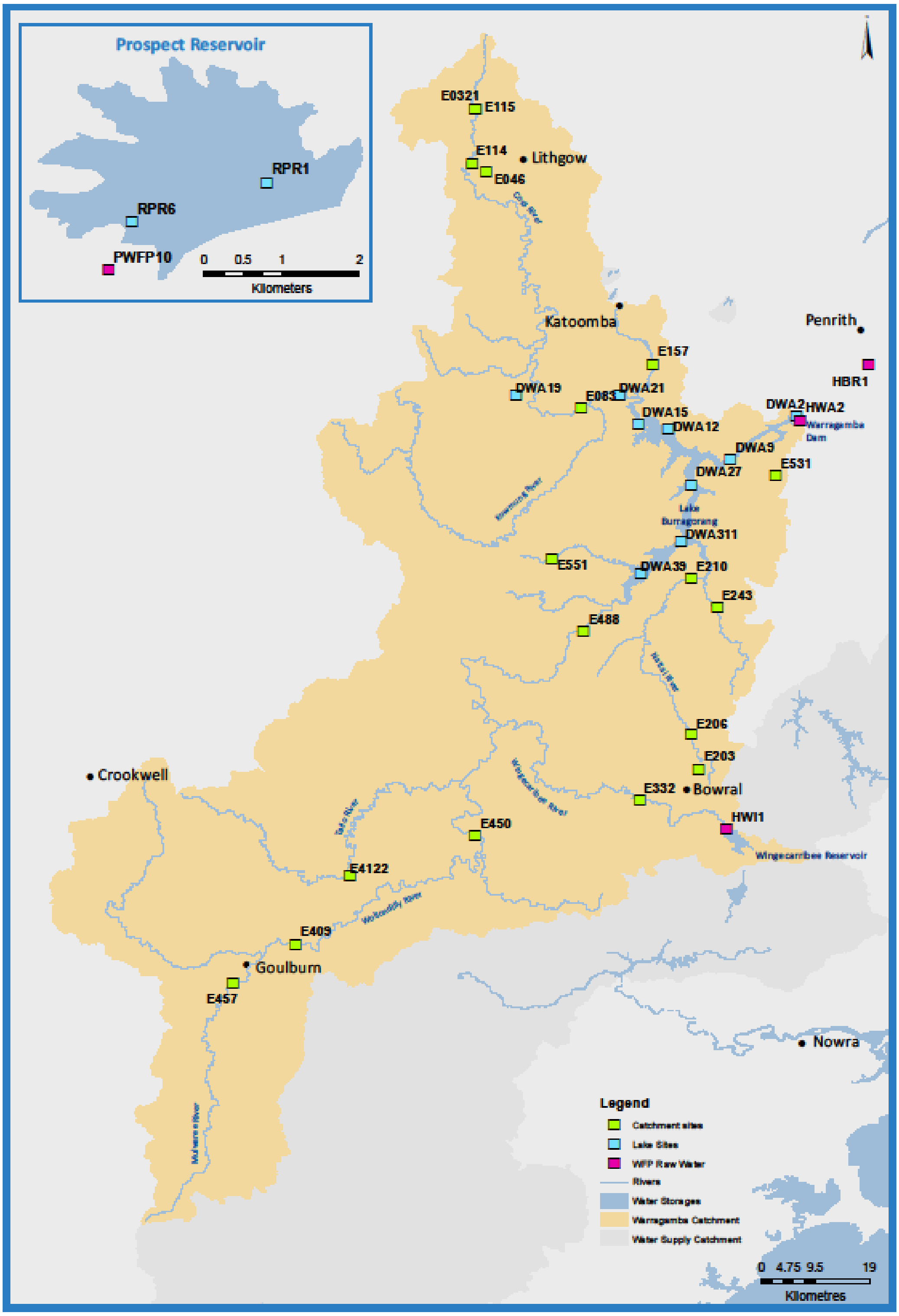

Figure 5.1: Sampling sites in the Warragamba system (Prospect Reservoir inset)

Table 5.1: Warragamba system catchments - percentage of routine samples outside benchmarks

Site	Station Code	Physico-Chemical							Nutrients						Metals			Cyanobacteria	
		Alkalinity (mgCaCO3/L)	Dissolved Oxygen (%Sat)	pH (Lab/Field)	Total Hardness (mgCaCO3/L)	True Colour at 400nm	Turbidity Lab/Field (NTU)	Conductivity (mS/cm)	Nitrogen Total (mg/L)	Phosphorus Total (mg/L)	Filtered Reactive Phosphorus (mg/L)	Oxidised Nitrogen (mg/L)	Ammoniacal Nitrogen(mg/L)	Aluminium Total (mg/L)	Iron Total (mg/L)	Manganese Total (mg/L)	Areal Standard Unit (algae)	Chlorophyll a (ug/L)
Catchments (ANZECC guidelines refer Table 4.4, where there is no applicable benchmark the cells are greyed out).																		
Coxs River D/S Lake Lyell	E0114		58	67			0	92	100	33	25	100	33	50		0		33
Coxs River U/S Lake Lyell	E0115		25	42			0	92	92	0	0	92	17	25		0		0
Coxs River at Lithgow (next to the Power Station)	E0321		36	0			0	100	92	25	0	75	25	67		0		8
Farmers Creek Mt Walker	E046		33	25			0	8	100	75	33	100	33	83		0		17
Coxs River @ Kelpie Point	E083		8	50			17	0	67	25	0	75	8	50		0		17
Kowmung River @Cedar Ford	E130		8	0			17	0	42	17	0	75	17	75		0		17
Kedumba River@ Maxwells Crossing	E157		8	0			0	0	58	0	0	100	25	42		0		0
Gibbergunyah Ck 400m d/s of Mittagong STP Disch.	E203		42	0			0	17	100	92	42	100	100	100		0		0
Nattai River @ The Crags	E206		0	8			0	0	100	42	25	100	17	75		0		0
Nattai River @ Smallwoods Crossing	E210		25	0			25	8	100	17	0	100	92	75		0		25
Little River @ Fireroad W4I	E243		8	25			0	0	50	0	0	100	50	42		0		0
Wingecarribee River @ Berrima	E332		83	8			0	0	100	100	8	100	83	100		0		100
Wollondilly River @ Murrays Flat	E409		75	0			8	83	100	75	8	75	42	100		0		92
Wollondilly at Upper Tarlo	E4122		92	0			8	67	92	50	0	42	67	67		0		42
Wollondilly River @ Golden Valley	E450		33	42			0	58	100	50	0	42	25	83		0		83
Mulwaree River @ Towers Weir	E457		92	8			8	92	100	100	58	42	67	75		0		100
Wollondilly River @ Jooriland (Fowlers Flat)	E488		0	33			17	25	100	42	0	42	33	67		0		17
Werriberri Creek @ Werombi	E531		75	0			0	25	83	17	0	100	100	100		0		8

Site	Station Code	Physico-Chemical							Nutrients					Metals			Cyanobacteria	
		Alkalinity (mgCaCO3/L)	Dissolved Oxygen (%Sat)	pH (Lab/Field)	Total Hardness (mgCaCO3/L)	True Colour at 400nm	Turbidity Lab/Field (NTU)	Conductivity (mS/cm)	Nitrogen Total (mg/L)	Phosphorus Total (mg/L)	Filtered Reactive Phosphorus (mg/L)	Oxidised Nitrogen (mg/L)	Ammoniacal Nitrogen(mg/L)	Aluminium Total (mg/L)	Iron Total (mg/L)	Manganese Total (mg/L)	Areal Standard Unit (algae)	Chlorophyll a (ug/L)
Storages (ANZECC guidelines refer Table 4.3)																		
Lake Burragorang 9km d/s of DWA15	DWA12		46	31			0		100	58	4	100	12	65		0		54
Lake Burragorang @ 4KM U/S BUTCHERS CK.	DWA15		67	50			0		100	17	0	100	0	50		0		67
Lake Burragorang @ Kedumba River arm	DWA19		67	50			0		100	33	0	100	0	50		0		83
Lake Burragorang @ 500m u/s Dam Wall	DWA2		62	19			0		100	38	8	100	8	65		0		38
Lake Burragorang @ Coxs Arm 37km u/s Dam	DWA21		67	50			0		100	33	0	100	0	50		0		83
Lake Burragorang @ Woll. Arm 23 km u/s Dam	DWA27		58	35			0		100	54	12	100	15	65		0		65
Lake Burragorang @ Woll. Arm 300m u/s of Nattai R.	DWA311		50	33			0		100	67	0	100	17	50		0		67
Lake Burragorang @ Wollondilly Arm, 40km from dam	DWA39		50	17			0		100	67	17	100	33	50		0		67
Lake Burragorang @ 14km u/s of Dam Wall	DWA9		52	8			0		100	48	4	100	12	64		0		56
Lake Prospect @ Midlake	RPR1		17	8			0		8	0	0	58	8	42		0		100
Lake Prospect @ Inlet to RWPS	RPR6		17	0			0		0	0	0	67	0	50		0		100
Raw Water (raw water supply agreement site specific standards refer Table 4.2)																		
Orchard Hills WFP raw water	HBR1	0			0	0	0							0	0	0	0	
Warragamba WFP raw water	HWA2	8			0	0	0							0	0	0	0	
Prospect WFP inlet - Channel 2, 2nd dosing bridge	PWFP10	0			0	0	0							0	0	0	17	

5.2.1 Catchments

Water quality in Lake Burragorang's river catchments in 2020-21 showed similar characteristics to previous years, with catchments dominated by agricultural and urban land uses regularly exceeding ANZECC benchmarks. Water monitoring sites in the upstream parts of all the catchments continued to frequently exceed benchmarks, particularly for nutrients and conductivity. Slight improvements are noted in some analytes throughout the catchment when compared to last year indicating the recovery after the fires and floods of 2020 and early 2021.

Sites downstream of sewage treatment plants (Farmers and Gibbergunyah Creeks) continued to regularly exceed benchmarks, particularly for nutrients. This is typical for these sites and represent the input from urban runoff as well as contributions from the sewage treatment plants.

Highly protected natural catchments such as the Kowmung, Kedumba and Little River returned fewer exceedances for most parameters when compared to upstream sites.

The Coxs River continues to show significant effects of pollution sources in the upper catchment, showing notable improvements in the lower Coxs River catchment where the river enters protected areas.

5.2.2 Storages

The lake continued to recover from the impacts of fire and flood throughout the period. The most notable indicator of fireground ingress being increased total and oxidised nitrogen, and to a lesser degree aluminium.

Water was otherwise of good quality in Lake Burragorang for the period and impacts to the supply were minimised through active monitoring and offtake selection.

Chlorophyll *a* continued to show a significant number of exceedances in the Coxs River arm of the lake near the Kedumba River (site DWA19), further downstream at DWA12 exceeded the guideline in all samples. There were no associated algal issues or impacts downstream.

Water quality in Prospect Reservoir was of good quality and posed few challenges for treatment to the Prospect Water Filtration Plant.

5.2.3 Water Filtration Plants

Water supplied for filtration remained of high quality throughout the period. Alkalinity exceeded the supply agreement standard once at Warragamba and algal ASU exceeded the standard twice at Prospect Water Filtration Plant. All samples complied with ADWG for health-related characteristics and customers' water filtration plants continued to treat water to meet ADWG.

5.3 Upper Nepean system

Sampling sites in the Upper Nepean system are shown in Figure 5.2 below.

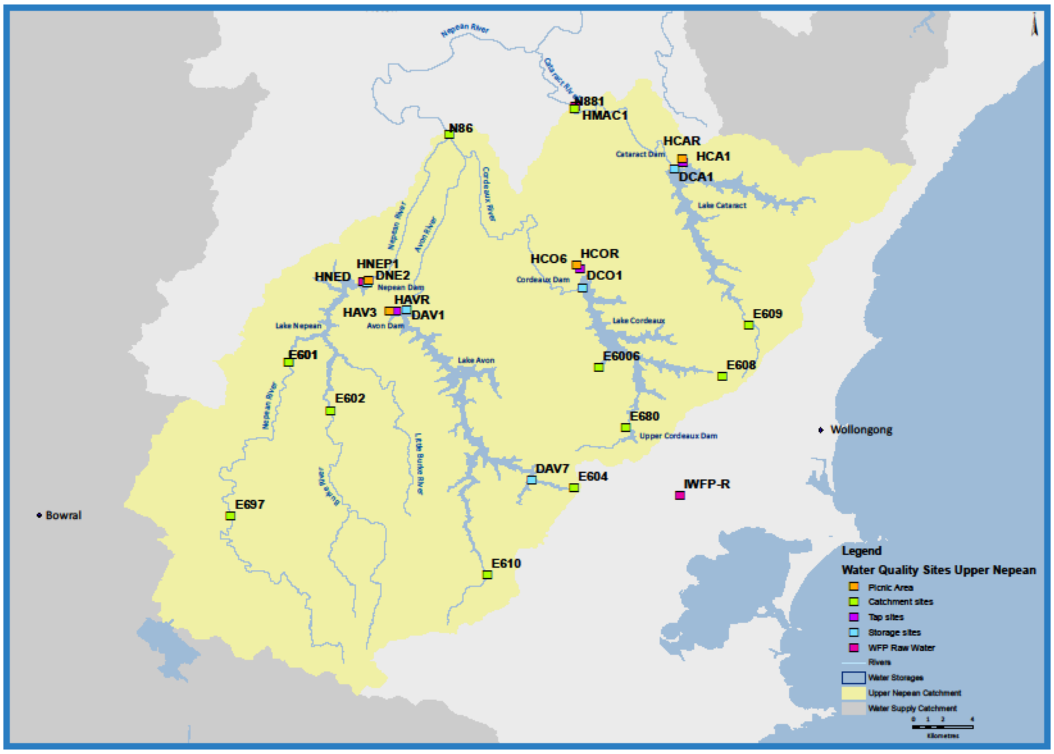

Figure 5.2: Sampling sites in the Upper Nepean system.

5.3.1 Catchments

Water quality across the Upper Nepean catchment sites varies according to land use and natural catchment characteristics. Catchment water quality in 2020-2021 showed similar patterns to the previous year.

The Nepean River and Cordeaux catchments record the highest proportion of nutrient samples outside benchmarks. Despite the available nutrients, chlorophyll *a* was low in the rivers throughout most of the year.

Natural geology and rainfall events are factors which influence water quality. Aluminium was above benchmark at catchment sites which reflects wetter conditions throughout the year. pH is naturally low in some sub-catchments particularly in Sandy Creek and Cataract River. The dissolved oxygen saturation in the flowing rivers is often below the benchmark of 90% saturation. Turbidity increases during rain events then steadily declines. Routine monitoring after inflow events only captured one elevated turbidity result in the Nepean catchment. All other routine monitoring recorded very low turbidity in the catchments.

Table 5.2: Upper Nepean catchments - percentage of routine samples outside benchmarks

Site	Station Code	Physio-Chemical							Nutrients						Metals			Cyanobacteria	
		Alkalinity (mgCaCO3/L)	Dissolved Oxygen (%Sat)	pH (Lab/Field)	Total Hardness (mgCaCO3/L)	True Colour at 400nm	Turbidity Lab/Field (NTU)	Conductivity (mS/cm)	Nitrogen Total (mg/L)	Phosphorus Total (mg/L)	Filtered Reactive Phosphorus (mg/L)	Oxidised Nitrogen (mg/L)	Ammoniacal Nitrogen(mg/L)	Aluminium Total (mg/L)	Iron Total (mg/L)	Manganese Total (mg/L)	Areal Standard Unit (algae)	Chlorophyll a (ug/L)
Catchments (ANZECC guidelines refer Table 4.4). Where there is no applicable benchmark cells are greyed out.																		
Sandy Creek inflow	E6006		25	100			0	0	0	58	0	8	17	100		0		0
Nepean River @ Inflow to Lake Nepean	E601		0	8			8	0	67	17	0	100	0	100		0		17
Burke River @ inflow to Lake Nepean	E602		17	50			0	0	0	0	0	8	8	83		0		0
Flying Fox Creek No.3	E604		17	0			0	0	17	0	0	100	0	42		0		0
Goondarin Creek inflow	E608		42	8			0	0	0	0	0	100	8	100		0		0
Cataract River inflow	E609		83	75			0	0	0	0	0	92	67	100		0		0
Avon River - Summit Tank	E610		25	17			0	0	0	0	0	0	0	50		0		0
Cordeaux River at causeway between U.Cord. 1 & 2	E680		50	33			0	0	0	0	0	42	58	50		0		8
Nepean River @ McGuire's Crossing	E697		17	0			0	0	100	17	0	100	8	100		0		17
Storages (ANZECC guidelines refer Table 4.3)																		
Lake Avon @ Dam Wall	DAV1		33	58			0		0	0	0	100	42	17		0		17
Lake Avon @ Upper Avon Valve Chamber	DAV7		33	25			0		0	8	0	75	42	0		0		67
Lake Cataract @ Dam wall	DCA1		25	75			0		0	25	0	58	58	83		0		25
Lake Cordeaux @ Dam wall	DCO1		42	8			0		25	33	0	50	50	75		0		75
Lake Nepean @ 300m u/s dam wall	DNE2		50	58			0		100	67	0	100	67	92		0		42
Lake Nepean @ Jn Burke Arm at Thermistor Chain	DNE6		58	33			0		92	42	0	100	33	83		0		50
Raw Water (raw water supply agreement site specifications refer Table 4.2)																		
Nepean WFP raw water	HNED	0			0	0	0							0	0	0	0	
Illawarra WFP raw water	IWFP-R	0			0	0	0							0	0	0	0	
Macarthur WFP raw water	HMAC1	0			0	0	0							0	0	0	0	

5.3.2 Storages

Water quality in the Upper Nepean lakes remains at a high standard. Heavy rain fell in August 2020 and March 2021, transporting significant wet weather intrusions into the lakes, resulting in increased organics and catchment-derived metals entering the lakes.

Overall for the year, the lakes recorded a high compliance against most ANZECC benchmarks, aside from samples collected during inflow events. Turbidity was low in all of the routine samples with no exceptions to the ANZECC benchmark. High turbidity recorded during rain events generally does not persist in the lakes for an extended period.

Manganese concentrations were low and achieved full compliance against the ANZECC benchmark. Aluminium continued to be elevated in the Upper Nepean storages other than Lake Avon.

There were rises in available nutrients, particularly phosphorus, which is likely to have entered with inflows. Chlorophyll *a* increases were recorded in all of the lakes, with the highest percentage of exceedance recorded in Lake Cordeaux. Algal concentrations were elevated in Lake Cordeaux from January to May 2021.

5.3.3 Water Filtration Plants

Full compliance with the raw water standards and health related characteristics was achieved for Nepean, Macarthur and Illawarra WFPs.

Wet weather events in August 2020 and March 2021 resulted in minor and major incident level exceedances in the supply to these WFPs, however these were in special samples collected during incidents and are excluded from the routine compliance table below.

Elevated turbidity, metals and resultant high true colour are common during heavy wet weather, with metals and organic matter leached from the catchment. During these events the treated water produced by the WFPs continued to meet the Australian Drinking Water Guidelines.

5.4 Woronora system

Sampling sites in the Woronora system are shown in Figure 5.3 below.

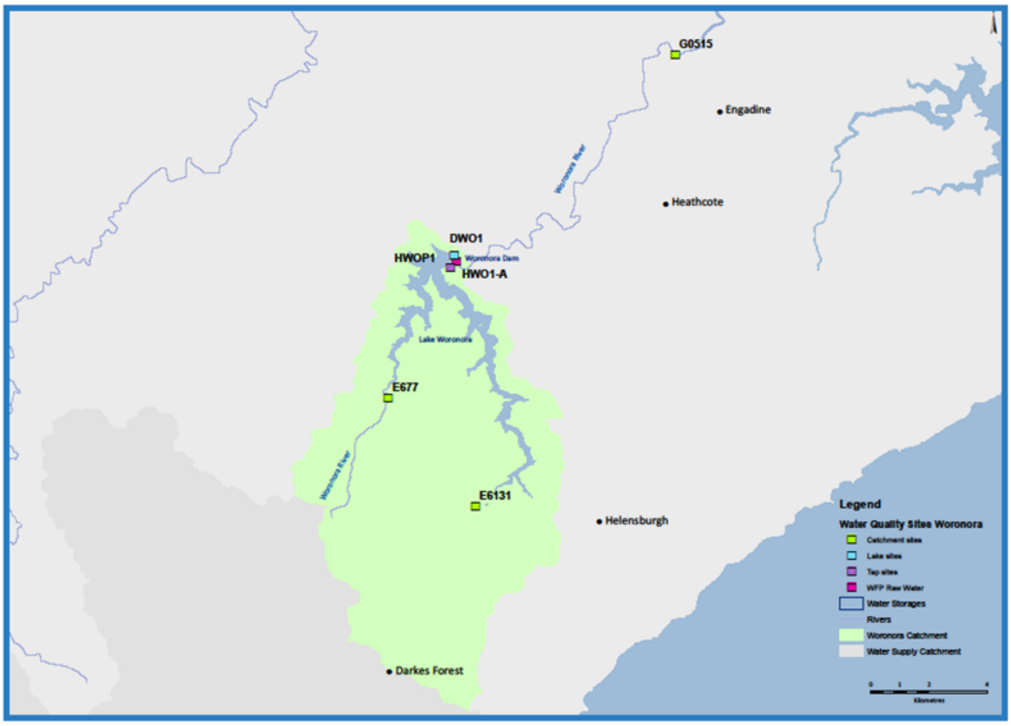

Figure 5.3: Sampling sites in the Woronora system.

Table 5.3: Woronora system catchments - percentage of routine samples outside benchmarks

Site	Station Code	Physio-Chemical							Nutrients						Metals			Cyanobacteria	
		Alkalinity (mgCaCO3/L)	Dissolved Oxygen (%Sat)	pH (Lab/Field)	Total Hardness (mgCaCO3/L)	True Colour at 400nm	Turbidity Lab/Field (NTU)	Conductivity (mS/cm)	Nitrogen Total (mg/L)	Phosphorus Total (mg/L)	Filtered Reactive Phosphorus (mg/L)	Oxidised Nitrogen (mg/L)	Ammoniacal Nitrogen(mg/L)	Aluminium Total (mg/L)	Iron Total (mg/L)	Manganese Total (mg/L)	Areal Standard Unit (algae)	Chlorophyll a (ug/L)
Catchments (ANZECC guidelines refer Table 4.4). Where there is no applicable benchmark cells are greyed out.																			
Waratah Rivulet d/s Flatrock Crossing	E6131		75	8			0	0	8	0	0	8	8	17		0		0
Woronora River	E677		67	100			0	0	8	8	0	8	8	100		0		0
Storages (ANZECC guidelines refer Table 4.3)																			
Lake Woronora @ Dam Wall	DWO1		25	50			0		0	0	0	100	92	100		0		8
Raw Water (raw water supply agreement site specific specifications refer Table 4.2)																			
Woronora WFP	HWO1-A	0			0	0	0							0	0	0	0	

5.4.1 Catchments

Water quality in the Waratah Rivulet and Woronora River was consistently good throughout the year. The largely natural bushland catchment resulted in most water quality characteristics being within ANZECC benchmarks. Where full compliance was not achieved, there was generally only one sample (8%) which was not within the benchmark range.

Aluminium compliance was stable in the Waratah Rivulet, however increases were recorded in the Woronora River. This is likely a reflection of wetter conditions.

The Woronora River recorded a high number of samples outside the pH benchmarks. This is similar to previous years with a low pH is expected due to the surrounding Hawkesbury sandstone.

Dissolved oxygen recorded in the catchment rivers did not meet the ANZECC benchmarks on several occasions. Median concentrations were still high and plentiful for aquatic life.

5.4.2 Storage

Water quality in Lake Woronora remained of superior standard with high compliance against ANZECC benchmarks. Lake quality changed post wet-weather inflows, particularly with rises in true colour and organic carbon, which are not included in the ANZECC catchment assessment. Aluminium concentrations remained elevated following large inflows in 2020.

Nutrients remained low in Lake Woronora and there were no issues with algae. There was a decrease in chlorophyll *a* in comparison to 2019-20.

5.4.3 Water Filtration Plant

Full compliance with the raw water standards was achieved for supply to Woronora WFP. Aesthetic qualities, such as true colour, had increased significantly post wet weather. All samples complied with ADWG for health-related characteristics.

5.5 Blue Mountains system

Sampling sites in the Blue Mountains system are shown in Figure 5.4 below.

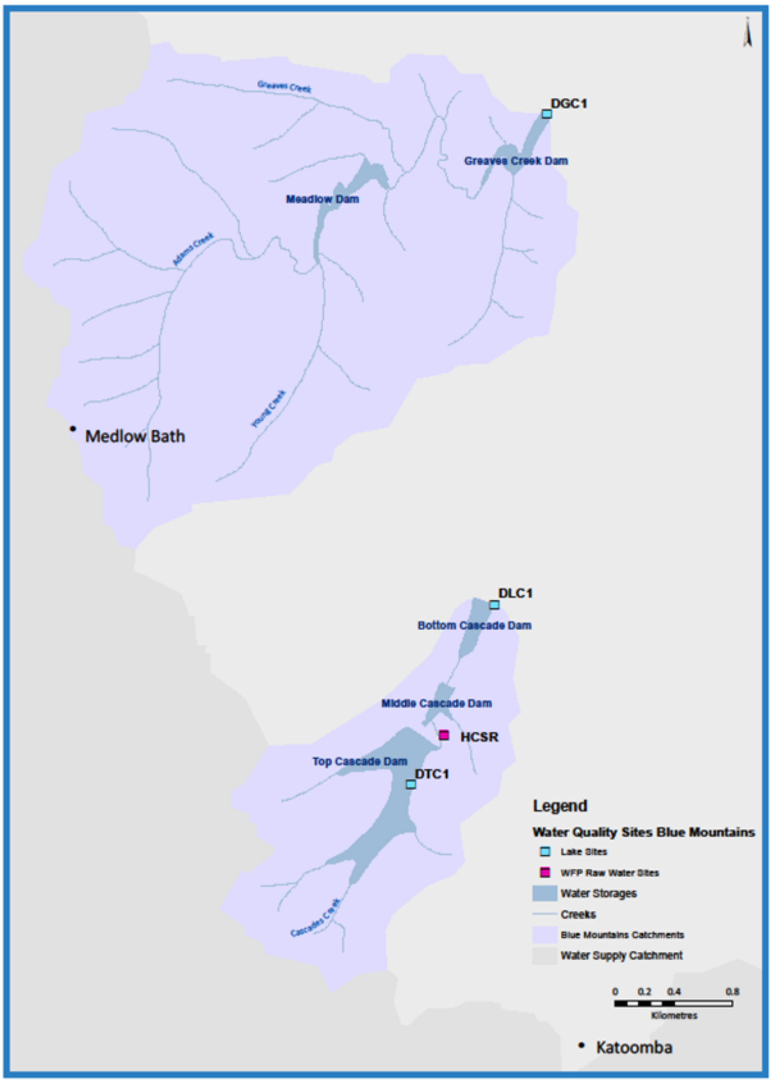

Figure 5.4: Sampling sites in the Blue Mountains system.

Table 5.4: Blue Mountains system storages - percentage of routine samples outside benchmarks

Site	Station Code	Physio-Chemical							Nutrients					Metals			Cyanobacteria	
		Alkalinity (mgCaCO3/L)	Dissolved Oxygen (%Sat)	pH (Lab/Field)	Total Hardness (mgCaCO3/L)	True Colour at 400nm	Turbidity Lab/Field (NTU)	Conductivity (mS/cm)	Nitrogen Total (mg/L)	Phosphorus Total (mg/L)	Filtered Reactive Phosphorus (mg/L)	Oxidised Nitrogen (mg/L)	Ammoniacal Nitrogen(mg/L)	Aluminium Total (mg/L)	Iron Total (mg/L)	Manganese Total (mg/L)	Areal Standard Unit (algae)	Chlorophyll a (ug/L)
Storages (compliance with ANZECC guidelines – refer Table 4.3). Where there is no applicable benchmark cells are greyed out.																		
Lake Greaves @ dam wall	DGC1		17	100			0		0	17	0	33	17	100		0		25
Lake Lower Cascade@ 50m U/S	DLC1		17	17			0		0	33	0	83	50	50		0		17
Lake Top Cascade @ 100m u/s Dam Wall	DTC1		0	25			0		0	17	0	33	8	58		0		58
Raw Water (compliance with raw water supply agreement site specific standards - refer Table 4.2)																		
Cascade WFP raw water	HCSR	0			0	0	0							0	0	0	17	

5.5.1 Catchments

The Blue Mountains catchments are very small (<20 km^2 in total) and inflow quality is represented by water quality in the lakes. There are no routine monitoring sites in the Blue Mountains catchments.

5.5.2 Storages

Water quality in the Blue Mountains lakes experienced some impacts from wet weather events during the year. The Greaves sub-catchment, in particular, is prone to increases in metals and organics post-rainfall.

Aluminium increased in Top and Lower Cascade Lakes. This change is likely to be related to increased rainfall and transfers from Lake Greaves, which recorded the highest concentrations of aluminium.

Dissolved oxygen levels were kept high through use of destratification fans in the lakes. Most samples this year were within the ANZECC benchmark range, which is an improvement from last year.

Increases in phosphorous and nitrogen were recorded in the Blue Mountains. These slightly elevated nutrient concentrations may have sustained increased algal growth. Chlorophyll *a* was more frequently above the benchmark at Top and Lower Cascades Lake compared to last year. The peak chlorophyll *a* in Top Cascade Lake was recorded in May 2021 prior to cooling water temperatures in winter. Chlorophyll *a* improvements were recorded in Lake Greaves this year.

5.5.3 Water Filtration Plant

Water supplied to the Cascade WFP was of a high standard throughout the year, however filter clogging algal concentrations were elevated from March to May 2021. There were two occasions where the algal ASU exceeded the site specific standard (April and May 2021). Water supplied for treatment had 100% conformance with ADWG.

5.6 Shoalhaven system

Sampling sites in the Shoalhaven system are shown in Figure 5.5 below.

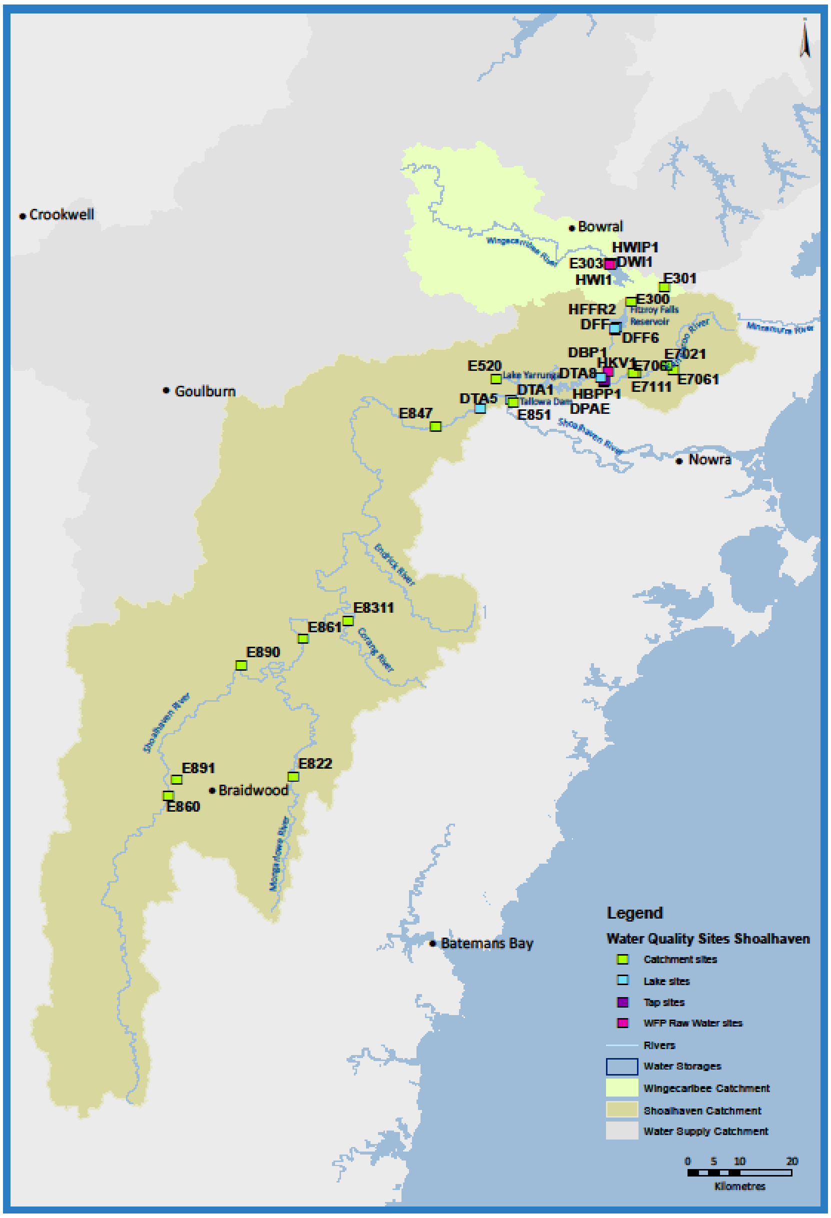

Figure 5.5: Sampling sites in the Shoalhaven system

Table 5.5: Shoalhaven system catchments - percentage of routine samples exceeding benchmarks

Site	Station Code	Physio-Chemical							Nutrients					Metals			Cyanobacteria	
		Alkalinity (mgCaCO3/L)	Dissolved Oxygen (%Sat)	pH (Lab/Field)	Total Hardness (mgCaCO3/L)	True Colour at 400nm	Turbidity Lab/Field (NTU)	Conductivity (mS/cm)	Nitrogen Total (mg/L)	Phosphorus Total (mg/L)	Filtered Reactive Phosphorus (mg/L)	Oxidised Nitrogen (mg/L)	Ammoniacal Nitrogen(mg/L)	Aluminium Total (mg/L)	Iron Total (mg/L)	Manganese Total (mg/L)	Areal Standard Unit (algae)	Chlorophyll a (ug/L)
Catchments (ANZECC guidelines refer Table 4.4). Where there is no applicable benchmark cells are greyed out.																		
Wildes Meadow Creek at gauge	E300		83	8			0	0	100	0	0	100	75	100		0		0
Caalang CK Old Kangaloon Rd Ford	E301		33	8			0	0	100	0	0	100	33	42		0		0
Bundanoon Creek at the Rocks	E520		27	9			18	0	91	9	0	100	73	91		0		9
Brogers Creek@Clinton Park	E7021		17	17			0	0	33	58	8	92	40	92		0		8
Kangaroo River @ Hampden Bridge	E706		8	8			0	0	91	64	9	100	82	82		0		17
Kangaroo River at Oakdale	E7061		33	17			0	0	17	17	0	83	17	83		0		0
Mongarlowe R. at Mongarlowe	E822		75	17			0	0	25	42	0	100	0	100		0		0
Corang River	E8311		45	9			0	0	64	18	0	73	45	100		0		9
Shoalhaven R @ Fossickers Flat	E847		8	0			8	8	75	33	0	92	17	92		0		25
Shoalhaven R @ Mount View	E860		17	8			0	0	58	67	0	50	17	92		0		8
Shoalhaven R @ Hillview	E861		25	0			25	0	58	58	8	75	50	100		0		33
Boro Ck @ Marlowe	E890		100	45			9	0	100	67	0	33	33	100		0		33
Gillamatong Creek @ Braidwood	E891		92	8			0	75	100	75	17	33	25	50		0		67

Site	Station Code	Physio-Chemical							Nutrients					Metals			Cyanobacteria	
		Alkalinity (mgCaCO3/L)	Dissolved Oxygen (%Sat)	pH (Lab/Field)	Total Hardness (mgCaCO3/L)	True Colour at 400nm	Turbidity Lab/Field (NTU)	Conductivity (mScm-1)	Nitrogen Total (mg/L)	Phosphorus Total (mg/L)	Filtered Reactive Phosphorus (mg/L)	Oxidised Nitrogen (mg/L)	Ammoniacal Nitrogen(mg/L)	Aluminium Total (mg/L)	Iron Total (mg/L)	Manganese Total (mg/L)	Areal Standard Unit (algae)	Chlorophyll a (ug/L)
Storages (ANZECC guidelines refer Table 4.3)																		
Lake Fitzroy Falls @ Midlake	DFF6		8	33			0		75	67	0	67	67	75		0		92
Lake Yarrunga@ 100m from Dam Wall	DTA1		50	0			8		75	75	8	92	50	83		0		67
Lake Yarrunga @ Shoalhaven River	DTA5		42	0			8		67	75	17	92	58	92		0		58
Lake Yarrunga @ Kangaroo River at Bendeela PS	DTA8		33	8			0		67	100	50	92	92	100		0		58
Wingecarribee Lake at outlet	DWI1		33	0			0		83	92	0	75	33	92		0		92
Bendeela Pondage	DBP1		0	0			0		50	100	0	67	67	100		0		83
Raw Water (raw water supply agreement site specifications refer Table 4.2)																		
Kangaroo Valley WFP Inlet	HKV1	0		0	0	0	0								0		17	
Wingecarribee WFP raw water	HWI1	0		0	0	0	0								0		0	

5.6.1 Catchments

Water quality was consistent with previous years, with sampling sites in agricultural and urbanised regions continuing to regularly exceed ANZECC benchmarks.

Water quality in the upper catchment sites such as Boro Ck in the Shoalhaven and Wildes Meadow Creek and Caalang Creek in the Kangaroo River remain poor, with regular exceedances for dissolved oxygen, nutrients and aluminium, though both sites have shown an improvement in phosphorus concentration and chlorophyll *a*.

Aluminium continues to regularly exceed the guidelines at all sites, and nutrients continue to be high across the system.

5.6.2 Storages

Analysis of the storages in the Shoalhaven system continue to return high exceedance rates for chlorophyll *a* and nutrients. This is typical of the Shoalhaven system and reflects the agricultural land use in the catchment.

Aluminium concentrations continued to be high across the Shoalhaven storages, with sites within Lake Yarrunga regularly exceeding the guidelines. The high levels of aluminium are typical of the geology of the region with fireground ingress from these catchments contributing to high concentrations of aluminium.

Fitzroy Falls Reservoir showed a slight improvement in nutrients, chlorophyll *a* and dissolved oxygen. Nutrient and chlorophyll *a* concentrations in Bendeela Pondage remain high exceeding benchmarks in most samples. Dissolved oxygen concentrations improved this year with all samples falling within the target range.

5.6.3 Water Filtration Plants

Raw water supplied to Kangaroo Valley Water Filtration Plant exceeded relevant standards for algal ASU on two occasions, up from one in the previous year. These results did not cause problems for treatment processes. All samples complied with ADWG for health-related characteristics.

Wingecarribee WFP effectively managed the risk of algal cells and toxins through the use of dissolved air floatation and powdered activated carbon in the treatment process. Cyanobacterial blooms were managed in accordance with Water Quality Incident Response Protocol throughout the monitoring period and details of incidents involving potential toxin producing cyanobacteria in Wingecarribee Reservoir are reported in section 8.1.

Water supplied for treatment had 100% conformance with ADWG.

5.6.4 Recreational Monitoring

Fitzroy Falls exceeded the minor alert benchmark for primary contact on four occasions. On each occasion *Microcystis* sp. and *Radiocystis* sp. were present although concentrations were well below the major benchmark. No other exceedances were recorded.

Lake Yarrunga recorded high concentrations of enterococci in three samples for the year. Each occasion triggered the primary contact major alert benchmark (> 200 cfu/100 mL). Minor inflow events were recorded around these sampling dates.

Table 5.6: Recreational monitoring - percentage of samples exceeding benchmarks

Site	Station Code	Primary Contact Minor Alert Benchmark Percentage Exceedance				Secondary Contact & Primary Contact Major Alert Benchmark Percentage Exceedance			
		Enterococci (cfu/100 mL)	Microcystin LR+ YR + RR (µg/L)	Toxic Cyanobacterial biovolume (mm3/L)	Toxic Cyanobacterial cell count (cells/mL)	Enterococci (cfu/100 mL)	Microcystin LR+ YR + RR (µg/L)	Toxic / Total Cyanobacterial biovolume (mm3/L)	Toxic Cyanobacterial cell count (cells/mL)
Recreational monitoring (MRRW and ADWG guidelines – refer Table 4.5).									
Fitzroy Falls	DFF6	0	0	0	11	0	0	0	0
Lake Yarrunga	DTA8	25	0	0	0	25	0	0	0

5.7 Algal monitoring

All routine catchment and lake samples are analysed for algae if chlorophyll *a* exceeds 5 µg/L. Selected lake sites, which are the closest point to supplying water filtration plants have unconditional algae counts and speciation undertaken regardless of chlorophyll *a*. At locations with a history of algal activity, seasonal monitoring is conducted more frequently in the warmer months between October and May to facilitate early detection of emerging algal events. Routine algal monitoring is also undertaken in raw water supplied to water filtration plants. Statistical summaries are provided in Appendix A. Refer to section 4.7 for relevant benchmarks.

5.7.1 Warragamba system

A slight improvement is noted in the Coxs River catchment with regard to chlorophyll *a* exceptions, particularly in the downstream sites and in the Kowmung River.

A significant increase in the number of exceptions for chlorophyll *a* was experienced in the Wollondilly catchment samples, particularly in the Mulwaree River an at the Wingecarribee River at Berrima which exceeded benchmarks in 100% of samples. Potentially toxin producing cyanobacteria were once again rarely detected.

Similar to previous years, a brief increase in potentially toxin producers was noted in the Wingecarribee River at Berrima during late December 2020 and early January 2021, though the numbers remained relatively low with a peak of only 798 cells/mL, and a six month bloom of potentially toxin producing species in Mulwaree River at Towers Weir, peaking in March 2021 with 33,700 cells/mL.

A single positive sample for potentially toxin producing cyanobacteria was noted at Kelpie Point on the Lower Coxs River.

In the major tributaries of Lake Burragorang low numbers of, potentially toxin producing cyanobacteria persisted in the counts throughout the lake, peaking with only 5,900 cells/mL at DWA15 (Butchers Creek).

Downstream in the gorge, sporadic positive detections of potentially toxin producing cyanobacteria occurred throughout the year, with a minor bloom occurring in April and May of 2021. Though the counts generally returned low populations of these organisms, one notable sample returned a count of 24,040 cells/mL. The impact of these organisms was effectively avoided through selectively withdrawing water for supply from a position deep in the water column.

Chlorophyll *a* concentrations in Prospect Reservoir exceeded the benchmarks more frequently this year, with 100% of the samples at both the mid lake site and at the inlet to the RWPS recording results above the threshold. Low to moderate concentrations of potentially toxin producing algal species were periodically recorded but remained well below levels of concern. No algal toxins (combined microcystin) were detected during the reporting period.

Algal ASU at Prospect exceeded Raw Water Supply Agreements on two occasions while there were no exceedances recorded at Orchard Hills or Warragamba related to algae.

5.7.2 Upper Nepean system

Catchment sites in the Upper Nepean system continue to record very low chlorophyll *a* concentrations. The Nepean and Cordeaux catchments typically have the highest chlorophyll *a* in rivers. This was recorded again this year, with the maximum concentrations recorded in the Nepean River (E697) at 8.3 µg/L closely followed by the Cordeaux River (E680) at 7.8 µg/L. These were seasonal spikes and the annual median for these sites was low at <2.5 µg/L.

All of the lakes in the Upper Nepean recorded rises in chlorophyll *a*. Algal concentrations were highest in Lake Cordeaux, with elevated concentrations sustained for most of the year. The maximum of 13,360 ASU/mL was recorded in March with the dominant contributor being a green alga, *Ankistrodesmus falcatus*. High concentrations of filter clogging algae were avoided through system configuration and selective offtake at the dam. Spill of the dam in May followed by cooling ambient conditions in winter reduced the algal concentrations in the lake.

The Upper Lake Avon recorded 67% samples above the ANZECC chlorophyll *a* benchmark, compared to only 8% last year. The raw water recorded minor incident level of filter clogging algae in May with a result of 2,879 ASU/mL. Green algae, *Ankistrodesmus falcatus*, contributed the largest proportion to the filter clogging load. There was also an alert range potentially toxin producing cyanobacteria concentration (0.127 mm^3/L *Radiocystis* sp.) in May. Conditional toxin analysis was triggered which returned nil microcystin (combined LR+RR+YR at <0.3 µg/L). There were no potentially toxin producing cyanobacteria recorded from the lake samples during May, however earlier in March low concentrations were recorded.

Throughout the year there were two occasions of potentially toxin producing cyanobacteria detections in Lake Nepean and one in the Nepean raw water. The concentrations were very low and well below the alert level (>1,000 cells/mL). Cataract and Cordeaux lakes recorded nil potentially toxin producing cyanobacteria throughout the year.

There was no impact on raw water supplied to Illawarra, Nepean and Macarthur water filtration plants.

5.7.3 Woronora system

Chlorophyll *a* remained below the threshold for algal analysis in the Waratah Rivulet and Woronora River throughout the year. Chlorophyll *a* in Lake Woronora only rose above 5 µg/L in December. Algal concentrations were low in the lake throughout the year, with nil potentially toxin producing cyanobacteria throughout the year.

5.7.4 Blue Mountains system

Chlorophyll *a* and algal concentrations recorded a rise this year in Top Cascade Lake. An algal bloom dominated by the diatom *Synedra* was recorded between March to June 2021. April and May recorded very high filter clogging algal concentrations exceeding the supply agreement standard at the inlet to Cascade Water Filtration Plant. The peak algal load to the WFP was at 3,705 ASU/ in April mL, while the peak chlorophyll *a* was in May at 14.1 µg/L. The WFP was challenged from algal ingress, along with a combination of water quality factors, however WaterNSW worked with Sydney Water, providing jar samples for testing to optimise treatment processes and all treated water continued to meet guidelines.

There was a once-off detection of the potentially toxin producing cyanobacteria *Phormidium* in Top Cascade Lake during December. This alga is known to produce cyanotoxins as well as taste and odour compounds. Otherwise, there were no other detections of potentially toxin producing cyanobacteria during 2020-2021 in the Blue Mountain storages.

Chlorophyll *a* was elevated during October to November 2020 due to presence of small cyanophyta. Overall, there were improvements in algal concentrations compared to last year. Decreases seen this year may be related to the dam spilling water containing the algal cells downstream during a time when conditions are typically favourable for algal growth.

5.7.5 Shoalhaven system

A moderate general improvement in chlorophyll *a* exceedances is noted throughout the Shoalhaven catchment when compared to last year's results.

The Upper Shoalhaven River sites continue to show similar numbers of exceedances as last year, with two-thirds of samples exceeding the benchmark at Gillamatong Creek, and approximately a third of samples at the other two sites.

Chlorophyl a concentrations were significantly lower in the Kangaroo River sites compared to last year, with the Hampden Bridge site recording only 17% of samples above the benchmark and Wildes Meadow Creek and Caalang Creek both recording nil exceedances.

All storages in the Shoalhaven system once again exceeded the chlorophyll *a* benchmark regularly throughout the year.

Low numbers of potentially toxin producing cyanobacteria were present in most samples in Bendeela pondage, peaking in March 2021 with 2,810 cells/mL of these organisms.

Likewise, Fitzroy Falls returned low to moderate detections of potentially toxin producing cyanobacteria throughout the year, peaking at DFF6 returning 12,130 cells/mL in January 2021.

Once again, potentially toxin producing cyanobacteria blooms persisted in Wingecarribee Reservoir throughout the year, though positive detections of combined microcystin toxin were relatively rare, peaking in November 2020 recording a concentration of 0.51 µg/L (ADWG health guideline is 1.3 µg/L).

Raw water supplied to Kangaroo Valley Water Filtration Plant exceeded the site specific standard for algal filter clogging potential (ASU) in July 2020 and January 2021. Supply to Wingecarribee WFP complied with the guidelines throughout the reporting period with no ASU exceedances.

5.8 *Cryptosporidium* and *Giardia* monitoring

Routine monitoring is undertaken in catchments, storages and delivery networks at varying frequencies as agreed between WaterNSW, Sydney Water and NSW Health. Statistical summaries are provided in Appendix A.

5.8.1 Catchments

Routine monitoring for *Cryptosporidium* and *Giardia* is undertaken at seven selected streams in the Warragamba catchment as part of the pathogen monitoring program. The sampling schedule is monthly, except for Werriberri Creek (E531) which is weekly. This section discusses routine monitoring for *Cryptosporidium* and *Giardia*, refer to Section 7.1 for wet weather monitoring.

Cryptosporidium oocysts were detected in three samples from two of the catchment sites during the reporting period, all at alert level (<10/10 L). *Giardia* cysts were detected at minor incident levels in one sample at each of four of the catchment sites during the reporting period. A rain event in December resulted in 138 cysts/10 L at E210, although no incident was recorded as this site falls outside of the catchment site group. The occurrence of pathogens increased generally compared to the previous year, which is not unusual following large inflows at the end of a drought.

5.8.2 Storages

Routine monitoring was conducted weekly at Prospect (RPR1) and Wingecarribee (DWI1) reservoirs, in the Warragamba to Prospect pipeline (COMP2 or HWA1/HWA2), and monthly at Prospect Reservoir (RPR6). Fortnightly sampling of water from the Oberon pipeline at Leura (HOP6) was undertaken when on supply Top Cascade.

Of the 251 routine samples collected during the reporting period, *Cryptosporidium* was detected in 32 (13%) with two in the minor incident range, and *Giardia* were detected in 32 (13%) with two in the minor incident range.

5.8.3 Water Filtration Plants

A joint monitoring program for raw water at the inlet of Sydney Water's water filtration plants is undertaken by Sydney Water and results are provided to WaterNSW and NSW Health. Larger sample volumes (up to ~100 L) are used to improve the detection limit and assist in quantifying catchment risk.

There were no incident level detections (i.e. ≥10 oocysts/10 L) of *Cryptosporidium* from routine monitoring of water filtration plants during the reporting period. One *Giardia* minor incident occurred at Nepean raw water (HNED), where 14.4 cysts/10 L were detected from additional monitoring during the heavy rain event in August. One *Giardia* minor incident occurred at Wingecarribee raw water (DWI1), where 53.3 cysts/10 L were detected during a dry period in July but investigation did not reveal a hazardous event.

Cryptosporidium was detected at alert levels (≥1 (oo)cysts/10 L) once each at two raw water supplies during the reporting period; Cascade (HCSR) and Macarthur (HMAC1) and on 12 occasions at Nepean (HNED). *Giardia* exceeded the alert threshold infrequently at Cascade, Macarthur, Illawarra and Woronora but was detected in 50% of the Nepean (HNED) raw water samples. Preliminary investigations into the cause of the increased (oo)cyst detections at Nepean suggests a possible link to Shoalhaven transfers, which is being investigated further.

5.9 Picnic area monitoring

WaterNSW undertakes routine monitoring at picnic taps where the water is supplied directly from the storages or where potable water is carted in, both water sources undergo chlorination prior to distribution. Annual monitoring is also done at the picnic areas which receive reticulated town water.

Table 5.9: Picnic areas - percentage of samples exceeding benchmarks

Site	Station Code	pH (Lab/Field)	Turbidity Lab/Field (NTU)	Aluminium Total (mg/L)	Iron Total (mg/L)	Manganese Total (mg/L)	Free Chlorine residuals (mg/L)	Chlorophyll a (ug/L)	Toxic Cyanobacteria (cells/mL)	Microcystin variants (µg/L)	*E. coli* (orgs/100 mL)
Picnic taps (ANZECC guidelines refer Table 4.6).											
Avon Picnic Area Tap	HAV3	15	2	0	4	0	100	0	-	-	2
Cataract Picnic Area Fountain	HCA2	25	2	0	25	6	96	0	-	-	2
Cordeaux Picnic Area Tap	HCO6	0	17	0	100	15	96	0	-	-	2
Fitzroy Falls Picnic Area Tap	HFFR2	2	2	8	8	2	24	0	-	-	0

Closure of the picnic areas throughout the year impacted water quality due to low usage. Low residual chlorine was again observed in the picnic area end taps due to the long residence time in the reticulation resulting in chlorine decay. The efficacy of chlorination is validated based on chlorine concentrations and contact times at the treatment plants and is verified by the absence of indicator bacteria and presence of chlorine residuals in the reticulation.

Turbidity has improved at most sites particularly at Cataract following the installation of the drinking water fountains. Cordeaux saw a slight increase in exceedances where low water usage at times has resulted in stripping of biofilms. Routine flushing has been implemented at the site.

Iron concentrations at Cordeaux picnic area have increased this year which is also largely attributed to low water usage in the reticulation as well as source water concentrations. Cataract has seen improvements in metal exceedances due to the installation of fountains.

Raw water at Lake Cataract has seen a slight increase in results below pH targets with 25% of samples below 6.5 units. Avon picnic area supply has seen samples becoming more alkaline at the end tap with 15% of samples above the 8.5 target. Samples at the end tap are more alkaline than raw water and at the dosing reservoir.

6 Monitoring for the Water Licences

6.1 Water quality

Sampling of downstream storages is undertaken in accordance with the requirements of the Water Licences. Table 6.1 reports the results of downstream sampling against the ANZECC benchmarks.

Table 6.1: Downstream of storages - percentage of samples exceeding benchmarks

Site	Station Code	Number of samples	pH (Lab/Field)	Turbidity Lab/Field (NTU)	Dissolved Oxygen (%Sat)	Nitrogen Total (mg/L)	Phosphorus Total (mg/L)	Chlorophyll a (ug/L)
Wingecarribee River								
Wingecarribee River @ Sheepwash Bridge	E303	12	0	0	75	42	0	92
Shoalhaven River								
Shoalhaven R @ d/s Tallowa Dam	E851	10	9	0	0	42	8	67
Woronora River								
Woronora River @ the Needles	G0515	12	25	0	17	8	0	33
Nepean River								
Nepean River @ Yarramundi	N44	12	0	0	17	100	0	75
Nepean River at Penrith Weir	N57	12	0	0	8	92	0	67
Nepean River 500m D/S of confluence of Warragamba River	N64	12	0	8	33	100	8	67
Warragamba River U/S of confluence of Nepean River	N641	12	0	8	25	100	8	33
Nepean River @ Wallacia Bridge	N67	12	0	8	25	100	17	100
Nepean River @ Sharpes Weir	N75	12	0	0	8	100	0	58
Nepean River @ Menangle Br	N85	12	8	0	33	17	0	33
Pheasant's Nest Weir Pool	N86	12	0	0	0	17	8	0
Cataract River @ Broughtons Pass	N881	12	8	0	0	0	0	0
Nepean River @ Maldon Weir	N92	12	50	0	50	33	0	25

Wingecarribee River nitrogen concentrations have improved with only 42% of samples exceeding guidelines compared with 100% of samples from last year. pH at the Sheepwash Bridge site was within targets in all samples collected. Dissolved oxygen has increased slightly in the system. Although overall river health has improved chlorophyll *a* continues to exceed ANZECC guidelines.

The downstream Shoalhaven River site was sampled 10 times in the year due to access issues. Water quality is similar to previous years with nitrogen exceeding guidelines in 42% or samples. Chlorophyll *a* concentrations have increased this year likely due to increased algal activity in the upstream storage.

The Woronora River downstream site saw similar water quality to last year which has been an improvement on historical trends. Chlorophyll *a* concentrations were in line with previous years, exceeding 5 μg/L in 33% of samples.

Water quality in the Nepean River system typically declines in a downstream direction. Increases in nutrient loads have been observed at most sites which is likely related to run-off from fire burnt catchments. Chlorophyll *a* concentrations has increased in the system indicating increased algal activity. Dissolved oxygen concentrations have improved due to increased flows while only minor exceedances in turbidity were recorded.

7 Targeted and investigative monitoring

WaterNSW undertakes targeted and investigative monitoring to understand and assess impacts that are not addressed by the routine monitoring program. The results of the monitoring are discussed in greater detail in the sections below.

A summary of water quality incidents during the reporting period is included in Section 8.

7.1 Wet weather inflow monitoring

WaterNSW conducts wet weather sampling to assist in evaluating impacts on water quality from runoff during significant rainfall events. A key component of the wet weather monitoring program is the use of autosampler stations at strategic catchment sites which are programmed to automatically take samples once a river height trigger has been reached.

Wet weather monitoring is used to quantify the water quality risks from inflows to storages. During high rainfall events, catchments are often closed to operational traffic and storages closed to boat traffic to protect the health and safety of staff and members of the public. Using autosamplers helps to acquire valuable water quality information on the water quality effects of rainfall events.

Autosamplers are programmed to collect samples for:

- total organic carbon, suspended solids, total phosphorus, total nitrogen, total aluminium, total iron and total manganese (Type 1).
- Cryptosporidium and Giardia (Type 2), (plus total nitrogen, total phosphorus at site E203 only).
- Or both Type 1 and Type 2.

Where specific water quality issues have been identified, additional characteristics are analysed on request. At high priority reservoir inflow locations, both autosampler types have been installed. Given the differing sampling mechanisms, trigger values may differ between the two autosampler types. Type 2 samples are reserved for locations identified as potentially significant pathogen sources, requiring a much larger sample volume (hence the lower number of samples). Appendix B tabulates the number of samples collected from Type 1 and Type 2 autosamplers for each site during the year.

7.2 Catchment Risk Characterisation

The average pathogen risk for catchments supplying each storage lake was determined from an assessment of catchment hazards and historical water quality data based on the Health Based Targets (HBT) procedure developed by Water Services Association of Australia (WSAA).

It is recognised that the greatest challenges to water treatment occur during heavy rain events when contaminants from the catchment and higher river flows result in poor water quality. At such times water quality monitoring is increased at raw water intakes and selected catchment and storage sites. The Pathogen Campaign Monitoring Program was instituted to enhance pathogen monitoring during high inflow events at selected catchment sites to allow the pathogen risk to be refined during events.

Cryptosporidium hazard assessment is conducted weekly based on a range of factors to inform any decisions on potential advisory for boil water if filtration plants fail their turbidity targets. During an event the pathogen risk factors such as the condition of the storages and catchments, rainfall, inflow volumes, reports of overflows from sewage treatment plants, dairy effluent ponds and stormwater overflows, and turbidity and pathogen data are used to reassess pathogen risk more often.

During the reporting period there were four events in July and August that triggered autosamplers, resulting in 40 samples tested for pathogens, of which *Cryptosporidium* oocysts and *Giardia* cysts were detected in 13 and 19 samples respectively.

7.3 Macroinvertebrate monitoring

Macroinvertebrates are monitored annually under the Macroinvertebrate Monitoring Program (MMP) as a catchment health indicator across the Sydney Drinking Water Declared Catchment. In 2020, all 86 scheduled sites were sampled. Since the previous sampling year, drought conditions eased across the declared catchment. Large areas of the catchment were also affected by fire in the 2019/2020 'Black Summer', and this would have influenced macroinvertebrate habitat and community structure at many of the sampling sites.

Figure 7.1 shows the distribution of 2020 and 2019 AUSRIVAS band grade ratings for each individual catchment. Of the 77 sites monitored in both 2019 and 2020, 43 received a lower AUSRIVAS score value in 2020, and 34 received a higher AUSRIVAS score. This suggests there was an overall decline in macroinvertebrate health across the declared catchment, although the change in OE50 score value at each site was not always large enough to result in a change of AUSRIVAS band grade.

Across the Warragamba, Tallowa, Metropolitan (Upper Nepean) and Woronora catchments, most sites in 2020 were rated as below reference (AUSRIVAS band B). Macroinvertebrate health improved in the Warragamba catchment in 2020, with 15 sites increasing, and seven sites decreasing by one band grade. There was an overall decline in macroinvertebrate health in the Tallowa and Metropolitan catchments, which had six and four sites moving to a lower band grade, respectively and no sites increasing in band grade. Both sites in the Woronora catchment declined by one band grade. The Blue Mountains catchment site improved by two band grades from 2019. Further site information and site-averaged AUSRIVAS scores are presented in Table 7.1.

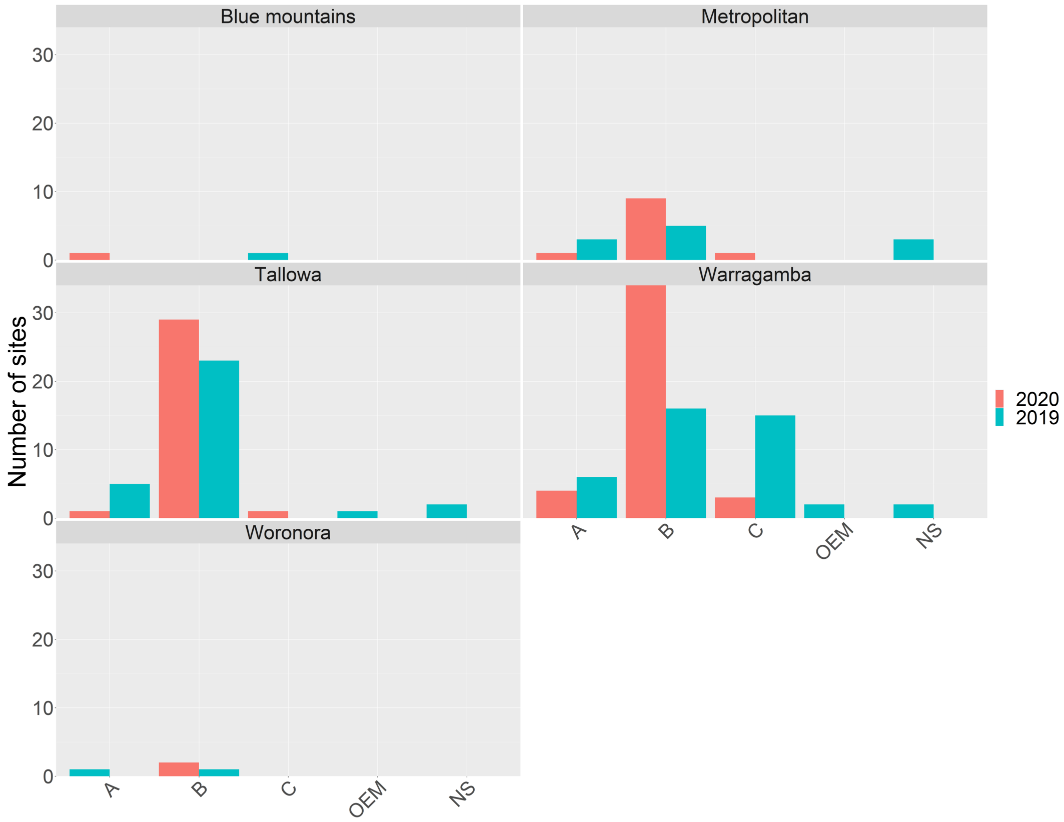

Figure 7.1: Distribution of AUSRIVAS band grades for sites monitored in 2019 and 2020. Band grades are Above Reference (X), Reference (A), Below Reference (B), Well Below Reference (C), Outside experience of the AUSRIVAS model (OEM) or Not Sampled (NS).

Table 7.1: Mean AUSRIVAS scores for sites monitored in 2019 and 2020. Band grades are Above Reference (X), Reference (A), Below Reference (B), Well Below Reference (C), Outside experience of the AUSRIVAS model (OEM) or Not Sampled (NS). AUSRIVAS band thresholds are adjusted to the mean edge and riffle band value for sites where both edge and riffle habitats were sampled.

Sub-catchment	Site	Site Name	OE50		Band Grade	
			2020	2019	2020	2019
Warragamba Dam catchment						
Kowmung	E130	Kowmung River at Cedar Ford	0.84	0.30	A	C
Lake Burragorang	MMP59	Butchers Creek u/s of Lake Burragorang	0.57	NS	B	NS
Little River	E243	Little River at Fire Trail W4I	0.59	NS	B	NS
Lower Cox's	E153	Leura Falls Creek at FT W7F	0.69	0.35	B	C

Lower Cox's	E157	Kedumba River at Kedumba Crossing	0.75	0.32	B	C
Mid Cox's	E0114	Cox's River d/s Lake Lyell	0.82	OEM	B	OEM
Mid Cox's	E083	Cox's River at Kelpie Point	0.85	0.37	A	C
Mid Cox's	MMP276	Lowther Creek @ Ecclesbourne	0.74	1.12	B	A
Mid Cox's	MMP55	Little River at Six Foot Track	0.80	0.38	B	C
Mulwaree	A5	Mulwaree River at Lake Bathurst	0.68	OEM	B	OEM
Mulwaree	E457	Mulwaree River at Towers Weir	0.68	0.51	B	B
Mulwaree	MMP188	Mulwaree River @ Currawang Rd	0.60	0.78	B	B
Nattai	E203	Gibbergunyah Creek at Welby	0.42	0.26	C	C
Nattai	E206	Nattai River at The Crags	0.68	0.61	B	B
Nattai	E210	Nattai River at the causeway	0.79	0.44	B	C
Nattai	MMP277	Drapers Creek at Colo Vale Firetrail	0.57	0.71	B	B
Nattai	MMP278	Nattai Creek @ Wombeyan Caves Rd	0.76	0.60	B	B
Nattai	MMP279	Nattai River d/s Mittagong pool	0.56	0.49	B	B
Upper Cox's	A16	Cox's River at Lidsdale	0.49	0.46	B	C
Upper Cox's	E0115	Cox River u/s Lake Lyell	0.86	0.77	A	B
Upper Cox's	E0321	Coxs River at Lithgow	0.58	0.96	B	A
Upper Cox's	E046	Farmers Creek d/s of Lithgow STP	0.50	0.54	B	B
Upper Cox's	MMP280	Farmers Creek u/s STP at Geordie St	0.60	0.44	B	B
Upper Wollondilly	MMP27	Wollondilly River at Goonagulla	0.57	0.86	B	A
Upper Wollondilly	MMP281	Mount Wayo Creek @ Fenwicks Ck Rd	0.51	1.02	B	A
Upper Wollondilly	MMP282	Sooley Creek @ Crookwell Rd	0.56	0.68	B	B
Upper Wollondilly	Uwol1	Wollondilly River at Baw Baw Bridge	0.50	0.54	B	B
Werri Berri	E531	Werri Berri Creek at Serenity Park	0.67	0.35	B	C
Wingecarribee	E301	Caalang Creek @ Maugers	0.68	0.41	B	C
Wingecarribee	MMP283	Medway Rivulet at Cosh Park	0.80	0.55	A	B
Wingecarribee	MMP284	Whites Creek @ Cosgrove Park	0.17	0.27	C	C
Wingecarribee	MMP285	Mittagong Creek @ Mount Rd	0.50	0.36	B	C
Wingecarribee	U10	Wingecarribee River at Berrima	0.51	0.46	B	C
Wingecarribee	Winge2	Wingecarribee River at Greenstead	0.64	0.95	B	A
Wollondilly	E409	Wollondilly River d/s Goulburn STP	0.36	0.68	C	B
Wollondilly	E4122	Wollondilly River at Upper Tarlo	0.56	0.43	B	C
Wollondilly	E450	Wollondilly River at Golden Valley	0.46	0.71	B	B
Wollondilly	E488	Wollondilly River at Jooriland	0.74	0.35	B	C
Wollondilly	E5001	Wollondilly River u/s Goulburn STP	0.63	0.82	B	B
Wollondilly	MMP130	Tarlo River at Swallowtail Pass	0.51	0.73	B	B
Wollondilly	MMP226	Long Swamp Creek u/s Paddy's River	0.58	1.03	B	A

Sub-catchment	**Site**	**Site Name**	**OE50**		**Band Grade**	
			2020	**2019**	**2020**	**2019**
Tallowa Dam catchment						
Back and Round	MMP17	Shoalhaven River at Farringdon Crossing	0.75	0.59	B	B
Boro	E890	Boro Creek at Marlowe	0.63	0.77	B	B
Boro	MMP33	Kings Creek upstream of Boro Creek	0.79	0.97	B	A
Braidwood	E860	Shoalhaven River at Mount View	0.69	0.62	B	B
Braidwood	E891	Gillamatong Creek at Braidwood	0.57	OEM	B	OEM
Braidwood	MMP62	Jembaicumbene Creek at Bendoura	0.50	0.87	B	A
Bungonia	A8	Bungonia Creek at Bungonia	0.78	0.64	B	B
Bungonia	E847	Shoalhaven River at Fossickers Flat	0.45	0.57	C	B
Endrick	MMP12	Endrick River at Nerriga	0.48	0.73	B	B
Jerrabattagulla	MMP09	Jerrabattgulla Creek at Warragandra	0.53	0.76	B	B
Jerrabattagulla	MMP168	Jerrabattagulla Ck @ Hereford Hall Rd	0.64	0.80	B	B
Jerrabattagulla	MMP273	Shoalhaven River at Wyanbene Rd	0.67	0.60	B	B

Jerrabattagulla	MMP67	Stoney Creek @ Cooma Rd	0.63	0.69	B	B
Kangaroo	E300	Yarrunga Creek @ Wildes Meadow	0.75	0.83	B	A
Kangaroo	E520	Bundanoon Creek at the Rocks	1.02	NS	A	NS
Kangaroo	E7021	Brogers Creek at Clinton Park	0.56	0.68	B	B
Kangaroo	E706	Kangaroo River at Hampden Bridge	0.75	0.59	B	B
Kangaroo	E7061	Kangaroo River at Oakdale	0.76	0.61	B	B
Mid Shoalhaven	E8311	Corang River at Meangora	0.61	0.61	B	B
Mid Shoalhaven	E861	Shoalhaven River at Hillview	0.58	0.71	B	B
Mongarlowe	E822	Mongarlowe River at Mongarlowe	0.74	0.63	B	B
Mongarlowe	MONG1	Mongarlowe River at Charleyong	0.77	0.80	B	B
Mongarlowe	R13	Mongarlowe River at Monga	0.63	0.83	B	A
Nerrimunga	E8361	Nerrimunga Creek at Minshull Trig	0.67	0.62	B	B
Nerrimunga	MMP51	Jacqua Creek at Lumley Road	0.77	0.73	B	B
Nerrimunga	MMP52	Nadgigomar Creek at Oallen Ford	0.61	0.77	B	B
Reedy	MMP194	Manar Creek at The Dip	0.72	NS	B	NS
Reedy	MMP258	Durran Durra Creek at Nerriga Road	0.65	0.71	B	B
Reedy	R7	Mulloon Creek at Tawarri	0.50	0.69	B	B
Reedy	REED1	Reedy Creek at Mayfield Road	0.72	0.84	B	A
Upper Shoalhaven	MMP06	Shoalhaven River at Yarra Glen	0.62	0.52	B	B
Metropolitan Dams catchment						
Upper Nepean	E6006	Sandy Creek at Fire Road 15	0.38	0.64	C	B
Upper Nepean	E601	Nepean River at Nepean Dam inflow	0.71	NS	B	NS
Upper Nepean	E602	Burke R @ Nepean Dam Inflow	0.62	NS	B	NS
Upper Nepean	E604	Flying Fox Creek No.3 U/S of Gauge	0.53	0.92	B	A
Upper Nepean	E608	Goondarrin Creek @ Kemira 'D' cast	0.53	1.01	B	A
Upper Nepean	E609	Cataract River D/S Angles Creek	0.50	0.92	B	A
Upper Nepean	E610	Avon River at Summit Tank	0.48	0.61	B	B
Upper Nepean	E680	Cordeaux River b/w upper Cordeaux 1&2	0.70	0.82	B	B
Upper Nepean	E697	Nepean River at Maguires Crossing	0.89	NS	A	NS
Upper Nepean	MMP100	Wongawilli Creek DS of Fire Road 6	0.58	0.78	B	B
Woronora Dam catchment						
Woronora	E677	Woronora River at Fire Road 9F	0.57	0.75	B	B
Woronora	E678	Waratah River at Flatrock Crossing	0.73	0.87	B	A
Blue Mountains Catchment						
Grose	MMP246	Woodford Creek u/s Woodford Dam	0.81	0.37	A	C

7.4 Investigative monitoring

WaterNSW's investigative monitoring program is designed to target known risks, emerging issues and inform management options. Investigative monitoring can be used for identifying pollution sources, understanding pollutant fate and transport in a variety of flow conditions and investigating the risk of pollutants reaching inflows and raw water offtake points. Investigative monitoring is also one means of evaluating the effectiveness of actions in the catchments and lakes to address pollutants.

7.4.1 Monitoring to inform quality of scour releases from Lake Medlow

During 2020-21 there were changes to the storage level operating window and management of releases at Medlow Dam. Normal operation of the dam involves releases from the upper supply outlet. Faster drawdown of the storage level may be required at times, such as during spill or after an inflow event, with the use of the scour outlet identified as an option to increase the drawdown rate. The scour outlet had not been used at maximum discharge capacity for many years and there was uncertainty in regard to the water quality impacts to downstream Lake Greaves.

Lake Medlow is not routinely sampled under the current water monitoring program, largely due to its upstream location in the catchment. Special monitoring was undertaken to provide information on quality within Lake Medlow and identify issues surrounding the quality of scour releases. Monitoring included sampling of the full water column profile and a sediment sample near the scour outlet in the storage.

Sampling was undertaken in December 2020 and showed that the lake was heavily stratified with poor water quality near the bottom of the lake. Elevated iron, organics, true colour were recorded, with some heavy metals present at concentrations below the ADWG health values. The metal concentrations were expected to increase under prolonged anoxic conditions (summer to early winter). Transferring water via run of river may slightly improve the metal concentrations prior to entering Lake Greaves.

Sediment analysis was conducted to assess quality of deposited sediments near the scour outlet and potential impacts from dislodging this surficial sediment in scour releases. Size analysis showed that the majority of sediment was sand, with sandy and coarser sediments likely to have a lower contaminant risk through reduced binding capacity. Given the particle size distribution of sediments near the scour, most of the sediment was expected to settle under stable conditions in Lake Greaves (this would require short periods of keeping the destratification fan off). The finer sediments may take additional time to settle, which may be a source of prolonged contamination to Lake Greaves, which is a source of transferred water into Top Cascade Lake. This informed operational aspects in management of storage level, identified water quality risks, and further monitoring to be undertaken downstream in Lake Greaves following large scour releases from Lake Medlow.

8 Incidents and events

Water quality incidents are managed in accordance with the WaterNSW Water Quality Incident Response Protocol. The protocol sets out agreed water quality trigger levels for various actions and notifications. Any issue that poses a potential risk to public health is reported to NSW Health immediately and incident responses are developed in consultation with NSW Health and relevant customers.

The Water Monitoring Program also specifies monitoring required in anticipation of events which pose potential threats to raw water quality, such as large inflow events and seasonal turnover in lakes. The pre-planned monitoring during periods leading to and during such events allows operational changes to be made proactively and prevents such events manifesting into incidents.

During 2020–21 one major and 26 minor water quality incidents were recorded in the Sydney catchment area (see Appendix C for details of these incidents). A further four 'events' were recorded indicating hazards with a potential water quality impact, such as animals falling into the Upper Canal or spills that are contained before reaching the water supply.

8.1 Major and significant water quality incidents

There was one major incident relating to water quality during 2020-21. Details of all incidents and their management are provided in Appendix C. Prompt notifications and effective incident response ensured no reported issues or customer complaints relating to the water supply. Incident management responses for major and significant incidents are discussed in detail below.

8.1.1 Exceedance of Raw Water Supply Agreement site specific standards

There were seven results outside Raw Water Supply Agreement standards during the year. Six of these were due to elevated algal ASU (an indicator of filter clogging potential) in raw water supplied for treatment. This occurred in Kangaroo Valley in July 2020 and January 2021, Prospect in December 2020 and May 2021 and Cascade in April and May 2021. Each instance was reported to the water filtration plant operators along with details of algal species observed. There were no toxic species of algae involved and the plants did not experience any issues with filter clogging. Additional algal samples were requested at Cascades to allow the plant to perform testing to optimise treatment processes as part of investigations for a planned upgrade of the plant.

Alkalinity exceeded the upper end of the standard in the Warragamba supply system in April 2021. The supply agreement standard for alkalinity at Warragamba water filtration plants is 15-60mg/L CaCO3, (result was 64mg/L). The water filtration plant reported no issues with the elevated alkalinity levels.

8.1.2 March 2021 Intense rainfall event

During March a major rain event triggered establishment of an Incident Management Team to oversee flood operations in liaison with the Bureau of Meteorology, State Emergency Services, Sydney Water and NSW Health. Several dams in greater Sydney spilled, including Warragamba dam, which contributed to flooding of the Hawkesbury Nepean River. The Warragamba pipelines were configured to Orchard Hills contingency supply to avoid turbid water from Warragamba dam. Water quality incidents were raised in respect of total iron at Macarthur and total aluminium at Cascades but the plants were better able to treat elevated metals relative to elevated organics so no configuration changes were requested. There was also elevated turbidity in a grab sample from Prospect raw water but this was a suspected erroneous result as there were no alarms or turbidity spikes observed at the plant.

9 Trend analysis

Trend analysis identifies persistent changes in water quality parameters resulting from natural (e.g. rainfall, climate) and anthropogenic (e.g. land-use change, catchment interventions) perturbations. WaterNSW undertakes trend analysis biennially, with trend analysis last performed as part of the 2018-19 Annual Water Quality Monitoring Report.

Trend analysis for selected catchment, storage, water filtration plant raw water supply, and downstream river sites for the 2011 - 2021 period are reported in the sections that follow. The sites and analytes included in the trend analysis were agreed by NSW Health and DPIE. Statistically significant trends (99%) were identified using a Seasonal Kendall Trend test with rates of changes quantified using the Sen slope method. Statistically significant trends are reported in units per annum.

Where data gaps comprise > 20% of the total sampling events for the period, trend data has not been reported for the site or analyte. This may occur due to conditional analysis (algal speciation in catchments) or where an analyte is no longer routinely monitored. The Seasonal Kendall Trend test has not adjusted for discharge at time of sampling or long-term effects resulting from increased rainfall, stream discharge and groundwater baseflow discharges.
Statistically significant trends may not be of concern if:

a) The magnitude of the change is very small; and/or
b) The trend is not likely to result in the relevant guidelines/benchmarks being approached or exceeded. For relevant guidelines/ benchmarks refer to Section 4 (Applicable guidelines and benchmarks)

WaterNSW's Source Water Protection programs will target initiatives to address those trends where the magnitude of trend is large or results in more frequent exceedances of the relevant guidelines or benchmarks.

The following tables summarise identified trends. Catchment and storage sites are colour coded based on the following criteria:

NA	No significant trend
X	A statistically significant trend of no concern because the magnitude of change is either very small or not expected to impact relevant guidelines / benchmarks
X	A statistically significant trend - frequently outside ANZECC benchmarks in recent years
X	A statistically significant trend - more frequently within ANZECC benchmarks in recent years
	Insufficient dataset for trend analysis

The filtering method for testing true colour has changed over the timeline of this historical dataset. An assumption of this analysis is that these recent changes may have incrementally improved accuracy, leading to decreases in the reported true colour measurements.

9.1 Warragamba system

Table 9.1: Trend results for the Warragamba system. Results displayed as per key in Section 9.

Site	Alkalinity (mg $CaCO_3$/L)	Aluminium Total (mg/L)	Areal Standard Unit (algae)	Chlorophyll a (ug/L)	Conductivity (mS/cm)	Dissolved Oxygen (%Sat)	*E. coli* (orgs/100mL)	Iron Filtered (mg/L)	Iron Total (mg/L)	Manganese Filtered (mg/L)	Manganese Total (mg/L)	Nitrogen Total (mg/L)	Phosphorus Total (mg/L)	Total Hardness (mg CaCO3/L)	Toxic Total Algal Count	True Colour (@400nm)	Turbidity (NTU)
Catchments																	
E083	7.814	NA		0.170	0.015	NA	NA	NA	NA	0.000	0.002	0.010	NA	NA		1.439	NA
E130	1.200	NA		0.073	0.003	NA	-0.961	0.007	0.010	0.001	0.002	NA	NA	1.000		1.623	NA
E157	NA	NA		NA	NA	NA	NA	NA	NA	0.001	0.001	NA	NA	NA		1.035	NA
E203	0.867	NA		NA	NA	NA	-5.601	NA	-0.023	NA	NA	NA	NA	NA		NA	-0.214
E206	0.964	NA		-0.092	NA	NA	-1.844	-0.007	-0.011	NA	NA	NA	-0.001	NA		-0.649	NA
E210	2.704	NA		NA	0.005	0.895	NA	-0.025	-0.052	NA`	0.003	NA	NA	2.176		NA	NA
E243	0.333	-0.002		0.005	0.002	NA	-0.377	-0.005	-0.020	-0.001	-0.001	NA	0.000	0.341		NA	-0.057
E409	NA	0.014		NA	NA	NA	NA	NA	0.019	NA	NA	NA	NA	-4.138		NA	0.247
E450	1.860	0.008		0.469	NA	NA	NA	NA	NA	0.002	NA	NA	NA	NA		NA	0.270
E488	2.000	NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		-1.131	NA
E531	NA	NA		NA	-0.007	-1.060	NA	NA	0.040	0.011	0.011	NA	NA	-0.923		1.950	NA
Storages																	
DWA12	1.053	NA		NA	0.003	NA	NA	-0.003	-0.002	NA	NA	-0.005	NA	0.500		-0.479	NA
DWA2	0.923	NA	NA	-0.050	0.003	NA	0.000	-0.002	-0.002	NA	0.000	-0.005	0.000	0.474	NA	-0.400	-0.027
DWA27	0.991	NA		NA	0.003	NA	0.000	-0.003	-0.003	0.000	NA	-0.006	0.000	0.535		-0.503	NA
DWA9	1.000	NA		NA	0.003	NA	NA	-0.002	-0.003	NA	NA	-0.005	0.000	0.500		-0.447	NA
RPR1	-0.546	NA	21.054	0.162	-0.007	NA	0.000	-0.003	NA	NA	NA	NA	NA	-1.286	0.000	0.000	NA
Water Filtration Plants																	
HBR1	2.119	-0.005	NA		0.006	1.852	NA	-0.005	-0.01	NA	NA			1.212	NA	-0.628	NA
HWA2	1.945	-0.005	NA		0.006	1.415	NA	-0.006	-0.008	NA	NA			1.299	NA	-0.973	-0.160
PWFP10	2.473	-0.003	NA		0.008	NA	NA	-0.008	-0.013	NA	NA			1.750	NA	-0.571	NA

Analysis of the catchment streams of Lake Burragorang showed few significant trends during the period. Where a trend is identified, the variance is generally small and not indicative of a significant change in conditions in the catchment. Some increases in hardness and alkalinity are noted.

A small trend in true colour in the upstream sites can be attributed to the impact of fires in early 2020. In spite of the fires, the nutrient concentrations in the catchment showed no significant trend.

The water filtration plant inlet samples continued to show significant increases in hardness and alkalinity.

9.2 Upper Nepean system

Table 9.2: Trend results for the Upper Nepean system. Results displayed as per key in Section 9.

Site	Alkalinity (mg $CaCO_3$/L)	Aluminium Total (mg/L)	Areal Standard Unit (algae)	Chlorophyll a (ug/L)	Conductivity (mS/cm)	Dissolved Oxygen (%Sat)	*E. coli* (orgs/100mL)	Iron Filtered (mg/L)	Iron Total (mg/L)	Manganese Filtered (mg/L)	Manganese Total (mg/L)	Nitrogen Total (mg/L)	Phosphorus Total (mg/L)	Total Hardness (mg CaCO3/L)	Toxic Total Algal Count	True Colour (@400nm)	Turbidity (NTU)
Catchments																	
E602	0.200	-0.006		NA	0.002	-1.025	-0.500	NA	NA	0.001	NA	-0.004	NA	0.000		NA	NA
E609	0.563	-0.003	NA	NA	0.003	-1.068	-2.558	-0.008	NA	NA	NA	NA	-0.001	0.377	NA	NA	NA
E610	0.778	-0.003		NA	0.002	-0.880	NA	-0.005	-0.010	0.000	0.000	-0.002	0.000	0.667		-0.323	NA
E680	NA	-0.003		NA	0.002	-1.167	NA	NA	NA	0.002	0.003	0.004	NA	0.000		NA	NA
Storages																	
DAV1	NA	NA		NA	-0.001	NA	NA	-0.001	0.002	NA	NA	NA	NA	-0.225		NA	-0.034
DAV7	0.000	NA	41.634	0.153	-0.001	-0.695	NA	NA	NA	NA	-0.001	-0.253	NA	NA	NA	NA	0.000
DCA1	0.000	NA	NA	0.098	0.002	-0.521	NA	0.005	0.010	0.001	0.001	0.008	NA	0.226		NA	NA
DCO1	NA	NA	NA	0.267	NA	-0.411	NA	NA	0.010	0.000	NA	0.005	NA	NA		NA	0.032
DNE2	NA	NA	18.999	NA	NA	-1.352	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.545	NA
Water Filtration Plants																	
HMAC1	NA	NA	NA		NA	-.807	NA	NA	0.010	-0.001	-0.001			NA	NA	NA	NA
HNED	-0.128	NA	NA		NA	-1.079	NA	NA	0.010	-0.002	NA			NA	0.000	1.021	0.081
IWFP-R	NA	NA	33.328		-0.001	-0.542	NA	-0.003	NA	0.000	-0.003			-0.245	NA	NA	NA

Water quality was stable at most of the catchment sites and there were no trends likely to change the ANZECC compliance status. Where statistically significant trends are recorded, the magnitude of the change is minimal.

A notable trend was the minor increase in true colour in Lake Nepean and raw water. Wetter periods are believed to be a contributor to this trend. The Burke River catchment inflow site, however, did not record a significant trend in true colour. This may indicate that other catchments flowing to the lake are a significant contributor to colour.

The previous 2009 to 2019 trend analysis showed significant trends in filtered iron for all Upper Nepean sites, some increasing while others decreasing. Trends were observed at fewer sites this year, all with minor increases. Another notable change between trend periods was fewer sites recording turbidity changes. The magnitude of the turbidity changes is very low.

Chlorophyll *a* and algal ASU is increasing in all the lakes. This aligns with short-lived blooms experienced in recent years. There was no trend identified in chlorophyll *a* at the Avon dam wall lake site and not enough data to determine an algal trend.

9.3 Woronora system

Table 9.3: Trend results for the Woronora system. Results displayed as per key in Section 9.

Site	Alkalinity (mg $CaCO_3$/L)	Aluminium Total (mg/L)	Areal Standard Unit (algae)	Chlorophyll a (ug/L)	Conductivity (mS/cm)	Dissolved Oxygen (%Sat)	*E. coli* (orgs/100mL)	Iron Filtered (mg/L)	Iron Total (mg/L)	Manganese Filtered (mg/L)	Manganese Total (mg/L)	Nitrogen Total (mg/L)	Phosphorus Total (mg/L)	Total Hardness (mg CaCO3/L)	Toxic Total Algal Count	True Colour (@400nm)	Turbidity (NTU)
Catchments																	
E677	0.000	NA		0.008	0.003	-1.633	-0.207	NA	0.004	NA	NA	NA	NA	0.286		0.922	NA
Storages																	
DWO1	0.273	-0.007	NA	0.067	0.001	NA	NA	-0.015	-0.022	-0.001	-0.001	0.005	NA	0.000	NA	-0.813	NA
Water Filtration Plants																	
HWO1-A	0.239	-0.010	3.528		0.000	-0.686	0.000	-0.017	-0.022	-0.002	-0.002			0.000	NA	-0.960	0.039

Dissolved oxygen saturation in the Woronora River was again identified as decreasing with the potential to impact on ANZECC compliance. Dissolved oxygen is regularly below ANZECC benchmarks at this site.

Minor decreases in metals and true colour continued over the trend period. True colour in Lake Woronora has been well above baseline levels since March 2020, so the current trend does not reflect the status quo in the lake with decay expected to be slow.

A rising trend in total algae ASU was identified in the raw water to Woronora WFP but not in the lake. Baseline algal ASU concentrations are low in this system and minor rises are not expected to impact on treatability.

9.4 Blue Mountains system

Table 9.4: Trend results for the Blue Mountains system. Results displayed as per key in Section 9.

Site	Alkalinity (mg $CaCO_3$/L)	Aluminium Total (mg/L)	Areal Standard Unit (algae)	Chlorophyll a (ug/L)	Conductivity (mS/cm)	Dissolved Oxygen (%Sat)	*E. coli* (orgs/100mL)	Iron Filtered (mg/L)	Iron Total (mg/L)	Manganese Filtered (mg/L)	Manganese Total (mg/L)	Nitrogen Total (mg/L)	Phosphorus Total (mg/L)	Total Hardness (mg CaCO3/L)	Toxic Total Algal Count	True Colour (@400nm)	Turbidity (NTU)
Catchments																	
Storages																	
DGC1	NA	-0.003	28.171	0.300	0.001	0.710	NA	NA	NA	NA	NA	0.004	0.000	NA	0.000	0.614	-0.153
DTC1	1.295	-0.003	12.929	0.209	0.004	0.734	NA	-0.005	-0.010	NA	0.001	0.015	0.000	1.443	0.000	NA	-0.074
Water Filtration Plants																	
HCSR	1.454	-0.002	27.851		0.002	NA	NA	-0.006	-0.007	NA	0.001			1.431	0.000	NA	-0.031

Chlorophyll *a* was identified as increasing trends in both Greaves and Top Cascade Lakes, with potential to impact poorly on the ANZECC compliance status. The rise is very small but is also associated with an increase in total algal ASU and potentially toxic algal concentration. Minor increases recorded in nutrients may be one contributing factor to these algal increases. Total phosphorus is reported as a significant trend, but the degree of change per year is very small (less than 3 decimal points, reported as zero above).

Water quality in terms of iron and turbidity has improved in the raw water to Cascades WFP. There were also no trend identifying change in the true colour during the 10-year period.

9.5 Shoalhaven system

Table 9.5: Trend results for the Shoalhaven system. Results displayed as per key in Section 9.

Site	Alkalinity (mg $CaCO_3$/L)	Aluminium Total (mg/L)	Areal Standard Unit (algae)	Chlorophyll a (ug/L)	Conductivity (mS/cm)	Dissolved Oxygen (%Sat)	*E. coli* (orgs/100mL)	Iron Filtered (mg/L)	Iron Total (mg/L)	Manganese Filtered (mg/L)	Manganese Total (mg/L)	Nitrogen Total (mg/L)	Phosphorus Total (mg/L)	Total Hardness (mg CaCO3/L)	Toxic Total Algal Count	True Colour (@400nm)	Turbidity (NTU)
Catchments																	
E706	NA	-0.010		NA	0.001	-1.244	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA
E847	0.960	NA		0.147	0.002	-0.333	NA	-0.010	NA	0.000	NA	NA	-0.001	0.750		-0.797	0.248
Storages																	
DTA1	0.667	-0.012		NA	0.002	-0.904	0.000	-0.008	NA	NA	0.001	NA	-0.001	0.758		-1.101	NA
DTA8	0.367	NA	23.503	0.465	NA	-0.834	-3.827	-0.008	-0.015	NA	NA	0.007	-0.001	NA	NA	NA	NA
DWI1	0.250	-0.008	30.355	0.260	0.001	-0.914	NA	NA	NA	NA	NA	0.035	0.000	0.176	191.691	0.544	-0.230
Water Filtration Plants																	
HKV1	0.407	NA	NA		0.002	-0.793	NA	NA	NA	0.000	NA			0.514	NA	NA	NA
HWI1	0.167	-0.009	88.932		0.001	-0.660	NA	NA	NA	NA	NA			0.000	346.500	0.649	-0.297

A significant increasing trend in the numbers of dissolved oxygen failures is notable in the sites of Lake Yarrunga, and an increasing trend in chlorophyll *a* failures is also evident.

A moderately increasing trend is reported in hardness and alkalinity throughout the Shoalhaven system.

9.6 Downstream sites

Table 9.6: Trend results for selected downstream sites. Results displayed as per key in Section 9.

Site	Alkalinity (mg $CaCO_3$/L)	Aluminium Total (mg/L)	Areal Standard Unit (algae)	Chlorophyll a (ug/L)	Conductivity (mS/cm)	Dissolved Oxygen (%Sat)	*E. coli* (orgs/100mL)	Iron Filtered (mg/L)	Iron Total (mg/L)	Manganese Filtered (mg/L)	Manganese Total (mg/L)	Nitrogen Total (mg/L)	Phosphorus Total (mg/L)	Total Hardness (mg CaCO3/L)	Toxic Total Algal Count	True Colour (@400nm)	Turbidity (NTU)
N57	1.887	-0.005		NA	0.007	NA	NA	-0.006	-0.014	0.000	0.002	0.026	-0.001	NA		-0.401	-0.244
G0515	0.565	-0.005		0.250	0.003	NA	NA	NA	NA	0.000	NA	0.006	NA	NA		0.611	NA
E851	0.800	-0.010		0.188	0.003	-0.677	NA	NA	NA	0.002	0.003	NA	-0.001	NA		NA	NA

Chlorophyll *a* in the Nepean River at Penrith Weir (N57) is no longer identified as a significant trend in the trend analysis this year. Total nitrogen at this site is increasing with results more frequently exceeding ANZECC benchmarks. Improving trends for iron, true colour and turbidity were shown through the analysis.

Downstream of Lake Woronora (GO515) and in the Shoalhaven River (E851) showed an increasing trend for chlorophyll *a*. Concentrations are more frequently outside ANZECC benchmarks (> 5 µg/L).

Alkalinity was shown to be increasing downstream of the three storages.

10 References

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