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VOLUME 1 – MAIN FINDINGS

2016 Audit of the Sydney Drinking Water Catchment

June 2017

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Letter to the Minister

Dear Minister

On behalf of the independent audit team we are pleased to present the 2016 Sydney Catchment Area Audit report in three volumes. This report is intended for tabling in Parliament, as required under the *Water NSW Act 2014*.

The Audit provides scientifically based information about the health of the Sydney Catchment area during the period 1 July 2013 to 30 June 2016.

The 16,000 km^2 catchment collects and stores water to supply Sydney, the Blue Mountains, the Illawarra, the Southern Highlands and parts of the Shoalhaven area. The management of drinking water quality in the Catchment follows a multiple barrier approach in which catchment management is the first barrier for the protection of water quality and availability. By decreasing contamination of the source water, the level of water treatment required (and associated costs and risks) can be reduced.

The methodology adopted for the 2016 Audit has been based on the internationally accepted Pressure-State-Response (PSR) framework, used for State of Environment Reporting in Australia. The audit team has reviewed multiple sources of evidence to determine the condition and trends of indicators relevant to water quality, water availability, biodiversity and habitats, land use and human settlements, and the current responses by government authorities to these conditions.

The Audit Report acknowledges the significant work that WaterNSW and other public authorities have undertaken across the catchment over the three year period to 30 June 2016, however continued effort in catchment management responses is required by the NSW Government.

The Audit found variable conditions in different parts of the Catchment, with trends improving, worsening or stable in response to local land use changes, as well as Catchment-wide pressures such as climate change. Recommended responses are provided where the audit team identified that the state of an area is poor and has a worsening trend for multiple indicators. The recommended responses set out in the Audit, and summarised below, address the greatest risks to the drinking water quality and quantity, and the catchment environment.

Key findings and recommended responses from this Audit are:

- **Mining in Special Areas**: The Audit found an emerging issue of unquantified loss of surface flows associated with the cumulative impacts of underground coal mining activities. This issue requires attention and should be considered in implementation of the Metropolitan Water Plan and activation of licencing under Section 60I of the *Water Management Act 2000* and in accordance with the NSW Aquifer Interference Policy. Greater understanding of the effect of multiple mine workings on Catchment water yield is required, and this understanding should be reflected in relevant mine planning, appropriate water licencing, and the regulation of those licences.

- **Land degradation**: The Audit found continued decline in water quality in the Wingecarribee, Braidwood, Wollondilly, Mulwaree, Upper Wollondilly and Nattai River sub-catchments caused largely by soil erosion and gullying. This decline has been attributed to land management practices that result in overgrazing and uncontrolled stock access to riparian zones. Further work is required with landholders to reduce land degradation and associated impacts to receiving storages.

- **Sewerage infrastructure**: There is evidence that upgrades to sewage treatment infrastructure have been successful in decreasing nutrient loads and improving raw water quality supplied to storages. In particular, compared to the previous audit period, there has been a reduction in nutrient loads discharged to waterways near sewage treatment plants at Wallerawang, Lithgow, Bundanoon, Goulburn and Bowral. Upgrades to Lithgow STP have resulted in notable improvement to Farmers

Creek, with no cyanobacteria alerts issued at this site in the current audit period. In comparison, this site had 27 red alerts during the previous audit period.

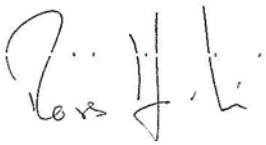
However, there is evidence that some sewage treatments plants are now at capacity and continued investment in sewerage infrastructure is required to keep risks to inflow water quality at an acceptable level. Priority should be given to upgrading the Bowral, Moss Vale and Mittagong sewage treatment plants (STPs).

- **Bushfire risk**: Risks of bushfire and associated impacts on water supply are increasing due to climate change and expansion of urban areas within the Catchment. Bushfire within a catchment increases flow variability and sediment and nutrient runoff. An improved fire planning and burning management response, including updated and implemented Bushfire Risk Management Plans are suggested to mitigate these risks to the Catchment and water supply assets.
- **Data quality and monitoring**: The inadequate availability and quality of data and monitoring has been raised in previous audits and remains a concern. Several datasets for indicator measures have not been updated since the 2013 audit (e.g. native vegetation, stream physical form) which restricted audit analysis. A number of recommendations are made in this Audit to improve data quality and monitoring as a basis for informed decision-making.

There is overlap and gaps in public authorities' responsibilities for management of the Sydney Catchment area. To address this it is suggested the Minister consider appointing the NSW Audit Office to monitor implementation of recommendations from this Audit and to lead subsequent catchment audits to ensure effective and coordinated responses to catchment pressures by the NSW Government.

The Audit has formed these response recommendations considering the current tools and programs available to the NSW Government. Most responses involve more effective and coordinated use of existing agency programs and legislation. The responses have been reviewed by the relevant public authorities and are considered feasible for implementation.

We commend this audit report to the Minister for tabling in the NSW Parliament.



Ross Hardie
Project Director, Sydney Catchment Audit

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Abbreviations

ARD	Acid rock drainage
AEMR	Annual Environmental Manager Report
Alluvium	Alluvium Consulting Australia Pty Ltd
DEST	Commonwealth Department of Environment, Sport and Tourism
DPE	NSW Department of Planning and Environment
DPI	NSW Department of Primary Industries
DWE	NSW Department of Water & Energy
EC	Electrical conductivity (salinity)
EEC	Endangered ecological community
ELA	Eco Logical Australia Pty Ltd
EPL	Environment Protection Licence
OECD	Organisation for Economic Cooperation and Developments
OEH	NSW Office of Environment and Heritage
PSAT	Pollution Source Assessment Tool
PSR	Pressure-State-Response
RFS	NSW Rural Fire Service
SCA	Sydney Catchment Authority
SoE	State of Environment
SDWTS	Springvale Delta Water Transfer Scheme
STP	Sewage treatment plant
TN	Total nitrogen
TP	Total phosphorus
WFP	Water filtration plants

1 About the audit

1.1 Purpose of the audit

The 2013-2016 audit of Sydney's water supply catchment (the Catchment Audit) has been prepared for the NSW Minister for Energy and Utilities in accordance with the requirements of Section 42 of the *Water NSW Act 2014*. This is the eighth catchment audit since 1999. It has been developed with input from government and non-government organisations and individuals, including a panel of independent experts external to the NSW Government.

The Catchment Audit provides credible, scientifically based information about the health of the declared Sydney Catchment Area ('the Catchment') during the period from 1 July 2013 to 30 June 2016. The Catchment comprises all or part of the Sydney, Illawarra, Blue Mountains, Southern Highlands and Shoalhaven regions (**Figure 1**). The Catchment Audit provides recommended actions to mitigate risks to catchment health and to greater Sydney's drinking water supply.

The *Water NSW Act 2014* defines catchment health as 'the condition of ecosystems and systems of management (such as sewerage and stormwater systems) in that catchment that protect water quality'. Catchment health is revealed through 18 approved indicators (**Table 1**), in accordance with Section 41 of the *Water NSW Act*.

Table 1. Indicators of catchment health

Theme	Indicator
Water quality	Ecosystem and raw water quality
	Nutrient load
	Cyanobacterial blooms
Water availability	Surface water flow
	Environmental flows
	Groundwater availability
Biodiversity and habitats	Macroinvertebrates
	Fish
	Riparian vegetation
	Native vegetation
	Fire
	Wetlands
	Physical form
Land use and human settlements	Land use
	Sites of pollution and potential contamination
	Soil erosion
	Population settlements and patterns
	Community attitudes, aspirations and engagement

Source: 19 December 2008 NSW Government Gazette No.158

1.2 Previous audits

Previous audits of the Catchment were undertaken in 1999 and 2002 by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). In 2003, the Environment Protection Authority (EPA) performed the audit of the Catchment. Audits in 2005, 2007 and 2010 were undertaken by the Department of Environment and Conservation, the Department of Environment and Climate Change, and the Department of Environment, Climate Change and Water, respectively.

GHD Pty Ltd conducted the 2013 catchment audit, which covered the period 1 July 2010 to 30 June 2013. Progress on matters raised in the 2013 audit have been reported to the Minister in Annual Catchment Management Reports prepared by WaterNSW and are incorporated in this 2016 audit.

1.3 Terms of reference

The Terms of Reference for this 2016 audit are as follows:

- The catchment audit is required to assess the state of the catchment having regard to the catchment health indicators approved under section 41 of the *Water NSW Act* and in force at the time of assessment.
- The catchment audit is to be conducted having regard to the current methodology used in the state of environment reporting for NSW.
- Consultation must be undertaken with stakeholders inside and outside the catchment to seek information and data that may assist with the audit and to seek comments relating to the state of the catchment.
- The audit is to cover the period from 1 July 2013 to 30 June 2016, and will also include long term trend analysis.
- Include long term trend analysis of catchment health indicators including any changes and trends over the audit period and the longer term.
- Be conducted in line with the Pressure State Response model and having regard to the current state of the environment reporting methodology and the Technical Report supporting the gazetted indicators.
- Ensure that any findings/recommendations arising from the audit are:
    - developed in consultation with responsible organisations/stakeholders and include a management response from those organisations
    - outcome focused with appropriate level of detail, costed and describe what measurable difference changes will make, making reference to the responsible organisation.

1.4 Key questions for this audit

The 2016 audit aims to respond to the following questions, consistent with the terms of reference and legislative context:

- Is the health of the catchment areas good, moderate or poor against criteria defined for each indicator?
- Is the health of the catchment areas better, worse or similar to the previous audit periods?
- Are the pressures on catchment health decreasing, increasing or similar?
- Are current management responses effective or do they need to change?

1.5 Report structure

The 2016 audit report is structured as follows:

- Volume 1 – Catchment overview and concepts, audit method, key findings and recommendations
- Volume 2 – Detailed analysis of each indicator
- Volume 3 – Supporting technical data and detailed information.

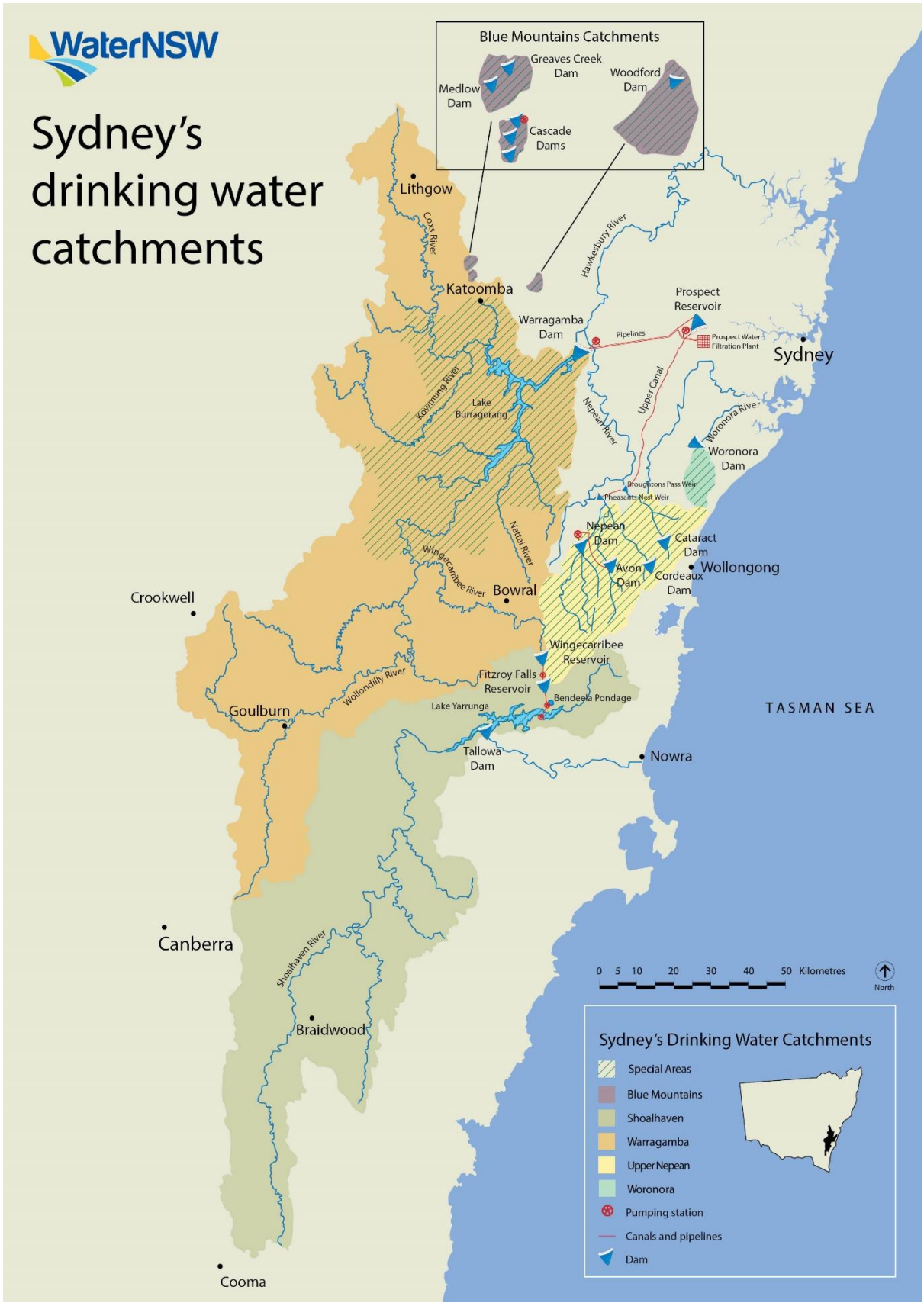


Figure 1. Sydney's drinking water catchments including the Special Areas (WaterNSW)

2 Overview of the Catchment

2.1 Description of the Sydney water supply catchment

The declared Catchment collects and stores up to 2.6 million megalitres of water to supply Sydney, the Blue Mountains, the Illawarra, the Southern Highlands and parts of the Shoalhaven area. The Catchment is extensive, covering parts of the hydrologic catchments of the Hawkesbury–Nepean, Shoalhaven and Woronora Rivers and extending over 16,000 km^2 (see **Figure 1**).

The Catchment extends from north of Lithgow on the Coxs River, from the head of the Shoalhaven River in the south near Cooma, and from the Woronora River in the east to the source of the Wollondilly River west of Goulburn (refer **Figure 2**). The Catchment includes the entire catchment area upstream of Warragamba Dam, including the Coxs, Kowmung, Nattai, Wollondilly and Wingecarribee River sub-catchments and their tributaries. It also covers the upper Nepean catchment upstream of the Nepean Dam and upstream of the Pheasants Nest and Broughtons Pass Weirs, and the small catchments of the Greaves Creek, Cascade, and Woodford Dams in the Blue Mountains. Outside of the Hawkesbury-Nepean Basin, it includes the catchment of the Woronora River upstream of Woronora Dam, and the catchments of the Shoalhaven and Kangaroo Rivers, upstream of Tallowa Dam.

The major water supply catchments (Upper Nepean, Shoalhaven, Warragamba, Blue Mountains and Woronora) are further divided into 27 minor sub-catchments as identified in **Figure 2**. The sub-catchments drain into dams that store 'raw water', which has not been treated. WaterNSW manages these water sources in the sub-catchments, and releases the water via a network of rivers, pipes and canals to water treatment plants, where it is treated and delivered to customers. The water supply system has some flexibility to balance storage needs, and can be reconfigured during times of drought, high rainfall or maintenance. It is noted that lands surrounding Prospect Reservoir are not covered by this catchment Audit.

2.2 The multi-barrier approach

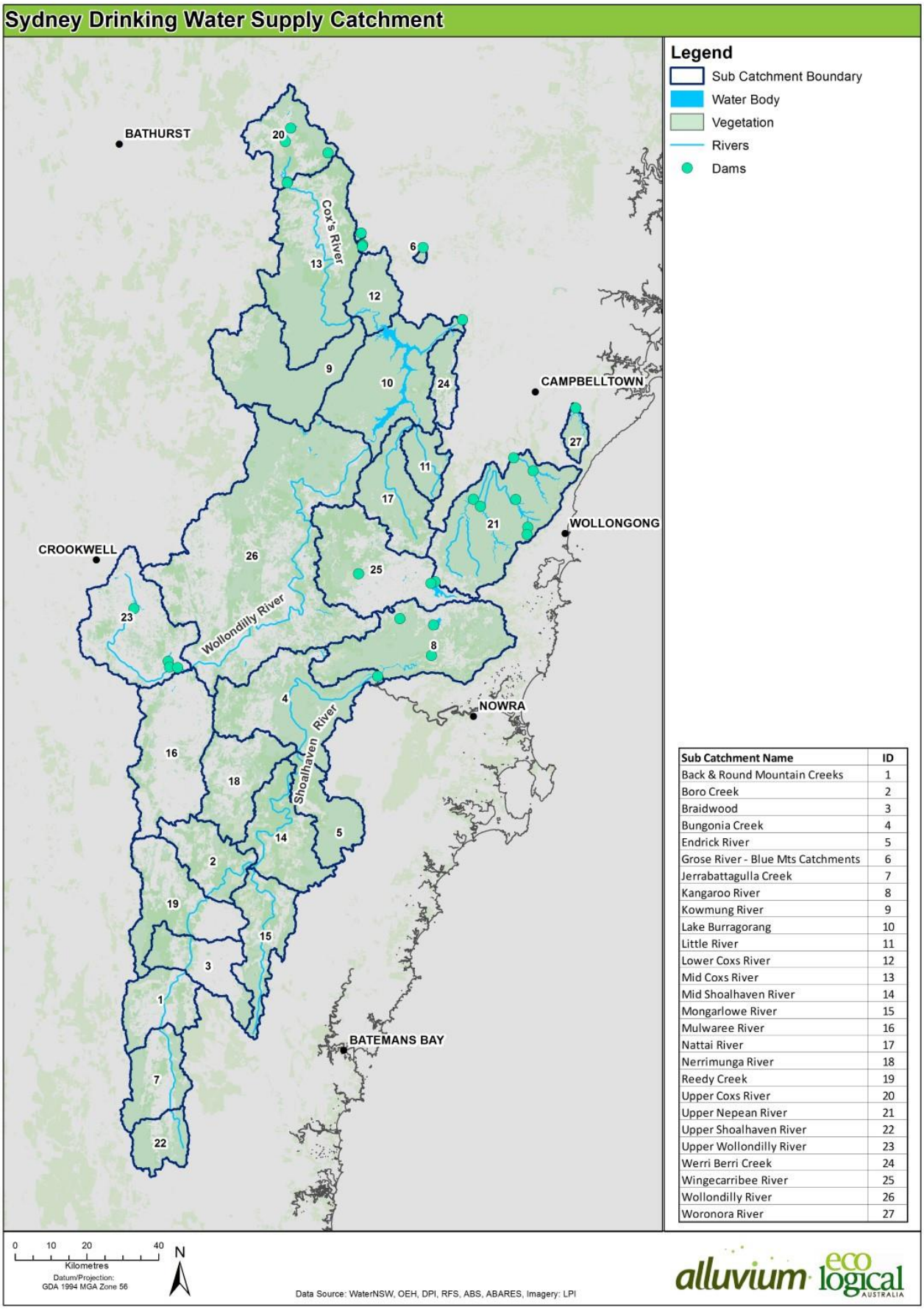
The management of drinking water quality in the Catchment follows a multiple barrier approach, as illustrated in **Figure 3**. The multi-barrier approach is consistent with the Australian Drinking Water Guidelines 2011 and includes:

- monitoring and influencing land uses, developments and activities across the catchments
- 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.

The strength of the multiple barrier approach is that a failure of one barrier may be compensated by effective operation of the remaining barriers, thereby minimising the likelihood of contaminants passing through the entire treatment system and being present in sufficient amounts to cause harm to consumers.

Catchment management is the first barrier for the protection of water quality and availability. By decreasing contamination of the source water, the level of water treatment required (and associated costs and risks) can be reduced.

*The Special Areas within the Catchment are identified in **Figure 1** and are an important part of the multi-barrier approach. They cover approximately 3,640 km^2 and comprise mostly bushland and natural landscapes around the water storages and water supply infrastructure. Public access and activities are restricted in the Special Areas, although restrictions do not apply to privately owned land and public roads. There are a number of mining leases in the Special Areas.



Sub Catchment Name	ID
Back & Round Mountain Creeks	1
Boro Creek	2
Braidwood	3
Bungonia Creek	4
Endrick River	5
Grose River - Blue Mts Catchments	6
Jerrabattagulla Creek	7
Kangaroo River	8
Kowmung River	9
Lake Burragorang	10
Little River	11
Lower Coxs River	12
Mid Coxs River	13
Mid Shoalhaven River	14
Mongarlowe River	15
Mulwaree River	16
Nattai River	17
Nerrimunga River	18
Reedy Creek	19
Upper Coxs River	20
Upper Nepean River	21
Upper Shoalhaven River	22
Upper Wollondilly River	23
Werri Berri Creek	24
Wingecarribee River	25
Wollondilly River	26
Woronora River	27

Figure 2. Sydney's water supply sub-catchments

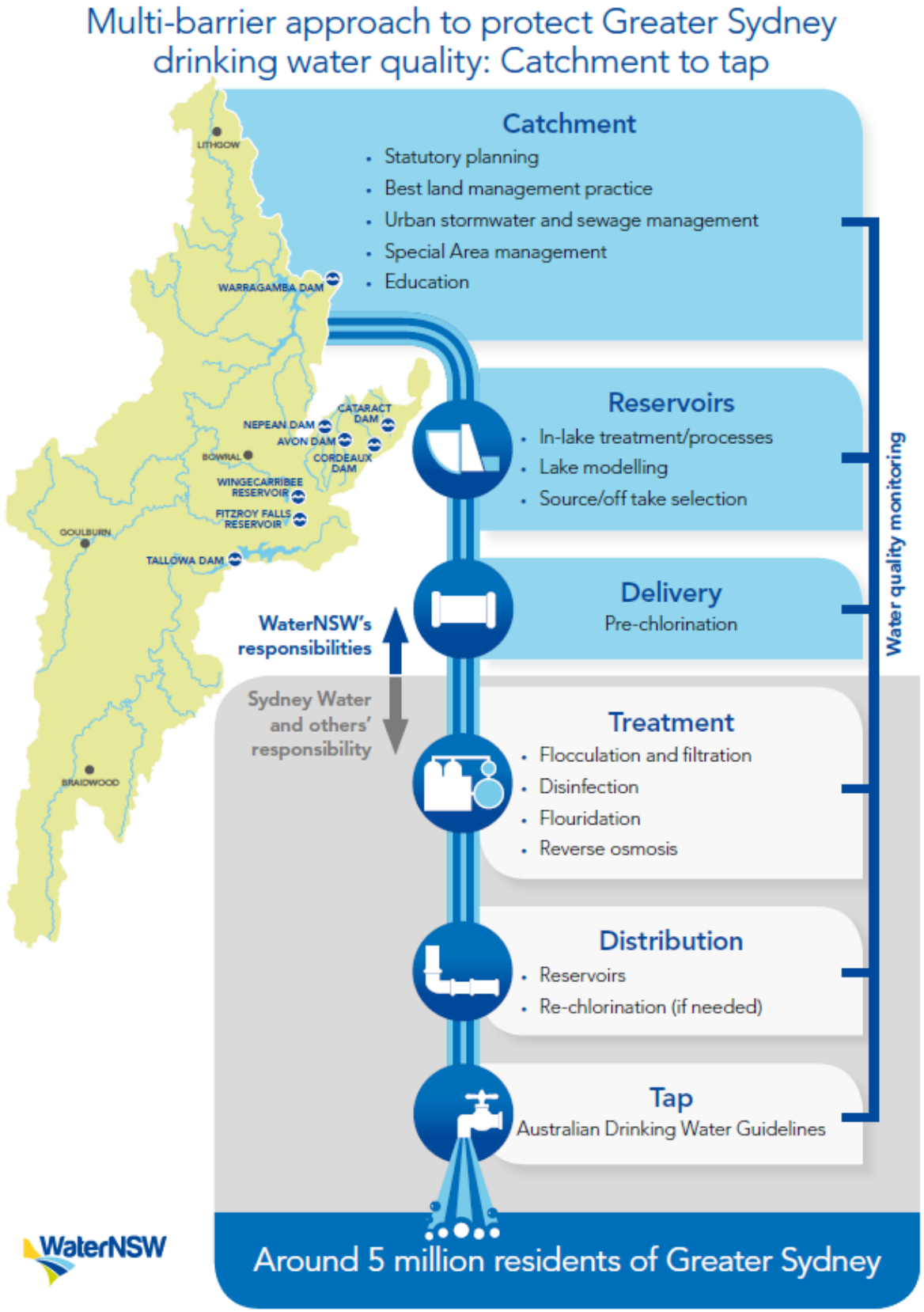


Figure 3. Multi-barrier approach to protect Sydney drinking water (Catchment to Tap) (WaterNSW)

2.3 Roles and responsibilities in the Catchment

The following table sets out the many stakeholders with an interest in the Catchment, highlighting the existing diverse responsibilities for catchment management. Notable changes in catchment management roles since the 2013 audit include the formation of WaterNSW (through a merger of the former Sydney Catchment Authority and the former State Water) and Local Land Services (former Catchment Management Authorities).

The audit team found overlaps and gaps in public authorities' responsibilities, particularly in relation to the collection, storage and sharing of data. This has created challenges for effective and coordinated responses to catchment pressures by the NSW Government.

Table 2. Catchment stakeholders

Name	Roles and responsibilities in relation to the Audit and Catchment
Department of Planning and Environment	DPE is responsible for environmental planning and assessment, and compliance monitoring and enforcement in accordance with the *Environmental Planning and Assessment Act 1979.* This includes management of the policies and approvals processes for developments such as mining, agricultural enterprises and major urban areas.
Department of Primary Industries – Fisheries	DPI Fisheries is responsible for ensuring that fish stocks are conserved and that there is no loss of key fish habitats upon which they depend. To achieve this, DPI Fisheries ensures that developments within the catchment comply with the requirements of the *Fisheries Management Act 1994*, and the associated Policy and Guidelines for Aquatic Habitat Management and Fish Conservation (1999). In addition, DPI Fisheries is responsible for sustainable management of commercial and recreational fishing in NSW.
Department of Primary Industries – Lands	DPI Land and Natural Resources develops strategy, programs and policy for the management of the Crown land estate, oversees forestry research, policy and regulations.
Department of Primary Industries – Water	DPI Water is responsible for surface and groundwater through planning, policy and regulation. DPI manages NSW water resources through: • planning to ensure water security for NSW • ensuring the available surface and groundwater resources are shared equitably • ensuring that water entitlements and allocations are secure and tradeable. There are water sharing plans applicable to all areas of the Catchment.
Environment Protection Authority	The EPA regulates activities scheduled under the *Protection of Environment Operations Act 1997* and enforces environmental regulations through licensing, monitoring and auditing. To help manage the potential water pollution impacts associated with development the EPA supports the use of a risk-based approach to considering water quality outcomes in land use decisions and the planning and design of water services and infrastructure. The EPA responds to major pollution incidents and can impose fines, stricter operating conditions, or clean up orders.
General community	Communities live and work in the Catchment. These communities use the water, and also have a basic responsibility to prevent pollution. Stormwater and sewerage systems are often sources of pollution within any water catchment. The community has the opportunity to be involved in major catchment management and landuse decisions.
IPART	The Independent Pricing and Regulatory Tribunal (IPART) has a range of roles, including setting maximum water prices and administering licences.
Local councils	Local councils have many roles and responsibilities in the Catchment, including: • A regulator under the *Protection of the Environment Operations Act 1997* • A land-use planner using *the Environmental Planning and Assessment Act 1979*;

Name	Roles and responsibilities in relation to the Audit and Catchment
	• An operator responsible for the management of infrastructure, such as urban stormwater systems, some limited sewerage services, and some councils treat and distribute drinking water. In January 2011, the NSW Government approved State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 enabling councils to assess development applications in the Catchment and requiring these developments to have a neutral or beneficial effect on water quality, and to incorporate current recommended practices or performance standards to help achieve desired water quality outcomes.
Local Land Services	Local Land Services (LLS) work with land managers and the community to: • improve primary production within healthy landscapes • help people make better decisions about the land they manage • assist rural and regional communities to be profitable and sustainable into the future. They connect people with groups, information, support and funding to improve agricultural productivity and better manage natural resources. Three LLSs that cover land in the Sydney Drinking Water Catchment are: • Greater Sydney • Central Tablelands • South East
Office of Environment and Heritage (OEH)	OEH has diverse responsibilities across the catchment, including to: • Conserve and care for national parks and reserves, biodiversity and threatened species. • Promote, protect and share Aboriginal culture and heritage in partnership with Aboriginal people and local communities. • Conserve, revitalise, care for the historic heritage within the catchment. • Support economic development by promoting sustainable industries, tourism in protected areas, jobs and access to natural resources without devaluing the environment. • Advise, support and educate communities, regions, industry and landholders on the environment and heritage. • Help communities and businesses build resilience to climate change, environmental hazards and risks. • Develop and lead reforms in biodiversity, native vegetation, Aboriginal, non-Aboriginal and shared heritage, energy efficiency, air and water quality, coastal protection and sustainability. • Joint management of Special Areas with WaterNSW
Metropolitan Water Directorate (Department of Planning and Environment)	The Directorate leads a whole of government approach to water planning for greater Sydney. The Directorate has an Independent Water Advisory Panel that provides strategic and technical advice. It has produced four long-term Metropolitan Water Plan for Sydney since 2004. The latest plan was released in March 2017.
Planning Assessment Commission	*Environmental Planning and Assessment Act 1979* No 203, Division 2 Planning Assessment Commission (PAC). The PAC is an independent body that decides significant development applications within the Catchment.
Sydney Water	Sydney Water is responsible for treatment and distribution of drinking water to customers.
WaterNSW	WaterNSW (formerly the Sydney Catchment Authority) was established under the *Water NSW Act 2014.* WaterNSW has responsibility to supply water in accordance with appropriate standards of quality, to ensure the declared Catchment and the dams, storages and pipelines in the declared catchment are managed and protected to promote water quality, and to protect public health and safety and the environment. Across the Catchment, WaterNSW promotes water quality through its statutory role in development and land use planning instruments, as well as through its compliance functions established under the *Water NSW Act 2014*, the *Protection of the Environment Operations Act 1997* and the Water NSW Regulation 2013 in relation to potentially polluting activities and incidents. WaterNSW also protects water quality in

Name	Roles and responsibilities in relation to the Audit and Catchment
	the catchments through management of its own land holdings and the Special Areas surrounding water storages. Section 43 of the *Water NSW Act 2014* states that WaterNSW must evaluate the findings of the catchment audit to the extent to which they relate to the activities of WaterNSW and risks to water quality in the declared catchment area. It states also that WaterNSW must incorporate the findings of the catchment audit, to the extent to which they relate to the activities of WaterNSW and water quality, into: • WaterNSW's risk framework • WaterNSW's programs and activities relating to catchment management. Section 44 of the Act states that WaterNSW must report to the Minister on WaterNSW's progress to achieve improvements in catchment health, to prevent degradation of existing catchment health and to maintain existing catchment health, having regard to the findings of the audit.

Plate 1: Flood gauging station on the Wollondilly River, about 10 km upstream of Lake Burragorang (Source: WaterNSW)

3 Audit method

3.1 Pressure-State-Response framework

The audit methodology is based on the internationally accepted Pressure-State-Response (PSR) framework, which was initially developed by the Organisation for Economic Cooperation and Developments (OECD) and is used for State of Environment Reporting in Australia (Department of Environment and Energy 2017). The PSR model provides a structure that links environmental policies to environmental monitoring and reporting (OECD 1993). The model considers that: human activities exert pressures on the environment and affect its quality and the quantity of natural resources ('state'); society responds to these changes through environmental, general economic and sectoral policies and through changes in awareness and behaviour ('response').

The PSR framework highlights cause-effect relationships, and helps decision makers and the public see environmental, economic, and social issues as inter-connected. This helps to select and organise indicators of the state of the environment in a way that is useful for decision-makers and the public.

In this audit, as illustrated in **Figure 4**, the *pressures* are related to land use and human settlement (and related indicators), the *state* of the Catchment is revealed by the primary indicators of water quality and availability and complementary indicators of biodiversity and habitats. The *response* part of the PSR model refers to the extent to which society responds to the *state* and *pressures*. *Response* refers to individual and collective actions intended to:

- mitigate, adapt to or prevent human-induced negative effects on the environment
- halt or reverse environmental damage already inflicted
- preserve and conserve nature and natural resources.

Existing and future *responses* may aim to achieve behavioural changes, or preventative and reactionary catchment management responses focussed on damage control and rehabilitation. Examples include education programs, grants and incentive schemes, planning controls and policies, and legislation. In general, a greater or changed response will be required if the *state* is poor and *pressures* are increasing.

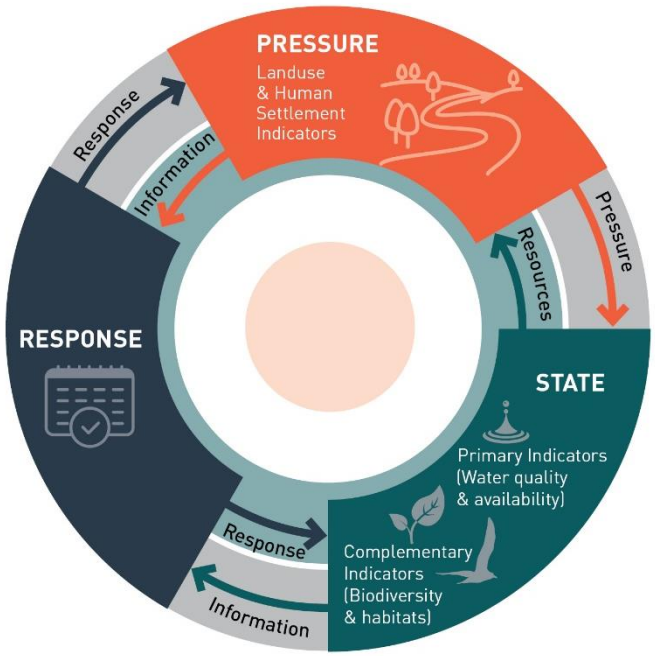


Figure 4. Pressure-state-response model (adapted from OECD 1993)

3.2 Audit steps

Table 3 outlines the overall audit method and identifies where further information relevant to each step can be found in this audit report. Detailed methods for analysis of each indicator are given in **Volume 2**.

Table 3. Overview of audit steps

Step	Description	Section in audit report
1	The audit scope and the project brief were defined.	**Volume 1 Chapter 1**
2	Government authorities and the community were invited to provide data and information to inform the audit. Stakeholders were notified of the audit and data requests via letters and media. Consultation included 89 organisations, including 14 local councils, 8 public authorities, 23 Aboriginal organisations, 13 conservation groups and 16 industry groups (mining, farming, water and energy). Seven written submissions and two phone enquiries were received from non-government organisations and individuals.	**Volume 1 Section 2.3** lists the types of stakeholders **Volume 3** provides copies of consultation materials
3	Key questions for the audit were developed based the audit scope and results of initial stakeholder consultation, and with input from the Audit Independent Expert Panel	**Volume 1 Section 1.4**
4	Data for indicators was collated and analysed relevant to the themes of: • Water quality ('primary indicators') • Water availability ('primary indicators') • Biodiversity and habitats ('complementary indicators') • Land use and human settlements ('pressure indicators')	Indicators relevant to each theme are listed in **Volume 1 Section 1** Evaluation criteria and analysis of each indicator are in **Volume 2**
5	Field inspections were conducted to investigate certain issues raised by the desktop assessment of indicators: • 9 February 2017 – Thirlmere Lakes, Little River Catchment, accompanied Office of Environment Heritage • 8 March 2017 – Woronora Catchment - Eastern Tributary and Waratah Rivulet and Cordeaux Catchment - Wongawilli Creek water course 21 and Swamp 1B, accompanied by WaterNSW	Informed analyses in **Volume 2**
6	Results from analysis of all primary, complementary and pressure indicators (in **Volume 2**) were considered collectively to identify issues and locations of greatest concern within the Catchment. Key findings from the audit relate to matters where there is a worsening trend, or a stable trend but poor status (see **Table 4**), across multiple indicators. The findings were prioritised using a risk-based approach that considered potential consequences to drinking water quality and supply if the issue is not addressed.	**Volume 1 Chapter 4**
7	Potential responses (actions) were developed in consultation with relevant authorities and other stakeholders to address prioritised issues.	**Volume 1 Chapter 4**

Table 4. Decision matrix for this audit indicating when an improved response to the pressure/s may be needed

State - Indicator status refers to the condition of the indicator over the reporting period.		**Trend** - The indicator trend describes the direction of significant change in condition and is generally judged over the reporting period, between the previous audit report and the current report. The trend reported, using the descriptors below, may have an impact on the overall status of the indicator in the future.		
		Improving – The trend in condition for the indicator is getting better (impacts are decreasing)	**Stable** – No significant change for indicator	**Worsening** – The trend in condition for the indicator is getting worse
	**Good**: the data shows a positive or healthy condition	Maintain response	Maintain response	***Improve response***
	**Moderate**: the data shows that the condition is neither good nor poor, or results may be mixed across the Catchment	Maintain response	Maintain response	***Improve response***
	**Poor**: the data indicates poor condition or condition under significant stress	Maintain response	***Improve response***	***Improve response***
	Unknown: insufficient data to make an assessment			

Based on NSW State of Environment Report (2016) nomenclature

4 Key findings and responses

4.1 Summary of key findings

Key findings relevant to the 18 gazetted indicators are summarised in this section based on detailed information in **Volume 2**. Where data was available to the auditors, the findings have been expressed in terms of the state of the indicator (ie. good, moderate or poor) and the trend (improving, stable or worsening). For some indicators, the absence of relevant information over the audit period meant that it was not possible for the auditors to define criteria for the state or trend, and therefore the key findings for these indicators are 'unknown' and relate to data availability.

Water quality

The audit undertook statistical analysis of data relevant to 12 water quality analytes from 57 stream and storage monitoring stations managed by WaterNSW in the Catchment. The analytes are:

- Chlorophyl—*a*
- pH
- Electrical Conductivity
- Dissolved Oxygen
- Turbidity
- Ammonium-Nitrogen
- Oxidised Nitrogen
- Total Nitrogen
- Soluble Reactive Phospohrus
- Total Phosphorus
- Total Aluminium
- Total Iron

The majority of sites monitored across the Catchment were found to have good levels of compliance with water quality guidelines for ecosystem health. Improvements in water quality in many locations across the Catchment in recent years can be attributed to sewerage infrastructure upgrades. However, the auditors found some locations associated with sewer systems and treatment plants (e.g. Wingecarribee River sub-catchment) continue to experience poor water quality, despite the sewage treatment plants operating within licence conditions.

Storages and catchments that were found to have the poorest water quality during the audit period are:

- Lower Coxs River and Lake Burragorang
- Wingecarribee River flowing to Wingecarribee Dam
- Kangaroo River and Bungonia Creek flowing to Lake Yarrunga
- Upper Nepean River flowing to Lake Nepean

Cyanobacteria was also assessed and found Mulwaree River at Towers weir' (near Goulburn) accounted for 10 weeks of red alerts for cyanobacteria.

Water availability

The availability of surface water flow was assessed for this audit by considering the level and variability of streamflow at 64 stream gauge locations throughout the Catchment and the compliance with surface water extraction licences within each sub-catchment. The auditors found that there was reduced water availability across the Catchment in 2013-16 compared to the previous audit period and the overall total surface water extraction has increased since the previous audit periods. The Woronora River, Wingecarribee River and Lake Burragorang sub-catchments experienced the poorest results for surface water flows.

Environmental flows were assessed by measuring the degree of compliance of the environmental water deliveries during the audit period with the environmental flow rules defined in the Water Sharing Plan for 11 locations (dams and weirs) within the Catchment. The analysis concluded that there are high levels of

compliance, although this was based on data that included spills as well as water released for the purpose of environmental flows.

Future environmental flow accounting would be improved by separating the volume of water that is actively released from that which is lost from storages via spills. This would improve resolution for examining the effect of environmental flow rules on the water supply system, and as drivers for maintaining healthy aquatic ecological communities. This accounting will better inform any future review of environmental flow rules.

Improved groundwater monitoring is needed, particularly near extractive industries such as mines and near key groundwater dependent ecosystems such as upland swamps. Proposed improvements to the public groundwater monitoring network across NSW through to 2019/20 is supported by the auditors as monitoring data will help determine the sustainability of groundwater resources.

Complementary catchment health indicators

The worsening trend for macroinvertebrates observed in the previous audit period appears to have stabilised or slightly reversed during the current audit period (2013-16). Some locations showed substantial improvements compared to results from the previous audit, in particular the Lower Coxs and Wollondilly sub-catchments.

No waterways in the Catchment were found to have very good or good fish community status based on modelling by DPI Fisheries. There were four sub-catchments that have a predominantly very poor fish community status (Mulwaree River, Nerrimunga River, Upper Wollondilly River and Wollondilly River).

Corridors of native riparian vegetation contribute to healthy waterways and improved water quality outcomes. Unfortunately, the lack of riparian vegetation data for the audit period means that it is not possible for the auditors to determine the status or trends for this indicator. Riparian management activities in Blue Mountains, Goulburn Mulwaree, Lithgow, Oberon and Wingecarribee Council areas are likely to have had a positive contribution to Catchment health. We recommend improved coordination of riparian vegetation monitoring by public authorities.

The available data indicates that there has been a decline in the extent and condition of wetlands in some areas of the Catchment and efforts to rehabilitate wetlands that were impacted by longwall mining have been unsuccessful to date. However, community groups have been working to regenerate and rehabilitate wetlands in some areas in the Blue Mountains, Goulburn Mulwaree and Wingecarribee council areas.

There was a significant increase in the area affected by uncontrolled bushfires during the audit period. Risks of bushfires and associated impacts to catchment health (e.g. soil runoff) are predicted to increase with climate change. Maintaining up-to-date Bushfire Risk Management Plans and implementation of more prescribed burns would help to mitigate these risks.

Inadequate data was available for the audit period to determine the status or trend for native vegetation or physical form, although experience suggests that the physical form is unlikely to have changed significantly since the previous audit.

Environmental pressures

Data from the Australian Bureau of Statistics suggests that the Catchment population is 118,600 as of 30 June 2016, an increase of 3,500 persons between 1 July 2013 and 30 June 2016. The population has increased within all Catchment LGAs, except Goulburn-Mulwaree LGA, and the population growth rates are similar to the previous audit period. Increasing population and associated development increases pressure on Catchment health.

Gully erosion risk remains widespread in the Sydney Catchment area, with the longest length of active ongoing eroding gullies is in the Wollondilly sub-catchment and mid-Shoalhaven region.

The available data indicates that community involvement in on-ground works and natural resource management advocacy remains strong in the catchments. Overall funding of community programs for on-ground works has been similar or slightly more than during the previous audit period. Special interest groups

continue to raise concerns about environmental pressures from mining and power stations in the northern part of the Catchment (refer to **Section 4.2** below).

4.2 Matters of community concern

Issues that were raised by the community during the Catchment Audit are identified in **Table 5** and mapped in **Figure 5**. The primary issues raised by the community were those related to environmental pressures arising from mining and power stations within northern areas of the Catchment. Comment is provided in **Table 5** for each of these issues based on observations during the audit. Key issues and responses regarding mining are provided in **Section 4.3**; further detail in relation to impacts of mining on specific indicators in contained in **Volume 2**. Further information about the community consultation process is included in **Volume 3**.

Plate 2: Thirlmere Lakes (Source: WaterNSW)

Plate 3: WaterNSW monitoring site WC21 at Dendrobium Area 3B – dry pools and no flows following persistent rainfall (Source:WNSW)

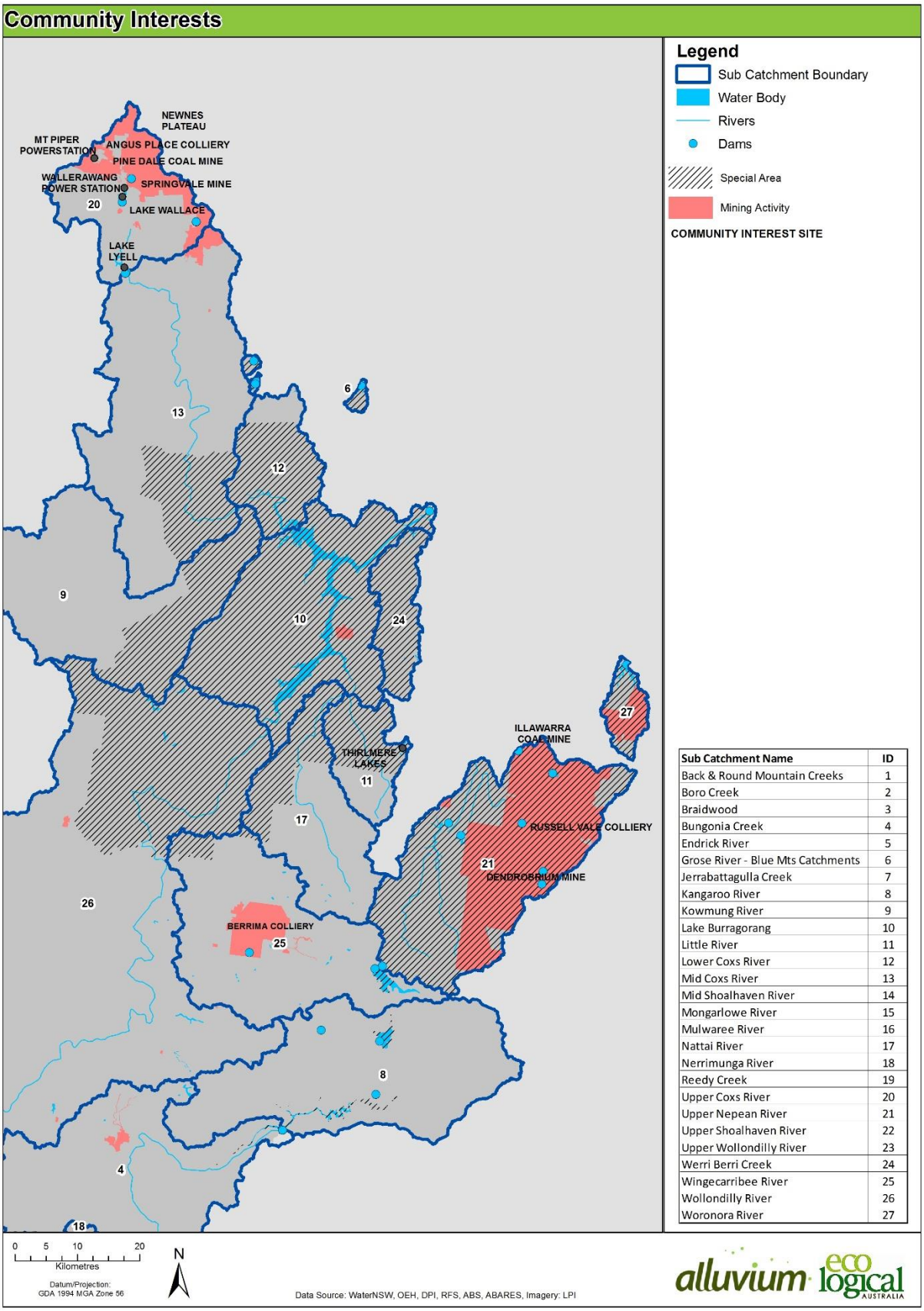


Figure 5. Locations of community concern and associated features of interest

Table 5. Community concerns and key findings

Area and issue of community concern (Source #)*	Audit observation
Illawarra Coal Mine - Methane rising in the Nepean River (1)	The EPA has advised that the gas bubbling related to underground coal mining activities conducted by South32 in the vicinity of the Upper Nepean River near Douglas Park. While South32 does not mine under the Nepean River, *Subsidence Management Plan Application* reports predicted a small amount of gas bubbling would occur in the river during mining. This bubbling can vary in location, duration and intensity. It is caused by subsidence cracking in the strata above the mine that releases gas to the surface. While the environmental consequences of the bubbling are predicted to be negligible, it is subject to monitoring, reporting and other management responses as part of the approved subsidence management plan.
Russell Vale Colliery extension - Impacts on the environment (1)	This mine has a long history and multiple seams have been mined. Subsidence and cracking response to mining is complex (NSW PAC 2016) and the potential for increase in infiltration of surface water and shallow groundwater to intermediate and deeper strata is poorly understood, making the assessment of loss of yield to storages difficult. The potential for increased losses also increases the impact on sensitive features such as upland swamps that rely on given underlying bedrock conditions that are altered by subsidence.
Dendrobium mine - Impacts on Cordeaux Dam draining to Nepean River (1)	Cordeaux Dam has the third best water quality of all storages based on WaterNSW monitoring data – with only low dissolved oxygen and high aluminium in the poor/very poor categories. Refer to **Volume 2** for further details of the water quality analysis including ecosystem protection guidelines. Subsidence and cracking impact yield to water storages and sensitive environmental features such as swamps and waterways. The potential for increased infiltration to intermediate and deep strata is not well understood. Critical to this is the depth of surface down fracturing and also its potential connectivity to seam up fracturing. The potential for ongoing increased infiltration to deep or intermediate strata that does not report to water storages is not yet well understood (impact time may be decades or centuries). Reduction in saturation of swamps may result in increased mobilisation of elements that negatively impact water quality.
Little River sub-catchment - Increased frequency of draining and drying of Thirlmere Lakes (1 & 2)	The AEMRs for Tahmoor Colliery provide no reference to Thirlmere Lakes over the period of the audit. The longwalls at that mine are within 2 km of the lakes on Little River. No direct correlation, however, has been made between the impact of those longwalls on groundwater at the mine and the Thirlmere Lakes. The NSW Chief Scientist and Engineer and the independent committee of enquiry (http://www.environment.nsw.gov.au/water/ThirlmereLakesInquiry.htm) found that there are many influences on groundwater in the area such as mining, private bores and natural groundwater flow paths away from the lakes. These influences are currently being studied by NSW Government. Rainfall deciles (amounts) over the audit period were around average, and lake levels had recovered somewhat at the time of audit inspection from lows experienced over the last decade. Little River has some of the best water quality of all catchments.

Area and issue of community concern (Source #)*	Audit observation
Newnes Plateau hanging swamps - Subsidence and surface cracking leading to draining of the swamps and diversion of surface water to underground (1, 2, 3 & 4)	The issue is on the border of the catchment, however as a general comment: swamps are drying as a result of cracking of the bedrock directly beneath them. This will alter ecological function and has potential for water quality impacts during more intense rainfall events with increased erosion potential and mobilisation of elements from an unsaturated zone that is previously saturated.
Springvale Mine extension - Increased salinity in the Coxs River and subsidence impacts on hanging swamps (1, 2 & 3)	The Springvale mine currently discharges mine waste to two small tributaries of the upper Coxs River (upstream of Lake Wallace). Salinity levels at all Burragorang storage sites show a rising 3 year and 20 year trend. The Springvale Colliery contributes to salinity in the Coxs River which flows into Lake Burragorang. Under its Environment Protection Licence, Springvale Mine is required to meet salinity target of 1.2 mS/cm (100th percentile) from its main licensed discharge point (LDP009). Approximately 21.5 ML/day was discharged from LDP009 to a tributary of the Coxs River during the audit period. The auditors have been informed by the EPA that this wastewater discharge will be transferred to Mt Piper Power Station for reuse. Subsidence is monitored and reported in the Springvale Mine AEMR (2014). For extraction panels removed during 2014, subsidence results were within the maximum limits of 1100 mm with a maximum reading of 747 mm. It is noted in the Springvale Mine AEMR (2014) (page 47), that none of the subsidence effects have caused any surface cracking or erosion impacts to surface features on the Newnes Plateau including shrub swamps, fire trails and powerlines and that there are no anomalous surface movements warranting further investigations.
Wallerawang power station - Impacts of closure resulting in cooling water previously diverted from Springvale Mine now being directed to Sawyer's Swamp Creek (Coxs River tributary) (4)	As detailed below in the Springvale Delta Water Transfer Scheme
Lake Wallace and Lake Lyell on the Upper Coxs River - Water quality impacts of more regular lake spilling due to increased flow as a result of the Wallerawang power station closure (4)	No AEMR reports in this area (Springvale, Pine Dale or Angus Place Collieries) refer to Lake Wallace or Lake Lyell on the Upper Cox River or lake spilling due to the Wallerawang Power Station Closure.
Springvale Delta Water Transfer Scheme (SDWTS) - Proposal to transfer mine water from Springvale Colliery to the Mount Piper Power Station generally supported (4)	Springvale annual review (2015/2016) refers to the Cox River Action Plan Document (June 2016). The report indicates the SDWTS pumps 30 ML / day from Springvale Coal and Angus Place Colliery to Wallerawang Power Station. Formal warnings were issued to Springvale Colliery regarding incidents in Feb 2015 and Sept 2014 involving discharges of mine water on the Newnes Plateau from the SDWTS. The EPA determined that the location of the SDWTS is vulnerable to damage by heavy vehicles and roadwork activity. Signs have been installed to improve communication to indicate its location.

Area and issue of community concern (Source #)*	Audit observation
Angus Place Colliery - Seepage into Lambs Creek (4)	Angus Place is in 'care and maintenance' since March 2015 but continues to make constant discharges to two tributaries of the upper Coxs – upstream of Springvale Mine. The AEMRs do not indicate any dams located near Lambs creek for seepage to occur.
Pine Dale Mine (Yarraboldy (stage 1) Extension) and Neubecks Creek project - Acid mine drainage (Acid Rock Drainage, ARD) and future impacts (4)	Currently under care and maintenance. The Pine Dale Mine Care and Maintenance Mining Operations Plan (Enhance Place 2017) notes that rehabilitation works undertaken in 1991 were largely unsuccessful as coarse reject was left on the surface and capped with only 0.1 m of clay prior to seeding. The surface acidified and much of the vegetation died. Material prone to ARD has been identified at the historic Wallerawang Colliery, Commonwealth Colliery and Pine Dale Mine. Works have been undertaken to address known and potential ARD impacts: • The removal of coal-bearing material near the concrete drain adjacent Neubecks Creek • Development and implementation of a channel health and stability monitoring program • Construction of rock lined drop structures to stabilise water channels at three locations • Continuation of progressive rehabilitation works • Covering of the coal bearing material identified on the south bank of Neubecks Creek in the vicinity of sampling point S3 • Spreading of lime over rehabilitated areas as required. The Pine Dale AEMRs (2013-2015) detail in the 2014 report that that the treed rehabilitation area has improved the ground cover following the treatment of acidic soils and reseeding, and in the 2015 report that the rural land capability assessment notes that the soil acidification hazard class has very low texture/buffering capacity pH 4-4.7 ($CaCl_2$). The Pine Dale Water Management Plan (2015) details removing potentially acid forming (PAF) material and burying within the Pine Dale Mine open cut or covering the PAF material with inert overburden to form a water shedding cover. pH testing in a grid pattern is detailed within the report and action will be taken when samples have a pH less the 5.0. The surface water monitoring program includes the stream health, vegetation health and channel stability of Neubecks Creek. Samples indicate the overburden and interburden materials do not present an acid mine drainage problem and the PAF material is generally confined to the siltstone and carbonaceous shale seams (within and above the Lithgow coal seam). This strata will be selectively stripped and placed at the floor of the open cut and covered with inert material.
Berrima Colliery – ongoing seepage into Wingecarribee River included in the Draft Rehabilitation and Final Closure Plan (5)	The Berrima Colliery is an underground coal mine in the Wingecarribbee subcatchment. It ceased mining in October 2013 and for the remainder of the audit period was under 'care and maintenance'. NSW Government approval has been sought for its closure and the 2015 Rehabilitation and Final Closure Plan is pending. The mine workings still accumulate groundwater which is discharged to the Wingecarribee River and regulated by the EPA through an Environment Protection Licence (EPL 608). The EPL imposes discharge limits on three pollutants from the mine (oil & grease, suspended solids and pH). The EPL also requires the owners of the mine to collect and report data on 11 pollutants in the mine's waste discharge to the Wingecarribee River, including salinity, manganese, nickel and zinc. These are to be assessed against monitoring points (Point 11 and Point 12) located approximately 5.5 km or more below the waste discharge outfall.

*Sources relevant to the table above are listed below:
Source 1: Nature Conservation Council. Letter from Chief Executive Officer, Nature Conservation Council dated 14 October 2016 "Input into the 2016 audit of the Sydney Drinking Catchment".
Source 2: Blue Mountains Conservation Society Inc. Letter from BMCS Management Committee dated 20 October 2016 "Response to the Sydney Water Catchment Audit 2016".
Source 3: The Colong Foundation for Wilderness Ltd. Letter from Director of The Colong Foundation for Wilderness dated 12 October 2016 referring to Pells Consulting report: Pells, S.E. & Pells, P.J.N. 2015 *Impacts from coal mining at Springvale Colliery on the Temperate Highland Peat Swamps of the Newnes Plateau*. Consultant's report by Pells Consulting for Colong Foundation. Ref S007.R1 Jan 2016.
Source 4: Lithgow Environment Group Inc. Letter from Vice President of the Lithgow Environment Group Inc dated 13 October 2016 "Submission on the Sydney Drinking Water Catchment 2016"
Source 5: Lee, J., Pells, P. & Pells, S. 2014 *Hume Project Sutton Forest Coal Exploration EL349 Groundwater Study*. Consultation report by Pells Consulting and Hydroilex for Southern Highland Coal Action Group.

4.3 Priority issues

Responses recommended in this Audit are evidence-based and targeted on key findings and to address catchment risks to Sydney's drinking water supply. Failure to act may make the water supply system more vulnerable to shocks (sudden changes) or gradual decline in quality and / or quantity.

Mining in the Special Areas
A number of issues were identified with relevance to underground coal mining in the Catchment, particularly in the Special Areas. As described in **Volume 2**, these concerns relate primarily to water availability, water quality and wetland health.

Catchment areas overlying historic and current underground mining (longwall, bord and pillar) have potential to experience as yet undetermined alterations of inflows of surface water and shallow returning groundwater. Observations of waterways near current mining areas indicate that many streams that were historically 'gaining' water from the adjoining shallow aquifers are now 'losing' water to groundwater or no longer receiving inflows at all. The potential interactions between surface water, groundwater and mine workings are conceptualised in **Figure 6**.

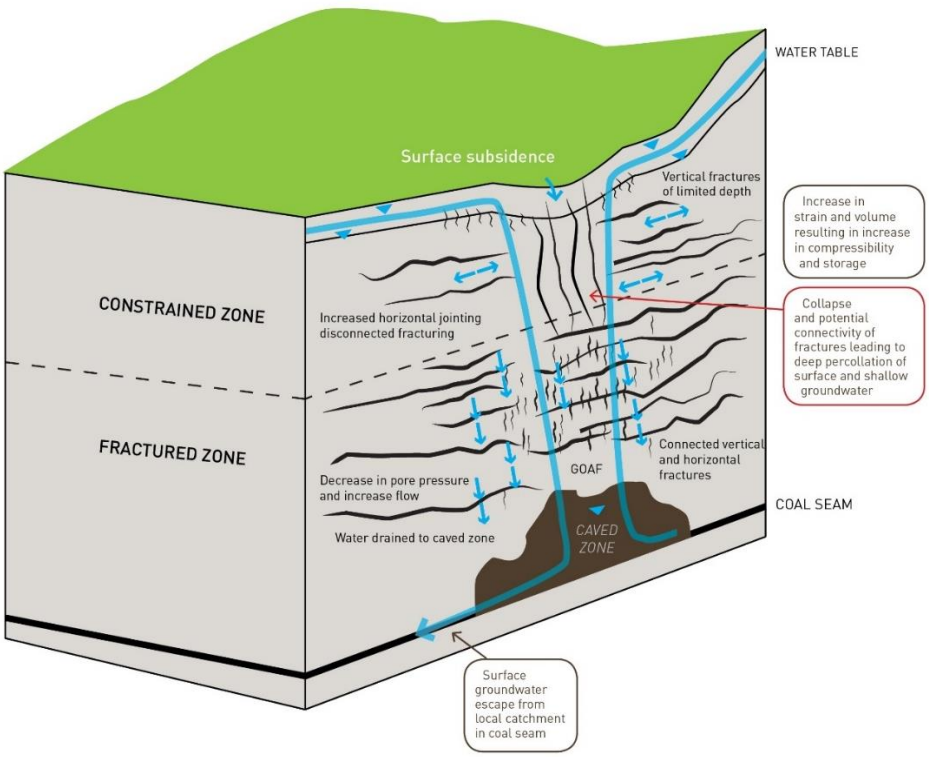


Figure 6. Potential interaction of surface water and groundwater to underground mining (after Tametta 2013)

The cumulative, and possibly accelerated, impact of mining on flow regimes in the Catchment is likely linked to the increased prevalence of the current longwall methods of underground mining. Longwall mining induces substantial compressive and tensile stresses in the strata overlying the extracted coal seams. These stresses result in cracking and may in turn increase the hydraulic conductivity from the surface down to the mine workings. The potential exists for the bedrock fracture network penetration to be greater than is commonly predicted with considerable additional contributions to increased hydraulic conductivity associated with mobilisation of existing structures (joints, bedding planes, faults). This is a topic of current interest and investigation that may inform future assessment of the take of surface and groundwater by mining in the Catchment.

A key question associated with the fracturing of strata and mobilisation of existing bedrock structures is whether or not increased rainwater infiltration returns to the surface or bypasses mine structures via deeper strata, including filling of the goaf (mine workings). Infiltration to deeper strata may provide contributions to aquifers to the north of the storages or to the escarpment and hence no longer contribute to the Catchment storage network.

Surface water loss into mine workings has been confirmed by the Department of Planning and Environment in investigations to support determination of the most recent subsidence management plan for the Dendrobium Area 3B mine (NSW Government 2016). This surface water, while thought to be small compared to evaporation loss, may have otherwise reported to catchment dams.

Evidence of the impacts of mining on surface water flows is very limited. WaterNSW gauging station density has inadequate coverage to identify direct longwall by longwall impacts or cumulative effects. (For example, only two gauging stations are present in the Woronora sub-catchment). This is supplemented by monitoring requirements placed on mining companies by the Department of Planning and Environment. Once volumes of loss from surface water and groundwater sources are determined, DPI Water can ensure that water take from mines are appropriately licensed under the relevant NSW surface and groundwater Water Sharing Plans for the area (NSW Government 2015, p.42) and the NSW Aquifer Interference Policy.

The impacts of increased infiltration, with potential for loss of yield may not be significant in wetter years. However, such losses could be significant in dry and drought conditions. The loss of surface water can also impact on bushfire severity, and thus the condition of upland swamps and their flora and fauna communities.

Responses recommended to reduce mining risks and impacts to the Catchment are presented in **Table 6**.

Land degradation

Continued overgrazing, uncontrolled stock access to riparian zones and other unsustainable land use practices have led to some areas in the Catchment experiencing sheet, rill, gully and streambank erosion, and poor downstream water quality. As described in **Volume 2**, the audit found that the worst affected areas are in the:

- Braidwood sub-catchment
- Wollondilly sub-catchment and its two major tributaries sub-catchments the Mulwaree and Upper Wollondilly. Sediment and nutrient generation in this region will have a direct impact on the downstream receiving waterbody of Lake Burragorang.
- Nattai River sub-catchment, although water quality impacts here may also be associated with the Mittagong sewage treatment plant (see below).

Extreme weather events are expected to become more frequent and more intense under predicted climate change. This is likely to exacerbate factors such as increased erosivity and streambank erosion (OEH 2011), and changes to surface runoff and groundwater recharge (OEH 2015a). An expanded response to protection and restoration of landscapes is therefore needed across the Catchment in response to climate change, particularly in areas that are already experiencing land degradation.

The Catchment Audit found that programs to protect or restore the landscape have generally had a beneficial effect and it is expected that a similar improved response could be expected if further investment was made. The Riparian Management Assistance Program which ran from 2006 to 2012 involved 100 projects on 69

properties. It is understood that 55 of these properties were revisited by WNSW staff 2 years after the completion of works for project outcome assessments. These evaluations showed that water quality risks have been reduced on average to 'low' based on increased groundcover and 'very low' where stock access to the riparian zone has been reduced (WaterNSW 2016).

Responses to assist agricultural land holders (e.g. graziers) protect and improve landscapes and waterways in the Catchment are identified in Error! Reference source not found..

Sewage treatment

Sewage treatment plants (STPs) are a well-documented source of pollutants in the Catchment. The Accelerated Sewerage Program involved upgrades to 10 STPs over the period 2001-2013. In 2012, WaterNSW carried out a statistical analysis of instream water quality before and after the upgrade of the Lithgow and Braidwood STPs. Statistically significant improvements were found for total and filterable phosphorus for the period after the Lithgow STP upgrade. There were also statistically significant decreases in total nitrogen and total phosphorus at the Braidwood STP following the upgrade.

Despite the success of the Accelerated Sewerage Program in decreasing point source nutrient pollution, sewage treatment plants at Bowral (EPL 1749), Moss Vale (EPL 1731) and Mittagong (EPL 10362) have been identified to require significant upgrades in the short to medium term due to capacity issues. These plants are collectively subject to 15 Pollution Reduction Programs administered by the EPA[1].

The Wingecarribee River at Berrima experienced poor water quality across a range of parameters during the audit period (refer to **Volume 2**). Wingecarribee LGA also experienced the largest number of sewerage system overflow incidents of all LGAs in the audit period. Wingecarribee River sub-catchment is under development pressure with the largest number of development applications submitted in the audit period of any LGA (251 of 554 applications) across the Catchment. The Wingecarribee sub-catchment, including Wingecarribee Reservoir, has also been impacted by high nutrient loads associated with dairy effluent and ongoing adverse impacts resulting from an incident in 1998 when the peat island in the reservoir separated from Wingecarribee Swamp.

Responses to reduce impacts from effluent in the Wingecarribbee sub-catchment are identified in **Table 6**.

Bushfires

Prescribed burning on public land within the Catchment is undertaken by NSW Fire and Rescue, RFS, Forestry Corporation, WaterNSW and the OEH. Extensive bushfires, such as those experienced in the Catchment in 2013/14, adversely impact catchment health and threaten drinking water supply. WaterNSW and NPWS jointly run a rapid, fire response program, across the Special Areas to minimise risk to water quality. The aim of the program is to keep any intense wildfires close to the storages to a minimum size. In the bushfire season this program involves rapid helicopter deployment of specialist crews to extinguish remote ignitions while they are still small.

Poor water quality recordings, particularly in the Nepean storage, appears to relate to the extensive bushfires across the sub-catchment in 2013 and heavy rainfall the following year. WaterNSW implements measures to safeguard water quality after rainfall in fire affected catchments as needed, including water quality testing after rain to provide early detections of potential issues, implementing erosion controls in vulnerable areas, and placing booms on lakes to manage floating ash or debris. As an example, monitoring was increased in the Nepean catchment, at Broughtons Pass Weir and Pheasants Nest Weir catchments following the October 2013 fires (SCA 2014a).

The 2013 fires increased the risk of pollutants being transported into the storages and rivers during subsequent storm events. The dry summer did not allow ground cover to re-establish sufficiently to reduce the risk of sediment and nutrient runoff. WaterNSW worked with Sydney Water to optimise raw water supply, undertaking additional monitoring and changing the source of supply to reduce the colour and turbidity in the raw water (SCA, 2014a, 2014b). In March 2014, heavy storms over the bushfire impacted Upper Nepean sub-catchments led to poor water quality in the Broughtons Pass Weir pool (monitoring station N881). As a result,

[1] Source: NSW EPA Protection of the Environment Operations Public Register http://www.epa.nsw.gov.au/prpoeoapp/

supplies to the Macarthur Water Filtration Plant and the Upper Canal were affected. Macarthur WFP was temporarily shut down while Upper Canal water was diverted to Prospect Reservoir (SCA 2014b).

Reduced bushfire activity during the 2014/2015 and 2015/2016 seasons resulted in limited impacts on the catchment and water supply from high intensity fires. Further, the presence of average and above-average rainfall across the catchment following prescribed burning and bushfires encouraged the re-establishment of vegetation post bushfire and reduced the magnitude of impacts.

Existing procedures (such as additional water quality monitoring and treatment) should be applied in the event of future fire events. However, climate change is predicted to result in 'large increases in bushfire risk, including a longer fire season' (OEH 2015b). Given this increasing risk and the limited extent of prescribed burning across the Catchment (collectively less than 3% of the total Catchment was subject to prescribed burns in 2013-16), an improved fire planning and burning management response is recommended as outlined in **Table 6**. In implementing the response, consideration should be given to Aboriginal 'cultural burn' practices and results of recent fire research.

Data quality and monitoring

High quality and relevant information (data) on water quality, water quantity and ecological health is vital to the assessment of the condition of the Catchment. Inadequate monitoring programs and poor quality data have the potential to undermine the credibility of future catchment audits.

Extensive effort was made by the audit team to obtain relevant data for this 2016 Audit, including contacting government and non-government organisations, as well as seeking information from the community. In undertaking the Catchment Audit it became apparent that some corporate knowledge had been lost from government authorities. This loss was most likely a result of staff turnover and reduced resourcing. Improved data collection, management and reporting is required to overcome and prevent ongoing loss of such knowledge.

The inadequate availability and quality of data and monitoring has been raised in previous audits and remains a concern. Several datasets for indicator measures have not been updated since the 2013 audit (e.g. native vegetation, stream physical form) which restricted audit analysis. It is suggested that conduct of future Catchment Audits and monitoring implementation of recommendations by the NSW Audit Office would assist these data issues.

Recommendations from previous audits that have not yet been finalised relate to data quality and monitoring, as discussed below.

Recommendation 17 from the 2010 audit

Recommendation 17 from the 2010 Catchment audit stated:

NOW and SCA to undertake research aimed at understanding the extent, connectivity and interaction between sub-surface aquifers (confined and unconfined), perched aquifers and surface waters within the Catchment.

The 2013 audit concluded that this recommendation could be closed and stated:

The SCA completed research on groundwater – surface water interaction in the mining impacted catchments of Special Areas (report to be published by June 2014).

The current audit found:

As the anticipated publication date of this research was during the current audit period it was attempted to locate the results of this research project. However, no published results could be located either in the public domain or through communications with key personnel within DPI Water and WaterNSW. It remains unclear which research project this statement refers to and the outcomes of this work. Concerns remain about the interaction and management of groundwater and surface water. Improved responses are therefore needed to better understand the interaction and establish an appropriate management regime.

Recommendation 7 from the 2013 audit
Recommendation 7 of the 2013 Catchment Audit stated:

NOW should extend existing monitoring to include groundwater quality data as well as groundwater levels to establish a baseline for groundwater resources in the Catchment.

DPI Water was assigned responsibility for this.

The 2015-16 Catchment report stated that this action is 'in progress'.

DPI Water is leading a Water Monitoring Framework which shall expand groundwater monitoring (levels and quality) in the coal basins of NSW, including areas within the Sydney drinking water catchment. The program is scheduled over five years 2015/16 to 2019/20.

The current audit found:

No additional monitoring has commenced since the 2013 audit. However, it is anticipated that monitoring in the catchment will be improved through implementation of the NSW Water Monitoring Framework, which aims to extend the public groundwater monitoring network through to 2019/20 and to harness the information generated by private monitoring (e.g. by mining companies). DPI Water has advised that this action remains in progress.

Recommendation 10 from the 2013 audit
Recommendation 10 from the 2013 audit stated:

The SCA undertake targeted projects to ground-truth the effectiveness of Catchment improvement activities at a drainage unit scale to verify the prioritisation of on-ground works via WaterNSW Pollution Source Assessment Tool (PSAT) and use this information as feedback to the Land Management Database.

WaterNSW was assigned responsibility for this.

The 2015-16 Catchment report stated that this action is 'in progress'.

This is addressed firstly by the grazing trial, which is being conducted at two sites in the Kangaroo Valley. Sampling has continued in rain events during the past year. As yet the results have not provided sufficient data to warrant further statistical analysis. Secondly, the sewage treatment plant evaluation study found that oocyst infectivity in raw sewage was high but was reduced by UV treatment to negligible concentrations of infective oocysts. Total Nitrogen and Phosphorous in raw sewage were reduced by 85.5% and 97% respectively by the improved sewage treatment process used at Lithgow.

The current audit found:

WaterNSW has undertaken a grazing assessment trial, assessed the Braidwood and Lithgow STP upgrades and trialled an approach using satellite imagery to assess pasture changes on adjacent properties to examine the impact of grazier education programs.

The PSAT generates estimates of potential annual pollutant export for individual grid cells and sites across the catchment. These values, summed for monitoring site catchments, have been compared with annual loads estimated using monitored storage inflow data. Catchment intervention scenarios can be run through the PSAT process, and the ratio between the summed PSAT results and annual monitored loads used to estimate their benefit in terms of changes to annual pollutant loads in inflows to storages. The Land Management Database is no longer used as a central repository for land management data, however the results of the above studies are feeding directly into catchment program planning, approval and development, and into future update of the PSAT.

An improvement to ground-truthing the effectiveness of Catchment improvement activities would be a co-ordinated approach to reporting results of the range of WaterNSW catchment improvement works.

Recommendation 11 from the 2013 audit
Recommendation 11 from the 2013 audit stated:

OEH and CMAs should investigate the potential to update the data on the extent and condition of native and riparian vegetation in the Catchment for the next audit period.

OEH and LLS were assigned responsibility for this.

The 2015-16 Catchment report stated that this action is 'in progress'.

OEH has recently completed a high resolution map of woody extent for NSW. This new data replaces an earlier version based on Landsat imagery (25 metre pixel resolution) with a SPOT5 derived product having a five metre pixel resolution. This level of detail is unprecedented in Australia. The layer does not differentiate native from non-native vegetation, but for the majority of the Sydney drinking water catchments it would be predominantly native. Analysis of the woody extent values for each of the sub- catchments encompassing the Sydney Drinking Water Catchment Area has been completed.

This new map layer will shortly become available for download through the OEH Open Data Portal or by request.

The current audit found:

In 2013, OEH prepared a *Native Vegetation Information Strategy 2014-2018* that defines the 'Vision for NSW' as 'conservation, planning and regulation are enabled through easy access to consistent, relevant and scientifically robust native vegetation information'. The strategy identifies eight objectives for the production, maintenance and delivery of native vegetation information for NSW. During the current audit, OEH advised that an updated native vegetation spatial database is being developed in accordance with actions identified in the *Native Vegetation Information Strategy 2013-2018* (OEH 2014). Development of an updated vegetation database is strongly supported by the audit team as a foundation for informed decision-making.

Recommendation 12 from the 2013 audit
Recommendation 12 from the 2013 audit stated:

OEH, SCA, CMAs and other relevant agencies collaborate to develop and apply a standardised procedure for assessing the extent and condition of wetlands in the Catchment.

OEH, WaterNSW and LLS were assigned responsibility for this.

The 2015-16 Catchment report stated that this action is 'in progress'.

OEH convened an interagency workshop and undertook a stakeholder survey in September 2014 to explore the development of a NSW Wetland Inventory, including Sydney's drinking water catchment. This inventory project will map the location, distribution and extent of wetlands, develop a standardised set of core biophysical data for wetlands, and assess wetland condition, values, threats and significance. A detailed business case has been developed, although funding for implementation is yet to be secured.

The current audit found that this action has not yet been implemented. Actions identified in the *Native Vegetation Information Strategy 2013-2018* (OEH 2014) would, once implemented, contribute to an improved understanding of the extent and condition of wetlands within the Catchment.

4.4 Recommended responses

Responses to the key findings of this Audit are tabulated below. The responses have been reviewed by the relevant public authorities and are considered feasible, subject to availability of resources and funding. It is recommended that all responses be delivered within three years of this Audit being tabled in the NSW Parliament.

Table 6. Responses to key findings of this Audit

ID	Recommendation	Purpose	Responsibility
Responses to reduce mining risks and impacts in the Special Areas			
M1	Establish the scope and commence a state-owned regional surface water and groundwater geotechnical model.	The model will quantify water loss to mine workings or to intermediary strata and input to Sydney yield calculations. It will improve the validity and independence of existing geotechnical and hydrogeological models which are critical to decision-making about mining proposals and cumulative regional impacts. The model will assist DPE develop mining operation approval conditions including potential buffer distances from critical features (e.g. wetlands) and specifying appropriate longwall parameters (including height of extraction and width of panels and/or pillars) and mining techniques to minimise impacts.	Department of Planning and Environment (DPE) / DPI Water
M2	Activate licencing under Section 60I of the *Water Management Act 2000* and in accordance with the NSW Aquifer Interference Policy to regulate surface water loss to mine workings.	Licencing will require the mines to account for water lost (extracted) from cracking to mine workings or other intermediary strata. Improved accounting for lost water will lead to better management of the water source. Refer to *Aquifer Interference Policy Fact Sheet 3* for further details. The independent panel (suggested in M3 below should have an advisory role in developing the method to quantify surface water lost).	DPI Water
M3	Establish an independent panel to review the monitoring, analysis and reporting program relevant to mines operating in the Catchment.	The independent panel review will provide the community with greater confidence about the results of monitoring studies undertaken.	Department of Planning and Environment
M4	Investigate thresholds at which mining activities cause loss of surface water to mine workings, and impact the yield of individual Sydney catchment water supply systems. Results to be considered in the Metropolitan Water Plan.	Thresholds will inform impact criteria for planning approval purposes.	Metropolitan Water Directorate / WaterNSW
M5	Identify surface water flow monitoring requirements in mining approval conditions.	Monitoring of the stream network (from 1st order streams to the largest) will enable determination of changes to surface water hydrology arising from mining operations.	Department of Planning and Environment

ID	Recommendation	Purpose	Responsibility
M6	Compile all empirical evidence of mining impacts in the Sydney Drinking Water Catchment in a regional cumulative impact assessment.	Mining approvals required under the Aquifer Interference Policy to consider the cumulative impacts of individual developments. The comprehensive inventory is to assist DPE take into account the potential cumulative impact from multiple adjoining mining activities and contribute to the development of mining operation approval conditions to minimise any cumulative impact.	Department of Planning and Environment
Response to reduce land degradation			
L1	Continue best practice land management programs, targeting 'high risk' properties in priority areas ie. Wingecarribee, Braidwood, Wollondilly, Mulwaree, Upper Wollondilly and Nattai River sub-catchments.	The programs will: • build capacity for sustainable grazing management and soil erosion treatment to maintain groundcover • protect riparian zones from uncontrolled stock access	WaterNSW and Local Land Services
Response to reduce impacts from effluent			
S1	Implement improvement programs in Wingecarribee sub-catchment targeting dairy effluent, stormwater, on-site sewerage and sewage treatment plant discharges based on analysis of contribution of nutrients. Accelerate pollution reduction programs to give highest priority to Bowral, Moss Vale and Mittagong STPs due to population growth.	Improvement programs will address areas and issues contributing to poor water quality and reduce risks of cyanobacteria outbreaks.	NSW EPA, Wingecarribee Council, Infrastructure NSW
Response to reduce bushfire risk			
B1	Update and implement bushfire risk management plans (BRMPs), taking into account 'cultural burn' practices and results of recent fire research.	Updated BRMPs will reflect and respond to current and predicted conditions to reduce the risk of wildfires and associated impacts to water quality, especially in the context of climate change.	RFS, Councils
Responses to improve data quality and monitoring			
D1	Assess time-series of water quality and flow data at key points, and combine with appropriate pollution fate modelling for evidence of statistical change from different catchment improvement projects.	Improved water quality monitoring data will support informed decision-making.	WaterNSW

ID	Recommendation	Purpose	Responsibility
D2	Integrate locations and timing for monitoring of macroinvertebrates, water quality and stream flow, including environmental flow monitoring sites.	Integrated monitoring will allow water quality and habitat assessment to be investigated with multi-variate data analysis techniques. This would enable inclusion of flow as an explanatory variable in water quality statistical analysis.	WaterNSW
D3	Develop / update the native vegetation spatial database in accordance with the *Native Vegetation Information Strategy 2013-2018* (OEH 2014).	Updated native vegetation data will support informed decision-making.	OEH
D4	Improve information on water quality changes resulting from catchment improvement works. Summarise assessed improvements at each project site, and any qualitative or quantitative evidence at the sub-catchment scale. Conduct co-variate statistical analysis of long-term water quality records at key monitoring stations.	The summary and statistical analysis will identify what 'signals' may be attributed to catchment improvements. This information can help to verify the prioritisation of on-ground works via the Pollution Source Assessment Tool (PSAT) and other methods.	WaterNSW
D5	Investigate feasibility and benefits of developing water quality guidelines for the Catchment by establishing suitable 'reference sites' which are in naturally vegetated sub-catchments in areas free of disturbance from human activity.	Catchment-specific water quality guidelines will be more relevant than the default ANZECC (2000) guidelines for south-eastern Australia.	WaterNSW
D6	Environmental flow accounting to separate the volume of water that is actively released from that which is lost from storages via spills, and specify when occurs.	Provide improved resolution on the effect of environmental flow rules on the water supply system, and as drivers for maintaining healthy aquatic ecological communities. This accounting will better inform any future inter-agency review of environmental flow rules.	WaterNSW
D7	Review the relevance and adequacy of the indicators and associated measures.	The review will consider the responsibility of public authorities for data collection, continuity with existing datasets, advances in monitoring techniques and data management, and emerging catchment issues.	DPI Water

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