State of the Special Areas

Report 2019-22

We acknowledge the Traditional Custodians of the land and water on which we work and recognise the continuing cultural and spiritual connections that Aboriginal and Torres Strait Islander People have to Country.
We pay our respects to Elders past and present.

Executive summary

Within Sydney's Drinking Water Catchment, the Special Areas cover approximately 364,000 hectares of mostly unspoilt, minimally disturbed, native bushland surrounding the water supply storages. The Special Areas help to protect the quality of stored waters and the ecological integrity of the lands.

Under the *Water NSW Act 2014*, WaterNSW and the NSW National Parks and Wildlife Service (NPWS) are joint sponsors of the Special Areas. Joint sponsorship of the Special Areas requires an integrated approach to management based on a shared vision as outlined in the Special Areas Strategic Plan of Management (SASPoM).

Every three years a State of the Special Areas Report is required to be prepared that assesses the condition of Special Area values, management effectiveness and trends over time. This report fulfills the requirement to prepare a State of the Special Areas Report for the period 1 July 2019 to 30 June 2022. It is the first of its kind prepared for the Special Areas.

The report uses the pressure-state-response framework widely used for state of environment reporting in NSW. A series of indicators were identified to track the progress of the SASPoM during the reporting period.

The main pressures on the Special Areas during the reporting period were the drought and bushfires (2019) and the bouts of intense rainfall with resultant floods (2020-22). Climate change and land use changes including mining, present more long-term pressures.

The state of the Special Areas and management responses for the reporting period were assessed related to the themes and objectives in the SASPoM. The assessment found the following for each of the SASPoM objectives:

SASPoM objective	Assessment
Pollutants are controlled so that impacts on water quality and natural and cultural values are minimised.	Partially achieved. There were exceedances of water quality guidelines most probably due to extreme weather impacts with resultant changes in flows. However, the joint sponsors undertook extensive bushfire recovery programs to reduce the risk of the 2019-20 bushfires to water quality and conduct water quality monitoring programs.
Surface and groundwater sources and their interactions will be better understood so decisions are made that seek to minimise impacts on Special Areas **hydrological integrity**.	Achieved. There are several water flow gauging stations and groundwater bores located within the Special Areas, Groundwater tended to rise across the Special Areas although this may not be the case close to longwall coal mines. Research was conducted including to monitor water tables and swamps,
Pests and weeds are controlled so that impacts on water quality and ecological integrity are minimised.	Achieved. There was extensive pest animal and weed control programs throughout the Special Areas. The control targets of the joint sponsors were achieved during the reporting period.

Measures are in place to minimise the impacts of built **assets** within the Special Areas on water quality, ecological integrity and cultural values.	Achieved. Proactive maintenance of roads and other assets was undertaken and damaged roads (bushfires and floods) were progressively repaired.
Access to the Special Areas is controlled to protect water quality and ecological integrity while providing for appropriate visitor opportunities.	Achieved. The joint sponsors controlled access to the Special Areas through compliance and access applications. Consent was given for 65% of the access applications which generally increased across the reporting period.
Fire management within Special Areas maximises protection of life and property and minimises impact on water quality and ecological integrity.	Not achieved. Whilst there were widespread bushfire risk management measures in place, this did not prevent the extensive and severe bushfires of 2019-20 in parts of the Special Areas. However, the joint sponsors undertook extensive programs to reduce the risk of the bushfires to water quality.
Ecological integrity including threatened plant and animal species, endangered populations, endangered ecological communities, geodiversity and other natural values are maintained.	Partially achieved. The severe bushfires of 2019-20 meant that the ecological integrity was compromised with long term recovery of endangered ecological communities and threatened species required. The status of macroinvertebrates was relatively stable across the reporting period and extensive pest and animal programs were successfully completed to help maintain ecological integrity in the reporting period. It is also noted that long-wall mining is having an impact on threatened species and Endangered Ecological Communities such as upland swamps and the Littlejohn's Tree Frog on the Woronora and Metropolitan Special Areas.
Cultural heritage values are acknowledged and conserved, and community associations supported.	Achieved. There was little change in the condition of non-aboriginal State Heritage Items, which were generally rated as 'good' during the reporting period. The joint sponsors continued to liaise with First Nations communities regarding the management of cultural heritage values during the reporting period. Long-wall coal mining continues to have a detrimental impact on aboriginal heritage across the Woronora and Metropolitan Special Areas.
Management of Special Areas is supported by appropriate **policy, planning and evaluation.**	Achieved. The SASPoM is the overarching policy for the management of the Special Areas. The joint sponsors worked together to achieve the responses outlined in this report.

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1. Introduction

1.1 WaterNSW

WaterNSW is a state-owned corporation established under the *Water NSW Act 2014*. It is one of four main agencies responsible for managing water in NSW.

WaterNSW operates the state's dams, capturing and storing water and supplying it ready for distribution. In Greater Sydney, WaterNSW collects water from river catchments to the south and west of Sydney, and stores it in 21 dams including Warragamba, Nepean, Cataract and Avon dams. WaterNSW supplies two thirds of water used in NSW, including the source water for the 5 million people across Greater Sydney, Illawarra, Blue Mountains, Southern Highlands, Goulburn and Shoalhaven regions.

WaterNSW aims to provide a reliable supply of safe and quality drinking water for these communities. It has the responsibility under the *Water NSW Act 2014* to ensure that Sydney's Drinking Water Catchment is managed and protected in a way that promotes water quality, the protection of public health, and the protection of the environment.

1.2 Sydney's Drinking Water Catchment and Special Areas

Sydney's Drinking Water Catchment covers almost 16,000 square kilometres (see Figure 1). There are four major water supply systems within the Catchment: Warragamba, Shoalhaven, Metropolitan and Woronora, plus smaller systems including Blackheath and Katoomba.

Within the Catchment, there are special and protected areas which cover approximately 364,000 hectares of mostly unspoilt, minimally disturbed, native bushland surrounding the water supply storages (Figure1).

These Special Areas are lands declared under the *Water NSW Act 2014* for the following purposes:

- Protecting the quality of stored waters, whether intended for drinking or other purposes.
- Maintaining the ecological integrity of an area of land declared to be a Special Area in a manner that is consistent with WaterNSW's objectives.

The Special Areas are declared in the following catchments (Figure 1):

- Warragamba
- Blackheath, Katoomba and Woodford in the Blue Mountains
- Woronora
- Upper Nepean
- Wingecarribee
- Fitzroy Falls
- Shoalhaven
- Prospect.

Special Area declarations are applied over national parks estate (~67%), WaterNSW land (~19%) and privately owned and crown lands (~14%).

The Special Areas contain native vegetation, wetlands, river systems, heritage sites, water storages and associated infrastructure, active and historic farmland, active and derelict mines, roads, utility corridors and water supply facilities.

These areas contain significant cultural heritage values plus a suite of natural values including conservation, scientific, habitat, resource, aesthetic, and ecological values. Parts of the Special Areas are recognised for their World Heritage and wilderness values.

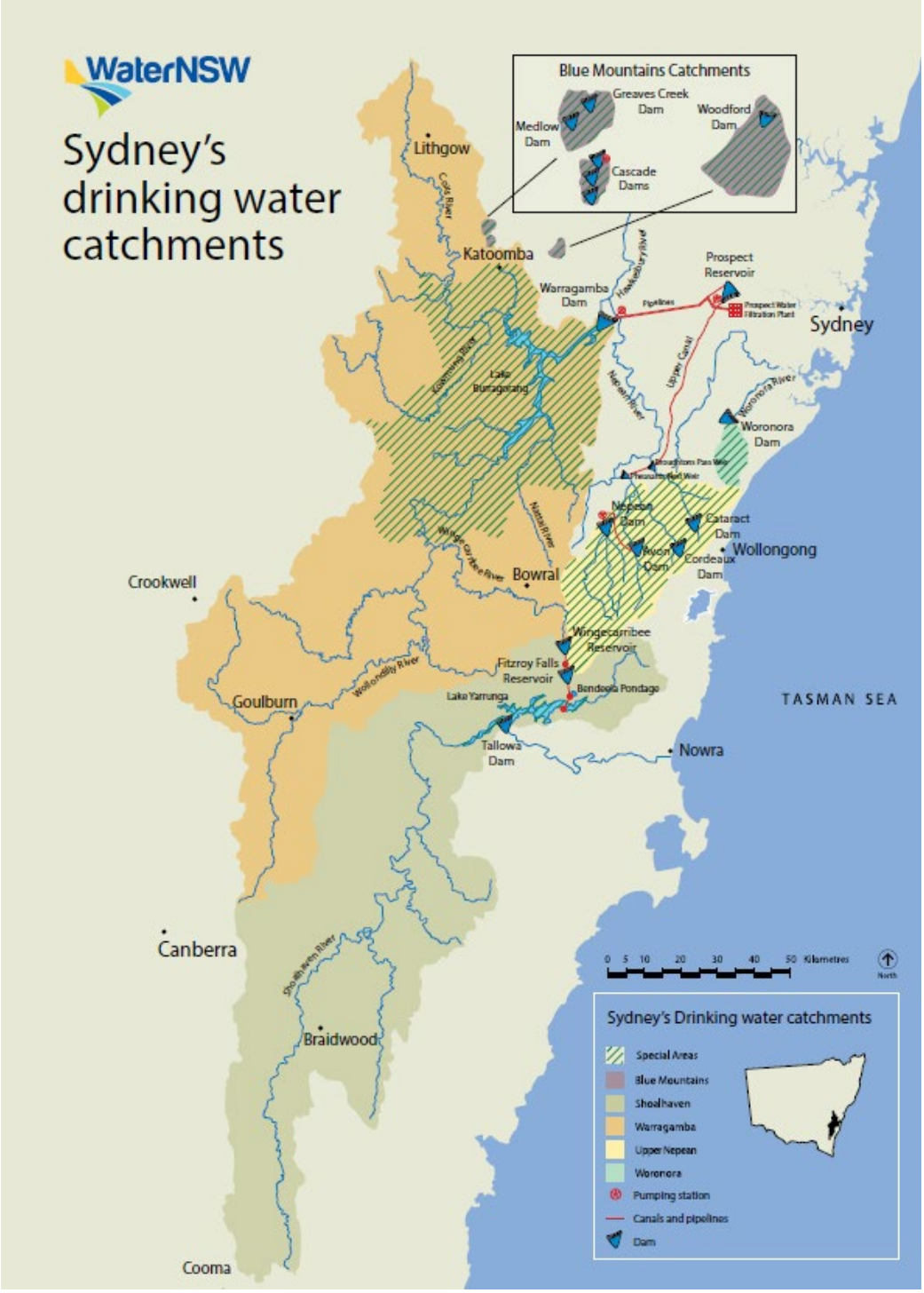

Figure 1: Sydney's Drinking Water Catchment and Special Areas (Source: WaterNSW and Office of Environment and Heritage, 2015)

1.3 Management of the Special Areas

Under the *Water NSW Act 2014*, WaterNSW and the NSW National Parks and Wildlife Service (NPWS) are joint sponsors of the Special Areas.

WaterNSW has responsibility for the quality of water in Sydney's Drinking Water Catchment. NPWS is the primary conservation agency in NSW and is also the landowner of reserves within the Special Areas that have been gazetted under the *National Parks and Wildlife Act 1974*.

Management of the Special Areas focuses on the ongoing protection of water quality and natural and cultural values, including responding to emerging threats, and seeking to address existing issues. Maintenance of ecological integrity within the Special Areas requires the protection of biodiversity, and the evaluation and protection of habitat values, maintenance of ecological processes and the conservation of geodiversity, including the protection of aquatic threatened species. Maintaining cultural significance includes conservation of significant objects, sites and cultural landscapes in consultation with local communities and other stakeholders.

To support the management and protection of the Special Areas, most of zones are off-limits or restricted to the public. There are two protection zones with different restrictions within the Special Areas (Figure 2):

- **Schedule 1, no entry** - lands that do not permit access to the public. This includes land surrounding water storages.
- **Schedule 2** - lands that allow restricted access. These areas include the water storages and surrounding land of Fitzroy Falls Reservoir and parts of Lake Yarrunga, and Lake Burragorang. This zone permits walking activities only, with all vehicles being prohibited.

Access restrictions do not apply to privately owned land and public roads within the Special Areas.

1.4 Special Areas Strategic Plan of Management

Joint sponsorship of the Special Areas requires an integrated approach to management based on a shared vision. Section 52 of the *Water NSW Act 2014* requires the joint sponsors to prepare a plan of management for the Special Areas and Section 53 requires the joint sponsors to implement the plan.

The Special Areas Strategic Plan of Management (SASPoM) applies to all Special Areas; however, the requirements of this plan do not apply to owners of private land in Special Areas.

WaterNSW and NPWS have undertaken joint reviews of the SASPoM every five years. The current version of the SASPoM was developed in 2015 (WaterNSW and Office of Environment and Heritage, 2015).

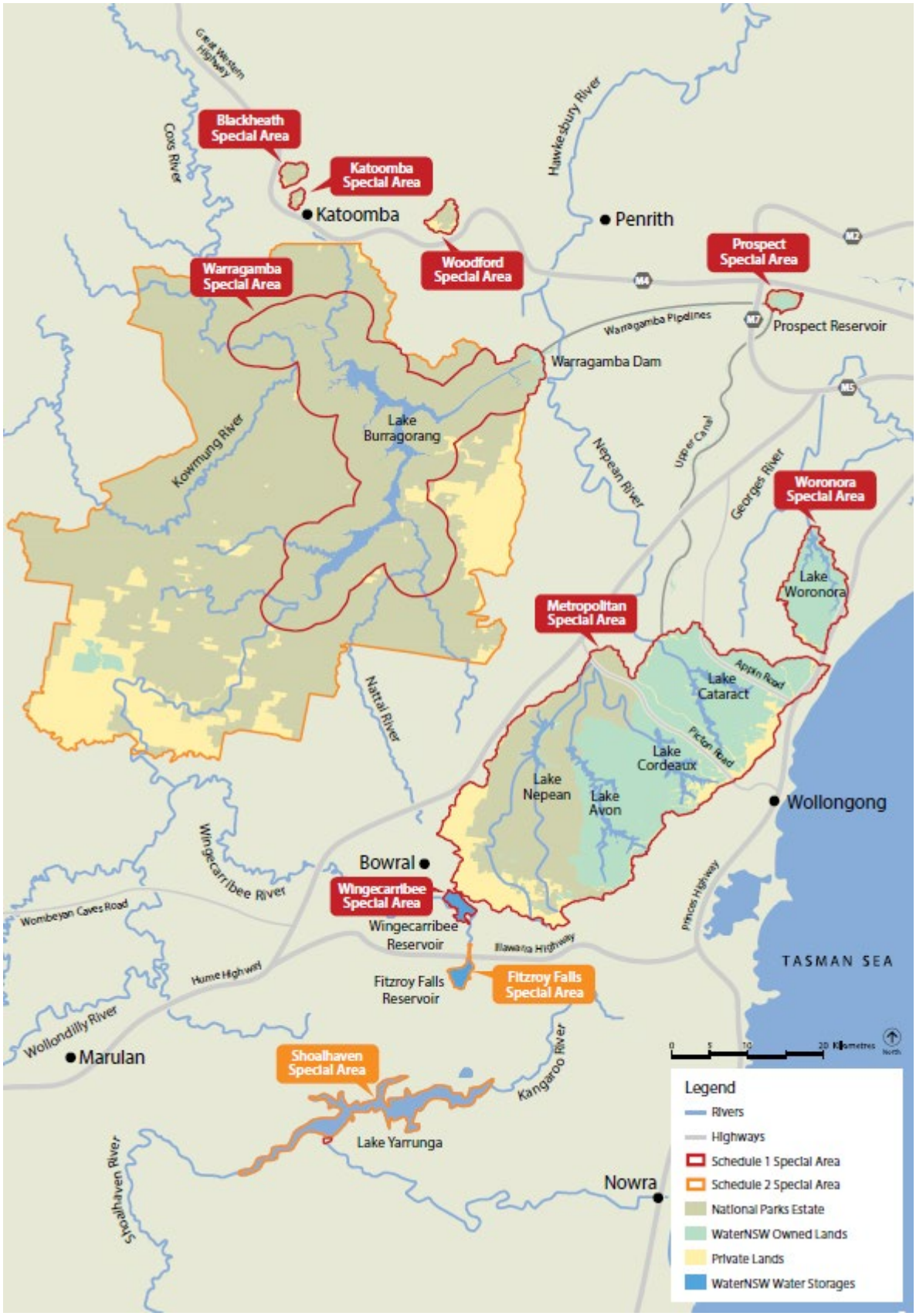

Figure 2: Location and tenure of lands in the Special Areas (Source: WaterNSW and Office of Environment and Heritage, 2015)

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1.5 This report

WaterNSW functions under an Operating Licence granted under Section 11 of the *Water NSW Act 2014*. The Operating Licence and associated reporting manual detail the reporting required by IPART. Specifically, WaterNSW is required to report to IPART on planned and actual catchment management and protection activities, expenditures and outcomes.

The Special Areas Plan of Management 2015 requires a State of the Special Areas Report to be prepared every 3 years that assesses the condition of Special Area values, management effectiveness and trends over time. This report fulfills the requirement to prepare a State of the Special Areas Report for the period 1 July 2019 to 30 June 2022.

This report uses the pressure-state-response framework, developed by the Organisation for Economic Cooperation and Development (OECD, 1993) and used for state of environment reporting in NSW. The pressure-state-response framework provides a structure that links environmental policies to environmental monitoring and reporting. The framework considers that human activities exert pressures or impacts on the environment that affect the quality and quantity of natural resources ('state'); and society responds to these changes through environmental, general economic and sectoral policies and through changes in awareness and behaviour ('response'). The framework highlights cause-effect relationships, and helps decision makers and the public see environmental, economic, and social issues as inter-connected.

Using the framework, Chapter 2 investigates the main 'pressures' on the Special Areas during the period 1 July 2019 to 30 June 2022. Chapter 3 assesses the 'state' of Special Areas during this period and provides an outline of 'response' by management. Chapter 4 summarises the report findings and makes recommendations for future improvements of reporting and management. Chapter 5 lists the references used in the report.

The sub-section headings in Chapters 3 relate to the strategic management outcomes of the SASPoM that focus on the following themes:

- water quantity
- water quality
- pests and weeds
- assets and infrastructure
- access
- fire
- ecological integrity
- cultural heritage.

A series of indicators and supporting data related to some of the themes were identified in the preparation of this report. These indicators are included and described throughout the report.

Several case studies are provided particularly to demonstrate management initiatives to respond to the Special Areas pressures and state.

2. Pressures on the Special Areas

There were several pressures on the Special Areas during the reporting period as identified in several references including the SASPoM (WaterNSW and Office of Environment and Heritage, 2015), Sydney Drinking Water Catchment Audit 2019-2022 (EcoLogical, 2023) and Annual Catchment Management Reports prepared by WaterNSW (WaterNSW, 2020a; WaterNSW, 2021a; WaterNSW, 2022a).

The main pressures identified were:

- weather patterns leading to drought, bushfires and floods
- the impacts of climate change
- land use changes in and around the Special Areas including mining
- changes in population particularly in the private lands of the Special Areas and in the neighbouring areas
- the impacts of the COVID-19 pandemic
- pollution and contamination emanating from within and outside the Special Areas.

2.1 Drought, bushfires and floods

Indicators particularly related to water quality, water quantity, assets and infrastructure, fire and ecological integrity were affected by severe drought in the initial months of the reporting period followed by intense rainfall and floods throughout 2020-22.

Figures 3 and 4 show the dramatic change in weather patterns across NSW throughout the reporting period.

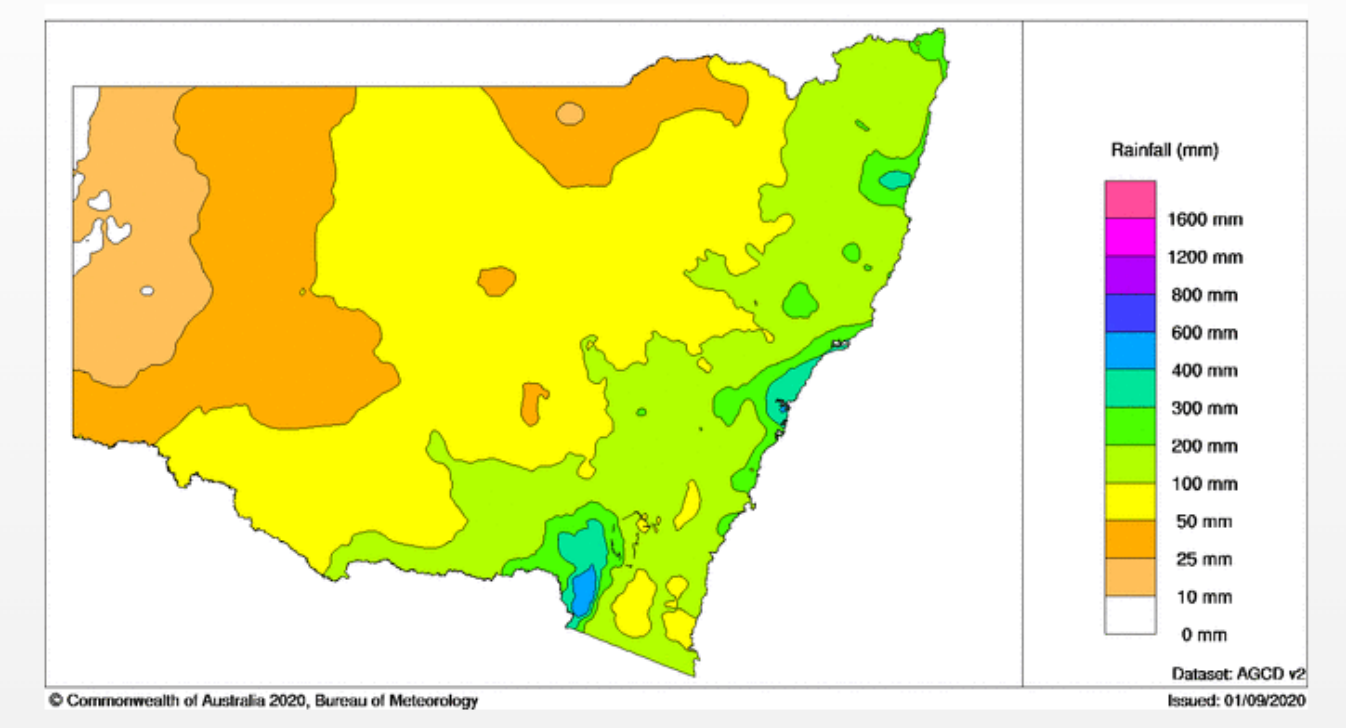


Figure 3: Rainfall across NSW in the period July-December 2019

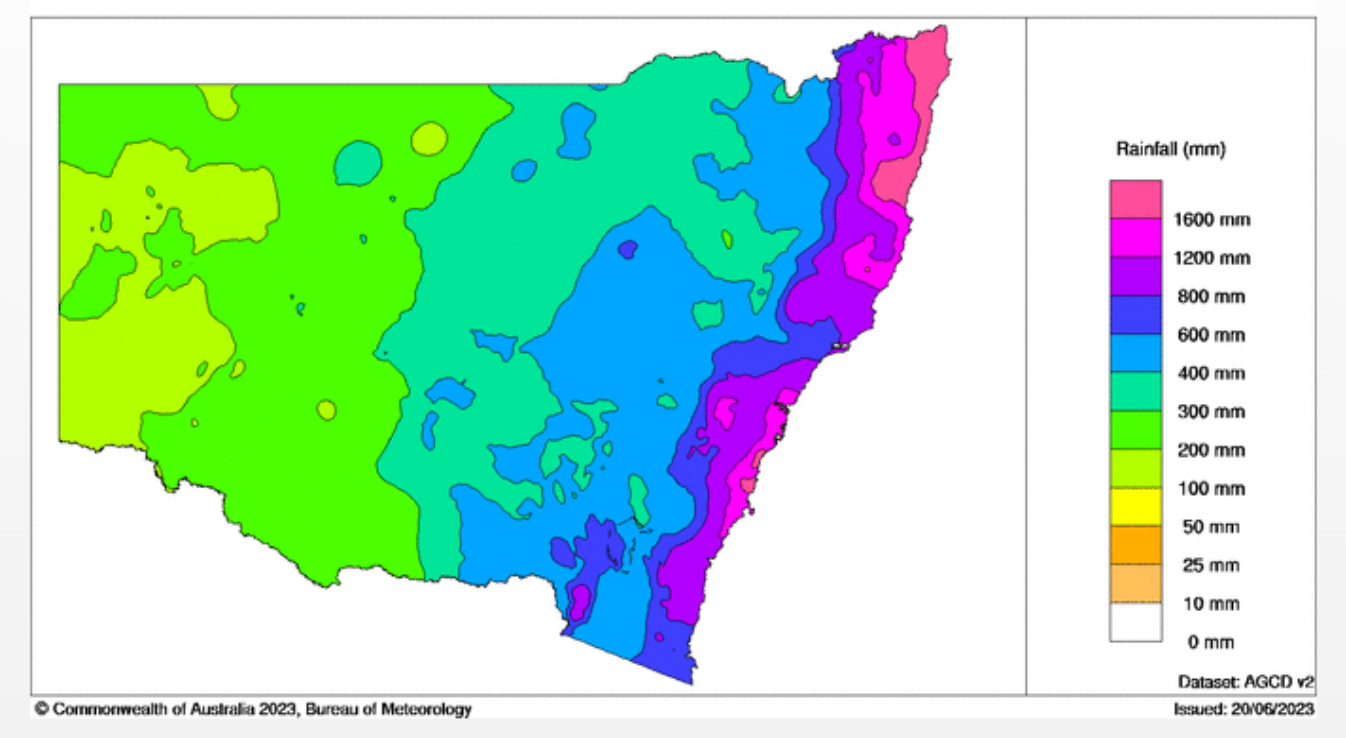


Figure 4: Rainfall across NSW in the period January-June 2022

More specifically, a location within the Warragamba Special Areas (Oakdale – Weather Station 68125), demonstrates the rainfall variations including the reporting period (Table 1).

Table 1: Annual rainfall at Oakdale Weather Station 2019-2022

2019 rainfall (mm)	2020 rainfall (mm)	2021 rainfall (mm)	2022 rainfall (mm)
489.8	1422.6	1,180.2	1,837.2

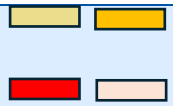
INDICATOR – COMBINED DROUGHT INDEX

The Combined Drought Indicator (CDI) uses 3 indices to determine drought category at a given time: Rainfall Index (RI), Plant Growth Index (PGI), and Soil Water Index (SWI). The CDI classifies each parish in NSW into one of five drought categories below:

- Non drought
- Recovery
- Drought affected (weakening)
- Drought affected (intensifying)
- Drought
- Intense Drought

As shown in Table 2, several parishes in the Special Areas were in intense drought conditions during 2019-20. However, due to increased rainfall drought conditions improved in all parishes in the subsequent years and by 2021-22, all parishes were not in drought.

Table 2: Indicator: Combined Drought Index *

Special Area	2019-20 CDI	2020-21 CDI	2021-22 CDI	Trend
Blackheath				↑
Katoomba				↑
Warragamba				↑
Woodford				↑
Prospect				↑
Woronora (Heathcote)				↑
Metropolitan				↑
Wingecarribee				↑
Fitzroy Falls				↑
Shoalhaven				↑

** Every condition recorded in a particular Special Area in a particular year is recorded in the CDI*

The previous years of below average rainfall and the low rainfalls experienced in 2019 led to the 2019–20 bushfire season which was the worst NSW has recorded. Higher than average temperatures and low moisture levels in bushfire fuels following several years of drought enabled devastating fires to burn across much of the state, with intense bushfire weather conditions continuing through most of the fire season.

Bushfires burned across extensive areas of Sydney's Drinking Water Catchment including the Special Areas. According to EcoLogical (2023), bushfires burnt 537,573 ha across Sydney's Drinking Water

Catchment during the 2019-20 season. Figure 5 shows the extent of the bushfires across Sydney's Drinking Water Catchment.

A detailed analysis of the bushfires and their impacts on the Special Areas is provided in Section 3.6 of this report.

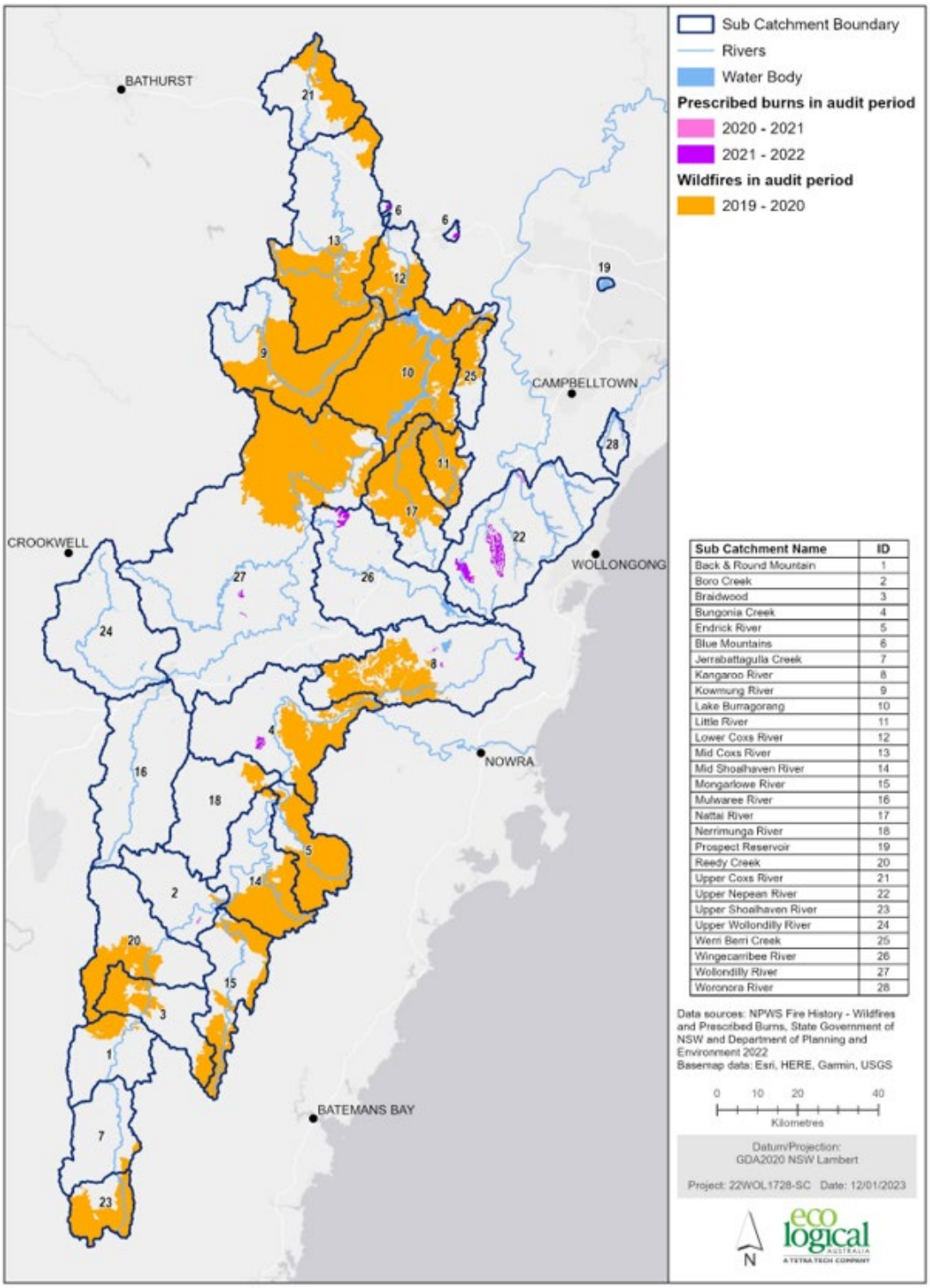


Figure 5: Bushfires (shown in orange) across Sydney's Drinking Water Catchment in the 2019-20 bushfire season (source: EcoLogical, 2023)

As exemplified in Figure 4, between 2020 and 2022 NSW received far above average rainfall, and experienced widespread areas of localised flooding. In late February and early March 2022, persistent heavy rain in north-east NSW broke all records, with some areas recording well over 1 metre of rain.

The impacts of the floods (high stream flows) on the Special Areas are examined in Sections 3.1 (Water Quantity) and 3.2 (Water Quality).

2.2 Climate change

Climate change is contributing to changes in fire weather through its impacts on temperature and relative humidity, and the associated changes to fuel moisture content. Considerable year-to-year variability in fire weather also occurs. The frequency of dangerous fire weather days has increased significantly in recent decades across many regions of Australia, especially in the south and east. These increases are particularly evident during spring and summer and are associated with an earlier start to the southern fire weather season (Bureau of Meteorology, 2022).

Australian rainfall is highly variable and is strongly influenced by drivers such as El Niño, La Niña, the Indian Ocean Dipole and the Southern Annular Mode. Despite this natural variability, long-term trends are evident in Australia's rainfall records. There has been a shift towards drier conditions across the south-west and south-east, with more frequent years of below-average rainfall, especially for the cool season months of April to October. On the other hand, observations show an increase in the intensity of heavy rainfall events in Australia that occur on timescales of less than a day (Bureau of Meteorology, 2022).

The extreme range of weather events during 2019-22 (Section 2.1) have been attributed, at least partly, to the impacts of anthropogenic climate change including for 2019/20 bushfires (van Oldenborgh et al., 2021) and for the 2021/22 floods in south-eastern Australia (Climate Council, 2022).

However, the challenges to attribute specific extreme events to climate change should be noted.

> *"After about a decade of event attribution studies on Australian extremes, it is clear that the confidence behind assessments is much greater behind some types of extremes than others. Longer duration heat events have the highest confidence, while smaller-scale events such as convective storms, tropical or east coast lows have the lowest confidence in their resulting attribution assessments Events associated with the land surface and vegetation (e.g., long duration drought, fire weather, and multi-year aspects of fire-relevant fuel) are also challenging to attribute. The different levels of difficulty likely explain why there are more attribution assessments on extreme heat in comparison with other events."*
>
> Lane et al., 2023

These extreme events during a short period may be a harbinger for the future, based on climate change projections for the region that include the Special Areas. These projections predict longer dry periods

which may involve drought and bushfires with relatively short periods of intense rainfall possibly leading towards floods (AdaptNSW, 2024).

Other climate change impacts affect the Special Areas including temperature trends. Temperature influences the state of Water Quality (Section 3.2), Fire (Section 3.6) and Ecological Integrity (Section 3.7).

> "Australia's warmest year on record was 2019. The eight years from 2013–20 all rank among the 10 warmest years on record. The long-term warming trend means that most years are now warmer than almost any observed during the 20th century. Warming is observed across Australia in all months with both day and night-time temperatures increasing. This shift is accompanied by an increased number of extreme nationally averaged daily heat events across all months, including a greater frequency of very hot days in summer. For example, 2019 experienced 41 extremely warm days, about triple the highest number in any year prior to 2000. Also in 2019, there were 33 days when national daily average maximum temperatures exceeded 39 °C, a larger number than seen in the 59 years from 1960–2018 combined. Extreme heat has caused more deaths in Australia than any other natural hazard and has major impacts on ecosystems and infrastructure."
>
> Bureau of Meteorology, 2022

2.3 Land use changes including mining

Pressures may arise from development within and adjacent to Special Areas. Examples include urban development across the Sydney growth corridors, proposed and ongoing coal mining.

While such developments bring significant economic and social benefits, they can impact water quality (Section 3.2), water quantity (Section 3.1) and ecological integrity (Section 3.7) by increasing pollution, unauthorised access (Section 3.5) and the incidence of fire (Section 3.6), reducing the viability of threatened species populations and reducing the connectivity between natural areas (Section 3.7) and, in the case of long wall mining, by causing creek beds and swamps to crack and dry up. Mining related subsidence also damages aboriginal cultural sites of significance.

2.3.1 Urban development

The most significant land use change close to the Warragamba and Metropolitan Special Areas during the reporting period was the commencement of the Wilton-Appin urban development and the Silverdale development which is close to the offtake at Warragamba.

The urban release area of Wilton will include 15,000 homes and space for 15,000 jobs in the next 20 years. The area of Appin identified in the Greater Macarthur Growth Area, containing approximately 15,000 homes, is identified as a longer-term prospect given the need to plan for, fund and build infrastructure across a geographically dispersed area.

The location of both growth areas is provided in Figure 6.

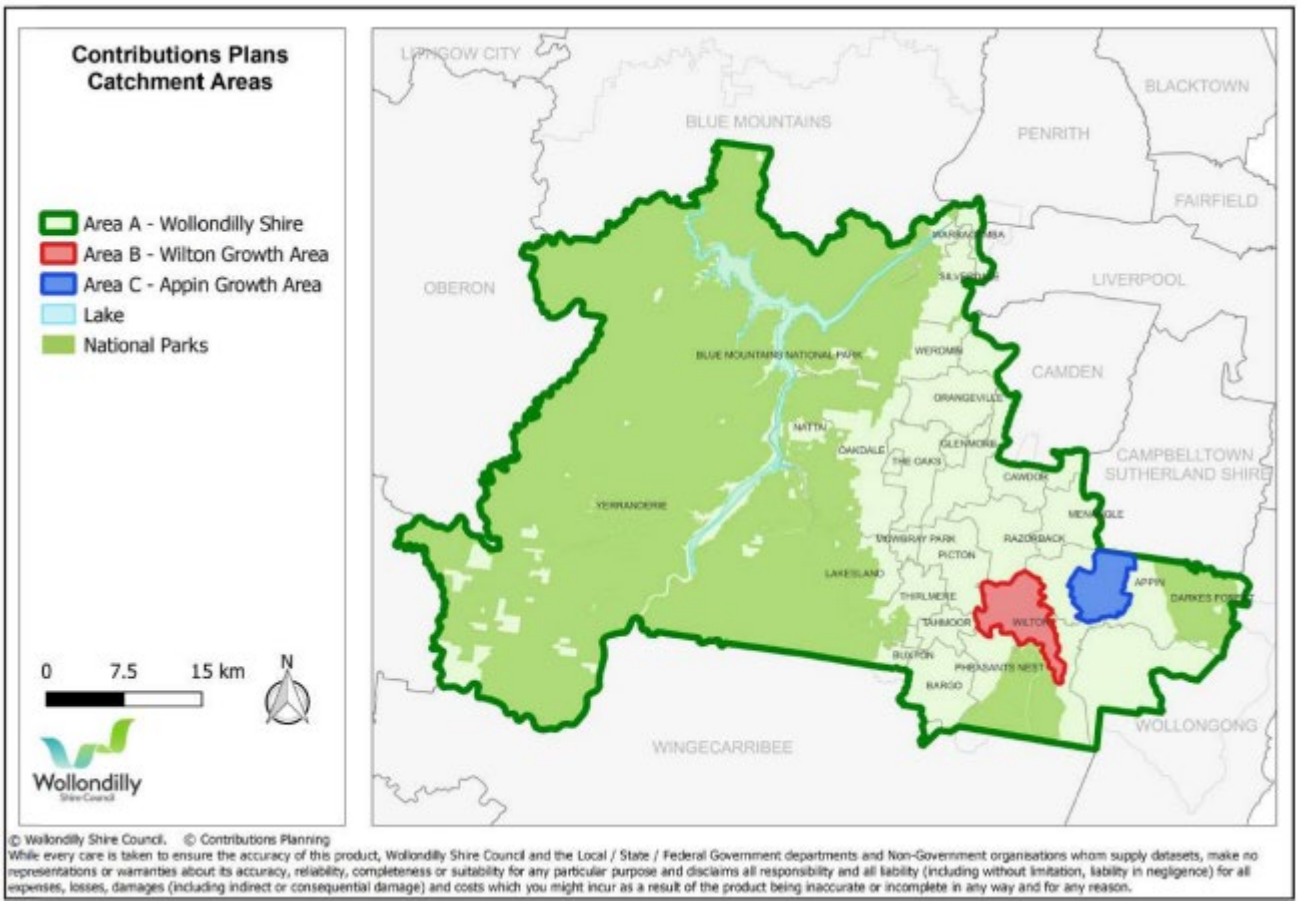


Figure 6: Location of the Appin and Wilton urban growth areas (Source: Wollondilly Shire Council, 2024)

2.3.2 Mining

Large parts of the Metropolitan and Woronora Special Areas, as well as the eastern and north-western fringes of the Warragamba Special Areas, have been the subject of mining, both historically and currently. Production and exploration mining titles extend across the majority of the Woronora and Metropolitan Special Areas.

Longwall coal extraction has affected the local water quality of impacted rivers and streams through increases in iron and manganese concentrations, the formation of bacterial mats and fine sediment accumulations. Surface and subsurface fracturing of the bedrock has seen the loss of surface water flows from some sections of rivers and creeks and groundwater discharges from upland swamps during low flow times in particular. There is evidence of an increase in the interconnectivity of surface and groundwater sources due to mining impacts, resulting in the loss of water from some sub-catchments. These changes cause impacts on local ecological processes, threatened species and contribute to increased concentrations of metals.

Mining has also caused the destabilisation of cliff lines about longwall operations resulting in rock falls in some locations. Mining operations also result in the clearing of vegetation of exploration programs, road establishment, monitoring equipment and infrastructure such as mine ventilation shafts. These activities have the potential to contribute pollutants to waterways through erosion and the unintended discharge of drilling fluids, wastewater, fuels and chemicals.

Mine subsidence is the movement of the ground that can occur after underground coal mining. After coal is extracted from beneath the ground, the land above can sink and fill the hollow mine workings. This can cause tilts and strains on the ground surface. Mine subsidence may cause:

- structural damage to buildings and services (including pipelines, and sewers), and reduced serviceability of roads and railways
- surface cracking, especially in areas towards the edges of subsidence zones
- fracturing and vertical drainage of groundwater from shallow aquifers, reducing the water available to springs, peat swamps and other ecosystems
- damage to cultural heritage sites
- surface water diversion, reducing the water supplied to features such as streams, lakes and swamps.

Regulatory action has been taken against a mining company in the Special Areas as a result of water take resulting from mine subsidence (Swamp 14).

2.4 Population change

Related to changes in urban development, population increase can cause pressures in the Special Areas particularly related to water quality (Section 3.2) from possible increases in pollution, illegal access (Section 3.5) and in the lighting of fires (Section 3.6).

A preliminary assessment of population growth within Special Area boundaries was undertaken through analysis of population records sourced from the Australia Bureau of Statistics (ABS) for 2011, 2016, and 2021 censuses. Population analysis included aggregation of population data from Statistical Areas Level 1 (SA1s) for all SA1 areas located entirely or partly within the boundaries of the Special Areas. Results are depicted in Table 3.

Table 3: Population recorded in the Special Areas

2011	2016	2021	Average Annual Increase (% p.a.)
30,415	33,762	33,610	1.0

It should be noted that the 2021 Census was conducted during the COVID-19 pandemic when many parts of Australia were in lockdown and movements within, into and out of Australia were tightly controlled. Subsequently, population growth across Australia was reported in 2020 and 2021 due the substantial decrease in net overseas migration.

There was a steady increase in population across Sydney's Drinking Water Catchment as shown in Table 4.

Table 4: Population recorded across Sydney's Drinking Water Catchment

2011	2016	2021	Average Annual Increase (% p.a.)
113,146	120,677	129,250	0.9%

2.5 COVID-19

It should be noted that the COVID-19 pandemic was at its peak between March 2020 and June 2022. Due to changes in people's behaviour related to a wave of government-controlled mobility restrictions, the pandemic may have caused more illegal access in the Special Areas and altered visitation numbers in Schedule 2 Special Areas (Section 3.5). Other potential pressures due to the pandemic are difficult to gauge.

2.6 Pollution and contamination

Pollution and contamination are pressures on the water quality of the Special Areas (discussed in Section 3.2). Pollution is the introduction of a harmful or poisonous substance into the environment. Pollutants can be natural (e.g., ash from a bushfire) or created by human activity. Pollutants can enter waterways via:

- Point sources – include sewage treatment plants, on-site sewage management systems, urban development stormwater infrastructure and intensive agriculture (e.g., dairies, piggeries). Some point sources are regulated by the EPA under an environment protection licence in accordance with the *Protection of the Environment Operations Act 1997*.
- Diffuse sources – involve pollutants entering waterways via uncontrolled runoff from land uses such as grazing and forestry, or the atmosphere.

Contaminated sites include former gas works and waste disposal depot with asbestos.

EcoLogical (2023) found that during the reporting period that "pollution and contamination continue to adversely affect the health of the Catchment but are generally well regulated, managed and monitored. This indicator was therefore assessed as having a moderate state and a stable trend".

3. State and response

3.1 Water quantity

Sydney's drinking water catchments supply water to around 4.5 million people, approximately 60 percent of NSW's population. WaterNSW manages a total of 21 storage dams that hold more than 2.5 million megalitres of water. It provides raw water to four key customers with water supply agreements in place to address water quantity and quality objectives.

The water quantity or catchment yield is significantly influenced by the climatic conditions (Section 2.1), land uses (Section 2.3) and extraction activities undertaken in the catchments outside the Special Areas. In all, approximately 77 percent of the hydrological catchment is located outside of the Special Areas.

However, the Woronora, Metropolitan and Blue Mountains Special Areas (see Figure 2) represent most of the hydrological catchments for those particular storages. In general, only activities within or adjoining these areas are likely to impact on water quantity.

Within the Special Areas, activities such as illegal water extraction, long-wall coalmining (Section 2.3) and climate change (Section 2.2) could lead to a reduction in yield and can have significant impacts on the available water supply.

3.1.1 State of the Special Areas – water quantity

3.1.1.1 Surface water flow

Surface water flow refers to the rate (ML/day) at which water moves in creeks or rivers. It is calculated using measured river levels at gauging stations. Flow rates are part of the calculation for stream discharge which is the volume of water flowing through creeks and rivers per unit of time.

There are several water flow gauging stations located within the Special Areas. All of these gauging stations experienced a large increase in discharge across the study period related to increased rainfall trends (Section 2.1). For example, the Coxs River gauging station at Kelpie Point located in the Warragamba Special Area shows significant discharge spikes in 2020-22 compared to 2019 (Figure 7).

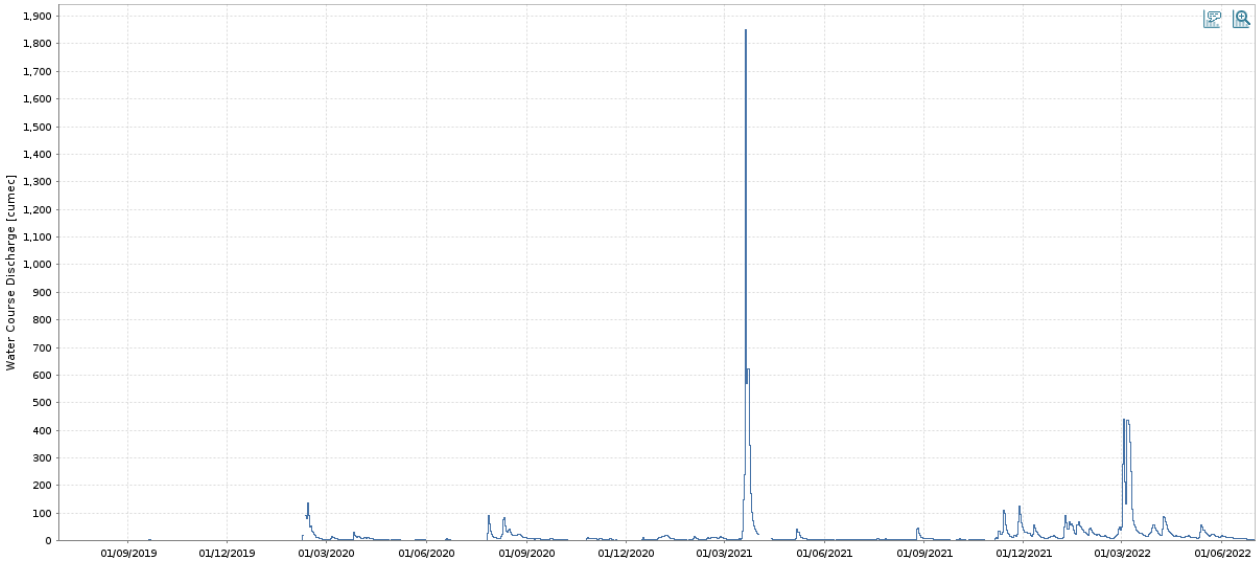


Figure 7: Stream discharge data at Coxs River (Kelpie Point) gauging station 2019-2022 (Source: Bureau of Meteorology)

Similar trends in water flow are shown in other parts of the Special Areas during the reporting period. Figure 8 shows stream discharge data for the Cordeaux River (located in the Metropolitan Special Area) and Figure 9 shows data for the Woronora River located in the Woronora Special Area.

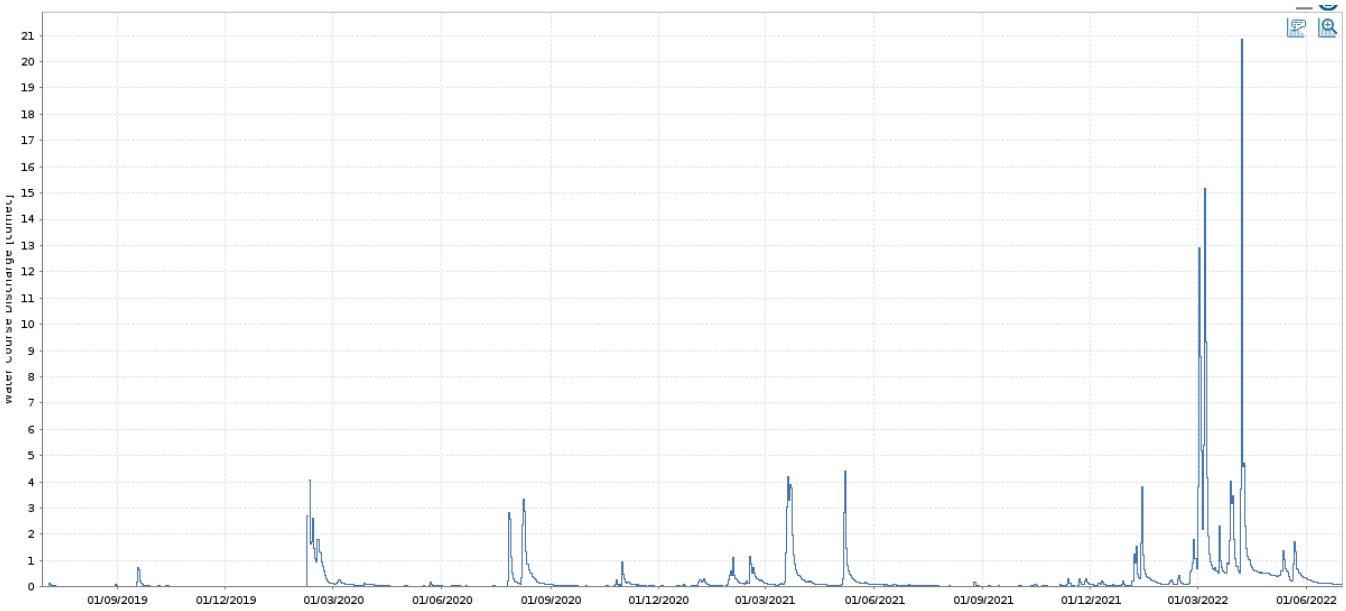


Figure 8: Stream discharge data at Cordeaux River gauging station 2019-2022 (Source: Bureau of Meteorology)

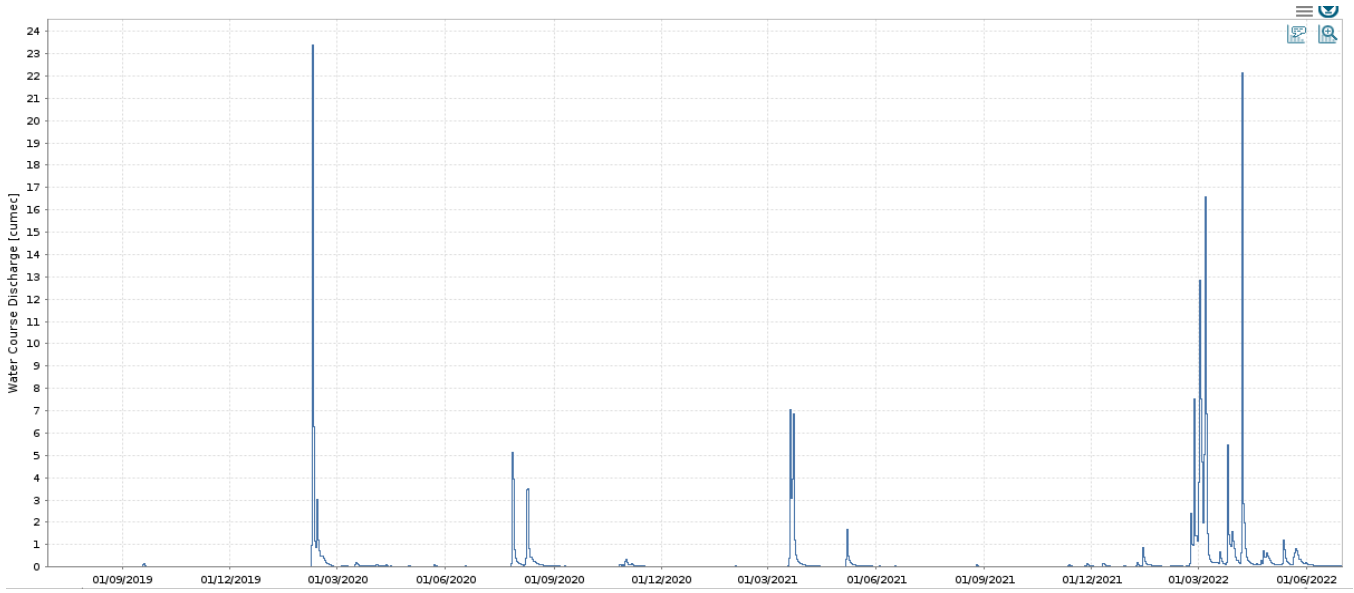


Figure 9: Stream discharge data at Woronora River gauging station 2019-2022 (Source: Bureau of Meteorology)

A slight variance with the Woronora data is a discharge spike in February 2020 most likely due to localised heavy rainfall in that catchment.

Rates of flow can affect aquatic ecosystems, erosion and water quality. This is further discussed in the Water Quality (Section 3.2) and Ecological Integrity (Section 3.7) chapters.

3.1.1.2 Groundwater

Groundwater is an important part of the water flow provision which is assisted by the Special Areas. Groundwater provides important base flow to the Special Area streams and storages especially during droughts such as was experienced leading into 2019. Acting like sponges in wet weather, swamps in and around the Special Areas play an important role in provide slow-release base flows to the streams.

Impacts to the hydrogeological connections of surface and groundwater sources can have negative impacts on surface flows, ecological values and potentially to the flows reporting to the storages. As discussed in Section 2.3, surface and subsurface fracturing of the bedrock due to longwall coal extraction has seen the loss of surface water flows from some sections of rivers during low flow times in particular. There is evidence of an increase in the interconnectivity of surface and groundwater sources.

Approximately 80% of the groundwater monitoring bores operated by WaterNSW in Sydney's Drinking Water Catchments are located in the coal mining areas in and around the Special Areas (Figure 10).

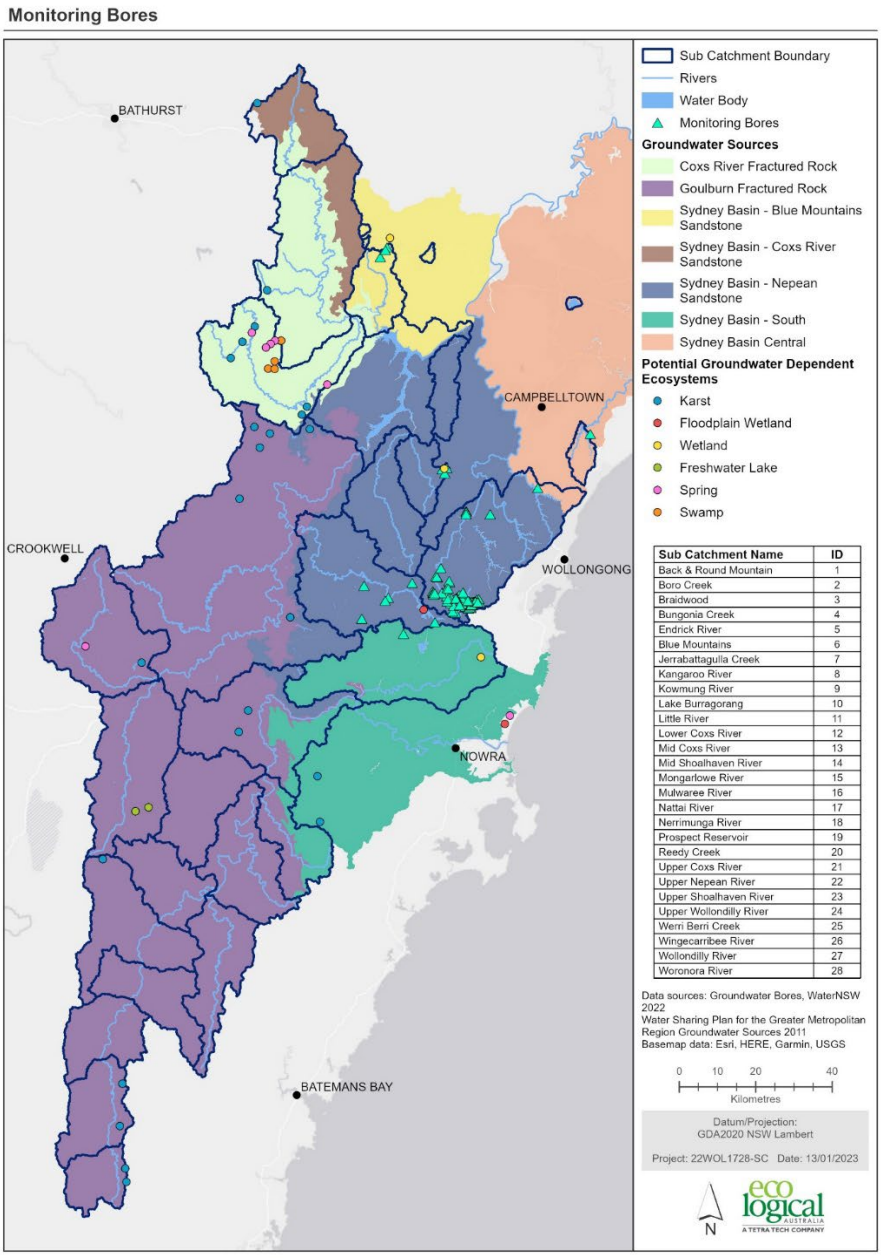


Figure 10: Groundwater monitoring sites (source: EcoLogical, 2023)

EcoLogical (2023) found that most of the groundwater monitoring bores in and around the Special Areas suggest a climate response, with the majority of water levels rising over the reporting period, reflecting increased rainfall. However, "local falling trends are observed at deep bores within the mining area of the Upper Nepean sub-catchment and reflect local mining activities on deep aquifers".

3.1.2 Response – water quantity

The Special Areas play a critical role in providing both surface water and groundwater as part of the Greater Sydney Water Strategy (NSW Department of Planning and Environment, 2022).

During the reporting period, WaterNSW continued to apply resources to understand catchment water quantity and how it relates to the supply of raw water and ecological values. It has several surface flow monitoring stations across the Special Areas (Section 3.1.1) to understand the sources of flows and relationships with water quantity.

As discussed in Section 3.1, within the Special Areas, activities such as illegal water extraction, long-wall coalmining, and climate change could lead to a reduction in yield and can have significant impacts on the available water reserves and flow regimes.

WaterNSW conducted research during the reporting period to understand these risks to water quantity and quality in the Special Areas.

Case study: Modelling water tables and swamps

During the reporting period, WaterNSW modelled water tables and swamps including in the Special Areas. Modelling water tables and swamps requires intricate hydrological and ecological models to comprehend and forecast the dynamics of these water reliant environments. Models of the water table generally include information on soil characteristics, land elevation, rainfall, evapotranspiration, and underground water movement to predict the water table's depth and changes over a period.

Mining operations could lead to a reduction in the water level by changing or using up groundwater sources that act as the hidden storage of water. A reduction in the water table can lead to swamps drying, as well as potential subsidence causing the ground surface to sink in certain instances. The reduction in the water table may also diminish the water supply for nearby ecosystems, farming, and human use.

A decrease in the water table can cause wetlands to dry up, leading to the disappearance of plants and animals which rely on these habitats. In addition, mining may lead to the discharge of harmful substances into groundwater, where they can infiltrate water bodies, leading to a decline in water quality and negatively impacting the overall health of the ecosystem. Reducing the water table and pollution can result in long-term harm to wetlands, causing a decrease in biodiversity, the loss of flood control capabilities, and the disturbance of nutrient cycles essential for the well-being of these delicate ecosystems.

Research was also conducted during the reporting period into the variability of water levels in Thirlmere Lakes which are located in the Special Areas.

Case study: Research into water levels at Thirlmere Lakes

Thirlmere Lakes is a group of 5 waterways: Lakes Gandangarra, Werri Berri, Couridjah, Baraba and Nerrigorang. Located near Picton, Thirlmere Lakes National Park not only protects the important wetland system but also allows recreational activities such as swimming, kayaking and walking.

Water levels in Thirlmere Lakes have fluctuated over time. However, a decline in water levels over the last decade caused significant community concern. Some members of the local community were concerned that the water loss could be the result of nearby mining activity.

In 2017, the NSW Department of Climate Change, Energy, the Environment and Water committed $1.9 million over 4 years for a special investigation, the Thirlmere Lakes Research Program, to help understand the fluctuating water levels in the lakes. The research program provided a more detailed understanding of the dynamics of water sources and water flow paths in Thirlmere Lakes by investigating the system's geology, geomorphology, hydrogeology and hydrology. Researchers investigated the sensitivity of these wetland systems to external influences, including looking for evidence of the potential effects of mining activity and groundwater extraction.

The community was presented with the key findings from the Thirlmere Lakes Research Program in June 2021. The study found that:

- Climate variability was the major driver of recent drying in Thirlmere Lakes and responsible for between 83% and 98% of water level fluctuations in recent times.
- It is likely that the lakes will continue to oscillate between being dry and maintaining higher water levels depending on drought and the frequency, intensity and duration of rainfall events.
- The research found no direct links between the drying of Thirlmere Lakes and the nearby coal mine but could not rule out a smaller (relative to climate) impact on water levels from mining.

3.2 Water quality

The quality of water within the Special Areas is important not only as a source of raw water, but also to support the habitat values of a range of fauna and flora (Section 3.7).

Most of the land within the Special Areas is protected native vegetation, which provides a foundation for sustaining good water quality. However, certain land use activities in Sydney's Drinking Water Catchment can increase the potential for adverse impacts on water quality because they generate additional sources or relatively high levels of pollutants compared to intact native vegetation. These activities include grazing, horticulture, intensive animal production, mining, urban and transport infrastructure development. Some of these activities also occur on leased or private land within the Special Areas.

The types of water pollutants can be broadly grouped into three main categories:

1. **Pathogens** or microorganisms such as *Cryptosporidium*, *Giardia* and enteric viruses and bacteria can cause health concerns for water users and are costly to remove from drinking water. Waterborne pathogens are excreted in the faeces of people, domestic and/or feral animals.
2. **Nutrients** – nitrogen and phosphorus within nutrient-rich runoff can lead to an increase in the frequency and severity of outbreaks of cyanobacteria (blue-green algae) blooms with their potential to generate cyanotoxins in water supplies. This can result in taste and odour issues and test the capability of water treatment. An increased risk of nutrient release in the Special Areas may arise because of large or high intensity fire.
3. **Sediments** – suspended solids are fine particles from soil and other sources suspended in the water which can impact the performance of water treatment plants, help transport phosphorus and nitrogen, and reduce the effectiveness of ultraviolet treatment and natural sunlight to remove pathogens. Erosion and sedimentation are typically caused by land clearing or disturbance associated with roads and trails, pest species and some recreational activities. Fire can also affect water quality, particularly if the fire is so intense that it denudes the landscape of vegetation cover and is followed by heavy rainfall that washes exposed soil and ash into waterways.

In addition, other pollutants such as pesticides, heavy metals, organic chemicals and salt are monitored as part of WaterNSW's water monitoring program.

3.2.1 State of the Special Areas – water quality

Water quality monitoring results are reported in the annual water quality monitoring report including for 2019-20 (WaterNSW, 2020b), 2020-21 (WaterNSW, 2021b) and 2021-22 (WaterNSW, 2022b). Further analysis is provided in the independent catchment audit report every three years (e.g. EcoLogical, 2023), as required under Section 42 of the *Water NSW Act 2014*.

INDICATOR – WATER QUALITY

An analyte is a chemical substance that is sampled and measured. There are several water quality analytes in WaterNSW's water monitoring program with the following outlined in this report:

- ***Conductivity**. Electrical conductivity is a measure of the saltiness of the water and is measured on a scale from 0 to 50,000 uS/cm. Levels of below 500 uS/cm generally indicate good drinking water for humans (provided there is no organic pollution and not too much suspended clay material).*

- ***Temperature**. Temperature is a critical water quality and environmental parameter because it governs the kinds and types of aquatic life, regulates the maximum dissolved oxygen concentration of the water, and influences the rate of chemical and biological reactions.*
- ***Turbidity**. Turbidity is the measurement of water clarity. It is used to indicate the presence of pathogens, bacteria, and other contaminants such as lead and mercury which are harmful to both aquatic life and human health.*
- ***Escherichia coli (E. coli)**. E. coli is a type of bacteria commonly found in the gut of warm-blooded animals and people. Water that is contaminated with human or animal faeces can contain a range of pathogens, including bacteria, viruses and protozoa. E. coli can enter waterways from a range of sources and pathways, including wastewater and stormwater discharges or overflows, runoff from urban and agricultural land, seepage from failing septic tanks, and direct deposition by livestock and wild animals.*
- ***Total Nitrogen**. Nitrogen is an effective fertiliser and essential plant nutrient, but increased concentrations in water can cause negative environmental effects. Some forms of nitrogen can become toxic to aquatic life at high concentrations, particularly under certain temperatures and pH conditions. Excess nitrogen (at lower concentrations than required to cause toxicity effects) can also contribute to rapid growth of aquatic weeds and algae in waterways. Commonly, this can result in plant or algal blooms. The most common sources are leaching and run-off from agriculture, wastewater treatment plants, fertilised lawns, leaky septic systems, and industrial discharges. Total nitrogen (TN) is a mix of nitrate, nitrite, organic nitrogen and ammonia.*
- ***Total Phosphorus**. Total phosphorus (TP) is a measure of all types of phosphorus present. It includes the phosphate that is stuck to soil (sediment) as well as dissolved reactive phosphorus (DRP) which is more readily available for plants. TP is an important measure because most phosphate enters waterways attached to sediment via run-off. Phosphorus can occur naturally in rocks and minerals, and it can be a common component in soils and sediments. Fertilisers can be applied to soils to improve phosphorus availability, enabling agricultural and horticultural intensification and improved pasture production. Very high phosphorus concentrations in a stream, river or lake are likely to cause rapid weed growth or algal blooms which can choke aquatic life and cause long-term damage to the health of a waterbody.*
- ***Total Suspended Solids**. Total Suspended Solids (TSS) is a quantitative measurement of suspended particles in water. As noted above, turbidity refers to water's transparency and the more suspended solids water contains, the less transparent it will be. High TSS may decrease water's natural dissolved oxygen levels and increase water temperature. This may prevent organisms living in the water, such as small fish, from being able to survive. TSS may also block sunlight, which may halt photosynthesis, decreasing the survival of plants and further decreasing water's oxygen levels. Increased erosion of banks of rivers and streams can increase the TSS level in water with other possible sources including clearing of vegetation for development.*

Table 5 provides results for these seven analytes from water sampling sites within the Special Areas. The results are averages from the water sampling sites for each of the years in the study period: 2019-20, 2020-21 and 2021-22.

Water sampling sites are located across the Special Areas catchments as follows:

- *Avon catchment (5 water sampling sites)*
- *Blue Mountains (3)*

- *Broughton Pass (3)*
- *Cataract (8)*
- *Cordeaux (5)*
- *Nepean (6)*
- *Pheasants Nest (1)*
- *Shoalhaven (8)*
- *Warragamba (16)*
- *Wingecarribee (13)*
- *Woronora (5)*

It is not pertinent to trend the results only across the years in the study period as:

- *Water quality is heavily dependent on weather impacts noting that there was a large variation in rainfall across the study period with drought in first few months of 2019-20 and above average rainfall in 2020-22 (see Section 2.1). It is anticipated that future reports will provide indicators that trend data relating to water quality and water quantity.*
- *There was no comparison with data from previous study periods as this is the first State of the Special Areas report.*

The Australian and New Zealand Environment Conservation Council (ANZECC) published the revised Australian and New Zealand guidelines for fresh and marine water quality in 2000. These guidelines, which are usually called the 'ANZECC guidelines' provide government and the community with a framework for conserving ambient water quality in our rivers, lakes, estuaries and marine waters.

The data provided in Table 5 shows in red where the result is greater than the upper levels prescribed in the ANZECC guidelines.

The catchments listed in Table 5 are shown in Figure 2. Some numbers in the data in Table 5 have been rounded out to allow for easy comparison.

Table 5: Mean annual water quality results for selected analytes sampled within the Special Areas 2019-22

Avon catchment

Measurement Unit	2019-20	2020-21	2021-22
Escherichia coli (E. coli) (orgs/100mL)	13	83	27
Nitrogen Total (mg/L)	0.098	0.125	0.110
Phosphorus Total (mg/L)	0.008	0.007	0.007
Suspended Solids (mg/L)	2.75	1.48	1.88
Conductivity (uS/cm)	72	66	64
Temperature (Deg C)	14	16	16
Turbidity Field (NTU)	0.67	1.17	0.49

Blue Mountains catchment

Measurement unit	2019-20	2020-21	2021-22
Conductivity (uS/cm)	47	48	35
Temperature (Deg C)	12	14	12
Turbidity Field (NTU)	1.55	1.86	2.06

Broughton Pass

Measurement unit	2019-20	2020-21	2021-22
Conductivity (uS/cm)	214	105	113
Temperature (Deg C)	22	16	17
Turbidity Field (NTU)	3.78	0.37	5.76

Cataract catchment

Measurement unit	2019-20	2020-21	2021-22
Escherichia coli (E. coli) (orgs/100mL)	8	18	38
Nitrogen Total (mg/L)	0.135	0.128	0.138
Phosphorus Total (mg/L)	0.008	0.009	0.010
Suspended Solids (mg/L)	7.50	1.75	2.17
Conductivity (uS/cm)	182	528	124
Temperature (Deg C)	16	17	17
Turbidity Field (NTU)	2.32	3.29	4.68

Cordeaux catchment

Measurement unit	2019-20	2020-21	2021-22
Escherichia coli (E. coli) (orgs/100mL)	46	106	48
Nitrogen Total (mg/L)	0.060	0.120	0.960
Phosphorus Total (mg/L)	0.010	0.013	0.014
Suspended Solids (mg/L)	2.60	2.06	2.56
Conductivity (uS/cm)	99	87	88

Temperature (Deg C)	13	14	14
Turbidity Field (NTU)	1.16	2.81	1.74

Nepean catchment

Measurement unit	2019-20	2020-21	2021-22
Escherichia coli (E. coli) (orgs/100mL)	18	90	28
Nitrogen Total (mg/L)	0.328	0.362	0.308
Phosphorus Total (mg/L)	0.012	0.016	0.013
Suspended Solids (mg/L)	4.20	4.95	1.92
Conductivity (uS/cm)	104	72	76
Temperature (Deg C)	15	16	15
Turbidity Field (NTU)	5.55	22.83	7.48

Pheasants Nest

Measurement unit	2019-20	2020-21	2021-22
Conductivity (uS/cm)	116	104	111
Temperature (Deg C)	15	24	1812
Turbidity Field (NTU)	0.80	5.00	6.39

Shoalhaven

Measurement unit	2019-20	2020-21	2021-22
Conductivity (uS/cm)	112	110	111
Temperature (Deg C)	14	16	16
Turbidity Field (NTU)	4.87	7.81	6.89

Warragamba catchment

Measurement unit	2019-20	2020-21	2021-22
Escherichia coli (E. coli) (orgs/100mL)	16	353	75
Nitrogen Total (mg/L)	0.265	0.695	0.330
Phosphorus Total (mg/L)	0.008	0.022	0.014

Suspended Solids (mg/L)	4	52	5
Conductivity (uS/cm)	236	197	175
Temperature (Deg C)	14	15	14
Turbidity Field (NTU)	2.88	12.58	12.64

Wingecarribee catchment

Measurement unit	2019-20	2020-21	2021-22
Conductivity (uS/cm)	98	90	80
Temperature (Deg C)	13	15	14
Turbidity Field (NTU)	10.35	6.52	4.67

Woronora catchment

Measurement unit	2019-20	2020-21	2021-22
Escherichia coli (E. coli) (orgs/100mL)	41	11	13
Nitrogen Total (mg/L)	0.113	0.090	0.055
Phosphorus Total (mg/L)	0.005	0.008	0.006
Suspended Solids (mg/L)	2.33	1.77	1.25
Conductivity (uS/cm)	99	87	88
Temperature (Deg C)	16	17	17
Turbidity Field (NTU)	1.04	4.57	1.62

Exceeds ANZECC Guidelines

The data showed varying trends in water quality across different catchments. Conductivity levels fluctuated, with most catchments experiencing changes in salt concentrations, likely due to seasonal variations, rainfall, or land-use activities. Temperature trends indicated higher values in 2020-21, suggesting potential warming or seasonal effects, with a slight reduction in some catchments in 2021-22. Turbidity values also showed notable increases, especially in 2020-21, which could be due to disturbances such as increased runoff and erosion due to above average rainfall. Overall, the data reflect dynamic changes in water quality, influenced by both natural factors and human activities, with certain catchments experiencing more significant fluctuations in conductivity, temperature, and turbidity.

Similarly, there were fluctuations in the other analytes across the study period. In most locations, E.coli tended to peak in 2020-21 possibly due to the onset of heavy rains with increased runoff from the upstream

catchments. Total Nitrogen also tended to peak in the wetter years of 2020-21 and 2020-22, whilst Total Phosphorus was reasonably stable across the study period.

As shown in Table 5, there were 10 exceedances of the ANZECC Guidelines across the Special Areas during the study period:

Warragamba catchment – 6 exceedances

Nepean catchment – 3 exceedances

Cataract catchment – 1 exceedance.

3.2.2 Response – water quality

Water quality management for Sydney's Drinking Water Catchment follows a multiple barrier approach consistent with the Australian Drinking Water Guidelines (National Health and Medical Research Council, 2011).

Elements of the multiple barrier approach are illustrated in Figure 11 and include:

- monitoring and influencing land use, development and activities across the catchment
- establishing, maintaining and managing Special Areas and Controlled Areas around water storages and water supply infrastructure, where human access or certain activities are restricted
- reservoir management
- water treatment and distribution.

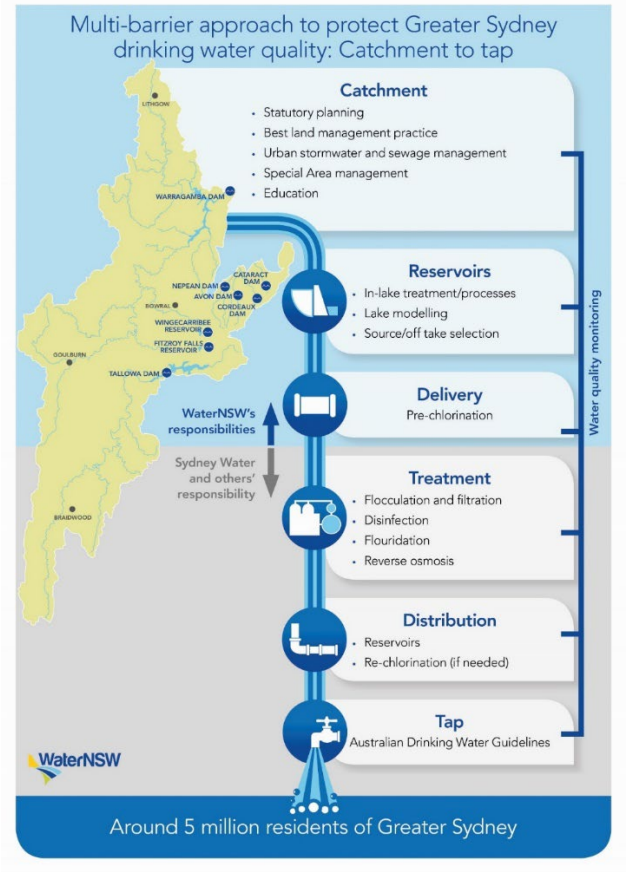


Figure 11: Multi-barrier approach to protect Greater Sydney drinking water quality (source: WaterNSW)

As shown in Figure 11, Special Areas management is an integral part of the approach to protect Greater Sydney drinking water quality.

With this in mind, the joint sponsors conducted several programs within the Special Areas to help manage water quality including:

- Water quality monitoring. The are numerous water quality monitoring stations across the Special Areas. The water quality monitoring results (some of which are analysed in Section 3.2.1) are reported in the annual water quality monitoring report including for the reporting period: 2019-20 (WaterNSW, 2020b), 2020-21 (WaterNSW, 2021b) and 2021-22 (WaterNSW, 2022b). The results help to understand water quality sources and impacts and appropriate land management activities.
- Pathogen risk management. The joint sponsors seek to reduce the pathogen hazard in the Special Areas by restricting human access (Section 3.5.2), fencing out domestic stock and by implementing feral animal control programs (Section 3.3.2), not only to reduce the overall level of pathogens introduced into the environment, but also by specifically targeting those localities with the greatest likelihood of the pathogens being transported into the water storages.
- Nutrient risk management. An increased risk of nutrient release in the Special Areas may arise as a result of large or high intensity fires such as those experienced in 2019-20. To address this, the joint sponsors seek to promote appropriate fire regimes within the Special Areas. This is achieved through rigorous fire management planning and the implementation of comprehensive programs across the Special Areas. Nutrients from sewage can be minimised by restricting human access and managing activity within the Special Areas.
- Sediment risk management. To address the issue of sediments, the joint sponsors seek to minimise disturbance during land management operations. This is achieved by addressing incidents of active erosion, managing fire and implementing an active program of asset maintenance (Section 3.4.2). The joint sponsors ensure that any activity meets the requirements of the NSW *Environmental Planning and Assessment Act 1979* to minimise impacts on the environment.

The reporting period saw some significant impacts on water quality in the Special Areas due to drought, bushfire and heavy rainfall (Section 2.1). This would help explain some of vagaries of the water quality results for the Special Areas provided in Section 3.2.1 and the exceedances of ANZECC Guidelines. The bushfires (Section 3.6) and floods also impacted proactive water quality management programs including those related to Pest and Weeds (Section 3.3.2) and Fire (Section 3.6.2).

3.3 Pests and weeds

Pest animals and weeds can out-compete or prey on native species, they can destroy or degrade habitat, and they can spread disease. They are regarded as threats to ecological integrity and the conservation values of Special Areas, and they can pose a risk to water quality and degrade areas of cultural significance.

3.3.1 State of the Special Areas – pests and weeds

3.3.1.1 Pest animals

The Greater Sydney Regional Strategic Pest Animal Management Plan 2018-2022 (Local Land Services, 2018a) covers much of the Warragamba Special Area, Woronora Special Area and the Special Areas in the Blue Mountains. Most of the other Special Areas are covered by the South East Regional Strategic Pest Animal Management Plan 2018-2022 (Local Land Services, 2018b). The plans support regional implementation of the *NSW Biosecurity Act 2015*. They present a clear vision by identifying regional priorities for pest animal management and outline how government agencies, community groups and individual land managers will share responsibility and work together across land tenures to prevent, eradicate, contain and manage the impacts of pest animals. In the case of the Special Areas, the joint sponsors – NPWS and WaterNSW – share responsibility for pest animal management.

The joint sponsors work with stakeholders through regional pest animal committees to advocate for the Special Areas and control pest animals around their perimeters. The Illawarra Deer Management Program is a landscape scale program to reduce deer impacts on the environmental and social values of the Illawarra region - both NPWS and WaterNSW are active in the program.

The regional plans identify the following main pest animal species that are found in the Special Areas:

- Feral pigs. Feral pigs (Figure 12) are established in the southern parts of the Blue Mountains (including the Warragamba Special Area), as part of the larger western population (Figure 13). From time to time, isolated populations are found across the region, most likely as a result of illegal translocations (releases) of feral pigs. According to Local Land Services (2018a), "Feral pigs are well known to have a significant impact on water quality, which is of particular concern around drinking water catchments in Greater Sydney". They also impact threatened species and threatened ecological communities 'due to rooting and wallowing behaviours' and present a significant threat to Australian native fauna and flora through habitat degradation, weed dispersal and opportunistic feeding behaviour.
- Feral deer. According to mapping for the plans, feral deer are "moderately distributed" throughout both regions including the Special Areas. Feral deer have a range of environmental impacts, including browsing and grazing that affects plant seedling recruitment and growth, damage to vegetation through trampling and antler rubbing, impacts on water quality through wallowing and faecal contamination and transporting weed seeds. Deer impacts on endangered ecological communities (EECs), particularly Upland Swamps and Bristle bird habitats,
- Feral goats. Throughout both regions, feral goats are often found in small, isolated populations managed through asset-based protection. They are rated as a 'low risk' in the Warragamba Special Area according to the Plan (Local Land Services, 2018a). Feral goats compete with native animals for food, water and shelter, cause soil erosion through overgrazing and trampling vegetation ground cover, as well as spread disease to native species.

Figure 12: Feral pig (photo: Andrew Bengsen)

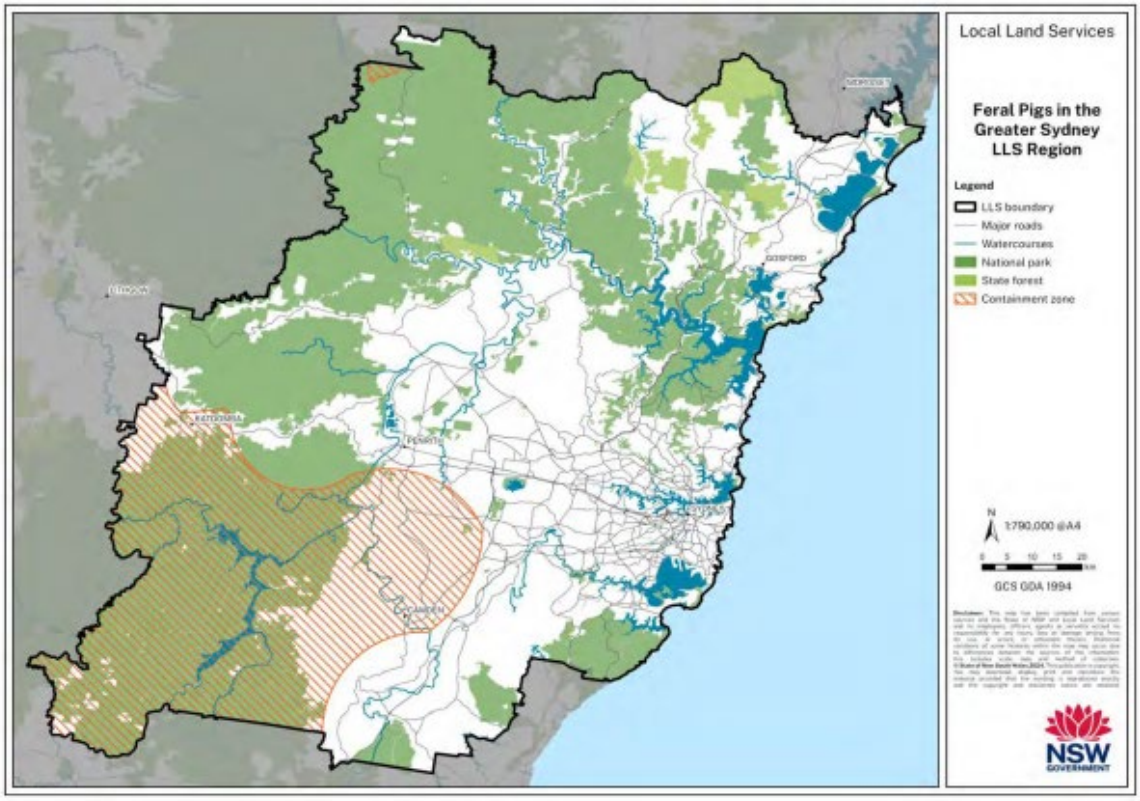


Figure 13: Distribution of feral pigs in the Great Sydney Region (source: Local Land Services, 2018a)

"The main challenge with monitoring hard-hoofed pests in the Special Areas is measuring population change and environmental impact caused by species that occur at low densities in a vast, remote, and mostly forested landscape."

NSW Department of Planning and Environment, 2022a

Remotely located motion/heat triggered camera arrays or camera traps are a reliable method for recording pest animal activity. During the reporting period, 4 camera traps were established at:

Warragamba Special Area

- Kedumba Valley (Blue Mountains National Park)
- Wollondilly Valley (Yerranderie State Conservation Area and Nattai National Park)
- Burragorang State Conservation Area.

Metropolitan Special Area

- Upper Nepean State Conservation Area.

At the Kedumba Valley site, feral pig populations were estimated to have grown exponentially since July 2020 (Figure 14). "This is consistent with the ideal environmental conditions for pig population growth following the 2019-20 fires" (NSW Department of Planning and Environment, 2022a). Wild horses and cattle were also observed at this site.

Pests detected at Wollondilly and Burragorang site included feral pigs and feral deer including Red, Rusa, Sambar and Fallow deer (*Cervus elaphus, timorensis, unicolor* and *Dama dama)*. Only deer were found at the Upper Nepean site.

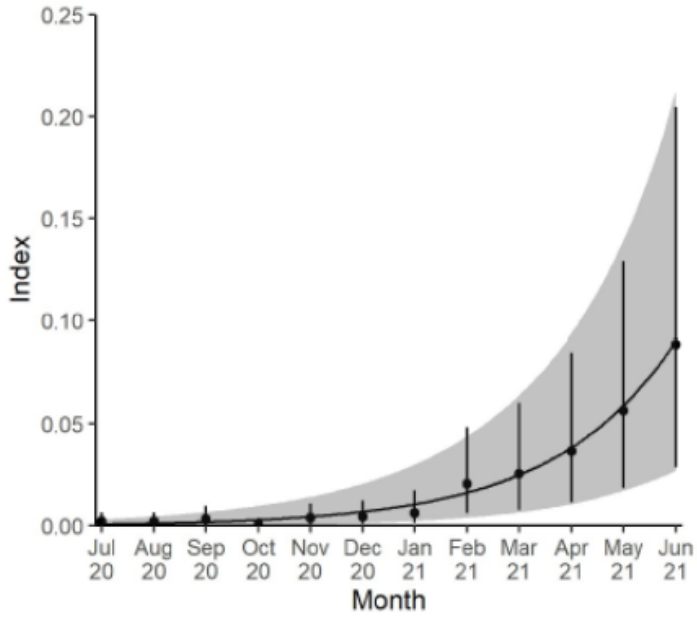


Figure 14: Exponential growth of the feral pig activity index at Kedumba Valley (source: NSW Department of Planning and Environment, 2022a)

3.3.1.2 Weeds

The Greater Sydney Regional Strategic Weed Management Plan 2017-2022 (Local Land Services, 2017a) covers much of the Warragamba Special Area, Woronora Special Area and the Special Areas in the Blue Mountains. Most of the other Special Areas are covered in the South East Regional Strategic Weed Management Plan 2017-2022 (Local Land Services, 2017b). The plans support regional implementation of the *NSW Biosecurity Act 2015* by articulating community expectations in relation to effective weed management and facilitating a coordinated approach to weed management in the region. In the case of the Special Areas, the joint sponsors – NPWS and WaterNSW – share responsibility for weed management.

Of particular concern in the Special Areas are Willows (*Salix* spp) and aquatic weeds such as Long-leaf willow primrose (*Ludwigia* spp).

Willows are among the worst weeds in Australia due to their invasiveness, potential for spread, and economic and environmental impacts. They are a Weed of National Significance and listed as a State and Regional Priority Weed in both plans. They have invaded riverbanks and wetlands in temperate Australia, occupying thousands of kilometres of streams and numerous wetland areas. Unlike most other vegetation, willows spread their roots into the bed of a watercourse, slowing the flow of water and reducing aeration. They form thickets which divert water outside the main watercourse or channel, causing flooding and erosion where the creek banks are vulnerable. Willow leaves create a flush of organic matter when they drop in autumn, reducing water quality and available oxygen. This, together with the amount of water willows use, damages stream health.

Figure 15: Willows (photo: NSW Department of Primary Industries)

An aerial survey for Willows across the Warragamba Special Area was conducted in May 2021 by NPWS - see Figure 17. The survey results provided intelligence for a willow treatment program conducted by WaterNSW via watercraft on Lake Burragorang.

The plans (Local Land Services, 2017a; Local Land Services, 2017b) also identify several aquatic weed risks to the regions that include the Special Areas.

Long-leaf willow primrose (Figure 16) is an aquatic weed that could invade large areas of NSW waterways and wetlands. It forms dense colonies in slow moving and still waterways.

Long-leaf willow primrose was discovered in Lake Yarrunga on both WaterNSW and NPWS lands. A joint treatment program coordinated by WaterNSW has been implemented to control the incursion from 2021. A small outbreak of Ludwigia was also observed on NPWS land in the Warragamba Special Area that had originated from a dam on private property. This was treated by a WaterNSW. No other new aquatic weed incursions have been observed in the Special Areas during the audit period (NSW Department of Planning and Environment, 2022a).

Figure 16: Long-leaf willow primrose (photo: NSW Department of Primary Industries)

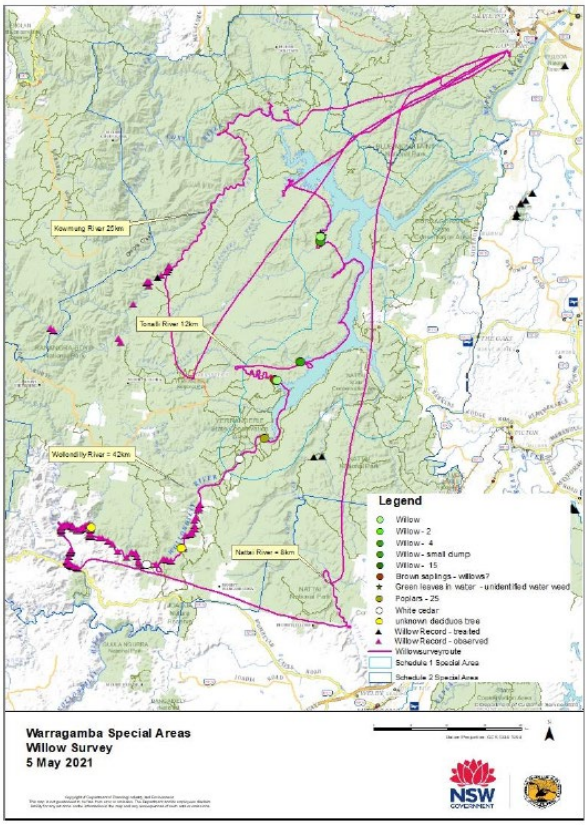


Figure 17: May 2021 survey for Willows in the Warragamba Special Area (source: NSW Department of Planning and Environment, 2022)

3.3.2 Response – pests and weeds

In response to the state of pest animals and weeds in the Special Areas (Section 3.3.1), the joint sponsors implement programs to manage pests and weeds, with an emphasis on those introduced species that have the greatest potential to impact on water quality and ecological integrity.

The complete eradication of pests and weeds over wide areas is not practicable, and it is necessary to prioritise management effort and allocate resources where they will be of greatest benefit. The joint sponsors work with other agencies, landholders and the community to identify pest and weed control priorities.

According to the NSW Department of Planning and Environment (2022a), the joint sponsors embarked on a program during the reporting period with the following targets:

- A reduction in pigs and deer, including:
  - in the Metropolitan Special Areas:
    – a 20% reduction in deer population
    – a 10% reduction in pig population
  - in the Warragamba Special Areas:
    – a 10% reduction in deer population
    – a 10% reduction in pig population
- A reduction in other vertebrate pests, including:
  - a 50% reduction in horse population
  - no increase in goats and cattle
  - new pests are eradicated.
- A reduction in weeds, including:
  - 75% reduction in willows
  - new aquatic weeds are eradicated.

WaterNSW implemented a research program to monitor the home range of deer in the Metropolitan Special Areas by collaring and tracking deer using GPS. It trialled feeder devices to aggregate deer into areas that would make ground control easier and more effective.

INDICATOR – PEST AND WEED ERADICATION

Table 6 provides data on pest and weed eradication conducted by NPWS and WaterNSW during the reporting period.

Table 6: Pest and weed eradication in the Special Areas 2019-22

Measurement unit	2019-20	2020-21	2021-22
PESTS (numbers)			
Deer destroyed	171	95	64
Fox destroyed	126	105	188

Goats destroyed	0	118	85
Pigs destroyed	323	204	602
WEEDS (hectares)			
Ludwigia	16 ha	_	5 ha

Table 6 shows considerable effort by the joint sponsors to reach the targets outlined above. It is important to note that the data in Table 6 should be related to resourcing priorities and changes in pest and weed populations including related to weather conditions. For this reason, it is not pertinent to identify trends over the reporting period.

In relation to Table 6, the conclusion that should be drawn from the numbers is that pest animal populations were increasing as wetter weather conditions favoured population growth. Management efforts continued as evidenced by increases in the number of animals controlled. The area treated for Ludwigia remained constant (506 ha patrolled) and will fluctuate with water levels.

WaterNSW continued to deliver an intensive willow control program on the ecologically significant Wingecarribee Swamp.

3.4 Assets and infrastructure

3.4.1 State of the Special Areas – assets and infrastructure

A range of built assets are maintained within the Special Areas. These include roads, buildings and water supply infrastructure. The Special Areas also contain built assets managed by other parties that relate to utilities, mining, transport corridors and telecommunications. The owners of these assets must maintain facilities to relevant industry standards and must also respond to the hazards represented in the Special Areas, such as fire. The joint sponsors actively work with the asset owners to ensure the maintenance needs of the assets are considered in the context of the Special Area values.

Construction activity and the failure to appropriately maintain infrastructure within the Special Areas has the potential to result in adverse environmental impacts and impede land management activities. These may include clearing of habitat, spreading weed propagules, inadequate access for fighting fires and other management purposes and an increased risk of pollutants being discharged into the environment.

Clearing for new infrastructure including the creation of roads and easements, and developments for other purposes may also affect biodiversity, ecological processes and water quality. Clearing has the capacity to impact on vegetation communities and fauna habitat and introduce new corridors for the movement of pests. New and existing infrastructure may conflict with the maintenance of ecological integrity, where it alters natural stream flows, water tables and flooding regimes. Construction and maintenance activity, if done inappropriately, has the potential to impact water quality and quantity.

The joint sponsors ensure their construction and maintenance activities and those of other parties operating within the Special Areas, will meet environmental planning requirements. The joint sponsors conduct an active program of asset maintenance to maintain safety and operational effectiveness and to minimise the incidence.

The maintenance of roads within the Special Areas is critical to the ability of the joint sponsors and the NSW Rural Fire Service to conduct fire hazard reduction activities and to fight bushfires. The network of

roads also enables the joint sponsors to access parts of the Special Areas to conduct other land management activities including the management of pests and weeds (Section 3.3), cultural heritage (Section 3.8) and ecological integrity (Section 3.7).

Roads and other infrastructure within the Special Areas were damaged in the 2019-20 bushfires (Section 3.6) and from washaways and other impacts of the heavy rains in 2020-22.

The joint sponsors maintain a network of management trails across the Special Areas to provide access for delivery of land management activities and accessing key water monitoring sites.

The Special Areas are routinely closed to third parties when the wet weather causes trails to become susceptible to damage. Other closure may be required due to fire danger ratings or management activities.

The Special Areas needed to be closed during the reporting period to keep staff and other visitors safe from bushfires (2019-20) and floods (2020-2022) as shown in Table 7.

INDICATOR – SPECIAL AREA CLOSURES

Table 7: Special Areas closures 2019-22

Measurement unit	2019-20	2020-21	2021-22	Trend
Total number of Special Area closures	84	99	161	↓

↓ *worsening trend*

Table 7 shows that across the reporting period there was an increase in the number of Special Area closures. Figure 18 shows that even within a given year (2019-20) there were closures due to fire and rainfall events.

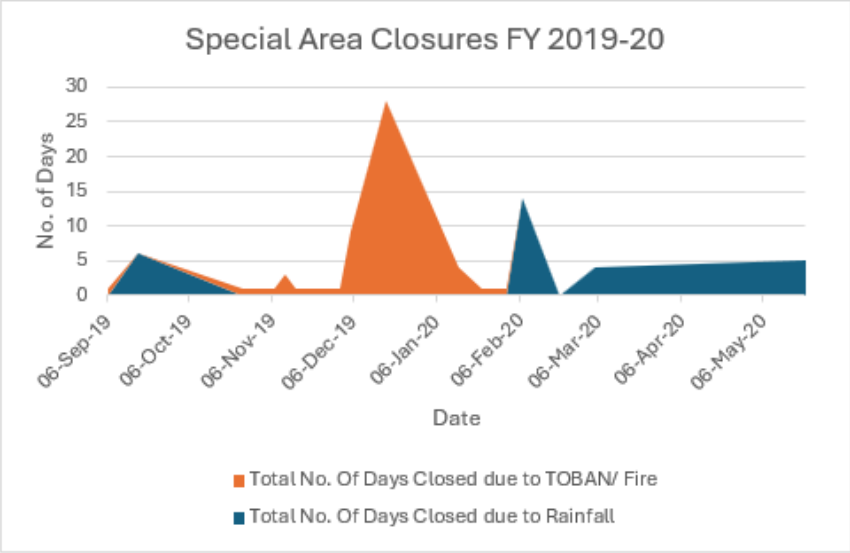


Figure 18: Special Areas closures 2019-20

3.4.2 Response – assets and infrastructure

During the reporting period, the joint sponsors ensured their construction and maintenance activities and those of other parties operating within the Special Areas, met environmental planning requirements. The joint sponsors conducted an active program of asset maintenance to maintain safety and operational effectiveness and to minimise the incidence of suspended solids in waterways.

Roads can have considerable impacts on water quality particularly through sediment runoff. Considerable effort was made by the joint sponsors in the maintenance of roads in the Special Areas during the reporting period. There was a significant and sustained program of road repairs in the Warragamba Special Area in response to damage resulting from the Green Wattle Fire event in 2019-20. For example, during 2019-20, 149 kms of road were maintained, in 2020-21, 43 km of roads were maintained, whilst in 2021-22, 128 km were maintained.

3.5 Access

3.5.1 State of the Special Areas - access

The *Water NSW Regulation 2020 (NSW)* prohibits certain activities in Special Areas to protect the quality and quantity of the water supply. WaterNSW can give its consent to carry out these activities in specific circumstances. The NPWS assists WaterNSW to implement its regulatory responsibilities.

The restrictions act to protect the values of the Special Areas. Unregulated access involving vehicle movement and unauthorised recreational pursuits, stock movement and grazing, and illegal activities such as track creation, hunting, rubbish dumping, bush rock removal and reptile collection may impact water quality and ecology.

Potential issues arising from such activities include:

- erosion and sedimentation of streams and storages
- increased risk of fire
- pollution of waterways
- introduction or spread of disease
- damage to significant plant and animal communities and vegetation that plays an important role in protecting water quality.

To minimise these risks, the Special Area lands have been classified into water quality protection schedules and public access to the Special Areas is regulated in accordance with these schedules as explained in Section 1.3.

The joint sponsors may impose temporary access restrictions to protect public health and safety during periods of high fire danger (such as that experienced during parts of 2019-20) and during management operations including fire suppression, hazard reduction and pest control.

3.5.2 Response – access

During the reporting period, the joint sponsors regulated access to the Special Areas by implementing access restrictions and conducting programs to enforce those restrictions.

INDICATOR – ACCESS APPLICATIONS

Table 8 provides details of applications by external parties to enter the Special Areas during the reporting period.

Table 8: Requests to access the Special Areas 2019-22

Measurement unit	2019-20	2020-21	2021-22	Trend
Total number of applications to enter the Special Areas	81	69	111	↓

↓ *worsening trend*

There was a general increase in the number of access applications during the reporting period thus a 'worsening trend'. Across the reporting period, consent was given for 65% of the access applications.

In 2019-20, the joint sponsors conducted 6 single day joint compliance operations across the Special Areas. In that year, WaterNSW conducted a total of 1,320 hours of Special Areas surveillance.

In 2020-21, the joint sponsors completed 4 Joint Agency Operations with 2 further operations cancelled due to wet weather. WaterNSW conducted 1,415 hours of Special Areas surveillance in that year.

In 2021-22, planned compliance operations with interagency partners were unable to be completed due to weather conditions and access restrictions. However, 1,507 hours of Special Areas surveillance were undertaken in that year.

3.6 Fire

Fire plays an important part in many Australian ecosystems. However, fires that are too frequent or intense may threaten natural and cultural heritage values, and water quality, as well as potentially affecting life and property. High frequency fire has been listed as a key threatening process under the *Threatened Species Conservation Act 1995* (NSW).

The joint sponsors seek to minimise inappropriate fire regimes within the Special Areas. This is achieved through rigorous fire management planning and the implementation of comprehensive programs across the catchment.

3.6.1 State of the Special Areas - fire

Severe, widespread bushfires were experienced in the Special Areas during the summer of 2019-20. This was caused largely by the prolonged drought conditions (Section 2.1) and raised vegetation fuel loads.

Due to effective early response efforts, the Metropolitan and Woronora Special Areas were the largest areas of bushland in the region unaffected by the 2019/20 bushfires. These areas provided habitat for several key species including koalas.

INDICATOR – REMOTE SENSED FUEL LOADS

Bush fire fuel consists of all living and dead vegetation. However, it is fine fuels less than 6 mm in diameter, consisting of leaves, sticks, twigs, bark and grass, that are most likely to be consumed by a fire. The presence and arrangement of fine fuel significantly affects flame height and the speed at which a fire moves. Heavier logs and stumps tend to burn after the fire front has passed and take longer to extinguish.

There are currently many Earth observing satellites acquiring a large amount of data relevant to surface vegetation. Many remote sensing approaches have been developed to estimate fire relevant properties of the fuel. There are numerous advantages in remote sensing methods including cost effectiveness, high spatial and temporal coverage, providing much faster and more consistent update time, and easier access to data.

Remote sensing was used to examine fuel loads across the Special Areas during the reporting period with the results provided in Table 9. The average and total fuel load across the Special Areas in Table 9 shows that there was a higher fuel load during 2019-20 which is one of the drivers for the bushfires in the period, The fuel load declined across the Special Areas in the subsequent years due mainly to the areas burnt by bushfires and hazard reduction burning.

In 2019-20, 330,000 ha (37%) of the Warragamba Catchment was burnt by bushfires including 90% of the Warragamba Special Area. 900 ha (62%) of the Shoalhaven Special Area was burnt.

In 2020-21,, only 3 bushfires occurred in the Special Areas, and all were contained to less than 10 ha. In 2021-2022, there were 4 bushfires in the Special Areas. The largest fire in that year was a fire in the Cataract Catchment which burnt 22 ha before it was contained.

Table 9: Remote sensed fuel loads

Measurement unit	2019-20	2020-21	2021-22
Average fuel load across Special Areas (SA)(tonnes/ha)	16.3	7.6	9.7
Total fuel load across SA (millions of tonnes)	5.9	2.8	3.6

The severity or intensity of bushfires can have significant impacts on water quality and ecological integrity.

INDICATOR – BUSHFIRE SEVERITY

High intensity or severe fires in the Special Areas can cause enormous damage to water catchments by destroying ground cover and changing hydrology, as well as altering the structure, behaviour and erosion of soil. The loss of riparian vegetation may result in high volumes of sediment (measured as turbidity) entering the stream and may also increase stream temperatures due to a lack of shade.

Chemical reactions triggered by fire can release nutrients, metals and other toxicants stored in vegetation and soil. Rainfall after a fire washes these contaminants into waterways and reservoirs, which can have substantial implications for agriculture, human safety and amenity.

Combined with increased contaminant loading, increased water temperature can trigger greater breakdown of organic matter by bacteria, which may deplete oxygen levels in the water. Fish kills are a common result of this sudden depletion of dissolved oxygen.

As a result of high intensity fires, the vegetation of these areas may not recover locally but rather rely on windblown seed gradually dispersing into the burnt areas. Some of these areas can take ten or more years to recover, potentially resulting in changes to vegetation composition.

Fire extent and severity mapping uses satellite imagery and machine learning to assess vegetation consumption by fire across NSW. This semi-automated approach to fire mapping was developed by the NSW Government and launched in July 2020, with a prototype system deployed in December 2019. Fire extent and severity mapping has standardised severity classes to allow comparison of different fires across the landscape as shown in Figure 19.

The severity classes were used to assess bushfire severity across the Special Areas during the reporting years with results provided in Table 10.

Table 10 shows that during 2019-20 of the 215,412 ha burnt in the Special Areas, 40,873 ha were in the extreme category while 51,758 ha were classified as high severity burns.

There was a significant reduction in bushfire severity for the remainder of the reporting period, largely due to the increased rainfall which lowered bushfire risk.

Severity class	Description	Percentage foliage fire affected
Unburnt	Unburnt surface with green canopy	0% canopy and understorey burnt
Low	Burnt understorey with unburnt canopy	>10% burnt understorey >90% green canopy
Moderate	Partial canopy scorch	20–90% canopy scorch
High	Complete canopy scorch / partial canopy consumption	>90% canopy scorched <50% canopy biomass consumed
Extreme	Complete canopy consumption	>50% canopy biomass consumed

Figure 19: Fire extent and severity classification (source: NSW Department of Planning and Environment, 2020)

Table 10: Fire severity levels across the Special Areas 2019-22

Measurement unit	2019-20 (ha)	2020-21 (ha)	2021-22 (ha)
Area of Extreme Severity	40,843	0	1
Area of High Severity	51,758	0	9
Area of Moderate Severity	79,919	0	16
Area of Low Severity	42,892	0	7
Unburnt	150,392	365,804	365,772

Figure 20 is a map showing the spatial extent and severity of the 2019-20 bushfires including within the Special Areas. The dark brown colour indicates the areas of Extreme Severity bushfire.

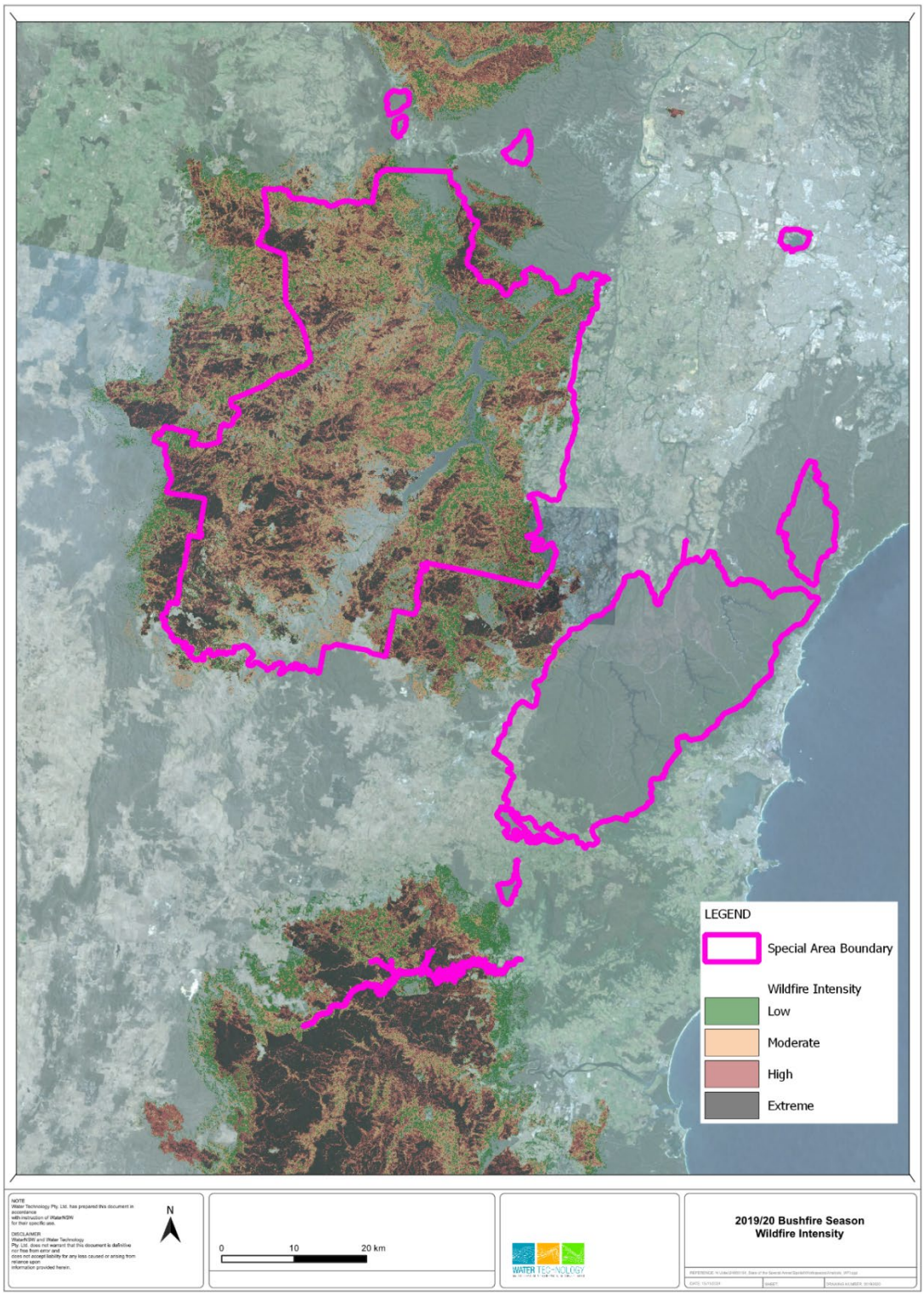


Figure 20: Extent and severity of 2019-20 bushfires in the Special Areas (map prepared by Water Technology Pty Ltd)

3.6.2 Response – fire

3.6.2.1 Bushfire risk management

The joint sponsors have detailed fire management strategies and plans for the Special Areas that are regularly updated in consultation with the Rural Fire Service (RFS) and District Bushfire Management Committees. These guide operational activities, and are based on analysis of fire history, fire ecology thresholds, water quality, a risk assessment of assets and feedback from community consultation.

Two of the main bushfire risk management operations involve hazard reduction burns to reduce fuel loads in high risk areas and vegetation slashing for fire breaks and asset protection zones (APZs).

INDICATOR – HAZARD REDUCTION BURNS

Table 11 shows the area of the Special Areas that underwent hazard reduction burns during the reporting period.

Table 11: Hazard control burns across the Special Areas 2019-22

Measurement unit	2019-20	2020-21	2021-22	Trend
Hectares (ha) treated	6,661	7,019	7,205	↑

↑ *improving trend*

Table 11 shows that there was an increase across the reporting period in the area treated with hazard reduction burns. However, the trend for hazard reduction burns is highly dependent on weather conditions and fuel loads. Also, the fact that large parts of the Special Areas were burnt during 2019-20 bushfires (Section 3.6) would mean that there was less need for hazard reduction burns at least during the following year.

INDICATOR – VEGETATION SLASHING

As shown in Table 12, a significant area of the Special Areas was slashed during the reporting period.

Table 12: Vegetation slashing across the Special Areas 2019-22

Measurement unit	2019-20	2020-21	2021-22	Trend
kms slashed	538	379	216	↓

↓ *worsening trend*

It is the priority of the joint sponsors to slash at least 200 kms of vegetation annually along linear fire breaks and asset protection zones (APZs). As shown in Table 11, this target was reached for each of the years in the reporting period. Slashing may have been reduced after the fires as it was not required or not accessible for the first year.

INDICATOR – VEGETATION COMMUNITIES WITHIN FIRE THRESHOLDS

The interval between fires is a critical factor in the capacity of individual species to survive and reproduce (Bradstock & Kenny 2003). The minimum fire intervals needed to maintain a full complement of biodiversity within vegetation communities have therefore been developed for NSW vegetation formations. These allow sufficient time between fires for species to complete the crucial stages of their life cycles essential for regeneration, such as plants being able to reach an age where they can produce adequate seed. A key component of long-term monitoring of the effects of fire on ecological systems is matching fire history to vegetation formations. While there are still some limitations due to the deficiencies in the historical data, it is now being collected on an annual, coordinated basis.

Based on 2022 data, as shown in Table 13, approximately 83% of the vegetation formations in the Special Areas is within fire threshold, 2% of the lands has burned too frequently, 5% has not burned frequently enough.

Table 13: Percentage of Special Areas by Fire Threshold Category

Status	2022 area percentage
Long unburnt	5
Too frequently burnt	2
Vulnerable	64
Within Threshold	19
Unknown or NA ((i.e. developed lands, lakes, dam walls, etc).	10

The Black Summer fires (2019-20) caused a significant shift in the status of recommended fire intervals for vegetation. Table 13 Identifies that 19% of all vegetation with fire history available is both within threshold and would remain within threshold if it burned in the next three years. 64% of the Special Areas is vulnerable because whilst it is within threshold, a fire in the coming years would push it into the too frequently burned category. With time, and in the absence of fire, land which is 'too frequently burned' comes back into threshold, and conversely, a fire can push land out of threshold.

The joint sponsors work collaboratively to ensure the hazard reduction burning activities are planned effectively and strategically, minimising the impacts of fire regimes on the ecological integrity of the Special Areas.

3.6.2.2 Bushfire response

NPWS is a statutory firefighting authority as defined by the *Rural Fires Act 1997*(NSW). WaterNSW also partners with the NSW RFS through a long-term agreement and contributes to firefighting and fire management through planning, preparation, response and recovery. The joint sponsors were heavily involved with the provision of resources in both incident management and on ground response during the 2019-2020 bushfires

As public authorities, landowners and land managers, under the *Rural Fires Act 1997*(NSW), the NPWS has primary responsibility for fire management on NPWS lands and WaterNSW has primary fire management responsibility on WaterNSW lands.

The 2019 bushfires were followed by a significant rainfall event in February 2020 which affected bushfire recovery activities. Rainfall further damaged roads and key river crossings delaying access to assess and repair damage.

The quality of water supplied for treatment from Warragamba Dam was not impacted, however, as a precaution WaterNSW reconfigured supply to be provided from alternate sources for a short period.

WaterNSW established a project team to assess the damage. The damage assessment indicated repair costs in excess of $8.5 M. Much of the damage was covered by insurance (ICARE) and claims were made to undertake recovery work. Key damage to assets included:

- 11 water monitoring and telemetry sites damaged
- 150 km of fire trail and containment line requiring repair and rehabilitation
- 1,300 km of fire trail within the Warragamba Special Area assessed and prioritised for repairs
- Damage to recreational areas in the Shoalhaven Special area
- 130 fence, gate and barrier locations requiring repairs within Warragamba Special Area

The bushfires and following flooding had a significant impact on the works program for 2021-22. The extent of fire damage across the state meant that contractors for key works were difficult to procure. This resulted in some programmed activities being delayed in favor of bushfire and flood damage repair works.

The following works were completed, in addition to normal operations:

- repairs to containment lines in Warragamba Special Area
- repairs to fire roads
- repairs to water monitoring sites
- repairs and replacement of gates, barriers, signs and fences in Warragamba Special Area and Shoalhaven Special Area
- installation and maintenance of in-lake booms to capture and detain floating ash and debris in Lake Burragorang
- ash and sediment composition sampling to assess potential water quality impacts
- Targeted water quality sampling to monitor potential impacts from bushfires.

Case study: Post-fire erosion mitigation works

During the 2019/2020 bushfire season, the Erskine Creek, Green Wattle Creek, and Ruined Castle Fires burned approximately 320,000 hectares in the Warragamba Catchment. Following these fires, severe storms posed a raw water quality risk to Warragamba Dam due to erosion and runoff.

WaterNSW engaged the Soil Conservation Service to conduct a post-fire catchment investigation, implement erosion mitigation works, and undertake a monitoring program. The erosion mitigation works, completed in September 2021, included the installation of 250 coir logs and 13 in-channel structures.

Monitoring from September 2021 to November 2022 showed improvements in watercourse conditions, soil formation, and sediment stabilisation, with significant sediment capture and vegetation recovery.

The erosion mitigation methods successfully captured sediment and withstood several intensive rainfall events without failure, proving to be a low-impact option without adverse environmental effects. Monitoring revealed that sediment capture rates would likely increase if works are completed sooner after bushfire events and before post-fire rain. While effective at capturing sediment, the techniques are difficult and costly to implement across a large scale. The project provided valuable insights and recommendations for future bushfire response and recovery efforts, demonstrating effective erosion control and site stabilisation (Soil Conservation Service, 2023).

3.7 Ecological integrity

Maintenance of ecological integrity in the Special Areas requires the protection of biodiversity, with particular emphasis on threatened plant and animal species, endangered populations and endangered ecological communities.

3.7.1 State of the Special Areas – ecological integrity

Approximately 68% of the Sydney's Drinking Water Catchment features native vegetation and Dry Sclerophyll Forest is the predominant vegetation formation across the Catchment (EcoLogical, 2023). By nature of their function, most sub-catchments in the Special Areas have greater than 85% native vegetation (EcoLogical, 2023).

Within Special Areas, the maintenance of natural flow regimes supports important ecological communities and species. Wetlands are lands covered or saturated with fresh, brackish or salt water that are generally still or slow-moving. Wetlands feature ecosystems that have adapted to or depend on wet conditions for at least part of their life cycles. They include groundwater dependent ecosystems and are often referred to as swamps. There are numerous wetlands in and around the Special Areas (Figure 21) including hanging swamps and major wetlands such as Wingecarribee Swamp, Boyd Plateau Bogs and Thirlmere Lakes.

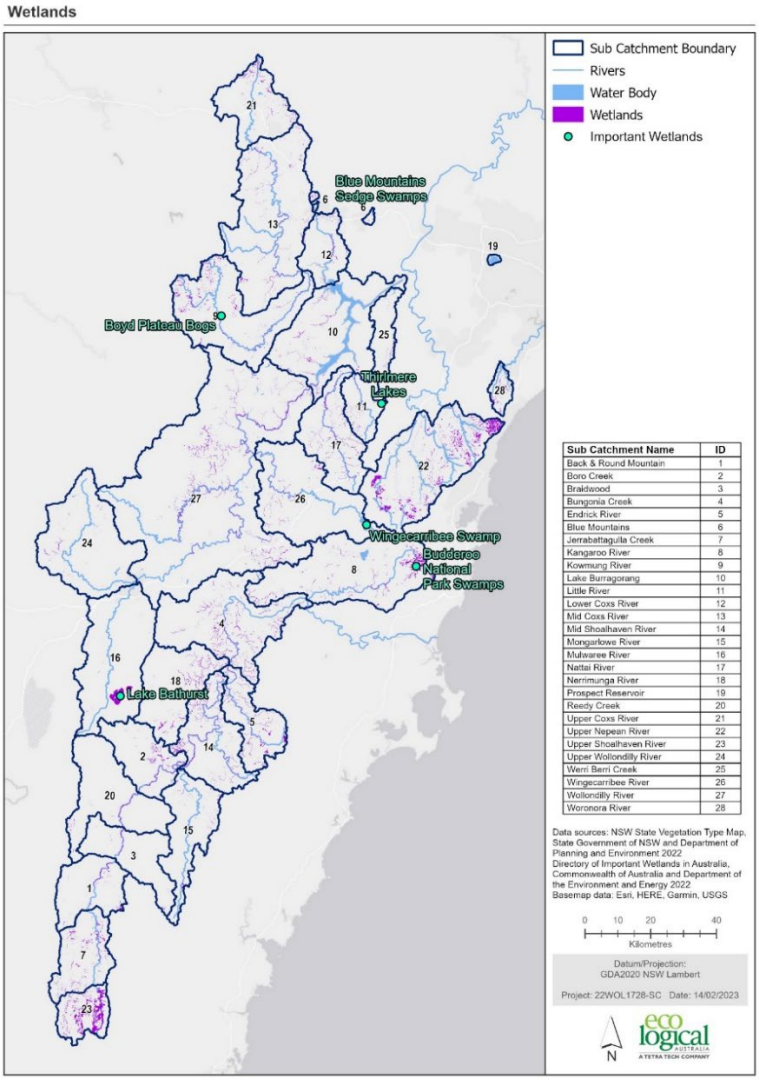


Figure 21: Wetlands in Sydney's Drinking Water Catchment including the Special Areas (source: EcoLogical, 2023)

Aquatic macroinvertebrates ('water bugs') are small aquatic organisms, mostly insects, that live in creeks and rivers, mainly on the stream bed. They are an indicator of catchment health as they perform several ecological functions, such as processing organic matter, and making nutrients and energy available for other organisms in river food webs (such as fish, birds, lizards and platypus). A broad range of macroinvertebrates present in complex assemblages of indicate healthy aquatic ecosystems.

Macroinvertebrate data is complementary to water chemistry data (Section 3.2.1). Whilst water chemistry represents a series of 'snapshots' of water quality, macroinvertebrates represent a cumulative measure of water quality and habitat conditions over their life cycles that range from weeks to years.

INDICATOR – MACROINVERTEBRATES

The Australian River Assessment System (AUSRIVAS) is a predictive tool created as part of the National River Health Program to evaluate the biological health of Australian rivers. It assesses ecological health by comparing the expected aquatic fauna at a site with the actual fauna present. The system uses models customised for different habitat types across Australia.

Site conditions are categorised as Reference (A), Below Reference (B), or Well Below Reference (C). The results were aggregated by calculating an average annual AUSRIVAS score for sites in each catchment in the Special Areas (Table 14). It is important to note that some catchments may have limited sites or sampling.

Table 14: Mean annual macroinvertebrate scores across catchments in the Special Areas 2019-22

Catchment	2019-20	2020-21	2021-22	Trend
Avon	B	B	B	→
Blue Mountains	C	A	B	↑
Broughton Pass	B	B	B	→
Cataract	A	B	B	↓
Cordeaux	B	B	B	→
Nepean		B	B	→
Pheasants Nest	B	B	B	→
Shoalhaven	B	B	B	→
Warragamba	C	B	B	↑
Woronora	A	B	B	↓

↑ *denotes improving trend*

→ *no or little change*

↓ *worsening trend*

Most catchments showed no change in the AUSVIRAS score over the three reporting years generally with scores of Below Reference (B). However, the Cataract and Woronora catchments showed a decline in scores, whilst there was an overall improvement in the Warragamba and Blue Mountains catchment scores.

3.7.2 Response – ecological integrity

Threats to ecological integrity, as previously described in Section 3.7.1, can arise from pests and weeds, asset construction and maintenance activity, long-wall coal mining, uncontrolled access and inappropriate fire regimes. In addition, ecological integrity may be affected by diseases to flora and fauna, such as *Phytophthora* and Myrtle Rust. The joint sponsors implement government and agency-specific responses to these threats.

There are significant links between the maintenance of ecological integrity and the maintenance of water quality. For example, some diseases, pests and weeds may significantly impact on flora and fauna

populations and in so doing, progressively degrade the environment and diminish water quality. Addressing such issues can have significant benefits for both water quality and ecological integrity.

In addition to addressing threats, the joint sponsors may undertake survey and monitoring activities to improve information and to measure the effectiveness of management in protecting the values of the Special Areas.

During the reporting period, WaterNSW managed 22 macroinvertebrate monitoring sites in the Special Areas (the results of the monitoring are provided in Section 3.7.1). Aquatic ecology monitoring programs and impact assessments also take place near longwall coal mines in the Woronora River and Upper Nepean River sub-catchments (e.g., Bio-Analysis 2020 and Cardno 2022). Those studies investigated changes or impacts to biological communities from mining activities at a small number of long-term monitoring sites and compared to nearby control sites.

NSW Department of Primary Industries Fisheries used records collected since the late 1990s to model and map indicative distributions of threatened freshwater species. This research, including surveys conducted during the reporting period, found that the threatened Macquarie Perch – east coast population was found in the waterways of much of the Special Areas (507 km in Lake Burragorang, Little River, Mid/Lower Coxs, Nattai River, Werri Berri Creek, Wollondilly River and Upper Nepean (Reference).

During the reporting period, Environmental DNA (eDNA) gained recognition as a transformative tool for biodiversity monitoring and ecosystem management. Proposed studies aim to expand the use of eDNA for detecting vertebrate pests, such as fish species, and to build on existing baseline data for weed monitoring. Special Area monitoring presents an opportunity to implement eDNA techniques in designated regions. The WaterNSW Strategic Research and Innovation team is leading efforts to broaden eDNA studies, combining them with statistical analysis and quantitative methods to enhance pest and weed management. Additionally, integrating eDNA with remote sensing data is expected to improve wetland health assessments, with a particular focus on vegetation research in swamps and waterways.

Following the 2019-20 bushfires, NPWS implemented projects to assess the status of priority at-risk species, and to undertake erosion and pest mitigation work to benefit those species. This work, supported by the Australian Government Wildlife and Habitat Bushfire Recovery Program regional fund, was implemented in the Warragamba, Blue Mountains and Metropolitan Special Areas. This included:

- eDNA surveys targeting platypus
- assessments of arboreal mammals
- ground pest control targeting pigs, deer, goats and wild dogs
- aerial baiting and aerial shooting programs.

Also, across the entire reporting period, under the Saving Our Species program, NPWS actively managed twenty threatened species across 30 sites within the Special Areas.

Case study: Saving the rock wallaby

A small colony of around 15–30 brush-tailed rock wallabies lives in Nattai National Park, which is located in the Warragamba East Catchment Area. This important colony is one of the few remaining in south-eastern Australia.

At Nattai National Park, the rock-wallaby population had declined to three individuals. The Nattai population is identified in the National Recovery Plan as an important population which must be retained because its loss would create a large range gap.

The wallabies continue to be threatened due to predation by foxes, dogs and cats; competition for food and shelter with rabbits and feral goats; and fragmentation of habitat. As a result, they are listed as endangered in NSW under the *Threatened Species Conservation Act 1995*.

"With the support of Aboriginal owners and park neighbours, a 92-hectare feral predator-free area is under construction in Nattai National Park, with a stage one area (0.3 hectare) already complete," the head of the National Parks and Wildlife Service (NPWS), Atticus Fleming AM said.

"Two individuals are now in this secure area and have had their first baby. Supplementation with additional animals will allow us to rebuild the Nattai population.

"While larger rock-wallaby populations in the Blue Mountains and further north could be protected by landscape-scale feral animal control, the establishment of feral predator-free areas is now the only strategy that will protect and restore these small rock-wallaby populations," Mr Fleming said.

3.8 Cultural heritage

3.8.1 State of the Special Areas – cultural heritage

The cultural values of the Special Areas are significant for communities. Parts of the Special Areas have been protected as water supply catchments for over 100 years and are relatively undisturbed. This has resulted in rich and well-preserved examples of cultural heritage.

Culturally important places, sites and objects of both Indigenous and non-Indigenous origin occur throughout the Special Areas and provide a record of human activities related to the natural features of the region.

These features may be affected by the impacts of recreational activities, fire regimes, mining, research, introduced species and management operations, as well as by natural deterioration resulting from weathering erosion and vegetation growth. Cultural sites may be deteriorating and non-renewable and may require effective management to ensure their conservation.

INDICATOR – CONDITION OF STATE HERITAGE ITEMS

The NSW State Heritage Register, is a heritage list of places and items in NSW, that are protected by legislation, generally covered by the NSW Heritage Act 1977 and its 2010 amendments.

Table 15 provides an assessment across the reporting period of State Heritage Items listed in the NSW State Heritage Register and managed by WaterNSW in the Special Areas.

Table 15: Condition of State Heritage Items in the Special Areas 2019-22

State Heritage Item	2019-20	2020-21	2021-22	Trend
Avon Dam	Good	Good	Good	→
Cataract Dam	Good	Good	Good	→
Cordeaux Dam	Good	Good	Good	→
Nepean Dam	Good	Good	Good	→
Woronora Dam	Good	Good	Good	→
Windmill Hill	Good	Good	Good	→
Wingecarribee Swamp	Fair	Fair	Fair	→
Prospect Reservoir	Good	Good	Good	→
Medlow Dam Reservoir	Good	Good	Good	→
Haviland Park	Good	Good	Good	→

→ *no or little change*

Over the reporting period from 2019 to 2022, the condition of State Heritage Items under the stewardship of WaterNSW has largely remained stable, with most items consistently rated as 'Good'.

Wingecarribee Swamp has maintained a 'Fair' condition rating consistently over the three years. Despite not showing improvement, this indicated a stable condition without further degradation. Haviland Park, part of which is within a controlled area, has consistently been rated 'Good' suggesting that the management measures in place are effective in preserving its heritage value.

Figure 22: Cataract Dam (photo: NSW Government)

3.8.2 Response – cultural heritage

Under the *National Parks and Wildlife Act 1974* and the *NSW Heritage Act 1977*, the joint sponsors are required to have regard to the conservation of Indigenous sites and other historic places within the Special Areas. The joint sponsors have a range of policies, plans and procedures that guide Indigenous cultural heritage and historic heritage management on Special Area lands. The joint sponsors are guided by the provisions of the Australian ICOMOS Charter for the conservation of places of historic significance (the Burra Charter, ICOMOS 2013) and the views of local communities who have an ongoing and active interest in the management of Indigenous and non-Indigenous cultural heritage within the Special Areas.

During the reporting period, the joint sponsors consulted and where appropriate, actively involved communities with cultural connections in the management of the Special Area lands. For example,

WaterNSW and NPWS continued to liaise as part of the Gundungurra Indigenous Land Use Agreement Consultative Committee.

The joint sponsors planned and implemented programs to conserve significant cultural sites within the Special Areas as required.

In 2019-20, activities to conserve significant cultural sites within the Special Areas included:

- repair of the heritage stone wall at Nepean Dam
- protection works commenced on an Aboriginal heritage site in Cataract Catchment with removal of camping gear and litter from the site.

In 2020-21, work to repair a collapsed stone wall in Avon Recreation Area was delayed because access was prevented due to closure of a bridge damaged by flood on the Avon Dam Access Road.

In 2021-22, conservations activities included:

- Illawarra Local Aboriginal Land Council inspection, heritage recording using Lidar and laser scanning of Whale Cave
- maintain asset protection works around various non-indigenous heritage items in Metropolitan, Woronora and Warragamba Special Areas.

It should be noted that there are a large number of other indigenous heritage items in the Special Areas; however, a public report such as this is not the place for commenting on specifics of those items and works undertaken to protect them. Actions are routinely undertaken by the joint sponsors to ensure indigenous heritage is protected.

4. Conclusions

Nine strategic management objectives have been identified in the SASPoM:

- **Pollutants** are controlled so that impacts on water quality and natural and cultural values are minimised.
- Surface and groundwater sources and their interactions will be better understood so decisions are made that seek to minimise impacts on Special Areas **hydrological integrity**.
- **Pests and weeds** are controlled so that impacts on water quality and ecological integrity are minimised.
- Measures are in place to minimise the impacts of built **assets** within the Special Areas on water quality, ecological integrity and cultural values.
- **Access** to the Special Areas is controlled to protect water quality and ecological integrity while providing for appropriate visitor opportunities.
- **Fire** management within Special Areas maximises protection of life and property and minimises impact on water quality and ecological integrity.
- **Ecological integrity** including threatened plant and animal species, endangered populations, endangered ecological communities, geodiversity and other natural values are maintained.
- **Cultural heritage** values are acknowledged and conserved, and community associations supported.
- Management of Special Areas is supported by appropriate **policy, planning and evaluation.**

The reporting period, with fire, flood and drought (Section 2.1) and the impacts of COVID-19, put short term pressures on the achievement of the Special Areas management objectives. Longer term impacts such as climate change (Section 2.2), demographic (Section 2.4) and land use changes including mining (Section 2.3) are also challenging the achievement of the objectives. With these pressures in mind, a concluding assessment of the management objectives of the Special Areas based on this report is provided in Table 16.

Table 16: Achievement of the management objectives for the Special Areas 2019-22

Management objective	Assessment
Pollutants are controlled so that impacts on water quality and natural and cultural values are minimised.	Partially achieved. There were 10 exceedances of ANZECC guidelines most probably due to extreme weather impacts with resultant changes in flows (Section 3.2.1). It is important note that there is considerable catchment upstream of some of the Special Areas and these water quality issues may have originated there. The joint sponsors undertook extensive bushfire recovery programs to reduce the risk of the 2019-20 bushfires to water quality (Section 3.6.2) and to monitor water quality and conduct related land management practices (Section 3.2.2).
Surface and groundwater sources and their interactions will be better understood so decisions are made that seek to minimise impacts on	Achieved. There are several water flow gauging stations and groundwater bores located within the Special Areas (Section 3.1.1). Groundwater water tables tended to rise across the Special Areas although this may not be the case close to longwall coal

Special Areas **hydrological integrity**.	mines (Section 3.1.1). Research was conducted to monitor water tables and swamps, and also to investigate water level fluctuations in Thirlmere Lakes (Section 3.1.1).
Pests and weeds are controlled so that impacts on water quality and ecological integrity are minimised.	Achieved. There was extensive pest animal and weed control programs throughout the Special Areas (Section 3.3.1). The control targets of WaterNSW and NPWS were achieved during the reporting period (Section 3.3.2).
Measures are in place to minimise the impacts of built **assets** within the Special Areas on water quality, ecological integrity and cultural values.	Achieved. Although there was an increase in the number of road closures across the reporting period, proactive maintenance of roads and other assets was undertaken (Section 3.4.2) and damaged roads (bushfires and floods) were repaired in a timely fashion (Section 3.6.2).
Access to the Special Areas is controlled to protect water quality and ecological integrity while providing for appropriate visitor opportunities.	Achieved. The joint sponsors controlled access to the Special Areas through compliance and access applications. Consent was given for 65% of the access applications which generally increased across the reporting period (Section 3.5.2).
Fire management within Special Areas maximises protection of life and property and minimises impact on water quality and ecological integrity.	Not achieved. Whilst there were widespread bushfire risk management measures in place, this did not prevent the extensive and severe bushfires of 2019-20 that burnt 215,412 ha of the Special Areas with 40,873 ha in the extreme category (Section 3.6.1). However, the joint sponsors undertook extensive programs to reduce the risk of the bushfires to water quality (Section 3.6.2).
Ecological integrity including threatened plant and animal species, endangered populations, endangered ecological communities, geodiversity and other natural values are maintained.	Partially achieved. The severe bushfires of 2019-20 meant that the ecological integrity was compromised with long term recovery of endangered ecological communities and threatened species required. The status of macroinvertebrates was relatively stable across the reporting period (Section 3.7) and extensive pest and animal programs were successfully completed to help maintain ecological integrity in the reporting period (Section 4.3).
Cultural heritage values are acknowledged and conserved, and community associations supported.	Achieved. There was little change in the condition of State Heritage Items which were generally rated as 'good' during the reporting period (Section 3.8.1). The joint sponsors continued to liaise with Indigenous and other communities regarding the management of cultural heritage values during the reporting period (Section 3.8.2). Long-wall coal mining continues to have a detrimental impact on aboriginal heritage across the Woronora and Metropolitan Special Areas.
Management of Special Areas is supported by appropriate **policy, planning and evaluation.**	Achieved. The SASPoM is the overarching policy for the management of the Special Areas. The joint sponsors worked together to achieve the responses outlined in Section 3 of this report.

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