# Draft Regional Water Strategy

## Macquarie–Castlereagh: Shortlisted Actions – Consultation Paper

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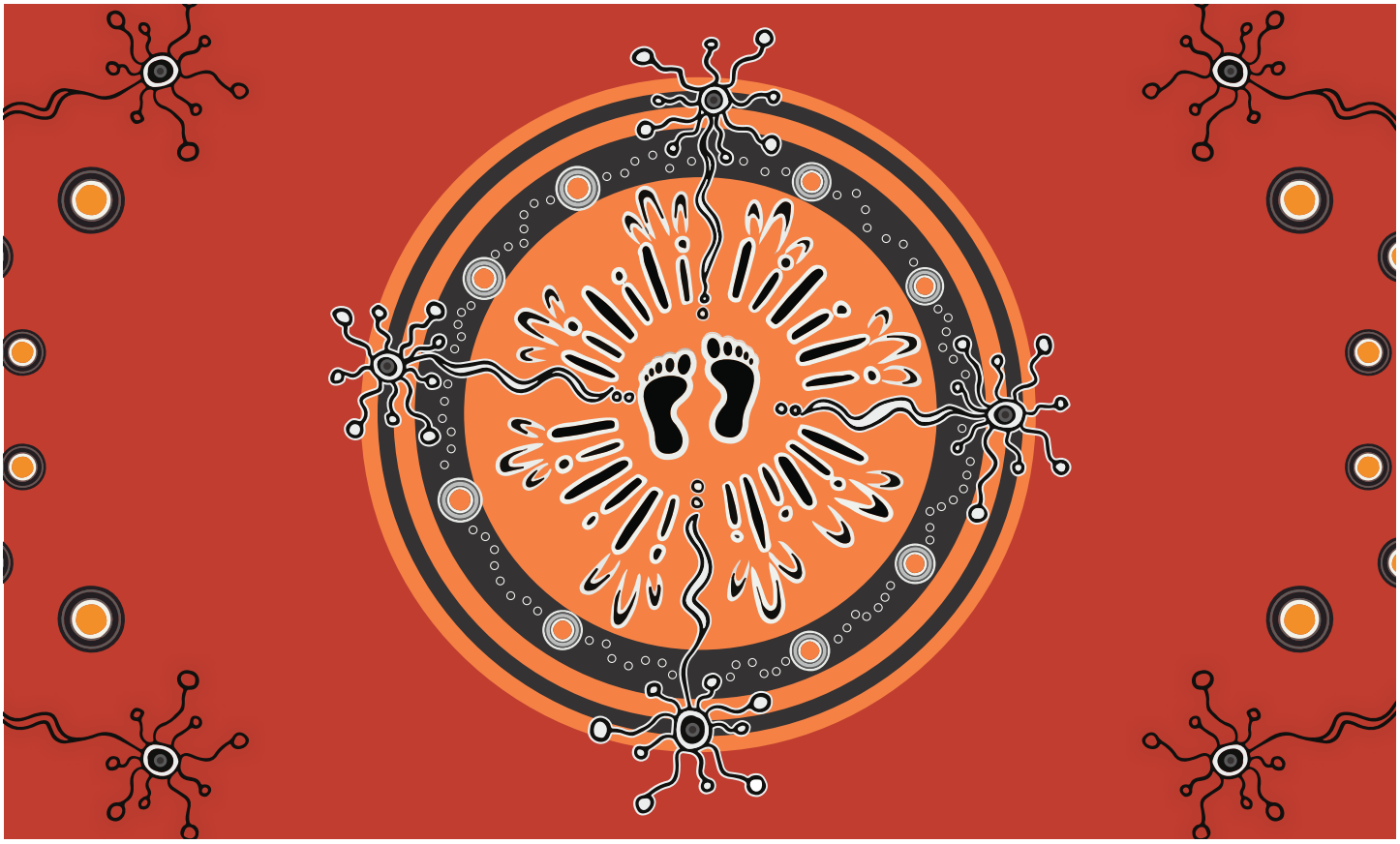

# Acknowledgment of Country

The NSW Government acknowledges First Nations people as its first Australian People and the traditional owners and custodians of the country's lands and water. We have recognised that First Nations people have lived in NSW for over 60,000 years and have formed significant spiritual, cultural, and economic connections with its lands and waters.

Today, they practice the oldest living culture on earth.

The NSW Government acknowledges the Gomeroi/Kamilaroi, Ngemba, Ngiyampaa, Wailwan and Wiradjuri Nations from the Macquarie–Castlereagh region as having an intrinsic connection with the lands and waters of the Macquarie–Castlereagh Regional Water Strategy area. The landscape and its waters provide the First Nations people with essential links to their history and help them to maintain and practice their Traditional culture and lifestyle.

We recognise the Traditional Owners were the first managers of Country and by incorporating their culture and knowledge into management of water in the region is a significant step for closing the gap.

Under this regional water strategy, we seek to establish meaningful and collaborative relationships with First Nations people. We will seek to shift our focus to a Country-centred approach, respecting, recognising and empowering Cultural and Traditional Aboriginal knowledge in water management processes at a strategic level.

We show our respect for Elders past, present and Emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places where First Nations people are included socially, culturally and economically.

As we refine and implement the regional water strategy, we commit to helping support the health and wellbeing of waterways and Country by valuing, respecting and being guided by Traditional Owners/First Nations people, who know that if we care for Country, it will care for us.

We acknowledge that further work is required under this regional water strategy to inform how we care for Country and ensure First Nations people/Traditional Owners hold a strong voice in shaping the future for Indigenous/Aboriginal and non-Aboriginal communities.

Artwork courtesy of Nikita Ridgeway.

# Minister's foreword

**The Hon. Kevin John Anderson, MP**
**Minister for Lands and Water, and**
**Minister for Hospitality and Racing**

The NSW Government is committed to managing our state's water, improving water security and better preparing our communities for future extreme events. Our towns, industries, and natural and cultural assets all rely on water, and the way we manage it deeply affects the lives and livelihoods of the people of NSW. Water is our most precious resource.

When it comes to managing water in NSW my view is healthy rivers, healthy farms and healthy communities. Not one or the other.

That is why we have invested in cutting-edge scientific modelling to bolster our knowledge and understanding of our waterways and enhance our policies and long-term planning, so we can manage water for the benefit of everyone.

The Macquarie–Castlereagh is home to more than 200,000 people and the important regional centres of Bathurst, Orange and Dubbo. The region is located within the traditional lands of the Gomeroi/Kamilaroi, Ngemba, Ngiyampaa, Wailwan and Wiradjuri people and is home to a range of rare, endangered and threatened animal and plant species.

Agriculture, mining and tourism are the engines of the region's $13.5 billion economy. Water drives many local businesses, supports towns and ensures a healthy local environment. The region is also home to the internationally recognised, RAMSAR listed Macquarie Marshes.

Our state is no stranger to extremes; we have always had to manage our water resources through prolonged floods and droughts. In the face of an increasingly variable climate future, we must prepare for even longer and more severe wet and dry periods.

We need to start a conversation now with the community on how to support and structure the future economic growth of the region. This strategy is the start of that conversation.

Working closely with the community, we are now making decisions around future investments that will set up the region for the future.

Engaging with our Aboriginal communities is vital, given water is an essential part of their connection to Country and culture. Ensuring that these communities have access to water and cultural water holdings will be crucial to creating local jobs into the future.

Local government has contributed greatly to the draft strategy, and I thank councils for their engagement and support. We will continue to partner with them to ensure the strategy addresses the needs of all communities across the Macquarie–Castlereagh region.

This strategy, alongside 11 other regional and 2 metropolitan strategies across the state has been developed using the best and latest scientific evidence to ensure we can understand and mitigate risk even in the most extreme climatic circumstances.

We engaged leading academics to undertake historic climate-informed rainfall and evaporation modelling. This climate modelling is based on a deliberately conservative scenario that is intended to 'pressure test' the effectiveness of the strategy in a worst-case scenario. These climate scenarios will not necessarily eventuate, but they give us an idea of the possible climate risks and allow us to begin planning to mitigate these risks should they arise.

The Macquarie–Castlereagh Regional Water Strategy will put forward the best mix of solutions to address these challenges and support environment, social and economic outcomes. After widespread community consultation, we have shortlisted proposed actions to ensure secure water supplies for growing cities and towns, reduce water security risks in the region's west, support industry climate adaptation, and best use existing water to support a healthy environment.

To complement the regional water strategies, the NSW Government is delivering the Future Ready Regions Strategy, which aims to improve the resilience and drought preparedness in regional NSW by drawing on lessons learnt from previous droughts.

In short, the evidence and information we now have means we can better plan for the future to ensure this precious shared resource is managed to sustain secure regional lifestyles, create jobs, support industry and protect our precious natural environment.

There is no 'one size fits all' policy to manage water in our regions. I encourage all members of the community and stakeholders in the Macquarie-Castlereagh to get involved and contribute to the strategy. Water is for everyone, and we are ensuring our water management policies support the future of the Macquarie–Castlereagh and all of NSW.

We need healthy rivers, healthy farmers and healthy communities. The way we manage water deeply affects the livelihoods of people in NSW.

# Contents

Image courtesy of Nicola Brookhouse, Department of Planning and Environment. Monkeygar Lagoon, South Macquarie Marshes.

# Snapshot

## The Macquarie–Castlereagh region

**Aboriginal Nations:**
Gomeroi/Kamilaroi, Ngemba, Ngiyampaa, Wailwan and Wiradjuri Nations

**212,000**
population

**Major regional centres:**
Dubbo, Orange and Bathurst

**Smaller towns include:**
Wellington, Mudgee, Warren, Narromine, Nyngan, Coonabarabran, Coonamble and Gilgandra in the lower Wambuul/Macquarie

Oberon, Molong, Cumnock and Yeoval in the upper Wambuul/Macquarie

Cobar and Lithgow are outside the region but draw water from the Macquarie–Castlereagh region

**Main rivers:**
Wambuul/Macquarie River, Cudgegong River, Bogan River, Castlereagh River, Campbells River and Fish River

**Key environmental assets:**
The region supports the internationally recognised Ramsar listed Macquarie Marshes and 8 other nationally significant wetlands. It also provides habitat for hundreds of species of plants and animals

Wellington Caves is also an important environmental asset and site of national heritage

**Major water storages:**
Burrendong Dam, Windamere Dam, Chifley Dam, Winburndale Dam, Oberon Dam and Timor Dam

**Economy:**
Agriculture (including cotton, grains and horticulture), food processing and mining are major contributors to the region's economy, along with tourism, health and education services, and the transport, freight and logistics industry

**Water for the environment:**
Approximately 25% of licences in the regulated rivers, or 184,300 ML of water entitlements, are managed by state and Commonwealth environmental water holders. The majority of these are general security licences. In addition, there are environmental water allowances of 171,283 ML in the regulated Wambuul/Macquarie and Cudgegong rivers

**Groundwater:**
Groundwater is an important source for stock, domestic, irrigation, industrial and town water supplies. It also supports many groundwater-dependent environmental assets.

Groundwater aquifers located in the upper and lower Macquarie have high yields and are in high demand for agriculture and town water supply

Groundwater resources in the region's east have lower reliability and yield

## Figure 1. Map of the Macquarie–Castlereagh region

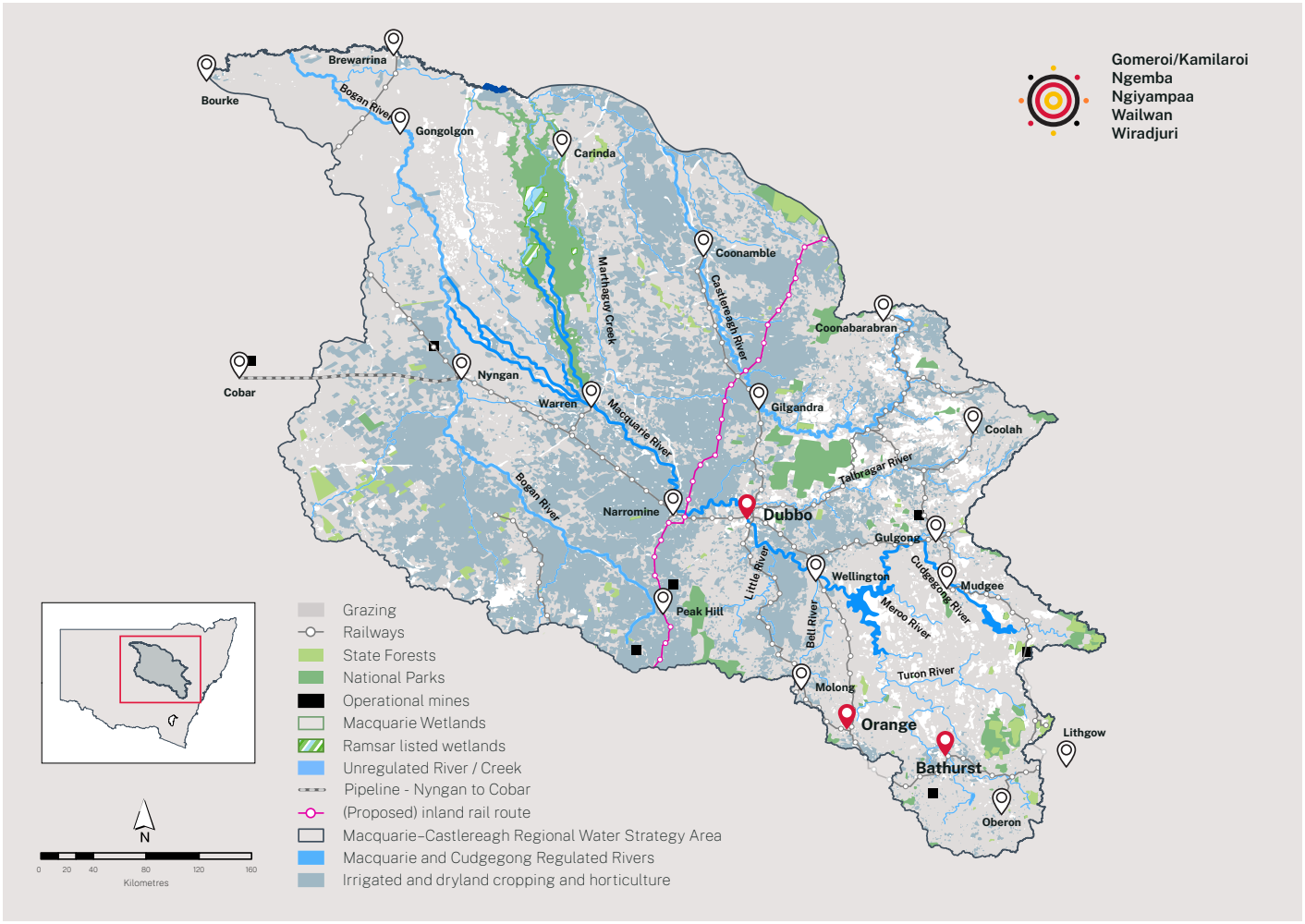


Image courtesy of iStock. Bathurst, NSW.

# What is the purpose of this consultation paper?

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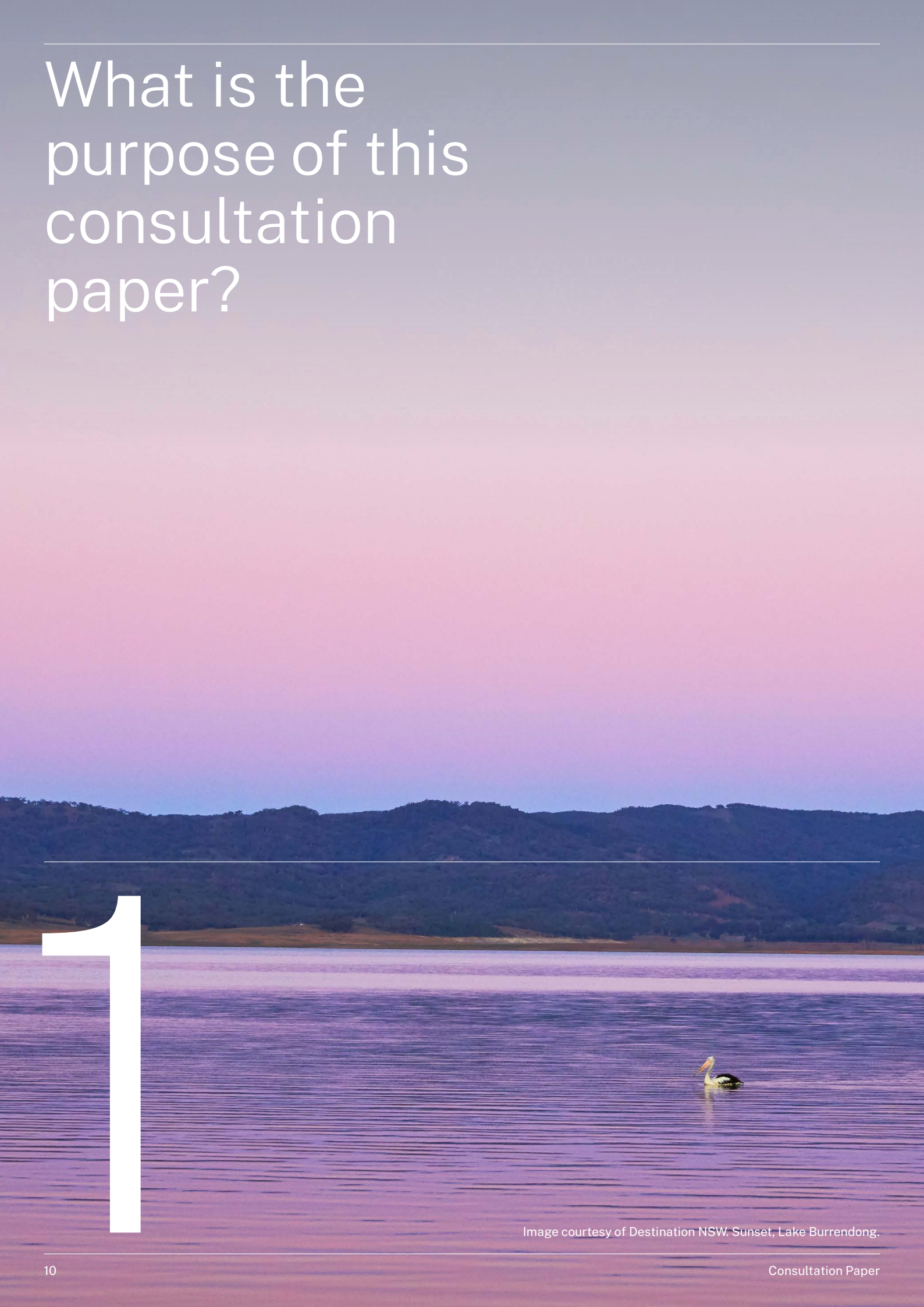

Image courtesy of Destination NSW. Sunset, Lake Burrendong.

The New South Wales (NSW) Government is developing 12 regional water strategies that bring together the best and latest climate evidence with a wide range of tools and solutions to plan and manage each region's water needs over the next 20 to 40 years.

The first draft of the Macquarie–Castlereagh Regional Water Strategy, including a long list of options, was released in September 2020.[1]

Since public consultation on the draft strategy, we have taken on board what we heard. We have undertaken additional analyses to prioritise the key challenges in the region that need to be tackled first and have shortlisted actions to help meet these challenges. The process we went through is described in the *Options assessment process: Overview*.[2] This consultation paper presents the outcomes of this work, which is summarised in Figure 2.

No decisions have been made on the shortlist of proposed actions. This consultation paper seeks your views on what the best actions are to set the Macquarie–Castlereagh region up for the future before a final strategy and implementation plan are developed.

You can find additional background information in *Macquarie–Castlereagh region: Draft Regional Water Strategy: What we heard*.[3]

Other regional water challenges described in the Draft Macquarie–Castlereagh Regional Water Strategy are important and will be revisited during future ongoing reviews of the final strategy, planned to be every 3 to 4 years.

Image courtesy of Department of Primary Industries. Furrow irrigation of cotton, Warren.

1. The Draft Macquarie–Castlereagh Regional Water Strategy and long list of options can be viewed at www.water.dpie.nsw.gov.au/plans-and-programs/regional-water-strategies/what-we-heard/macquarie-castlereagh-regional-water-strategy
2. Available for download at www.dpie.nsw.gov.au/water/plans-and-programs/regional-water-strategies/identifying-and-assessing
3. Macquarie-Castlereagh region: Draft Regional Water Strategy: What we heard can be viewed at www.water.dpie.nsw.gov.au/plans-and-programs/regional-water-strategies/what-we-heard/macquarie-castlereagh-regional-water-strategy

**Figure 2. Proposed water security challenges and priorities for the Macquarie–Castlereagh region**

## Vision

Support the delivery of healthy, reliable and resilient water resources for a liveable and prosperous region.

### Objectives

- Deliver and manage water for local communities
- Recognise and protect Aboriginal water rights, interests and access to water
- Enable economic prosperity
- Protect and enhance the environment
- Identify most cost effective policy and infrastructure options

### Regional challenges to meet our vision and objectives

- Reducing water supply risks for regional cities, towns and villages
- Supplying water to high priority needs in the lower river system and connected valleys
- Supporting a growing regional economy in a future of potentially reduced water availability
- Addressing barriers to Aboriginal water rights
- Maintaining and improving the health and resilience of the region's aquatic and floodplain ecosystems

Page 26

| Priority 1 | Priority 2 | Priority 3 | Priority 4 |
|---|---|---|---|
| Secure water supplies for growing regional cities and towns | Reduce water security risks in the region's west | Support industry and community climate adaptation | Best use of existing water for the environment |
| Page 48 | Page 66 | Page 78 | Page 96 |
| Actions 1.1–1.8 | Actions 2.1–2.4 | Actions 3.1–3.9 | Actions 4.1–4.8 |

# Why we are developing regional water strategies

Across NSW, valuable and essential water resources are under pressure. A more variable climate, as well as changing industries and populations, mean we may face difficult decisions and choices about how to balance the different demands for this vital resource and manage water efficiently and sustainably into the future. The regional water strategy process identifies these risks and seeks to understand how we can manage and be best prepared for these future uncertainties and challenges.

In addition to understanding and managing future pressures, there are opportunities to consider the role water resources will play in growing our regions, improving liveability and making sure each region remains a great place to work, play and raise a family.

The NSW Government's strategic investments in special activation precincts, regional job precincts, renewable energy zones, critical minerals hubs and actions identified through regional economic development strategies are critical to realising this vision. However, all these activities rely on access to water.

The regional water strategies program is helping to provide the evidence base needed to support these existing investments, identify new opportunities and sustain the successful regional industries of the future.

The regional water strategies will include a wide range of tools and solutions to help us better use, share, store and deliver water to ride the highs and lows of water availability and change how we manage water into the future.

Image courtesy of Peter Robey, Department of Planning and Environment. Field irrigation, Dubbo.

# How do regional water strategies fit with other water strategies?

The NSW Water Strategy, together with the 12 regional water strategies and 2 metropolitan water strategies that underpin it, will form the strategic planning framework for water management in NSW. The NSW Water Strategy was developed in parallel with the draft regional water strategies. The NSW Water Strategy guides the strategic, state-level actions that we need to take, while the regional water strategies will prioritise how those state-wide actions – as well as other region-specific, place-based solutions – should be staged and implemented in each region (Figure 3).

As part of delivering the NSW Water Strategy, the NSW Government will deliver other statewide strategies and programs including:

- the Aboriginal Water Strategy – co-designed with Aboriginal people to identify a program of measures to deliver on Aboriginal People's water rights and interests in water management
- the NSW Groundwater Strategy – to ensure sustainable groundwater management across NSW
- the Town Water Risk Reduction Program – in collaboration with local water utilities, this identifies long-term solutions to challenges and risks to providing water supply and sewerage in regional towns
- a new state-wide Water Efficiency Framework and Program – to reinvigorate water use efficiency programs in our cities, towns and regional centres.

The NSW Water Strategy and the Macquarie–Castlereagh Regional Water Strategy also complement other whole-of-government strategies, including the *20-Year Economic Vision for Regional NSW* and accompanying Future Ready Regions Strategy, the updated State Infrastructure Strategy 2022–2042 and the *Draft Central West* and *Orana Regional Plan 2041.*

The strategy will be cognisant of other NSW Government initiatives that are under development, like the review of the Regional Economic Development Strategies, the Housing 2041 – NSW Housing Strategy and the NSW Electricity Strategy.

Providing a coordinated approach to support the range of transformational NSW Government policies that have recently been introduced, we will be able to proactively build resilience in regional communities. The aspiration is to adopt a place-based framework that is flexible and adaptive to changing circumstances and enable government and regional communities to work together to ensure the Macquarie–Castlereagh is a great place to live, work, and visit.

Image courtesy of Destination NSW. Aerial overlooking Nielson Park, Coonabarabran.

**Figure 3. State and regional water strategies: priorities and objectives**

| NSW Water Strategy core objectives | NSW Water Strategy strategic priorities | Regional water strategy objectives |
|---|---|---|
| Protecting public health and safety | **Priority 1**<br>Build community confidence and capacity through engagement, transparency and accountability | **Aligned with all** regional water strategy objectives |
| Liveable and vibrant towns and cities | **Priority 2**<br>Recognise Aboriginal people's rights and values and increase access to and ownership of water for cultural and economic purposes | **Recognise and protect Aboriginal people's water rights, interests and access to water –** including Aboriginal heritage assets |
| Water sources, floodplains and ecosystems protected | **Priority 3**<br>Improve river, floodplain and aquifer ecosystem health, and system connectivity | **Protect and enhance the environment –** improve the health and integrity of environmental systems and assets, including by improving water quality |
| Cultural values respected and protected | **Priority 4**<br>Increase resilience to changes in water availability (variability and climate change) | **Aligned with all** regional water strategy objectives |
| Orderly fair and equitable sharing of water | **Priority 5**<br>Support economic growth and resilient industries within a capped system | **Enable economic prosperity –** improve water access reliability for regional industries |
| Contribute to a strong economy | **Priority 6**<br>Support resilient, prosperous and liveable cities and towns | **Deliver and manage water for local communities –** improve water security, water quality and flood management for regional towns and communities |
| | **Priority 7**<br>Enable a future focused, capable and innovative water sector | **Aligned with all** regional water strategy objectives |

**Affordability – identify least cost policy and infrastructure options**

# Regional water strategies are backed by new climate data

To improve our strategic water planning, new ground-breaking climate datasets have been developed for the Regional Water Strategy Program. These datasets provide us with a more comprehensive understanding of the climate variability in the Macquarie–Castlereagh region beyond the recorded historical data.

To support the development of the Macquarie–Castlereagh Regional Water Strategy, we are using the recorded dataset as well as 2 plausible climate scenarios to test their respective implications for regional water resources:

- **historical data:** data from rainfall and evaporation records collected by Australian Government meteorological records over the past 130 years
- **long-term historical past climate:** 10,000 years of stochastic-generated climate data developed using paleo climatic information from The University of Adelaide, Australia
- **dry future climate:** Applying the NSW and Australian Regional Climate Modelling (NARCliM) climate projections for 2060–2079 compared to the baseline period of 1990–2009 to define a dry climate change scenario.

The dry future climate change scenario[4] is the SRES A2 which represents a high carbon emissions scenario, and thus results in higher projected climate change impacts on the region.[5] This is not a forecast of how climate change is expected to eventuate, but it is one possible future outcome.

While this climate change scenario may not occur, it helps us to undertake strategic water planning and highlight key water challenges we may need to focus on in the future. It also helps us to understand how different options may respond to climate change.

Combined, these 3 datasets provide us with a range of plausible climate futures, that cover a range of wet and dry sequences. For further details about the new climate data and modelling, please refer to www.dpie.nsw.gov.au/water/plans-and-programs/regional-water-strategies/climate-data-and-modelling

Our climate science is continuously improving. The regional water strategies are an important first step to better understand the region's climate and the potential vulnerability of our towns, communities, industries and the environment to a more variable and changing climate. We know that the future climate is uncertain, and work is progressing to further enhance our understanding of the region's climate and how it affects our vital water resources, including groundwater.

Image courtesy of iStock. Bogan River, Nyngan.

4. The scenario uses the regionally downscaled factors from the NARCliM 1.0 Project to adjust the long-term past climate scenario rainfall and evapotranspiration data. Further information on NARCliM 1.0 Project is available on the NSW Government, AdaptNSW website: www.climatechange.environment.nsw.gov.au/climate-projections-used-adaptnsw
5. The SRES A2 assumes a 2°C warming over the regional water strategy planning horizon.

# What the future climate could look like in the Macquarie–Castlereagh region

We don't know for certain what the future climate will be like. It may be similar to what we have experienced in the past, or it might be drier than we have seen in our lifetimes. Our analysis of different climate scenarios tells us that droughts could become hotter and longer, there could be higher evaporation rates and more unpredictable rainfall events and variable river flows. We need to plan for these uncertainties and continue to refine our understanding of the water-related risks in the region.

## Changing rainfall patterns

Potential for
**less than average annual rainfall**
coupled with less frequent, but **higher intensity, rainfall events**.

## More droughts

Prolonged droughts could be more frequent. The probability of the catchment inflows experienced during the 2017–2020 drought happening again could **increase from 1 in 1,000 years to 1 in 30 years** by 2070 under a dry future climate change scenario.

## Higher evaporation

Evapotranspiration could **increase by up to**

**5%**
**by 2070**

compared to levels between 1990 and 2009, with the largest increases in autumn and winter.

## Lower inflows into Burrendong Dam

Median annual inflows into Burrendong Dam could **decline by up to 50% by 2070** under the driest climate scenario which may or may not occur.

# We want to hear from you

Developing an effective and lasting strategy requires input from communities, towns and industries across the Macquarie–Castlereagh region.

We are seeking your feedback on the key regional water-related challenges and proposed shortlisted actions in this document, including the focus questions under each priority.

The feedback we receive on the consultation paper will help us to finalise the Macquarie–Castlereagh Regional Water Strategy and Implementation Plan.

The final strategy will identify a range of solutions – from policies, plans and regulation through to new technology and infrastructure – that could mitigate water-related impacts across the region and support thriving regional communities. The strategy will bring together these solutions in an integrated package that is:

- based on the best evidence
- designed to respond to the Macquarie–Castlereagh region's water needs
- directed toward creating new opportunities for the region
- focused on delivering the objectives of the regional water strategies and the NSW Water Strategy.

## Assessing benefits and impacts of actions on Aboriginal people and communities

Aboriginal communities across NSW have told us that they need specific information on how the shortlisted actions will affect them.

We know that several of the shortlisted actions could impact on, or provide benefits to, Aboriginal people and Aboriginal communities. Currently, we do not have enough evidence about these potential impacts and benefits to provide a full assessment of the shortlisted actions. Some of this information will not be available until we begin to do more detailed analyses of specific options that remain in the final regional water strategy shortlist. Some of this additional analysis may be identified for early action in the strategy's implementation plan, while other work will progress as part of the strategic business case for specific options.

At this stage of the regional water strategies process, we are identifying and recording the types of questions that Aboriginal communities are likely to have about each of the proposed actions and working out what information communities will need to make informed decisions about how specific actions will affect them.

Once we have undertaken the detailed analysis required to progress preferred actions, we will share that information with Aboriginal communities and seek their feedback on how those actions may impact them. That evidence may help to refine a proposed action or identify risks in progressing with an action.

Image courtesy of Destination NSW. Coonamble Water Tower, Coonamble.

# What we have heard so far

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Image courtesy of Peter Robey, Department of Planning and Environment. Vineyard, Dubbo.

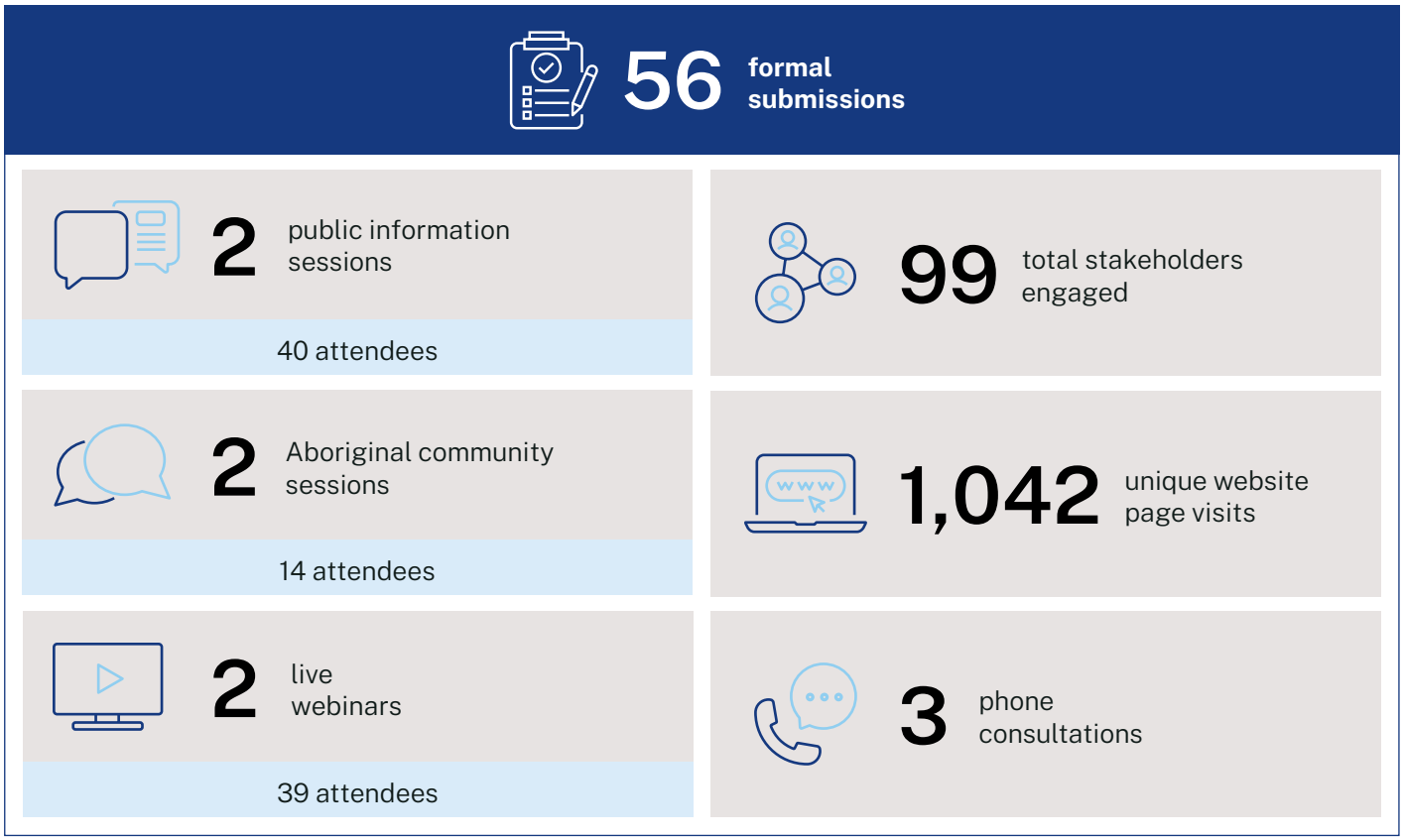
We sought input from the general public and Aboriginal communities on the Draft Macquarie–Castlereagh Regional Water Strategy and the long list of options (Figure 4). The *Macquarie–Castlereagh region: Draft Regional Water Strategy: What we heard Report*[6] summarises the key issues we heard during the first round of public exhibition and highlights how feedback received during this period has informed the next steps in the development of the Macquarie–Castlereagh Regional Water Strategy.

There was general support for the regional water strategies program and the Macquarie–Castlereagh Regional Water Strategy.

We also heard that the next phase of the Macquarie–Castlereagh Regional Water Strategy should be accompanied by an open, transparent and broad-scale consultation process to ensure that all stakeholder voices are heard, and that a broad cross-section of the community is represented in the discussion. This consultation paper has been developed to help deliver on this recommendation.

Stakeholders encouraged the department to continue developing the NSW Water Strategy and regional water strategies. Since then, the NSW Water Strategy has been finalised.

**Figure 4. Stakeholder engagement during the first public exhibition period**




6. Macquarie–Castlereagh region: Draft Regional Water Strategy: What we heard can be viewed at www.water.dpie.nsw.gov.au/plans-and-programs/regional-water-strategies/what-we-heard/macquarie-castlereagh-regional-water-strategy

# During consultation, we heard views on a range of water-related issues

## Climate and modelling

- There was interest in the new climate data sets and updated modelling, but there were some concerns about how it would be used in future decision making.
- Climate data and modelling should be made available to assist communities and councils in their planning.
- There was concern that the drought of record currently being used in water management decision-making is not representative of current conditions and encouragement to update the drought of record for the purpose of developing the Macquarie–Castlereagh Regional Water Strategy.

## New and existing water infrastructure

- There were mixed views on some of the proposed new infrastructure options.
- Some stakeholders commented that infrastructure development should only be undertaken after rigorous assessment and consultation.

## Aboriginal knowledge and cultural heritage

- There was broad support for improving the recognition of Aboriginal people's water rights, interests and access to water and Country, and the options that delivered on these outcomes.
- Further consultation and improvements to education on complex water policy were considered to be important.

## Water security

- Stakeholders expressed concerns about recent extreme drought conditions in the region affecting water security.
- Stakeholders acknowledged the importance of town water for human consumption and supporting economic growth and prosperity.
- There was strong support for the exploration of innovative alternate water supplies.

## Environment and ecosystem health

- There was a focus on the preservation and restoration of the Macquarie Marshes, along with the overall ecosystem of the river, through restoration of unhindered natural flows.
- Stakeholders supported land management options, as well as maintaining water quality and prioritising the environment in decision making.

## Groundwater

- There was strong support for improving our knowledge of groundwater resources and their connection to surface water.
- Some stakeholders expressed concern about declines in groundwater levels, thought to be influenced by an over reliance on groundwater and slow rates of groundwater recovery after drought.

## Water entitlement reliability and risk management

- Some stakeholders were concerned about the over-allocation of water licences given the challenges in supplying water during recent drought conditions.
- Some stakeholders raised concerns about compliance, policing and prosecution for breaches of water take and licence conditions in the region.
- There was support for education and information to enable risk management by water-dependent businesses and improved drought preparedness.

Image courtesy of Destination NSW. Streetscape, Mudgee.

# Where should we focus first?

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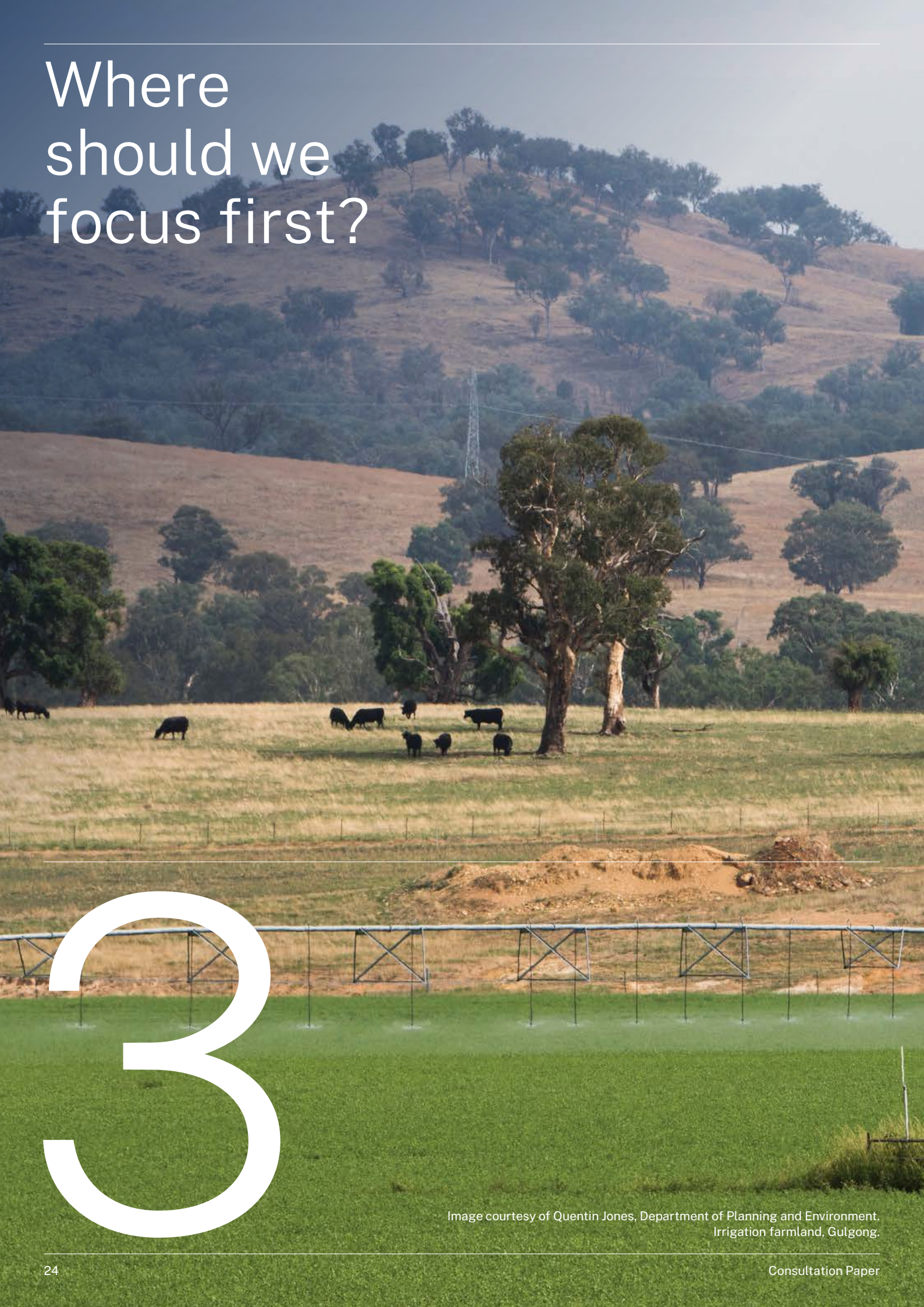


Image courtesy of Quentin Jones, Department of Planning and Environment.
Irrigation farmland, Gulgong.

Our vision for the Macquarie–Castlereagh region is to support the delivery of healthy, reliable and resilient water resources for a liveable and prosperous region.

The Macquarie–Castlereagh region is a productive agricultural, industrial and mineral resources region in central west NSW. It is part of the Murray–Darling Basin and lies within the traditional lands of the Gomeroi/Kamilaroi, Ngemba, Ngiyampaa, Wailwan and Wiradjuri people, who have been caretakers of this region for over 60,000 years. The region is also home to a wide variety of aquatic ecosystems including internationally and culturally significant wetland complexes.

Like all regions across Australia, the Macquarie–Castlereagh region faces a more variable and changing climate. We need to prepare now to do more with less water, make smarter decisions about our water use and management armed with better knowledge and information, and protect our most critical water needs.

**We have identified 5 key challenges that are immediate priorities for the region:**

- **Reducing water supply risks for regional cities, towns and villages.**
- **Supplying water to high priority needs in the lower river systems and connected valleys.**
- **Supporting a growing regional economy in a future of potentially reduced water availability.**
- **Addressing barriers to Aboriginal water rights.**
- **Maintaining and improving the health and resilience of the region's aquatic and floodplain ecosystems.**

Addressing these challenges will help us meet the vision and objectives we have set for the Macquarie–Castlereagh Regional Water Strategy.

Image courtesy of Department of Primary Industries. Macquarie River, NSW.

# Challenge: Reducing water supply risks for regional cities, towns and villages

There are immediate water security risks for regional cities in the Macquarie Valley. If there are no changes to infrastructure, policy or demand management practices, future droughts could result in regional cities like Bathurst and Orange facing greater water security risks as well as greater uncertainty for towns that rely on groundwater.

## Water security risks remain for growing regional cities despite recent investments

Bathurst, Orange and Dubbo are large and growing regional cities in the Macquarie Valley. Each city provides important health, education and retail services for residents and surrounding communities. In 2020, their local government areas jointly contributed a Gross Regional Product of $9.9 billion, driven by mining, agriculture, forestry and tourism.[7]

Bathurst, Orange and Dubbo account for around half of the region's population, with 38,000, 41,000 and 39,000 residents, respectively.[8] The population of all 3 regional cities is projected to grow over the next 20 years. Bathurst is expected to experience the largest increase of 34%.[9] Orange and Dubbo are projected to increase by 19% and 22%, respectively.[10]

Bathurst, Orange and Dubbo councils provide safe and secure water to their residents. The water supplies for these regional cities also underpin the water security of surrounding smaller towns, communities and rural residents during times of drought.[11]

Secure and sustainable water supplies will be required to support the household and town amenity needs of these growing populations. Many businesses also depend on town water being available, reliable and safe for their commercial operations. During public consultation, we heard about the importance that town water plays in supporting businesses and thereby the economy and prosperity of the region, as well as for the smaller towns and villages that these centres support during droughts.

### Understanding the economic and social cost of severe water restrictions

The 2017–2020 drought was the worst on record for Bathurst and residents were placed on level 4 water restrictions.

Following the drought, Bathurst Regional Council assessed what the economic impacts would have been if Levels 5 and 6 water restrictions had been applied, or the city had run out of water.

Bathurst's Level 4 restriction is the last level that impacts residential consumption only. Additional restrictions beyond that will mean that significant parts of the economy would need to be impacted. The analysis revealed that Level 6 restrictions would have resulted in a 40% decline in economic output and employment. If the system had failed, economic output and employment would have reduced by 90%.

7. REMPLAN 2021, *Central West Industries Gross Regional Product and REMPLAN*, 2021. Orana Industries Gross Regional Product.
8. Department of Planning and Environment, *Common Planning Assumptions*, 2022, available from pp.planningportal.nsw.gov.au/populations
9. Department of Planning and Environment, *Common Planning Assumptions*, 2022, available from pp.planningportal.nsw.gov.au/populations
10. Department of Planning and Environment, *Common Planning Assumptions*, 2022, available from pp.planningportal.nsw.gov.au/populations
11. Molong Creek Dam ran out of water in the recent drought but the recently completed pipeline from Orange provided emergency water for Molong. Since then, Cabonne Council has successfully supplemented its water supply system with groundwater bores. Cadia mine relies on the treated wastewater from Orange.

Each city is improving the security of their water supplies. Even with these investments, our analysis shows that further investment to improve supply is required to ensure Bathurst and Orange retain the security of their water supplies (Table 1) as their dams could go from full to near empty in less than 4 years, or sooner if climate change causes drier conditions (Table 1).

## Current water security investments for Dubbo, Orange and Bathurst

Actions to improve urban water security for Dubbo, Orange and Bathurst are underway. These actions include:

- **Dubbo – Expansion of borefields:** Works to enhance access to groundwater by bores northwest of the town and for pipelines from new bore fields.
- **Orange – Phase 2 of the Stormwater Harvesting Scheme:** Expansion of the Blackmans Swamp Creek Stormwater Harvesting Scheme with Stage 2 being an offline wetland in East Orange, upstream of the exiting harvest weir (Stage 1). This will provide 36 ML of air space for filling with harvested stormwater.
- **Bathurst – Stormwater harvesting and Winburndale pipeline projects:** Construction of 2 storage ponds (36 ML and 8 ML) to capture stormwater runoff and a replacement pipeline from Winburndale Dam to Bathurst. Construction of the stormwater harvesting scheme will commence in the second half of 2022.

**Table 1. Probability of Orange, Bathurst and Dubbo's water supplies being restricted or experiencing a supply shortfall under different climate scenarios if there are no changes to policy, infrastructure or demand management**

| Town | Historical climate | Dry future climate change scenario |
|---|---|---|
| **Percent of time in severe water restrictions*** | | |
| Orange | 3.3% (1 in 30 years) | 14.7% (1 in 7 years) |
| Bathurst | 1.8% (1 in 60 years) | 7.6% (1 in 13 years) |
| Dubbo^ | 0.2% (1 in 500 years) | 2.7% (1 in 40 years) |
| **Frequency of failure**** | | |
| Orange | 1.9% (1 in 50 years) | 11.8% (1 in 8 years) |
| Bathurst | 1.7% (1 in 60 years) | 6.3% (1 in 16 years) |
| Dubbo | 0.0% (No simulated occurrences) | 1.2% (1 in 80 years) |

Note: Climate projections are based on 10,000-year data sets.

*Severe restrictions are defined differently for each Council and depends on their restriction regime and water supply sources.

- Orange: Level 5 restrictions, which represents 62% of unrestricted demand, or worse
- Bathurst: Level 4 restrictions, which represents 67% of unrestricted demand, or worse
- Dubbo: Level 2 restrictions, which represent 70% of unrestricted demand, or worse.

**Failure is defined differently for each Council and depends on their restriction regime and water supply sources.

- Orange: Where water demands cannot be met under level 6 restrictions for Orange, which represents 60% of unrestricted demand
- Bathurst: Where water demands cannot be met under level 5 restrictions for Bathurst, which represents 52% of unrestricted demand
- Dubbo: When water demands cannot be met under level 3 restrictions for Dubbo, which represents 50% of unrestricted demand.

^Further work and model upgrades are needed to better understand the risks of Dubbo experiencing extended water restrictions. The Macquarie River system model at the time of the analysis was not accurately analysing the changes in the flow regime and drawdown of Burrendong Dam at the extreme dry ends at the end of the catchment. The model is in the process of being updated and this analysis will be reassessed with the upgraded model.

## Assessing town water security risks

Historically, the department has provided guidance to local water utilities on assessing and adapting to the impact of variable and changing climatic patterns on the secure yield of their town water supplies (TWS). The guidelines around the secure yield assessment focuses on using the last 100 or so years of observed historical data and applying a 2 degree warming scenario to understand the level of storage and water needed to allow local water utilities to manage their water supplies though droughts that occur in the forward planning horizon (typically 30 to 50 years).

The new data underpinning the regional water strategies include consideration of paleoclimate and climate change impacts in order to develop scenarios of plausible extreme climate events. These scenarios allow town water supply systems to be tested in droughts and scenarios beyond those that have occurred in the last 100 years and can help understand the level of risk that could be faced by towns in the future over a longer term planning horizon.

For towns like Bathurst, both the secure yield and regional water strategy assessment have demonstrated that additional action is needed both now and over the medium and long term to support the water needs of Bathurst.

The department will be preparing town water security guidelines on assessing town water security, together with service needs.

# There is uncertainty about water security in severe drought for towns that use groundwater

Groundwater is an important water supply for towns in the region.[12] All towns in the Castlereagh Valley totally depend on groundwater for their drinking water supply (Figure 5). The only exception is Coonabarabran, which relies partially on Timor Dam and uses groundwater as an alternate supply of water in drought. In the Macquarie Valley, groundwater is the primary supply for the towns of Warren and Narromine and is an important backup source for Dubbo and Wellington. In other places, such as Nyngan and Cobar, there are limitations to accessing groundwater as local aquifers typically have low productivity and high salinity.

Increased reliance on groundwater resources for irrigation and livestock during drought can result in severe localised water level decline. It can also reduce certainty of access for town water use at critical times. Several towns, including Gilgandra and Narromine, had difficulty accessing groundwater during the 2017–2020 drought despite town water supply licences having a higher level of priority than other groundwater licences. There is uncertainty in the Castlereagh Valley about the ability of alluvial groundwater systems to withstand higher demands during severe droughts, which presents risks to future town water security.

While the water quality of the aquifers used for town water supply in the region are generally suitable for this purpose, there are risks, such as diffuse and point-source pollution, that can affect drinking supplies. In recent years, specific industrial contaminants such as PFAS have affected many groundwater sources in NSW, including around Dubbo.

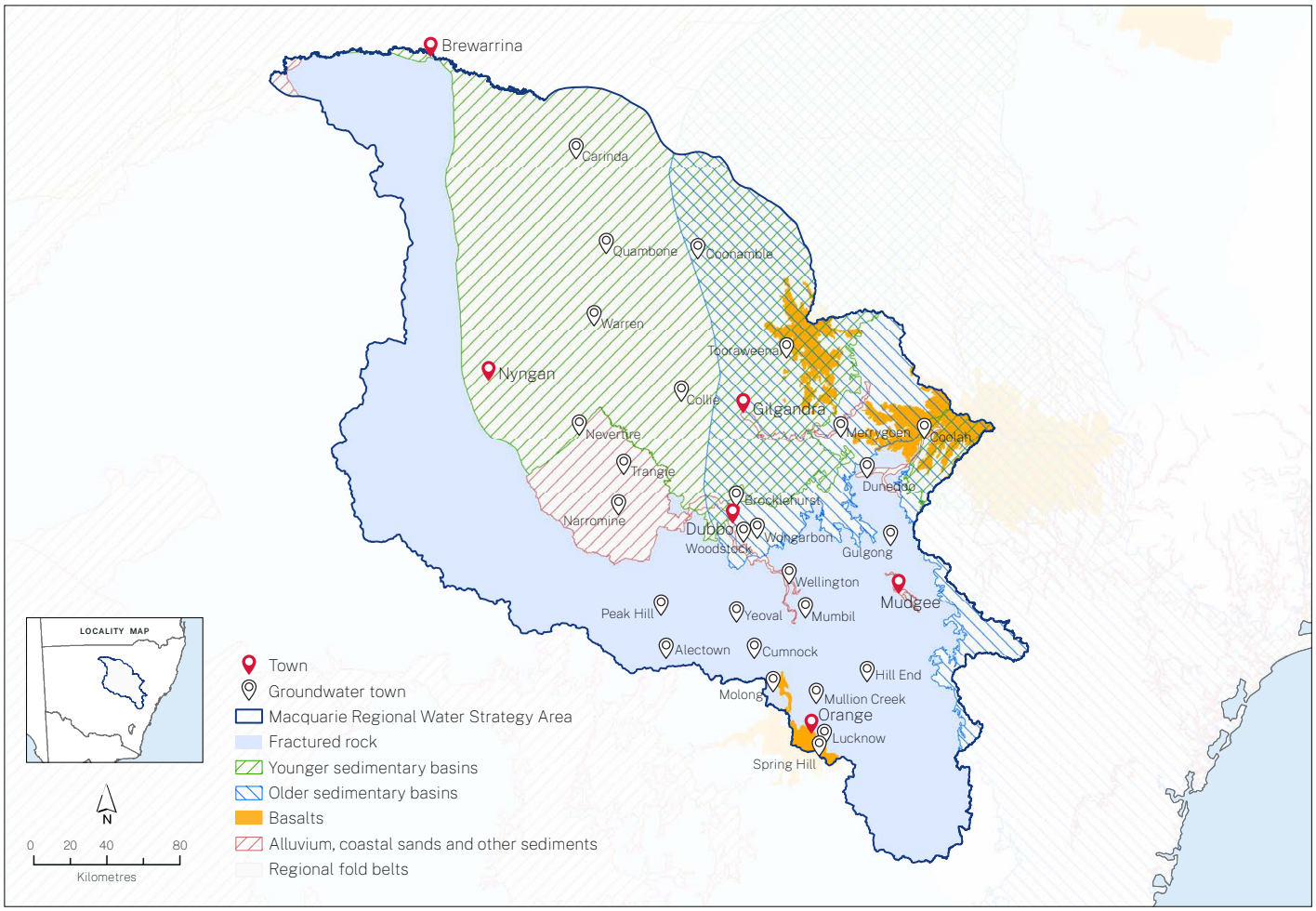
Access to groundwater will become increasingly important within the context of diminishing surface water availability under a potentially drier climate. Under a drying climate the amount of water seeping into the ground and replenishing groundwater could reduce, making it harder to meet current demand. It also means that if other users continue to turn to groundwater in extreme droughts, there may be increased risks for towns that rely solely on this resource.

While town water supply licences have a higher level of priority than other groundwater licences under the *Water Management Act 2000*, decreases in the reliability of groundwater will potentially affect all classes of water access licences.

Councils in particular will require more information on anticipated future demands and how groundwater is managed in the region to ensure it remains a reliable and safe water supply. The NSW Government collects data on groundwater levels at a regional scale; however, this information is often not sufficient to show local impacts on groundwater or to support council decision making. Because of the complexity of the aquifer systems, our knowledge of the physical characteristics of these aquifers is still developing. To better understand short-term localised behaviour of aquifers, we need further data, modelling and investigations.

12. 13,872 ML of groundwater entitlement is held by local water utilities in the region. Groundwater is drawn from the Macquarie, Bell, Talbragar, Castlereagh and Cudgegong alluvial groundwater sources, the Great Artesian Basin and Oxley Basins, the Orange Basalt and the Lachlan Fold Belt. Appendix C of the NSW Government's Draft Guide to Groundwater Resources in NSW contains details on the characteristics of these groundwater sources water.dpie.nsw.gov.au/plans-and-programs/nsw-groundwater-strategy

**Figure 5. Regional towns and cities in the Macquarie–Castlereagh region that use groundwater**




# Oberon faces ongoing water quality challenges

Oberon relies on water from Oberon Dam (part of the Fish River Water Supply Scheme), which is located a short distance from the township. While this is a very reliable supply, water quality has been a consistent concern for Oberon. High levels of minerals in the water, along with infrastructure and technical capacity limitations have contributed to water quality challenges in Oberon. These challenges are exacerbated in Oberon as the Fish River Water Supply Scheme is the only water source supporting Oberon's urban water needs.

Raw water supplied to Oberon's water treatment plant sometimes contains high concentrations of manganese, particularly when the dam's water level is low. The manganese in the treated water is an aesthetic issue, causing discolouration of the water and staining of laundry, while the treated water continued to be safe to drink. Oberon Council has reviewed operational procedures and optimised operations and as a result, reliable manganese removal is now undertaken at the plant.

In 2022, Oberon Council conducted a scour and flush program to clean the reticulation system of solids including manganese deposits that accumulated during the period of poor control. Continual cleaning of the reticulation system and ongoing capacity to manage water quality issues will need to be a priority for Oberon in coming years.

# Challenge: Supplying water to high priority needs in the lower river system and connected valleys

Delivering water long distances is challenging during dry periods and creates economic, social and environmental risks. A more variable and potentially drier climate will make it even more difficult to meet high priority needs in the west of the catchment, especially during dry periods.

## The region's west has critical water needs and supports high value water reliant industries

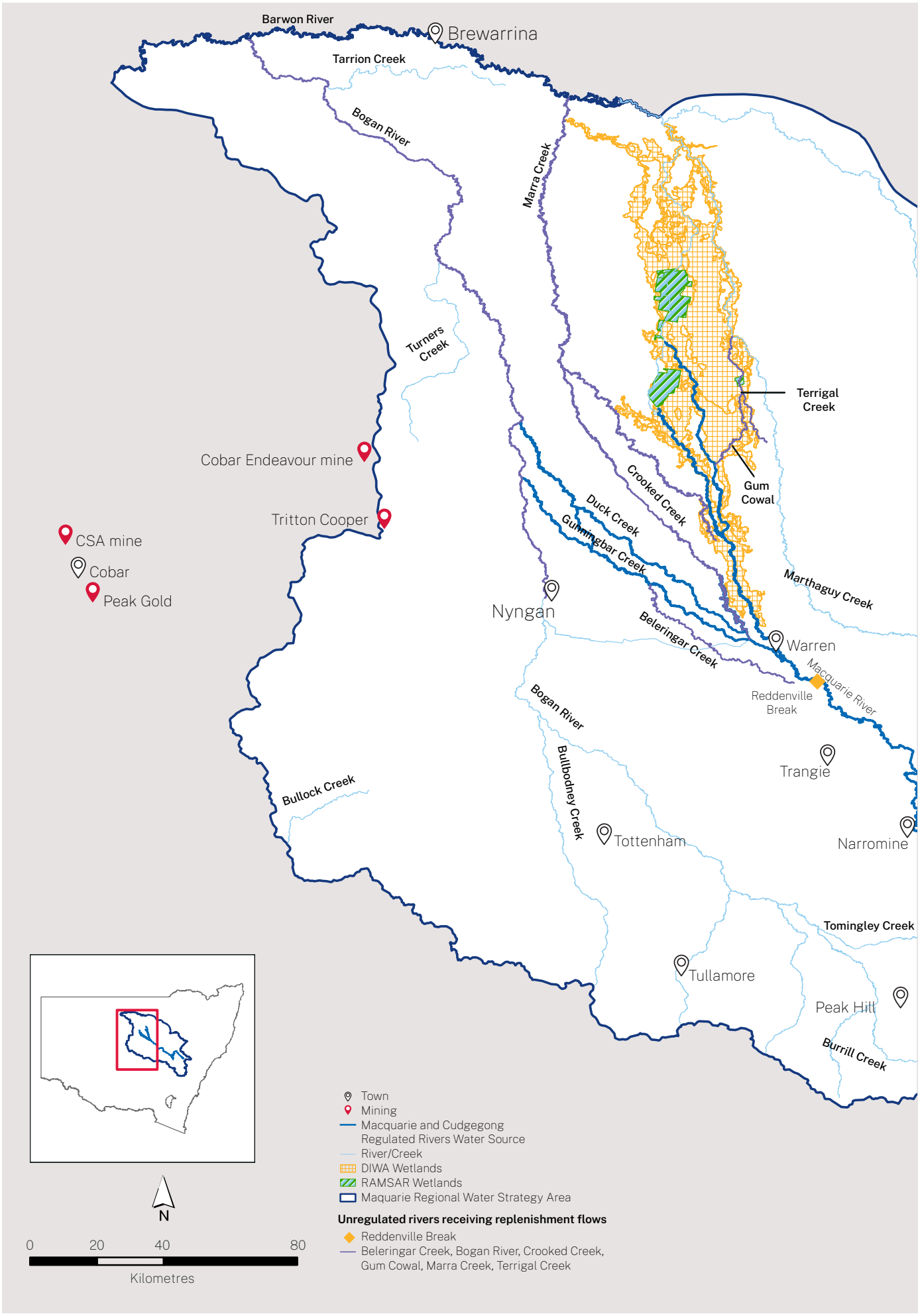
There are a range of high priority water needs in the catchment's west (Figure 6):

- **the internationally important Macquarie Marshes** – including extensive areas of River Red Gum woodlands, reed beds and other wetlands
- **the towns of Nyngan and Cobar** – water travels approximately 200 km down the Wambuul/Macquarie River from Burrendong Dam to supply Nyngan and Cobar. It is first diverted to Gunningbar Creek at the Warren offtake, before being transferred to Nyngan via the 60 km Albert Priest Channel. Water is then transferred from Nyngan to Cobar via a pipeline
- **mines near Cobar and Nyngan** – 4 mines located near Cobar and Nyngan (Endeavour metallic mines, Peak Gold, CSA Mine and Tritton Copper Operations) hold high security licences and source water from the Nyngan-Cobar water supply systems and Gunningbar Creek
- **landholders on rivers and creeks** that receive replenishment flows from the regulated Wambuul/Macquarie River during dry times or rely on unregulated flows for stock and domestic needs.

There are also productive irrigated cropping and livestock operations.

The Macquarie–Castlereagh catchment also provides flows into the Barwon and Darling-Baaka rivers during median to high flows, supporting communities, industries and the environment downstream.

**Figure 6. Map of high priority water uses in the region's west**



# Large volumes of water are needed to deliver supplies during dry periods

The Macquarie River system, from its headwaters to its junction with the Barwon River, is over 960 km long. The regulated section of the river below Burrendong Dam is around 500 km long.

The length of the river presents challenges in delivering water to the end of the system in dry periods. In extreme drought conditions, there are no tributary flows to help run the river. A large portion of the water released from Burrendong Dam to users in the catchment's west evaporates along the way and seeps into the dry river bed.

In the 2017–2020 drought, supplying water from Burrendong Dam to Nyngan and Cobar and nearby mines became especially difficult. At this time, approximately 27 GL of water needed to be released from Burrendong Dam to deliver 1 GL of supply to Nyngan and Cobar.[13]

The 2017–2020 drought was the first time in 50 years the regulated portion of the river was shortened to Warren to save water for critical needs.

Regulated releases down Gunningbar Creek for Tritton mine ceased in December 2019 to extend supplies to major towns on the Wambuul/Macquarie River. If the drought had continued, supply of water below Dubbo would have become impossible.

Our new climate datasets and risk modelling shows that droughts like the 2017–2020 could occur more frequently than previously expected. Burrendong Dam could more often sit at or below levels that trigger drought operations and management measures in a dry future climate change scenario (Table 2), making it harder to deliver water to Nyngan, Cobar and the mines connected to those water systems.

The challenges in delivering water along the length of the regulated river creates economic and social risks for towns, communities and industries. Water carting is not a viable back up option for Nyngan and Cobar. In the last drought water carting for emergency needs only would have required trains, costing approximately $1 million a day. In addition, 70% of the total economic output in the Cobar and Bogan local government areas and one-third of direct employment is linked to mining, which requires a constant supply of water to operate. Failure to supply water to the mines would have major consequences for the local economy.

**Table 2. Percentage of times (in days) that Burrendong Dam's storage falls to low levels at least once in a year under different climate scenarios**

| Storage volume | Historical data (% time) | Long-term historical past climate (% time) | Dry future climate change scenario (% time) | Drought operation measures used at each level in the 2017–20[14] drought |
|---|---|---|---|---|
| **Below 270 GL (22% of active storage volume)** | 36 | 35 | 60 | Drought Stage 3[15] – Severe Drought was introduced. Measures included zero general security allocations and restrictions to account carryover. |
| **Below 126 GL (10% of active storage volume)** | 10 | 11 | 31 | Stage 4 – Critical drought introduced at approx. 110 GL. Measures included suspension of access to all remaining water in general security accounts and environmental water provisions in the water sharing plan. Town and domestic and stock allocations reduced to 80% and high security 70%. All regulated flows downstream of Warren Weir ceased. |
| **Below 61 GL (5% of active storage volume)** | 1 | 1 | 9 | Flows to Gunningbar Creek (which supplies Tritton Mine) ceased. |
| **Below 36 GL (3% of active storage volume)** | 0.2 | 0.2 | 3 | The dam did not reach 36 GL in this drought. The lowest level was 51 GL (1.47%) in February 2020. |

13. In drought it takes 15 GL to get water into Warren Weir and another 12 GL to top up Nyngan Weir down the Albert Priest Channel.
14. For additional details about the measures implemented in the Macquarie Valley during the 2017–2020 drought see www.industry.nsw.gov.au/water/allocations-availability/droughts-floods/drought-update/previous-valleys-in-drought
15. The NSW Extreme Events policy establishes the principles for managing water resources within the NSW Murray–Darling Basin during an extreme event. The policy framework establishes a staged approach and provides a range of measures for water managers to deploy as conditions deteriorate. Further information on the drought stages is available from www.industry.nsw.gov.au/water/allocations-availability/droughts-floods/extreme-events

# Improving connectivity to the Barwon–Darling River

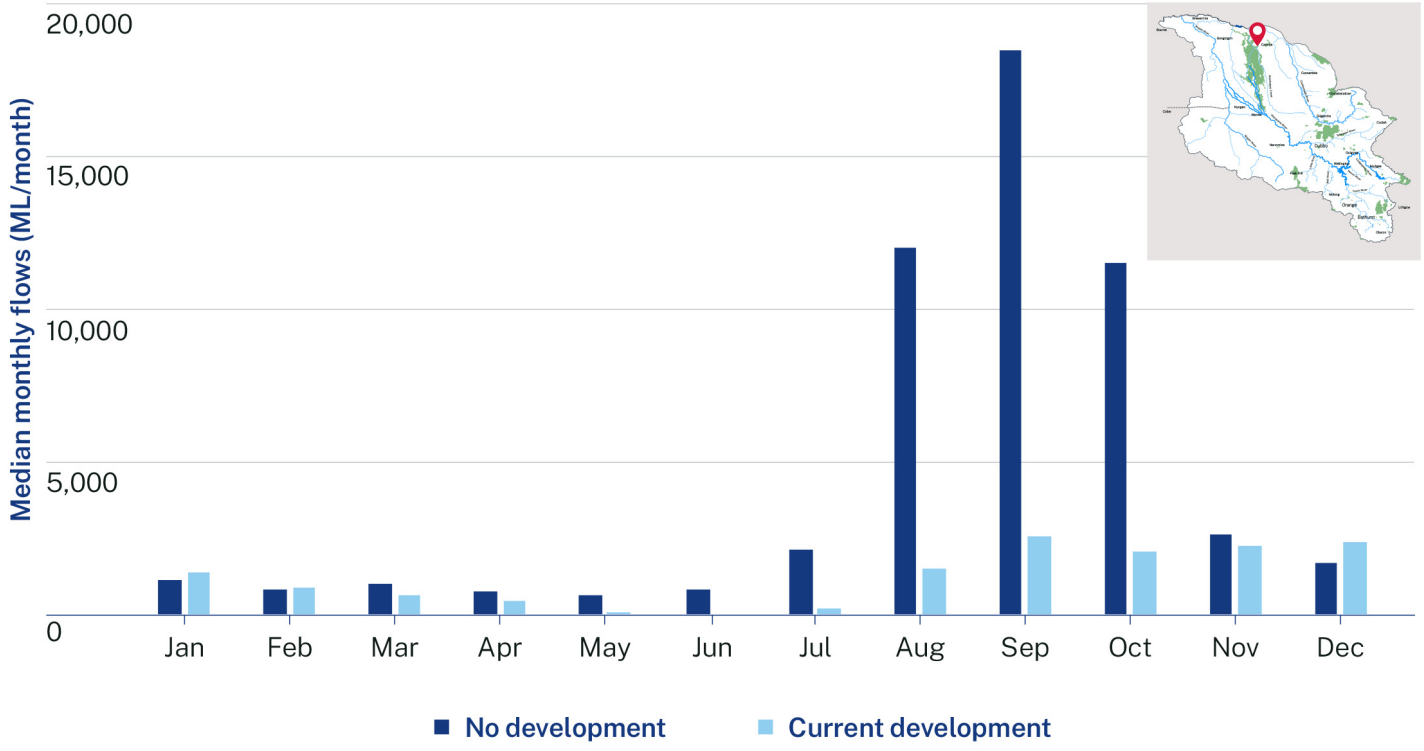
There are ecological, industry and community needs, including, critical human and environmental needs in the Barwon–Darling system that rely on surface water flowing in from the Macquarie–Castlereagh catchment and other catchments in the northern Basin. Flow connections also provide opportunities for fish movement between the Macquarie–Castlereagh and Barwon–Darling systems.

On average, approximately 42% of the total volume of mid-catchment flows in the Wambuul/Macquarie, Castlereagh and Bogan rivers flow downstream to the Barwon–Darling River system.[16] This makes up about 17.3% of the water in the Barwon–Darling River system.[17]

Flows into the Barwon–Darling River typically occur during periods of median and high flows, with minor connection opportunities during dry years. Flow connection along the Wambuul/Macquarie River is affected by the Macquarie Marshes which can absorb water before flows reach the 80 km Lower Macquarie River channel downstream.

Our analysis suggests that large flows at the end of the Wambuul/Macquarie River that would often occur during winter and spring have decreased in response to water resource development (Figure 7). There is also irrigation use below the Bell River Bridge streamflow gauge used in Figure 7 that further reduces connectivity to the Barwon–Darling River.

**Figure 7. Modelled median monthly flow in the Wambuul/Macquarie River at Bells Bridge at Carinda (Stream gauge 421012) (below the Macquarie Marshes) with and without development for the period 1892 to 2020**




16. This is the proportion of the long-term average modelled mid system flow from the Macquarie-Bogan catchment into the Barwon–Darling system. Further information is available in the report *Stocktake of northern Basin connectivity rules — analysis of implementation and effectiveness,* www.industry.nsw.gov.au/water/environmental-water-hub/outcomes
17. Murray–Darling Basin Authority 2011, *Water resource assessments for without-development and baseline conditions,* Supporting information for the preparation of proposed Basin Plan Technical report 2010/20, Version 2 November 2011, Table 10, pp 25. The modelled flow contribution figures are based on the without development figures in Table 10, accessed from, www.mdba.gov.au/sites/default/files/pubs/1111-BPKId-water-resource-assessments-development-baseline.pdf

# Challenge: Supporting a growing regional economy in a future of potentially reduced water availability

Agriculture and mining are major water-reliant industries in the Macquarie–Castlereagh region. The tourist economy is also important in the region's east and includes well-known food and wine destinations. Climate change could reduce water availability for these existing industries, leading to adverse economic and social impacts. While there is also significant potential for future development in high value industries, a shortage of reliable water supplies may hinder this growth.

## Water-reliant industries are important to the regional economy

Agriculture (including cotton, grains and horticulture), food processing and mining are major contributors to the region's economy, along with tourism, health and education services, and the transport, freight and logistics industry (Figure 8).

The Macquarie–Castlereagh region can be broadly divided into 3 economic zones:

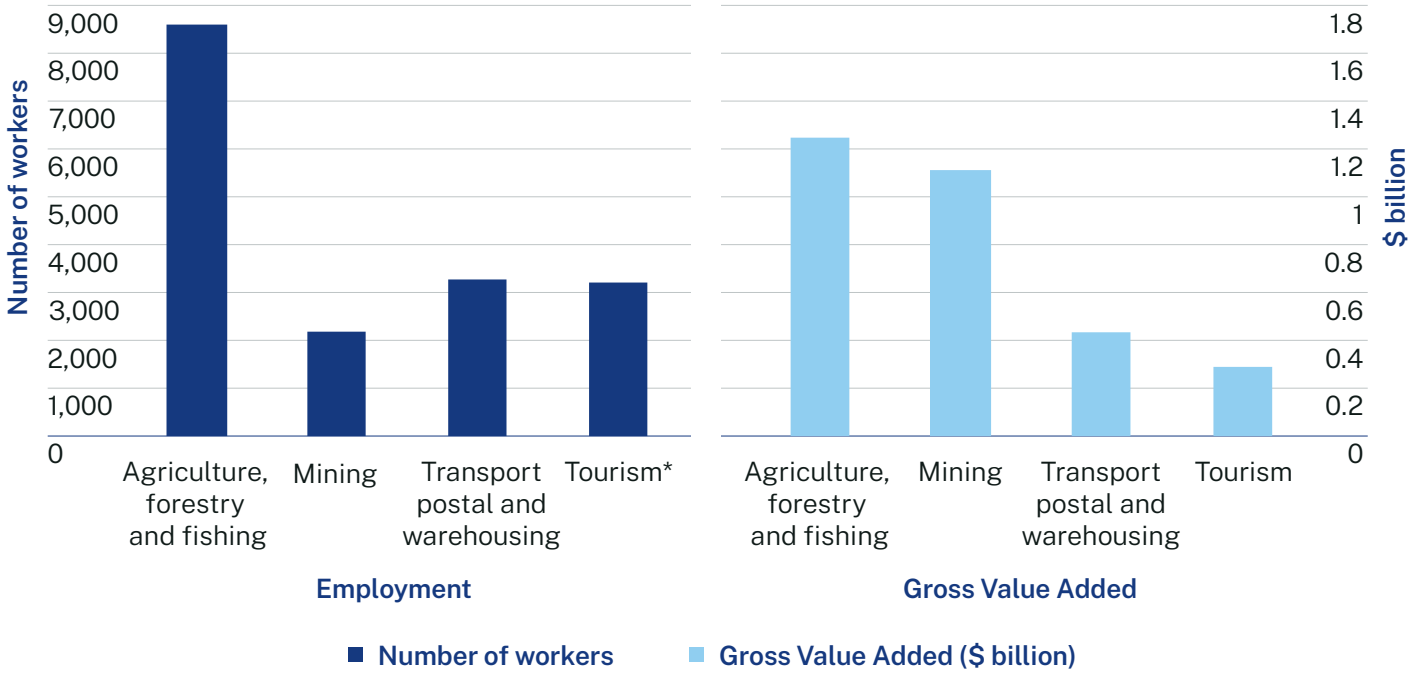
- the upland (eastern extent) around Orange, Bathurst and Mudgee
- the midland (central) around Dubbo and Wellington
- the lowland (western extent) around Narromine, Warren and Nyngan.

The upland and midland zones are where the largest population centres are located. Here, irrigated agriculture is predominantly permanent plantings such as apples, citrus, cherries, stone fruit and viticulture, along with some vegetable production. People from across Australia travel to the region to enjoy the wineries and fresh produce. This area also supports wool production and livestock grazing.

Irrigation, dryland agriculture and mining dominate the economy in the lowland areas in the region's west. Nearly 70% of the irrigated area is cotton grown near Narromine, Trangie and Warren. Major mines also operate in the west of the region and are dependent on reliable water supplies from the Wambuul/Macquarie River.

The Macquarie Marshes, one of the largest remaining inland semi-permanent wetlands in south eastern Australia, is located in the region's west. The Marshes support cattle grazing, some dryland cropping and irrigation cropping, as well as a limited amount of eco-tourism.

**Figure 8. Employment and economic outputs of key industries in the Macquarie–Castlereagh region**




Source: REMPLAN Economy: custom data 2019
* Tourism is not a defined industry category.

The level of economic activity in the region is closely related to water availability, particularly near Narromine, Warren, Trangie and Nyngan.

Agricultural production, and most licensed environmental water, rely on general security water licences. These licences have a lower reliability than high security water access licences or local water utilities licences. General security licences make up 61% of all available surface water licences in the regulated Macquarie and Cudgegong river valleys. These licences have an average effective end-of-year water allocation of 64%[18] and typically receive low annual water allocations during drought (Figure 9).

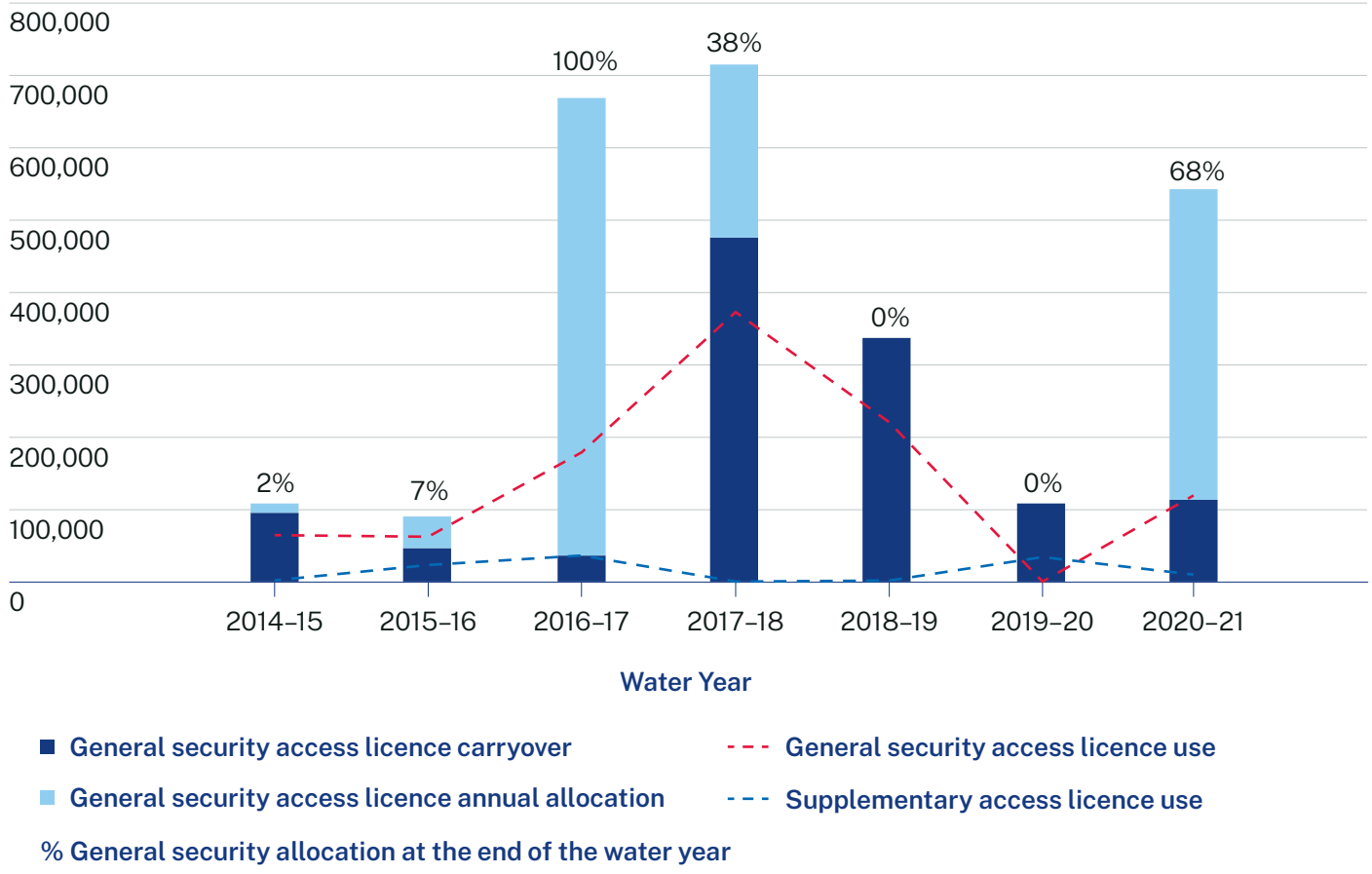
Many farm businesses have adapted to the region's highly variable climate and water availability by producing annual or seasonal crops and investing in technology and improved management practices. They rely on production in the years of good water availability to underpin their businesses during drier years.

The cotton industry has improved whole farm irrigation efficiency and producers now achieve almost twice as much cotton from the same volume of water as 25 years ago.

Even with all these adaptations, severe droughts place great pressure on the viability of farm businesses and the resilience of the broader regional economy. The Gross Domestic Product of the Far West – Orana region of NSW, which includes most of the Macquarie–Castlereagh region, declined by approximately 12% in the 2017–2020 drought. This is reflected in lower employment, reduced capital utilisation and productivity losses.[19]

18. Department of Planning and Environment – Water data
19. Wittwer, G. 2020 March, *Estimating the Regional Economic Impacts of the 2017 to 2019 Drought on NSW and the Rest of Australia* (COPS Working Paper No. G297), www.copsmodels.com/ftp/workpapr/g-297.pdf

**Figure 9. General security and supplementary water availability and use in the Wambuul/Macquarie and Cudgegong regulated rivers from 2014 to 2021**




Note: The general security access licence carryover figure is the start of the water year water balance. Data in the figure excludes the general security Environmental Water Allowance of 160 GL but includes Held Environmental Water. The general security annual allocation shown in this figure (light blue area of column and percentage) is the highest final allocation for the water year.

Source: Department of Planning and Environment – Water Group, General Purpose Water Accounting reports, www.industry.nsw.gov.au/water/allocations-availability/water-accounting/gpwar

Image courtesy of Department of Planning and Environment. Castlereagh River, Gilgandra.

# Less reliable surface water could impact the regional economy

Our new extended datasets and modelling suggest that droughts like that experienced from 2017–2020 are not unusual; nor are they the worst the region has experienced. Similar or even worse events have occurred in the longer climate record, meaning it is likely that they will again be experienced in the future.

Our analysis suggests that extremes could become more extreme, and under a dry future climate change scenario, there could be a significant decrease in average inflows into the region's rural water storages (Table 3). This could result in general security licences and supplementary licences having access to 23% less water when compared to the long-term historical past climate projection. If practices don't change, we could see a 45% reduction in profit generated by irrigated annual agriculture under a dry future climate change scenario.

As well as industries reliant on the regulated systems, a more variable or changing climate would also impact many of the region's mixed farming and grazing enterprises along unregulated rivers and creeks.

While these climate scenarios may not occur, they demonstrate that we need to act now to support the resilience of the region's economy.

**Table 3. Burrendong Dam minimum inflow sequences and the probability of these sequences occurring again under long-term climate scenarios (stochastic) and a dry future climate change scenario (stochastic and NARCliM)**

| Burrendong Dam minimum inflow sequence | Total inflow volume (ML) | When did it occur in the observed historical record? | Probability of it occurring in the long-term climate scenario (stochastic) | Probability of it occurring in a climate change scenario (stochastic and NARCliM) |
|---|---|---|---|---|
| 36-month | 225,316 | 2017–2020 | ~0.1% | ~2-3% |
| 5-year | 1,037,194 | 1937–1942 | ~1% | ~15-20% |
| 10-year | 3,135,971 | 1932–1942 | ~1% | ~20-25% |

Source: Department of Planning, Industry and Environment 2020, hydrological modelling

Image courtesy of Destination NSW. The Peak Hill Open Cut Gold Mine, Parkes Shire.

# New high-value industries need reliable water supplies

There is significant potential for growth in new and high value industries, stimulated by private sector and government investment.

The NSW Government's economic development strategies for the region[20] have identified potential increases in high value agriculture products, renewable energy and mining to support regional employment, population and economic growth. These include:

- NSW's first **Renewable Energy Zone** near Dubbo and Wellington is expected to be ready by the end of 2022.[21]
- **Pumped hydro** – with the phasing out of ageing coal fired power stations, the NSW Government is looking at potential pumped hydro storage energy projects to feed into the energy transmission network. This includes a potential site in the Central West.[22]
- **Transition towards specialised agriculture** – the region is strategically located between the major domestic markets of Melbourne, Brisbane, Adelaide and Sydney, and is close to the supply of raw agricultural materials. This means there are opportunities to add value to the agricultural sector through secondary food processing, packaging and associated industries.
- **Critical minerals hub** – the NSW Government is proposing to establish Australia's first minerals hub in the Central West. This would become a major global supplier of critical minerals needed for information and renewable energy technology, such as personal electronic devices, electronic vehicles, renewable energy generation and advanced manufacturing. The Inland Rail project will increase options for the region's ore production to be transported, processed and exported.

To support growing or emerging industries in the region, we will need to identify innovative ways to provide water and ensure that these industries are capable of operating in times of reduced water availability. This is because:

- there is only a relatively small volume of high security surface water entitlement in the entire Macquarie–Castlereagh region and it is fully committed to towns and existing industries
- groundwater sources with high quality water are fully committed and highly utilised (Figure 10)
- the development of new mines or expansion of existing permanent horticulture and viticulture plantings around Narromine, Dubbo, Mudgee and Orange is already constrained by the lack of high security water supply, or by difficulties in supplying high security water to downstream locations
- it is often difficult to establish new bores due to the potential impacts on existing bores. This means that, even if groundwater entitlements can be purchased, they cannot necessarily extract where it is needed. This difficulty also extends to the region's local water utilities.

Despite these challenges, there are opportunities in the Macquarie–Castlereagh region that may not be available in other inland regions in NSW. There are entitlements in the fractured and porous rock groundwater sources that extend beyond the Macquarie–Castlereagh region, which have lower yields and poor water quality but may still be useful for industries that do not require high quality water. Power stations adjacent to the upper Macquarie region near Lithgow are transitioning and there is a possibility some of their water entitlements could be redeployed. These create opportunities to assess where certain industries should be strategically located in the region.

20. Central Orana Regional Economic Development Strategy 2018–2022, Western Plains Regional Economic Development Strategy 2018-2022, Mid-Western Regional Council Regional Economic Development strategy 2018–2022, Abercrombie Regional Economic Development Strategy 2018–2022, Orange, Blayney and Cabonne Regional Economic Development Strategy 2018–2022.
21. www.energyco.nsw.gov.au/renewable-energy-zones/centralwest-orana-renewable-energy-zone
22. The Roadmap can be accessed at www.energy.nsw.gov.au/renewables/clean-energy-initiatives/hydro-energy-and-storage

**Figure 10. Average level of use and commitment of high yielding aquifers in the Macquarie–Castlereagh region**

# Challenge: Addressing barriers to Aboriginal water rights

Historical dispossession of land, the effects of colonisation and water management processes continue to impact Aboriginal people's access to water and their ability to care for Country. We need to restore lost access to water and change our engagement with Aboriginal people so we can all benefit from their traditional knowledge in managing our water resources.

## Aboriginal people have lost access to water and Country

The lands and waters of the Macquarie–Castlereagh region have been occupied by the Gomeroi/Kamilaroi, Ngemba, Ngiyampaa, Wailwan and Wiradjuri Nations for over 60,000 years. They have always been closely linked to rivers, groundwater, billabongs and wetlands, and this relationship is essential to culture, community and connection to Country. As the traditional custodians of this natural resource, Aboriginal people have rights and a moral obligation to care for water under their law (lore) and customs. These obligations extend across communities throughout the catchment and the connected surface water and groundwater systems.

Fences and locked gates on public land, can prevent Aboriginal people from accessing water, carrying out cultural practices and using traditional knowledge and science to care for and manage waterways. Access to waterways is essential for fulfilling cultural obligations and passing down knowledge to the next generation.

In addition, access to water entitlements now requires Aboriginal people to buy entitlements from the fully allocated market. We know from consultation undertaken regionally and for the NSW Water Strategy that there is strong community support for Aboriginal water rights. The small amount of water in Aboriginal ownership has frequently been identified as a key area for improvement.

As a signatory to the National Agreement on Closing the Gap, NSW is committed to establishing a target to measure progress towards securing Aboriginal interests in inland water. NSW is contributing to national processes to confirm this target, which could be expressed as a percentage of water licences held by Aboriginal people or organisations.

# Better incorporation of Aboriginal traditional knowledge and values into water management

In the past, water management decisions in the Macquarie–Castlereagh region have not been comprehensively informed by Aboriginal people's history, knowledge and experiences, which are based on many thousands of years of living on Country. Aboriginal people have had limited involvement in water consultation processes, due to:

- The consultation timeframes and processes around water policy changes do not allow the time needed for Aboriginal cultural governance processes. This erodes trust.
- There is a complex set of state and federal laws and systems around water management that is often not explained in a plain English or a visual manner.
- Limited resources and support for Aboriginal groups to drive their engagement in water management. Often, Aboriginal people and individual members of the public need to give up personal time and resources to have a say in water consultation processes.

For many years, government has committed to models around committees and advisory bodies that are not made up of local Aboriginal people with cultural connection to or authority to speak about their Country. Efforts are already underway to include and enhance Aboriginal representation in environmental water management, such as the Environmental Water Advisory Groups. The NSW Government also has a strategy to enhance their involvement in environmental water decision making.

We need a culturally appropriate engagement approach that allows for Aboriginal people in their Nation area/region to get the right people involved or appointed to seats at the table where decisions about water are being made. We heard that genuine consultation with Aboriginal people through such a process can be an important step in addressing past disparities, earning trust and encouraging participation in water management by Aboriginal communities.

# Improving water availability to important cultural locations

Beemunnel Reserve Aboriginal Place, a designated Aboriginal site on Ewenmar Creek, holds significant cultural and spiritual value for the local Wailwan people of the Warren region. The landscape of the Beemunnel Reserve, including Ewenmar (Beemunnel) Creek, the flood free ground beside it and the natural vegetation was used by the Wailwan people for economic, cultural and ceremonial purposes. It contains tangible evidence of traditional use, including burials and scarred trees.

> "We've always been on this creek, as far back as I can remember.
>
> It had regular flow when we were growing up, it was very seldom dry. We'd fish and swim and we used to drink it…never harmed us…we drank it all the time. We'd catch yellowbelly, cod, catfish and bream. That changed when they built the dam [Burrendong] in the 60s."
>
> George Riley[23]

During consultation we heard that water flows through Beemunnel Reserve have changed due to upstream diversion and infrastructure works at the connection to the Wambuul/Macquarie River (Redenville break), and that increasing flows at important times will help with the wellbeing of the community and allow for connection to Country and culture.

We heard during public consultation that there is support for securing flows for water dependent cultural sites such as the Beemunnel Reserve Aboriginal Place. However, Aboriginal people would like this to be expanded to provide better access to water entitlements that allow local Aboriginal communities to have an active role in making decisions about how and when this, and other culturally important sites, receive water.

23. This quote has been sourced from a brochure titled *Beemunnel Heritage Trail* available from www.warren.nsw.gov.au/discover/things-to-see-and-do

# Challenge: Maintaining and improving the health and resilience of the region's aquatic and floodplains ecosystems

Water use and landuse have impacted water-dependent ecosystems and native species in the Macquarie–Castlereagh region, including the Ramsar listed Macquarie Marshes. A range of water reforms, including the dedication of water to the environment, have sought to stop further decline and improve the condition and resilience of these environmental assets. However, parts of the catchment are still in poor condition and projected climate change will increase the risk for many species and ecosystems.

The Macquarie–Castlereagh catchment supports a diverse range of water-dependent ecosystems, including instream aquatic habitats, riparian forests, floodplain woodlands and wetlands. These ecosystems, including the Macquarie Marshes, rely on a range of river flows. Flows in the river at different times of the year support the lifecycles of fish, animals and plants by providing cues for movement, growth and reproduction. Recharge of groundwater sources supports groundwater-dependent ecosystems.

## Maintaining the Macquarie Marshes

The region is home to the Ramsar-listed Macquarie Marshes, one of the largest remaining inland semi-permanent wetlands in south eastern Australia. The Marshes form the heart of the traditional country of the Wailwan people, who valued them as an important traditional Aboriginal settlement because of their rich and reliable resources and iconic cultural values. The Marshes continue to be important for the Wailwan and other Aboriginal people.

The Marshes are ecologically important – they support threatened species, endangered ecological communities and species of conservation concern. This includes iconic water birds, fish, aquatic animals and vegetation communities. The Marshes contain the largest river red gum woodland in the northern Murray–Darling Basin (approximately 40,000 ha) and is home to extensive areas of coolibah and black box woodland. As well as being a nationally significant breeding site for waterbirds, the Marshes are an important refuge for wildlife during dry times.[24]

Conserving the marshes is a strategic priority stated in the long-term water plan for the region.[25] To maintain them into the future, the wetlands need a mix of regular inundation – for vegetation such as reedbeds and water couch meadows – as well as inundations provided by only the largest floods.

24. Department of Environment, Climate Change and Water NSW 2010, *Macquarie Marshes – Adaptive Environmental Management Plan*, retrieved 20 September 2021 from www.environment.nsw.gov.au/research-and-publications/publications-search/macquarie-marshes-adaptive-environmental-management-plan
25. Department of Planning, Industry and Environment 2020, *Macquarie-Castlereagh Long Term Water Plan Part A: Macquarie-Castlereagh catchment*, retrieved 20 September 2021 from www.environment.nsw.gov.au/topics/water/water-for-the-environment/planning-and-reporting/long-term-water-plans/macquarie-castlereagh

# Reductions in large flows are impacting ecosystems

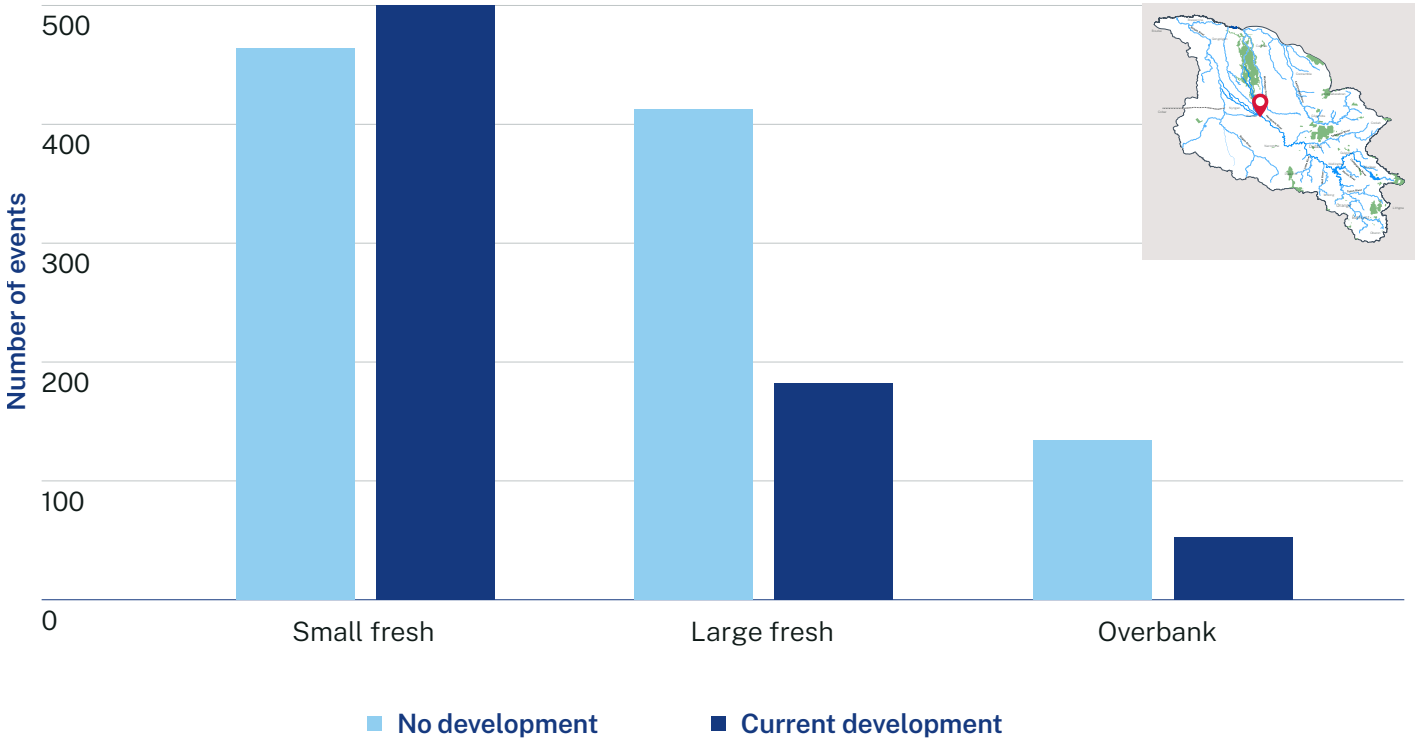
The flow regime in the Macquarie-Castlereagh region has changed over time.[26] The degree of change varies depending on the location within the catchment, however the frequency of large fresh and overbank flows has decreased in the region's regulated rivers.

In combination with other factors, the reduction in large freshes and overbank flows has contributed to reduced lateral connectivity between the regulated Wambuul/Macquarie River and its floodplain.[27] This has had various consequences, including a decline in the condition and extent of river red gum and coolibah-black box communities and a reduction in the number of breeding events for colonial waterbirds.[28]

The number of large fresh and overbank flows at Warren Weir and into the Macquarie Marshes have likely halved (Figures 11 and 12) and smaller flows have increased. Overbank flows in Warren are controlled by the Burrendong flood mitigation zone to reduce impacts on infrastructure and land access.

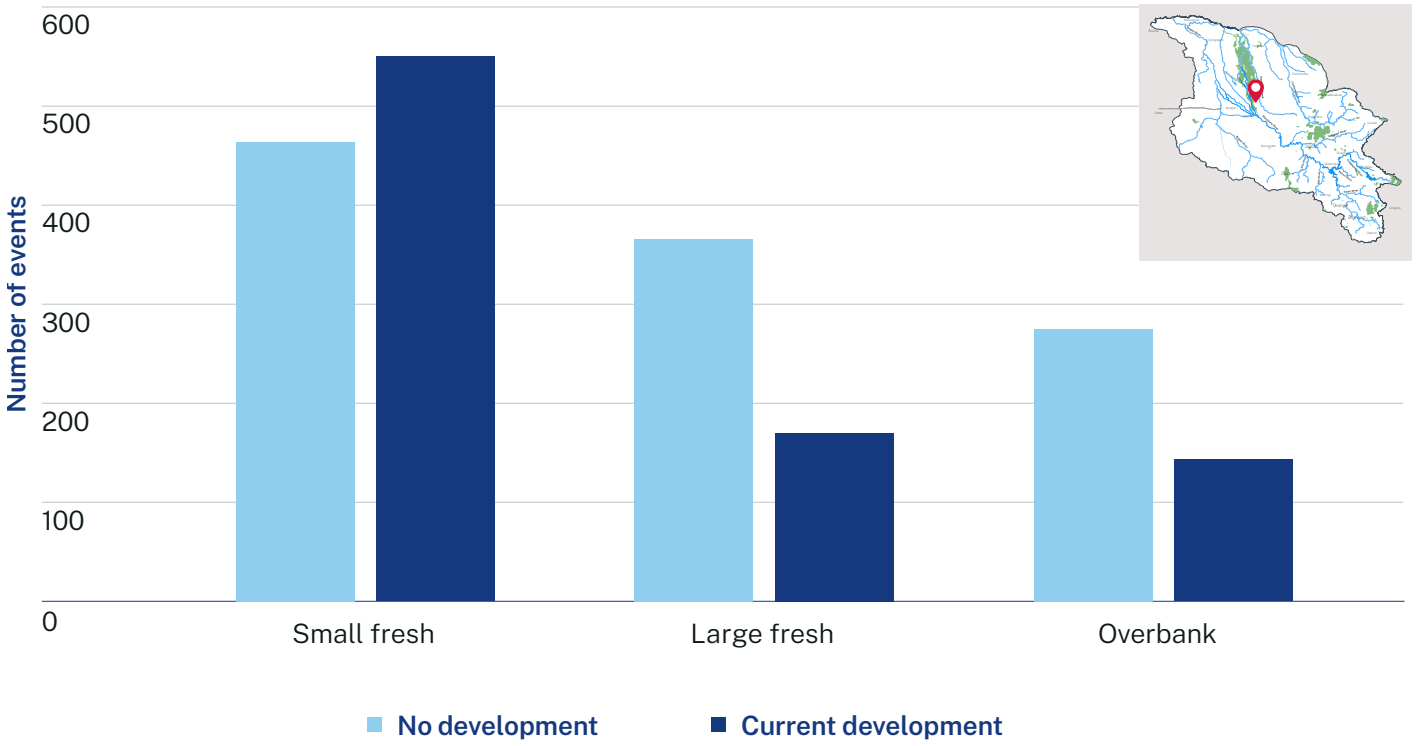
Implementing floodplain harvesting licensing and regulation, and addressing unauthorised structures in the floodplain will help deliver more water to the region's wetlands and floodplains.

**Figure 11. Modelled frequency of flow events in the Wambuul/Macquarie River at Warren Weir (Stream gauge 421004) with and without development for the period 1892 to 2020**




26. Kingsford, R.T 2000, *Ecological impacts of dams, water diversions and river management on floodplain wetlands in Australia,* Austral Ecology, 25(2), pp 109-127.
27. Kingsford, R.T 2000, *Ecological impacts of dams, water diversions and river management on floodplain wetlands in Australia,* Austral Ecology, 25(2), pp 109-127.
28. Macquarie-Castlereagh Long-term Water Plan, pp 12-14

**Figure 12. Modelled frequency of flow events in the Wambuul/Macquarie River at Marebone Weir and Break (Stream gauge 421088 and 421090) with and without development for the period 1892 to 2020**




## Constraints limit the ability of environmental water to reinstate large flows

Government water reforms over the past 2 decades have recovered significant amounts of water for the environment in the Macquarie catchment to support the health of the its ecological assets and ecosystem functions. The regulated Macquarie system includes the largest environmental water portfolio in the northern Basin,[29] equating to approximately 25% of the total licensed entitlement in the region. This portfolio includes approximately 160 GL of environmental water allowance which can be actively managed in the regulated rivers, as well as 175 GL of general security licence entitlement and 10 GL of supplementary licence entitlement.

At times there are constraints that limit the ability of the environmental water manager to use these entitlements and to reinstate some of the large flows. In non-flood times, Burrendong Dam is operated so that releases do not exceed the channel capacity upstream of the Macquarie Marshes. This is done to maintain system efficiency and to avoid flooding of cropping land and essential service assets. There is also potential for localised channel capacity competition when environmental water managers and consumptive water users are ordering water at the same time. This also limits the capacity for environmental flows to provide large freshes and overbank flows. There are opportunities to formalise channel capacity sharing or increase channel capacity at some choke points to help address this issue.

29. For further information, see www.environment.nsw.gov.au/topics/water/water-for-the-environment/about-water-for-the-environment/current-water-holdings

# Extended dry periods will place critical environmental assets at risk

In-stream pools and floodplain lagoons provide important refuges and habitats for waterbirds and fish in dry periods. Refugia are critical to the survival of many aquatic species during dry spells and act as source populations for subsequent recolonisation and population growth. Extended no flow or very low flow periods and new droughts of record put in-stream refugia at risk.

During the 2017–2020 drought, flows to the regulated Wambuul/Macquarie River were cut off below Warren and access to water held in general security accounts (including environmental accounts) was suspended along with reduced allocations to high priority licence holders to reserve remaining storage volumes as long as possible for critical human needs. While use of the Environmental Water Allowance was suspended in the Millennium Drought, 2019 was the first time that water held in general security environmental accounts could not be released from Burrendong Dam.

A potential dry future climate change scenario will increase the risk of more frequent and extended cease-to-flow periods, and of drought refuges drying out. It could also lead to a shift in seasonality of rainfall from spring to autumn, with implications for a range of plant and animal species that currently rely upon springtime flows.

# Water infrastructure, land management and pest species impact native fish

The Macquarie–Castlereagh catchment supports 19 native fish species, including 7 threatened or vulnerable species. The health of fish communities, particularly in the upper unregulated reaches of the Macquarie–Castlereagh catchment is poor.[30] In addition to modified flows, other threats to native fish include:

- **Physical structures and infrastructure** such as dams, weirs and road crossings restrict the ability for fish to move, find food and habitat. There are 238 major instream structures in the Macquarie River Valley, with 7 of these being high priority for remediation. Fish passage and restocking native fish programs can help address these challenges.
- **Land management** has reduced the quality of riparian vegetation in the region. This is particularly threatening for native fish as it takes away habitat opportunities and shade, as well as removing a source of food, nutrient and carbon input.
- **Pest fish species** are common throughout most of the catchment. The Macquarie Marshes have been identified as a carp breeding hot-spot during some years.[31]
- **Algae blooms** are common in Burrendong and Windamere dams. This impacts the quality of the water for town and household use, the amenity of the rivers, and increases the stress on aquatic species. Algal blooms also limit the ability to manage cold water pollution.
- **Cold water pollution** damages riverine ecological function, particularly in summer when biological cues such as fish spawning are disrupted. Cold water pollution can result in native fish failing to breed, breeding later in the season, fish eggs may fail to hatch, or the young may die or develop more slowly making them more susceptible to disease and predation. Cold water released from Burrendong Dam can persist for up to 325 km downstream to Warren Weir,[32, 33] and up to 90 km downstream of Windamere Dam.
- **Hypoxic blackwater events** can occur when the flows in the river restart after excessive dry periods. High levels of bare ground and a potential build-up of organic material can mean that rain after extended dry periods results in poor quality water running off the catchment and into the river channel and floodplain, depleting dissolved oxygen and impacting aquatic animals. In recent years hypoxic blackwater events have contributed to fish deaths in the Wambuul/Macquarie River, Cudgegong River and Burrendong Dam.

30. Department of Primary Industries 2015, *Fish and Flows in the Northern Basin: responses of fish to changes in flow in the Northern Murray–Darling Basin – Valley Scale Report,* Final report prepared for the Murray–Darling Basin Authority, Department of Primary Industries, Tamworth.
31. Gilligan, D., Hartwell, D and McGregor, C 2009, *Identification of 'hot-spots' of carp reproduction in the Murray–Darling Basin*, American Fisheries Society Conference, 30 August – 3 September 2009, Nashville, USA.
32. Lugg and Copeland 2014, *Review of cold water pollution in the Murray–Darling Basin and the impacts on fish communities*, www.doi.org/10.1111/emr.12074
33. Burrendong and Windamere dams were ranked by Preece 2004, [referenced in Water quality technical report for Macquarie Castlereagh surface water resource plan area (SW11)] as having severe and minor cold water impacts respectively.

# Addressing the challenges

# 4

Image courtesy of Peter Robey, Department of Planning and Environment.
Country landscape during roadtrip between Dubbo and Newcastle.

To address the key challenges in the Macquarie–Castlereagh region, we have 4 priorities with proposed actions under each.

The regional priorities are:

- secure water supplies for growing regional cities and towns
- reducing water security risks in the region's west
- supporting industry and community climate adaptation
- best use of existing water for the environment.

These priorities and proposed actions can improve the Macquarie–Castlereagh region's readiness to adapt to a more variable climate and support the difficult decisions we may need to make to deliver healthy, reliable and resilient water resources for the region's future.

Image courtesy of Destination NSW. Newey Reservoir, Cobar.

# Priority 1

## Secure water supplies for growing regional cities and towns

Regional cities and towns in the Macquarie–Castlereagh region will face increasing risks to the security of their water supplies over the coming decades. This is particularly the case for the growing centres of Bathurst, Orange and Dubbo, which combined supply water to more than half of the region's population. For many other towns across the Macquarie–Castlereagh region, groundwater is essential. Having reliable and sustainable access to groundwater allows communities to endure extreme climates.

To reduce the risk of severe restrictions and costly emergency water supply measures, the actions under this priority focus on a mix of demand management, efficiency, information, policy and infrastructure initiatives. These will help towns in the region to make the best use of the available water resources and better respond to the needs of a growing population and the risks associated with climate variability change.

## What we are already doing

Investments have been made in recent years to help secure water supplies for towns across the Macquarie–Castlereagh region.

### Safe and Secure Water Program

The $1 billion Safe and Secure Water Program, established in 2017, is managed by the Department of Planning and Environment and co-funds vital water and sewerage projects across regional NSW. This co-funding assists non-metropolitan councils, local water utilities, county councils, water supply authorities and joint organisations to deliver projects that provide safe, secure and sustainable water and wastewater services to regional NSW.

Projects funded in the Macquarie–Castlereagh region include:

- Bathurst Regional Council – $24.25 million for alternate water supply options planning, Bathurst water harvesting and Winburndale pipeline, and Winburndale Dam flood security upgrade
- Cabonne Council – $17.50 million for Molong emergency water supply and Orange to Molong Pipeline (Stage 1)
- Central Tablelands Water – $242,000 for Central Tablelands Water emergency drought works, Lake Rowlands permanent pumping station and Caragabal water supply
- Dubbo Regional Council – $30.02 million for groundwater infrastructure at Dubbo, Euchareena drought emergency water carting, and Geurie water supply feasibility study
- Mid-Western Regional Council – $2.45 million for Mudgee water filtration plant headworks and pump upgrade, and Charbon sewerage scheme (including Rylstone, Kandos and villages scheme early stages)
- Narromine Shire Council – $4.80 million for Tomingley water supply augmentation, Narromine water scheme, Narromine water treatment, Narromine water security and water quality project, Integrated Water Cycle Management strategy proposal, sustainable Narromine water supply scoping study, and additional bores at Narromine and Trangie
- Oberon Council – $4.95 million for Oberon sewerage project
- Orana Water Utilities Alliance – $528,750 for condition assessment of existing groundwater bores
- Orange City Council - $20.26 million for Cowra to Central Tablelands Water emergency water connection, pipeline from Spring Creek Dam to Icely Road water treatment plant, East Orange Harvesting Wetlands (Stage 2), and Gosling Creek Dam Safety Upgrade Works.

The 2022–23 State Budget has committed $370 million over the next 4 years for the Safe and Secure Water Program, including $90 million in new funding to expand the program.

The Program funds the resolution of priority risks and issues through infrastructure and non-infrastructure solutions that align with one of the following categories:

- Water security – risks that may affect current or future continuity of reliable and uninterrupted town water supply
- Water quality – risks to health posed by drinking water supplies, considering the source waters and the barriers present in treatment systems
- Environment – risks to human health or the environment from sewage management that does not satisfy community expectations or regulatory requirements.

Each risk or issue is assessed against a prioritisation framework to determine how critical it is to regional NSW water safety and security. Risks and issues are ranked based on the result of the prioritisation assessment.

### Town Water Risk Reduction Program[34]

The NSW Government is collaborating with local water utilities and the wider water sector on the Town Water Risk Reduction Program. This program is delivering a new approach to working together that enables local water utilities to manage risks and priorities in town water systems more strategically and effectively.

The program's focus is on working together with the sector to identify the most fundamental barriers within state and local government that prevent effective and strategic risk management, and to develop and implement long-term solutions to these barriers.

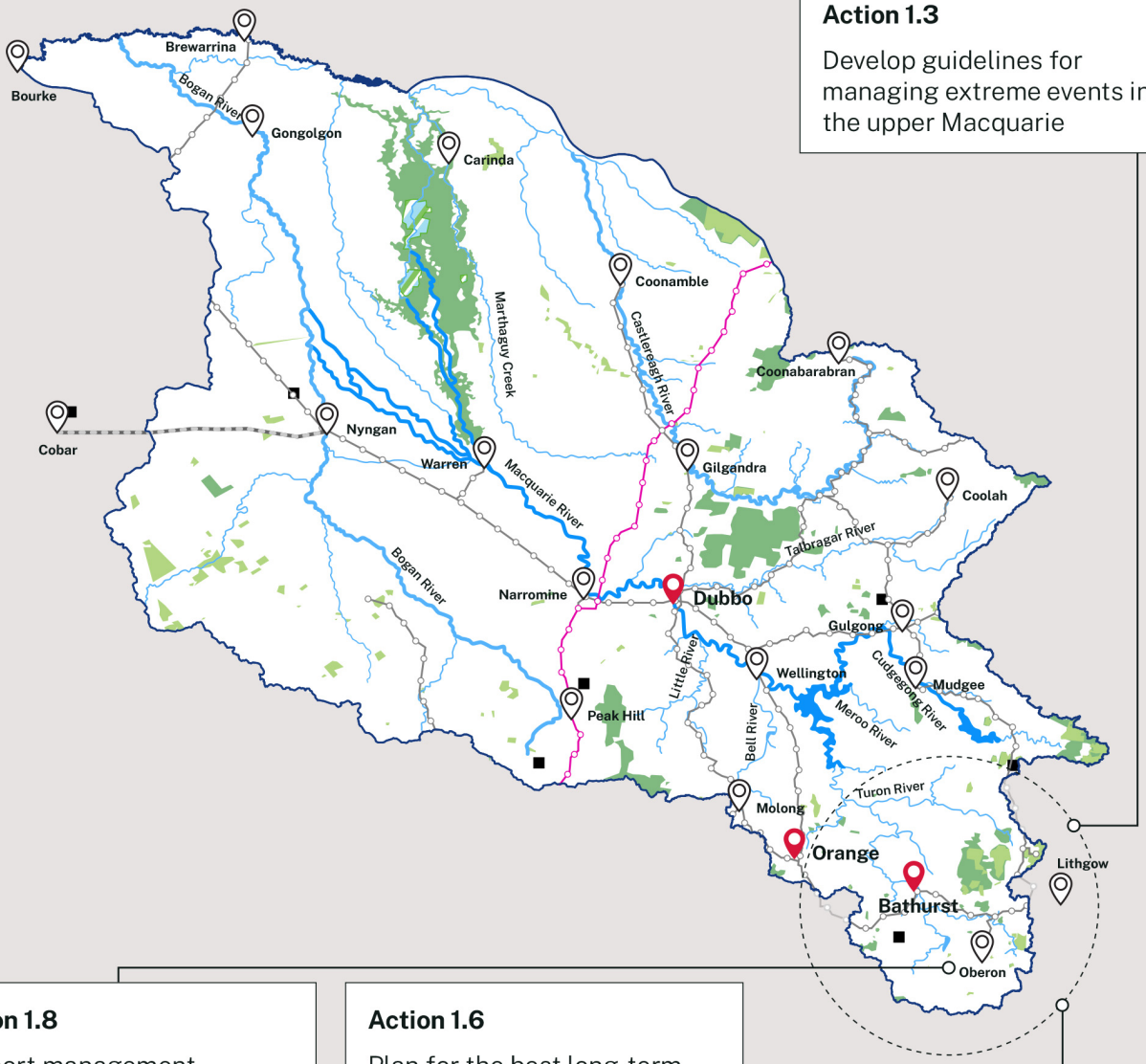
The program is based on a new partnership approach that recognises and leverages the wealth of expertise within councils and local water utilities and provides opportunities for them to design and refine better solutions in collaboration with the department.

Several pilots have been initiated through the Town Water Risk Reduction Program to trial new approaches to local water utility strategic planning. Recognising the important connection between each local water utility's strategic planning and regional water strategies, a pilot has been led by the Central NSW Joint Organisation of Councils to co-design an approach to regionally-based local water utility strategic planning incorporating the Integrated Planning and Reporting framework of the *Local Government Act 1993*.


Image courtesy of Quentin Jones, Department of Planning and Environment. Telegraph Hotel, Bank Street Molong.

34. For more details, refer to www.dpie.nsw.gov.au/water/plans-and-programs/town-water-risk-reduction-program

**Figure 13. Priority 1: Secure water supplies for regional cities and towns**




**Action 1.3**

Develop guidelines for managing extreme events in the upper Macquarie

**Action 1.8**

Support management of Oberon's town water quality issues

**Action 1.6**

Plan for the best long-term augmentation solution for the upper Macquarie

## Across the region

**Action 1.1**

Confirm the level of water security needed to support regional cities

**Action 1.2**

Establish a governance framework to coordinate actions under Priority 1

**Action 1.4**

Adopt a stronger focus on urban water conservation and efficiency

**Action 1.5**

Invest in innovative water supply options

**Action 1.7**

Reduce uncertainty in groundwater security for the region's towns

**Legend**

Reducing water supply risks for regional cities, towns and villages

Supplying water to high priority needs in the lower river system and connected valleys

Supporting a growing regional economy in a future of potentially reduced water availability

Addressing barriers to Aboriginal water rights

Maintaining and improving the health and resilience of the region's aquatic and floodplain ecosystems

| Proposed action | Summary | Challenges addressed |
|---|---|---|
| **Action 1.1** Confirm the level of water security needed to support regional cities | Develop guidelines on whether water security planning for large regional towns should be guided by an 'enduring level of supply' approach. |  |
| **Action 1.2** Establish a governance framework to coordinate actions under Priority 1 | Establish a governance framework and arrangements in consultation with local councils and local water utilities to support coordination of actions under this priority and improve timely decision-making during extreme events. |  |
| **Action 1.3** Develop guidelines for managing extreme events in the upper Macquarie | Update planning and preparation for how to respond and protect the water supply for critical needs in the upper Macquarie during extreme drought conditions. |  |
| **Action 1.4** Adopt a stronger focus on urban water conservation and efficiency | Support local water utilities in investing in measures to improve the efficiency of supplying water for domestic, commercial and industrial water uses, and encourage water users to minimise demands for water. |  |
| **Action 1.5** Invest in innovative water supply options | Support local water utilities to progress stormwater harvesting, recycled water and managed aquifer recharge projects for domestic and commercial water uses. |  |

| Proposed action | Summary | Challenges addressed |
|---|---|---|
| **Action 1.6**<br>Plan for the best long-term augmentation solution for the upper Macquarie | In collaboration with local councils, progress work to identify the best way to sequence water security projects across the upper Macquarie and neighbouring areas. This will include assessing the medium to long-term feasibility, costs and benefits of:<br>• supplying water to upper Macquarie towns from the Fish River or Coxs River catchment<br>• supplying water to Bathurst and/or Orange from the Lachlan Valley<br>• new infrastructure in the upper Macquarie, which could include a new Ulmarrah Dam at Dixons Long Point<br>• increasing the volume of water Orange can access each year from the Wambuul/Macquarie River. | |
| **Action 1.7**<br>Reduce uncertainty in groundwater security for the region's towns | Support local water utilities undertake local level investigations to understand and improve the security of groundwater supplies using the latest data. | |
| **Action 1.8**<br>Support management of Oberon's town water quality issues | Continue to provide council with technical support and guidance to help manage water quality matters and explore options to support council with the financial costs associated with sourcing water from the Fish River Scheme. | |


Image courtesy of Destination NSW, Amber Hooper. Streetscape, Gulgong.

## Proposed action 1.1: Confirm the level of water security needed to support regional cities

Our current approach to managing water security for regional cities towns relies on defining an 'acceptable risk' of running out of water. Existing NSW Government guidelines suggest town water supplies should meet a minimum service level. This roughly correlates to town water supplies being able to withstand a drought that has the probability of occurring one in 1,000 years. This level of risk may not be appropriate for large towns where there are no last resort options, such as water carting, in extreme droughts.

Large water utilities such as Sydney Water and the Hunter Water have moved away from the concept of an 'acceptable level of risk', recognising that running out of water is not a risk that governments and communities will tolerate for Sydney and the Lower Hunter, regardless of the probability of that risk. Instead, to inform their water supply planning, they have moved to understanding the minimum amount of water needed for the cities to keep running (an enduring level of supply), how long residents and businesses are willing to endure extended water restrictions, and the willingness of communities to pay for increased water security.

This proposed action would investigate whether a similar approach should apply to water supply planning for large regional centres where last resort options such as carting, is not a realistic option.

Progressing this would include understanding the supply that is capable of meeting the communities' minimum needs during periods of prolonged and extreme drought, irrespective of how long the drought lasts and the impact of climate change. This level of supply needs to consider the needs of all segments of the economy and community to ensure we can maintain the right level of health, economic, social and environmental outcomes.

Guidelines for large towns and regional cities would be developed to guide decisions on when the next water supply augmentation should be implemented, and at what cost, noting that sustainable financing for regional water infrastructure needs to be considered as a 'user-pays model' is often cost prohibitive in regional areas.

## Proposed action 1.2: Establish a governance framework to coordinate actions under Priority 1

Throughout the development of the Draft Macquarie–Castlereagh Regional Water Strategy, councils and joint organisations have told us that there needs to be a continued, coordinated focus on supporting and implementing water security measures and drought preparedness for towns. We have heard this needs to be an approach that involves all levels of government.

This proposed action would, in consultation with local councils and local water utilities in the Macquarie–Castlereagh region, establish a governance framework to support the actions under this priority of the Macquarie–Castlereagh Regional Water Strategy. It would consider council and local water utility capacity and capability to contribute to governance framework and take responsibility for actions.

The aim of this action is to support the drought resilience of local councils by improving coordination of water management actions and planning processes that support town water security across different levels of government.

This could build off existing governance structures already set up in the region.

### Have your say

Who should be represented in the governance framework in addition to water supply authorities and local government?

# Proposed action 1.3: Develop guidelines for managing extreme events in the upper Macquarie

The NSW Government has developed an Extreme Events Policy as well as Incident Response Guidelines for each inland valley, which provide a framework for how decisions are made during extreme events and sets out a range of increasing drought contingency measures to secure water for critical needs.

Most of the measures focus on the regulated rivers that are controlled by large state-owned headwater dams – such as Windamere and Burrendong Dams in the Macquarie Valley. This focus is because the regulated river systems are where the major extraction occurs, and state water managers have less ability to manage access for high priority uses in unregulated river catchments.

However, in the upper Macquarie's unregulated catchments there are a range of smaller but locally significant dams and weirs that are owned and operated by local councils to support town water needs. Towns, landholders with basic landholder rights, and environmental needs downstream of these dams also rely on water releases from the dams and there needs to be greater clarity around how the operations of town water supply dams may need to change as we head into droughts.

We also heard the need for greater consistency between town water restriction levels in dry periods, particularly when urban water is supplied from the same source. For example, the Fish River Water Supply Scheme that is operated and maintained by WaterNSW supplies Oberon, as well as Lithgow and the upper Blue Mountains.

This proposed action would develop guidelines that will provide a clear and transparent framework for how and when water releases from town dams in the upper Macquarie could change during extreme droughts, and the communication protocols associated with the changes. This work may also need to be supplemented by plans setting out triggers for how to balance water demand between commercial and social needs within towns during extreme dry periods.

To begin with, the guidelines could focus on Bathurst and Orange, and could address:

- **Triggers for suspending irrigation access below dams** – in Bathurst, the water sharing plan currently suspends irrigation access to water released from Chifley Dam when the dam is below 22% to help prolong water for Bathurst. In the last drought, at the request of council, irrigation access was restricted to 20% of entitlement when Chifley Dam dropped to 44% as an additional measure, which had a small effect on extending the life of the storage. Similarly, for Orange, environmental water releases are required to be made from Suma Park Dam and measured at a gauge 12 km downstream of the dam. Water users take water between the dam and gauging point which may create additional risks as we start to head into dry periods. This would explore whether a more permanent change is needed and if alternative approaches to setting suspension triggers or management measures would be more effective.
- **Operation of Suma Park and Winburndale dams** – developing triggers and communication protocols for when environmental water releases may need to be suspended from council-owned dams and infrastructure during extreme droughts. To give certainty to both Council and the environment, there may need to be changes to operating licences and water sharing arrangements.
- **Cooperative arrangements between council and irrigators to enable more accurate releases from dams** – Bathurst Regional Council has advised that because of dry conditions, high losses and regular irrigation extractions, they have had to release 4 to 5 times the water required for Council's needs from Chifley Dam over summer to ensure sufficient volume reaches their offtake. This task would progress more accurate forecasting of the amount of water needing to be released and would build on the non-urban metering requirements that are being rolled out across NSW.
- **Introduction of temporary river flow access rules for town water supplies** to enable water supply for critical human needs.
- **Communication protocols** – we heard that during the last drought there was limited notice to downstream landholders before water releases ceased from town-owned dams. This impacted the ability of landholders to find alternative options to support stock watering needs. Pro-active communication could help all water users to be in a better position to make decisions during droughts.

## What we have heard

Councils in the region have requested that government consider changes to legislation or regulations to ensure critical human needs are a primary consideration when progressing town water supply options through planning, environmental and development approval processes.

# Proposed action 1.4: Adopt a stronger focus on urban water conservation and efficiency

Using water more efficiently means making the best use of all our available water. The timing for large infrastructure investments can be pushed back by taking smaller incremental measures to reduce growth in water demand such as:

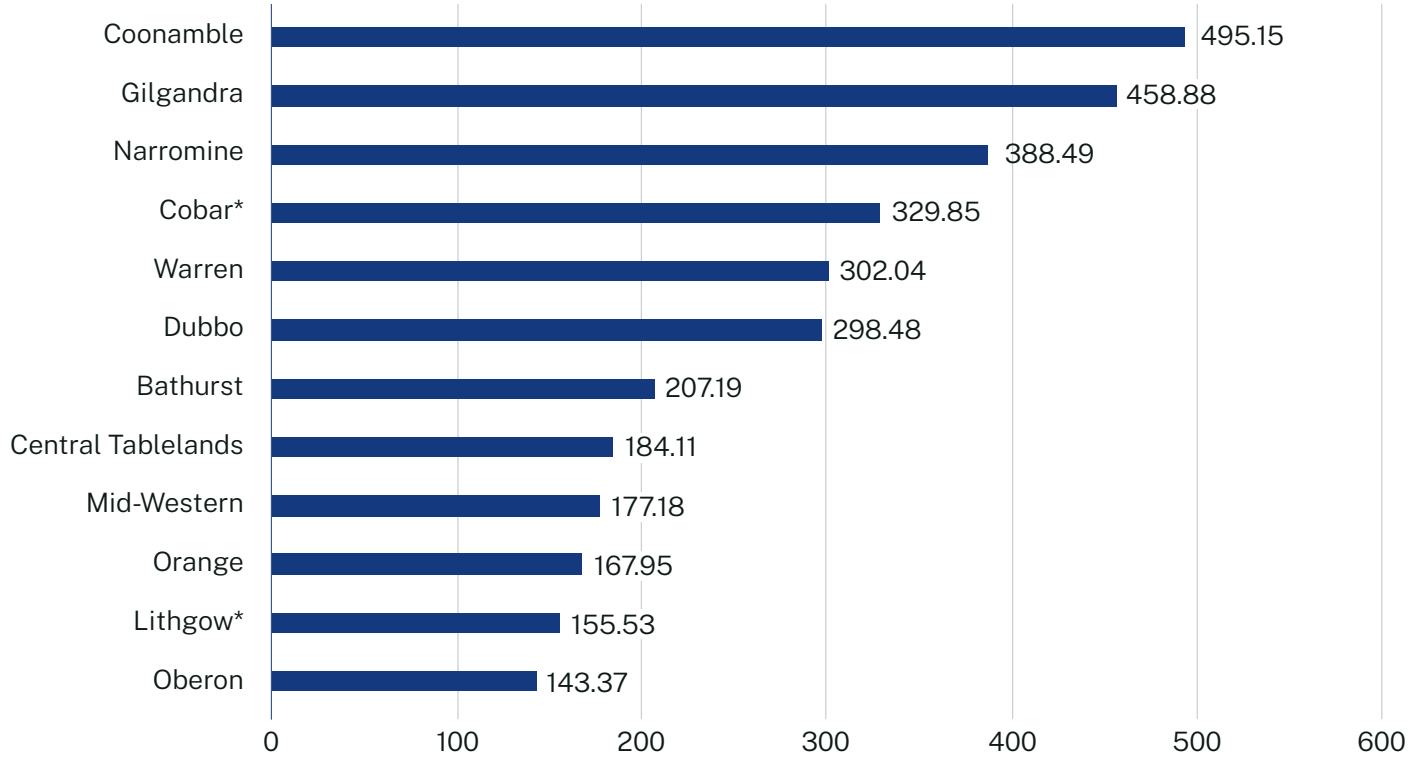
- water restrictions to limit town water use during dry periods and prolong water supplies
- community water conservation schemes, such as installation of rainwater tanks and greywater systems, and encouraging water-efficient appliances
- reducing leakage from pipes
- smart metering and pricing.

We heard strong support from communities and businesses, and across government, for such measures during public consultation on the Draft Macquarie–Castlereagh Regional Water Strategy. We also heard that many local water utilities in the region learnt a great deal through the millennium and most recent drought around demand management and continue to implement initiatives aimed at reducing water consumption in their communities.

Local water utilities have an important role in managing urban water conservation and improving town water use efficiency in the Macquarie–Castlereagh region. For large centres like Bathurst and Orange, demand management have been vital for sustaining essential town water supplies through extended droughts. However, urban water conservation and efficiency will continue to be required into the future to support population and industry growth without increasing water security risk. There are opportunities for a more concentrated focus on demand management and water efficiency measures for numerous towns in the region (see Figure 14) and standardisation of water restrictions across surface and groundwater users.

This proposed action would support councils to implement the Government's new state-wide Water Efficiency Framework, which is designed to increase the capacity and capability of local water utilities to plan and implement water efficiency measures and programs. The framework focuses on building water efficiency capacity, gaining a greater understanding of water use, improving the evaluation of water efficiency initiatives and increasing private sector involvement in water conservation and efficiency.

**Figure 14. Average annual residential water supplied (potable) (kL/property) in towns across the Macquarie–Castlereagh region (2013–2021)[35]**




*These towns do not lie within the Macquarie–Castlereagh region but receive water from the Macquarie–Castlereagh region catchment.

35. Data for other NSW towns can be found at www.industry.nsw.gov.au/water/water-utilities/lwu-performance-monitoring-data

## The NSW Water Efficiency Framework and Program

The NSW Government has introduced a new Water Efficiency Program and Water Efficiency Framework. Through this program, government is collaborating with key stakeholders to increase investment in water system efficiency, water conservation and demand management, which can delay the timing and reduce the scale of investment in new supply infrastructure.

### Regional Leakage Reduction Program

A key aspect of the Water Efficiency Program is addressing network leakage and water loss as a priority. The need to focus on local water utilities' network leakage and water losses became apparent during the drought and has been reinforced during consultation with councils and the wider sector as part of the Town Water Risk Reduction Program.

Coonamble and Warrumbungle Shire councils in the Macquarie–Castlereagh region are participating in this program. The Central West Joint Organisation is also overseeing a joint leakage reduction initiative across its member councils in the Upper Macquarie region, including Orange, Bathurst and Oberon.

The initiative will audit member councils' water loss management approaches and provide tailored assistance to improve approaches through co-funding infrastructure upgrades and training.

### Smart Approved WaterMark – Smart Water Advice Program

The NSW Government and Smart Approved WaterMark are partnering with local water utilities and councils to provide subsidised subscriptions to the Smart Water Advice Program. Subscribers to Smart Water Advice receive water efficiency tips and advice, interactive tools and information to share with their communities.

## Local Water Utility performance data

The NSW Government provides and maintains a public web-based database for NSW regional water utilities to annually report their current water supply and sewerage data.[36] Performance monitoring and benchmarking are required under the National Water Initiative and provide assurance to the NSW Government that the requirements of the *Water Management Act 2000* are being met (i.e. each local water utility is performing satisfactorily).


Image courtesy of Destination NSW. Streetscape, Dubbo.

36. Department of Planning and Environment, *Water Utilities Performance Data*, www.industry.nsw.gov.au/water/water-utilities/lwu-performance-monitoring-data

# Proposed action 1.5: Invest in innovative water supply options

Increasing rainfall-independent water supplies for domestic and town water needs will be critical to the long-term resilience of the region's communities. With diminishing surface water availability under a potentially drier climate and fully committed groundwater sources, innovative water supply options such as stormwater harvesting, re-use of water and managed aquifer recharge are important actions that will need a continued focus in the coming decades. Investing in water treatment and reuse initiatives will help to reduce reliance on potable water in dams and rivers.

Stormwater and recycled water are largely underused town water sources in the Macquarie–Castlereagh region. We heard strong support from the community, industry and towns for the development and adoption of these alternative water supplies.

## Stormwater harvesting

Stormwater is runoff from rain that falls on hard surfaces such as roofs, roads, footpaths and car parks. This runoff flows from property drains into street drains owned by local councils. It then flows into much larger channels and pipes that run to waterways.

Stormwater is a highly valuable resource and greater effort has been taken in recent years to collect, clean and re-use urban stormwater. Stormwater harvesting can relieve pressures on the wastewater system.

Orange City Council has implemented successful stormwater harvesting schemes in recent years and, if expanded, treated stormwater has the potential to supply over 25% of Orange's water demand.[37] Stage 2 of the Blackmans Swamp Creek Stormwater Harvesting Scheme is currently underway (known as the East Orange Harvesting Wetland). Bathurst Regional Council is constructing a $20 million 2-stage stormwater harvesting scheme, and recently secured NSW Government funding under the Regional Stimulus Program for the first stage. Bathurst Councils is beginning investigations for a second water harvesting scheme. The volume of water provided back into the system is 1,100 to 1,500 ML/year in Stage 1 and 1,800 to 2,350 ML/year in Stage 2.[38] Bathurst Council is beginning investigations for a second water harvesting scheme.

Our analysis suggests that additional stormwater harvesting schemes in Bathurst and Orange will reduce each city's time spent in severe water restrictions and reduce the pressure on their primary water supplies (Attachment 2). However, stormwater harvesting schemes alone will not go far enough to adequately reducing water security risks for the region's major cities – and these schemes need to be progressed as part of a broader package of actions.

This action would improve the regulatory framework and support councils to implement stormwater harvesting schemes.

37. Orange City Council 2019, *Stormwater Harvesting*, www.orange.nsw.gov.au/water/stormwater/
38. The yield is based on the average of the 3 years of the worst drought on record (2017–2019).

## Stormwater harvesting: a successful venture for Orange

In August 2008, Orange was in the midst of a critical water shortage as a result of the Millennium Drought. Water storages had dropped below 26.7%.[39] At the time, inflows to storages on the outskirts of town were not enough to meet demand and few alternative supplies were available.

Urban stormwater harvesting was identified as one solution to meet this shortfall. Blackmans Swamp Creek and Ploughmans Creek stormwater harvesting schemes now operate in urban creek catchments in Orange. These schemes capture a portion of the high creek flows during storm events and transfer them into the nearby Suma Park Dam, where the water is then treated according to the Australian Drinking Water Guidelines.

This alternative water supply has improved the city's resilience to drought. The schemes provide 10% of the town's water supply[40] and an average of 1,350 ML/year of additional water into Orange's raw water supply.[41]

### Advanced water treatment and purified recycled water facilities

With water availability limited, and water security under pressure from droughts and a potentially drying climate, advanced treatment and reuse of water could provide a means for towns to grow without increasing their drought risk. We heard from councils that increased use of advanced treated water for drinking water or industrial use is feasible, with rapidly improving technologies.

Advanced treatment of water has significant potential in reducing water security risks for regional cities:

- **Bathurst** – Bathurst's wastewater is currently treated and returned to the Wambuul/Macquarie River. The amount discharged to the river represents over half of total current average water demand. Advance treatment and purification could allow this water to be used for a range of residential, commercial and industrial purposes. Alternatively, it could be less rigorously treated and used to supply only that part of Bathurst's demand associated with parks and gardens or industries that can use lower quality water.
- **Orange** – Orange supplies wastewater to Cadia Mine, which is an important contributor to the regional economy. There are opportunities to use this water for multiple purposes, however the treatment of the water needs to be demonstrated and tested in regional areas. We have heard from Orange City Council that investing in a demonstration plant for purified recycled water can help provide the data and testing on advanced water treatment facilities in inland regions, as well as providing an opportunity to engage with customers on the technology and the range of beneficial uses for purified recycled water. Any demonstration plant will not form part of Orange's drinking water supply, but would be providing improved water quality back to Cadia Valley Operations for process use under the existing Section 60 approval. Any future decision to include purified recycled water would be subject to community consultation and require stringent Government approvals.
- **Dubbo** – Close to 100% of Dubbo's effluent is recycled to irrigate crops. Other recycling options are also being investigated, such as using recycled water on parks.

Advanced treatment and reuse of water is technically feasible and has been implemented in different locations around the world. However, there are barriers to implementation in New South Wales, including regulatory processes and standards, community acceptance and costs.

The NSW Government has committed to progressing regulatory reform, guidelines and community acceptance campaigns to make the development and use of recycled water easier.[42] The Government will continue to investigate ways to address these limitations at the state and local levels. This will include working with local water utilities to identify policy and regulatory barriers to recycled water use, which will also inform development of a policy framework for purified recycled water regulation.

An important part of progressing this option is gaining community acceptance and support. The primary barrier to progressing some forms of recycled water use at a local level is community hesitancy. We have heard that implementing purified recycled water schemes would require a 10-year conversation with the community. No decision on purified recycled water will be taken without extensive community consultation and stringent government approvals. There are no plans to introduce purified recycled water into the potable system at this time.

39. Cooperative Research Centre for Water Sensitive Cities 2018, *Case Study: Orange Stormwater to Potable: Building urban water supply diversity*, p.11, www.watersensitivecities.org.au/solutions/case-studies/orange-stormwater-to-potable/
40. CRCWSC, *Orange Council Stormwater to potable water Case Study*, May 2018
41. CRCWSC, *Orange Council Stormwater to potable water Case Study*, May 2018
42. www.dpie.nsw.gov.au/water/plans-and-programs/nsw-water-strategy

## Managed aquifer recharge

Managed aquifer recharge – also known as groundwater replenishment, water banking or artificial recharge – stores water in an aquifer or underground storage for future use, including during drought by artificially injecting it into the aquifer with pumps or infiltrated through ponds or purpose-designed wetlands.[43] A range of water sources can be used in aquifer recharge, including stormwater, treated wastewater, river or dam water, or industrial water.

Potential benefits from managed aquifer recharge include:

- minimising evaporation, compared to storing water aboveground
- providing additional recharge to groundwater sources to increase water reliability for groundwater-dependent users, including ecosystems
- reducing pressure on surface water supplies during drought, which could improve environmental outcomes for riverine environments.

During consultation we received support for investigating managed aquifer recharge. It was considered to be an innovative option with potential to enhance water security. Prior studies have indicated that the alluvial aquifers in the region have potential to be used for managed aquifer recharge.[44]

Initial assessments show that a pilot in the Dubbo region could be feasible. Dubbo Regional Council has indicated that a desirable capacity for the managed aquifer recharge scheme would be 1,500–2,000 ML/year. During the final quarter of each water year (April to June), the council could assess its likely surplus urban water entitlement and pump to an aquifer.

Progressing managed aquifer recharge is a NSW Government priority. We are developing the regulatory framework for managed aquifer recharge. As it is a new alternative way of managing and storing water in NSW, extensive stakeholder consultation will be needed, especially as existing users could be affected.

Image courtesy of Nicola Brookhouse, Department of Planning and Environment. Coolah Tops National Park, Bald Hills Creek Falls.

43. For MAR examples, see United Nations Educational, Scientific and Cultural Organisation 2018, *Nature-Based Solutions for Water*, www.unwater.org/publications/world-water-development-report-2018/
44. Gonzalez, D., Dillon, P., Page, D. and Vanderzalm, J 2020, *The potential for water banking in Australia's Murray–Darling basin to increase drought resilience*, Water, 12(10), pp 2936.

# Proposed action 1.6: Plan for the best long-term augmentation solution for the upper Macquarie

As regional centres in the upper Macquarie grow over the coming decades, so will water demand. Reducing water demand and investing in stormwater harvesting schemes can improve urban water security, but these actions alone may not prevent each town from running out of water in a severe drought.

To support longer-term growth in a future where droughts may be more severe than what we have experienced in our lifetimes, additional investment will be needed to maintain security of the water supply and provide confidence for people and businesses to live and work in the region.

The Macquarie–Castlereagh Regional Water Strategy needs to remain adaptive as the region's circumstances, climate and population changes over the next 20–30 years. Adaptive strategies typically do not rely on a single solution, but rather identify a range of feasible solutions. This can allow decision makers to choose the most appropriate options to implement, based on the information, technology and conditions at the time, along with consideration of future economic growth.

We have shortlisted a number of infrastructure and non-infrastructure options that could support medium to long-term water security for towns in the upper Macquarie in the future (Table 5). Note that these are not in any prioritised order, and include:

- supply water to upper Macquarie towns from the Fish River or Coxs River catchment
- supply water to Bathurst and/or Orange from the Lachlan Valley
- new infrastructure in the upper Macquarie, which could include a new Ulmarrah Dam at Dixon Long Point
- increase the volume of water Orange can access each year from the Wambuul/Macquarie River.

Each of these options merit further investigation and planning as they have their own advantages, disadvantages and costs. Each option will require more detailed investigations, community consultation, consideration against alternatives and economic and environmental assessments.

It is likely that several or all of these options may need to be implemented to reduce town water security risks in the upper Macquarie, particularly if we start to see impacts of a dry climate change scenario. The critical factor will be identifying the most appropriate staging and pathway for implementation.

## Supply water to upper Macquarie towns from the Fish River or Coxs River catchment

The Coxs River catchment and Fish River Water Supply Scheme straddles the border between the Macquarie–Castlereagh region and the Sydney catchment. There are a range of rivers, creeks, groundwater sources, weirs and dams in this system. The water from the rivers, dams and groundwater sources in this border area supplies water for customers in the Greater Sydney Metropolitan area, power generation, mines, minor consumers and the townships of Oberon, Lithgow and surrounding villages.

This option proposes to investigate augmenting Bathurst and Orange's water supplies with water from the Fish River Scheme or the Coxs River catchment. This could include assessing water availability from Duckmaloi Creek. If progressed, this option would need to ensure there are no adverse impacts on water security for Oberon or Sydney's Blue Mountains area.[45]

Our initial analysis indicates that an annual water entitlement of 4.6 GL from the Fish River Scheme could significantly reduce Bathurst's risk of water supply shortfall and ensure it has a secure water supply for many years into the future (Attachment 2). With some infrastructure changes at Oberon Dam,[46] water could be supplied to Bathurst either via the Fish River or via pipeline into Chifley Dam. However, if water needs to be released from Oberon Dam via Fish River, especially during drought, it causes significant water transmission loss.[47] This would also need to be considered during further assessment of this option. It could also be supplied to Orange either as flows in the Wambuul/Macquarie River or by input into a regional pipeline network.

The challenge in the short term will be securing this water from existing licence holders. Over the longer-term, water from the Fish River Scheme and the Coxs River near Lithgow could become available as coal fired power stations close down and industry transitions in the coming decades. The Wallerawang power station has shut down and the Mt Piper power station is scheduled to close in the next 10–15 years. It is not clear whether and when this water will become available. In addition, if the water becomes available, there will be competing demands for it, as it could also be used to further reduce the water security risks for towns in the Blue Mountains, support economic growth and new industries in the Lithgow region or be held by Aboriginal people for cultural and economic purposes. It is not clear whether and when this water will become available.

Progressing this action would involve further assessment of the timing of if and when water may become available, the design of infrastructure, the impacts on customer pricing, and the benefits or trade-offs of using the water for other needs. The financial costs associated with paying for water from the Fish River Scheme may be significant for water users.

45. The Greater Sydney Water Strategy has identified a portfolio of actions that are being progressed to support Sydney's water security.
46. Oberon Dam is a 45 GL water storage that is owned and operated by WaterNSW as part of the Fish River Water Supply Scheme.
47. Transmission losses – water, from an accounting perspective, that is considered lost through surface water seeping into the ground or evaporation.

## Supply of water from the Lachlan Valley to the upper Macquarie

The eastern part of the Lachlan Valley includes a range of state-owned and council-owned water storages that support the water needs of towns, industry and the environment in the Lachlan Valley.

The NSW Government is currently investigating the feasibility of augmenting Lake Rowlands and constructing a pipeline between Lake Rowlands and Carcoar Dam as part of the Belubula Water Security Project, and is considering raising Wyangala Dam as part of the Wyangala Dam business case.

There is already a pipeline connection from Orange into the Lachlan Valley. There is an opportunity to consider whether water from the Lachlan Valley could help reduce future water security risks for Bathurst and Orange through the changes to infrastructure currently being investigated. Impacts on the Lachlan Valley of these options will also need to be considered.

The viability of this option for Orange and Bathurst will depend on how effective this option is in reducing Bathurst and Orange's water security risks compared to other options presented in this strategy, and whether there are other viable options that a viable in light of business case analysis.

A Sub-regional Town Water Strategy is being developed by Orange City Council. Cabonne Shire Council and Central Tablelands Water to cover their areas of operation in the upper Macquarie Valley. Existing and proposed pipeline links between the towns of Manildra, Orange and Molong (and adjacent areas) will be assessed. Linking these existing town water supply schemes can provide shared benefits and improve the drought resilience of the individual town water supply schemes.

## New infrastructure in the upper Macquarie, such as an Ulmarrah Dam at Dixons Long Point

Additional infrastructure in the upper Macquarie could help support the water needs of Orange and Bathurst and surrounding communities.

A dam on the Wambuul/Macquarie River at Dixon's Long Point (Ulmarrah Dam) was proposed by several stakeholders in submissions on the Draft Macquarie–Castlereagh Regional Water Strategy. Our analysis suggests a dam of 20–30 GL capacity could meet Orange's long-term water needs. However, given the large cost and impacts of the dam on the environment and other water users (see Attachment 2), the other options in this action may be more cost-effective for reducing Orange's water security risks in the short to medium term.

We have also heard from councils that options such as a pipeline from Burrendong Dam to Orange and Bathurst should be considered in more detail and assessed against other infrastructure options.

## Providing additional water from the Wambuul/Macquarie River for Orange

Orange currently has a pipeline to the Wambuul/Macquarie River and a licence to take water from the river for town water supply. This is an important part of Orange's water supply system. Orange can take up to a maximum of 1,286 ML/year,[48] but cannot take water when the river levels are lower than the cease-to-pump threshold of 108 ML/day. One option to bolster Orange's water security is to increase the annual limit on water taken under this licence, while still adhering to the cease-to-pump rules.

Our analysis suggests that increasing in the annual take limit would very effectively decrease the time that Orange is under severe water restrictions (see Attachment 2) and has the potential to reduce the risk of Orange running out of water. However, these benefits deteriorate under a dry climate change scenario because this option relies on river flows which will become less reliable under the extreme climate change scenarios.

Increasing the annual take limit does not impact storage levels in the downstream Burrendong Dam or the reliability of allocations from the dam the Wambuul/Macquarie River water users (see Attachment 2). Subject to additional impact analysis, including consideration of how the increased water licence volumes would be sourced, this may be a good near-term option to progress.

48. Total transfer over any 3-year period not to exceed average 643 ML/year (i.e. maximum 1,929 ML total transfer over any 3-year period).

# Proposed action 1.7: Reduce uncertainty in groundwater security for the region's towns

Most towns in the Castlereagh catchment, including those in Warrumbungle Shire Council, and some towns in the lower Macquarie, such as Warren and Narromine, rely primarily on groundwater for water supply. Towns such as Dubbo rely more heavily on groundwater during droughts. We have heard from councils that there is uncertainty about how long the town water bores will be able to sustain the towns during droughts, and whether there needs to be emergency provisions to ensure groundwater supplies are available for towns during extreme events. We also heard concerns about declining groundwater levels during consultation on the Draft Macquarie–Castlereagh Regional Water Strategy.

Where there is a high density of irrigation bores, the local groundwater level can decline during the pumping season. This makes it harder to extract the same amount of water from nearby bores, including those used for town water. The problem is exacerbated during severe droughts because more water is extracted during the pumping season. In addition, strategic regulatory and policy actions are needed to improve groundwater certainty for towns, along with investigations at the local level.

## It can be challenging for councils to secure water for small towns

Thirteen water utilities in the Macquarie–Castlereagh region supply town water. These local water utilities are responsible for providing water and sewerage services for their communities. This responsibility extends to planning for and delivering secure water supplies, with support from the NSW Government.

For many small towns across the region, ensuring that water supplies are secure can be difficult. Councils such as Warrumbungle Shire, which has 8 individual water supply schemes servicing small and isolated communities in the Castlereagh, often do not have the technical skills and financial resources to undertake investigations to assess water security risks and to identify supply options.

The NSW Government is working on ways to improve support for councils in delivering water for small communities through the Town Water Risk Reduction Program and the Safe and Secure Water Program.

At the local level, the critical factor in supporting groundwater-dependent towns is to understand whether town water bore infrastructure is sufficient to sustain town water supply during droughts. This includes ensuring:

- there are an appropriate number of bores that are sufficiently deep and well-constructed so that bore yield is not affected by declines in the groundwater level during drought. It is important that these bores can sustain the needs of the local water utility over an extended period of time
- there are suitable water treatment facilities to support the long-term treatment and use of groundwater sources for towns.

The site-specific nature of this issue means that local-level investigations are the best way to understand risks to water supply. The NSW Government may provide funding and support councils to undertake these investigations through local level planning processes. Narromine Shire Council has commenced local level groundwater investigations.

At the strategic level, the NSW Government can provide clear guidance around how high priority groundwater needs such as town water supply will be managed in the Macquarie–Castlereagh region. This includes:

- ensuring policy positions and licence/approval assessment processes are clear and streamlined
- exploring the option of granting temporary licences to access groundwater during drought
- reviewing the regulation of basic landholder rights (including stock and domestic) to assess whether new rules are required to better manage this type of water take when water restrictions are in force
- investigating the degree of connectedness and time lags between groundwater and surface water and the influence that each has on the successful management of the other, and exploring a joint trigger arrangement in areas where it would be effective. This may be particularly useful in managing the Cudgegong Alluvial, which has high connectivity with the overlying river.

## Taking a closer look at groundwater sources in NSW

The NSW Government is developing a state-wide Groundwater Strategy that identifies the key risks to our groundwater resources and the associated management challenges for NSW. The strategy sets out the actions required to respond to these challenges and provide a logical framework for funding of groundwater management reform work over the next 20 years.

## Have your say

Do you support changing the groundwater assessment framework so that towns are given priority over all other water users?

Image courtesy of John Spencer, Department of Planning and Environment. Post Office residence, Hill End Historic Site.

# Proposed action 1.8: Support management of Oberon's town water quality issues

This action includes providing ongoing support to Oberon to improve water quality for Oberon's citizens and businesses. This will involve:

- the NSW Government continuing to provide ongoing technical support and guidance to help manage water quality matters. In the short-term this may continue to focus on managing the reticulation system
- working with WaterNSW to improve the quality of raw water supplied to Oberon to reduce treatment difficulties at Oberon
- exploring options to support the financial costs associated with sourcing water from the Fish River Scheme
- a first step may include more granular studies of Oberon's water quality and quantity needs to confirm the best immediate course of action.

Image courtesy of Destination NSW. Lake Oberon, Oberon.

Image courtesy of Destination NSW. Macquarie River, Dubbo.

# Priority 2

## Reduce water security risks in the region's west

Water in the lower Macquarie catchment, downstream of Burrendong Dam, plays a critical role in supporting major economic activity in the region and towns as well as globally significant ecological assets. A more variable or drier climate will mean more times when there is no water in the lower reaches of Wambuul/Macquarie River, increasing water security risks for towns at the end of the system and difficulty in meeting water needs downstream of Burrendong Dam. We have also heard a strong desire to support the drought resilience of industry.

We will need to invest in multiple actions to reduce these risks. There are opportunities to fast track and implement a range of no regrets, cost effective solutions in the lower Wambuul/Macquarie while gathering further evidence needed to progress large, regionally significant projects.

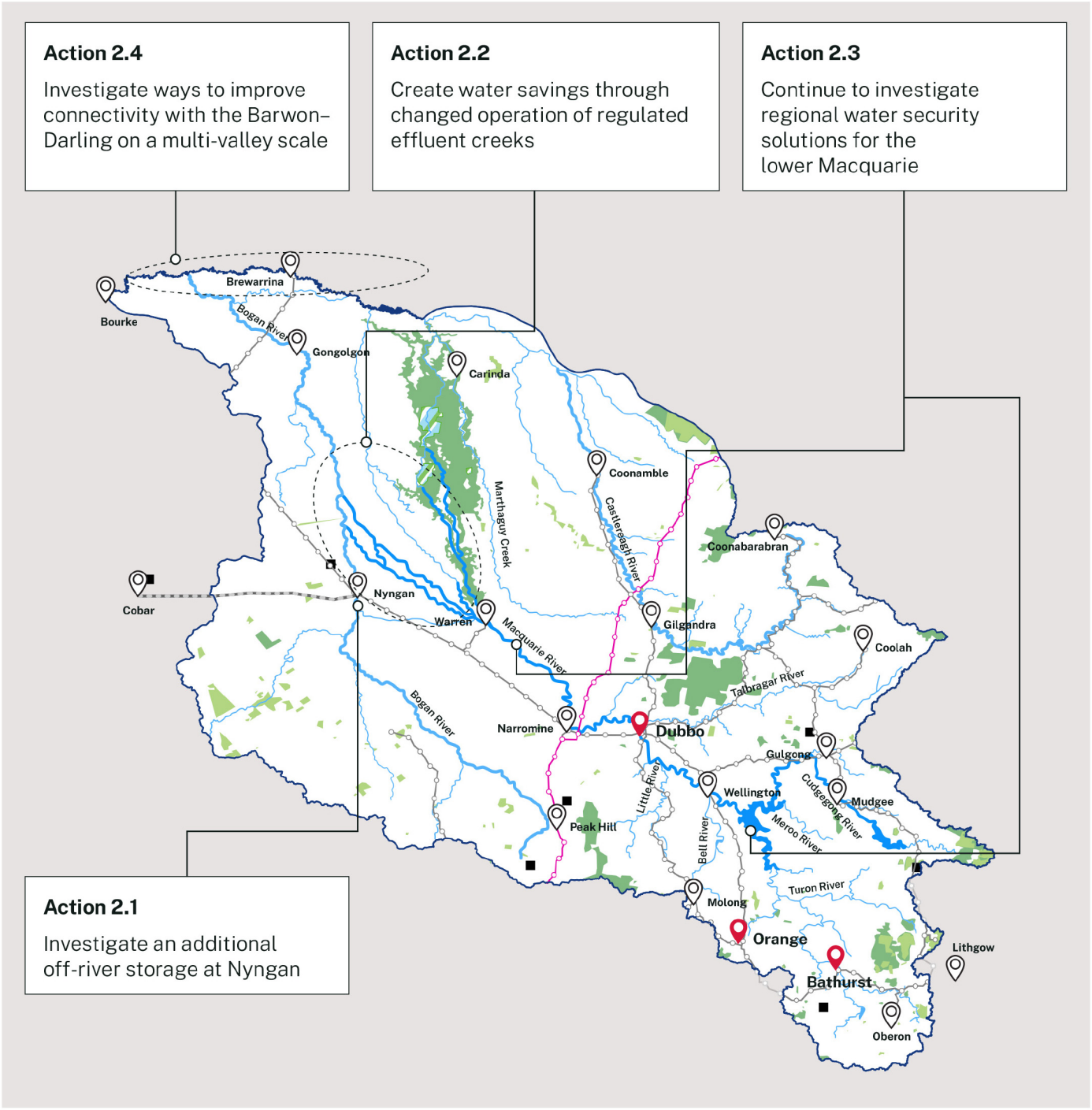
This priority focuses on actions to:

- more efficiently deliver water to high priority needs and reduce town water security risks in the lower Macquarie region
- improve the drought resilience of industry in the lower Macquarie region
- ensure that the actions progressed do not impact environmental assets, including reduce the flows into the Ramsar listed and ecologically significant Macquarie Marshes or the end of the Wambuul/Macquarie River.

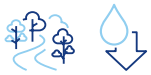
We also need to ensure we can secure water to contribute to needs downstream of the valley at important times. It may not be possible to always meet all needs from river flows given that the Macquarie catchment mainly connects with the Barwon–Darling catchment during high flow periods. However, it is important that when flows resume after a prolonged drought that they are initially protected from commercial extraction to ensure that they can flow through the system.

Image courtesy of Ines Richter, Department of Planning and Environment. Burrendong Dam Spillway.

**Figure 15. Priority 2: Reduce water security risks in the region's west**



| Legend | | | | |
|---|---|---|---|---|
|  Reducing water supply risks for regional cities, towns and villages |  Supplying water to high priority needs in the lower river system and connected valleys |  Supporting a growing regional economy in a future of potentially reduced water availability |  Addressing barriers to Aboriginal water rights |  Maintaining and improving the health and resilience of the region's aquatic and floodplain ecosystems |

| Proposed action | Summary | Challenges addressed |
|---|---|---|
| **Action 2.1**<br>Investigate an additional off-river storage at Nyngan | Undertake detailed investigations for a third off-river, town water storage at Nyngan. |  |
| **Action 2.2**<br>Create water savings through changed operation of regulated effluent creeks | Progress investigations to return the regulated Gunningbar, Duck and the upper part of Crooked Creek to a more variable flow regime with occasional periods of no flow, including alternative ways to supply water to the essential stock and domestic needs in dry periods through bores or pipelines. |  |
| **Action 2.3**<br>Continue to investigate regional water security solutions for the lower Macquarie | Assess in detail the following options:<br>• use some of the flood mitigation storage in Burrendong Dam for water supply<br>• a new re-regulating weir in the mid-Macquarie (Gin Gin)<br>• a regional pipeline connecting Dubbo to Nyngan and other towns. |  |
| **Action 2.4**<br>Investigate ways to improve connectivity with the Barwon–Darling on a multi-valley scale | Develop the most effective coordinated options to improve connectivity across all Barwon–Darling tributaries through the Western Regional Water Strategy. |  |

# Proposed action 2.1: Investigate an additional off-river storage at Nyngan

Water travels approximately 200 km from Burrendong Dam to supply Nyngan and Cobar via the Wambuul/Macquarie River, Gunningbar Creek and then the Albert Priest Channel. Bogan Shire Council's annual water demand is approximately 5,000 ML and future droughts may mean it is more difficult to deliver water down these rivers and creeks to meet this demand.

Bogan Shire Council has constructed a 650 ML off-river storage that requires sealing to prevent leakage. Council also has plans for a second 550 ML storage.

This action proposes a third off-river storage at Nyngan to reduce the risk of Nyngan running out of surface water or being in water restrictions for extended periods of time.

Our analysis indicates a third off-river storage at Nyngan with a capacity of 3,000 ML could significantly reduce the water security risks for Nyngan and increasing the resilience of Nyngan and Cobar during droughts. The analysis also indicates benefits for general security and high security licence holders in the regulated Macquarie River (see Attachment 2).

Further detailed investigations will need to be undertaken to confirm a preferred site, geotechnical site suitability, environmental implications and cost considerations. We have heard from Councils that if progressed, local businesses should be engaged to implement and build the off-river storage.

We also heard from other councils in the lower Macquarie system that an additional off-river storage may also provide local and regional drought security benefits if located near Warren or Narromine.

Image courtesy of Destination NSW. Bogan River, Nyngan.

# Proposed action 2.2: Create water savings through changed operation of regulated effluent creeks

Gunningbar Creek, Crooked Creek and Duck Creek all branch off the main trunk of the Wambuul/Macquarie River (refer to Figure 15) and are often termed as effluent creeks. Naturally, all 3 creeks would have flowed about 15% of the time. These creeks are now regulated and weirs on the Wambuul/Macquarie River and Gunningbar Creek allow water to flow into them whenever there is any flow in the Wambuul/Macquarie River, altering the ecological assets and processes that have now adapted to these conditions. As a result, it is rare for these creeks to stop flowing (Figure 16), and the ecological assets and processes have needed to adapt to these conditions.

Tritton mine, irrigation farms and livestock farmers rely on the water in these creeks. During dry periods large volumes of water are needed to deliver water to meet these needs. Supplying the stock and domestic needs on the effluent creeks through alternative means could save a substantial quantity of water that could be used to bolster town water security, be left in the river for environmental needs or support the drought resilience of industries.

This action proposes to return the Gunningbar, Duck and the upper part of Crooked Creek to a more natural regime with occasional periods of no flow. This action would be supported by investments in alternative ways to supply water to the essential stock and domestic needs in dry periods through bores or pipelines rather than the inefficient delivery of water down the creeks.

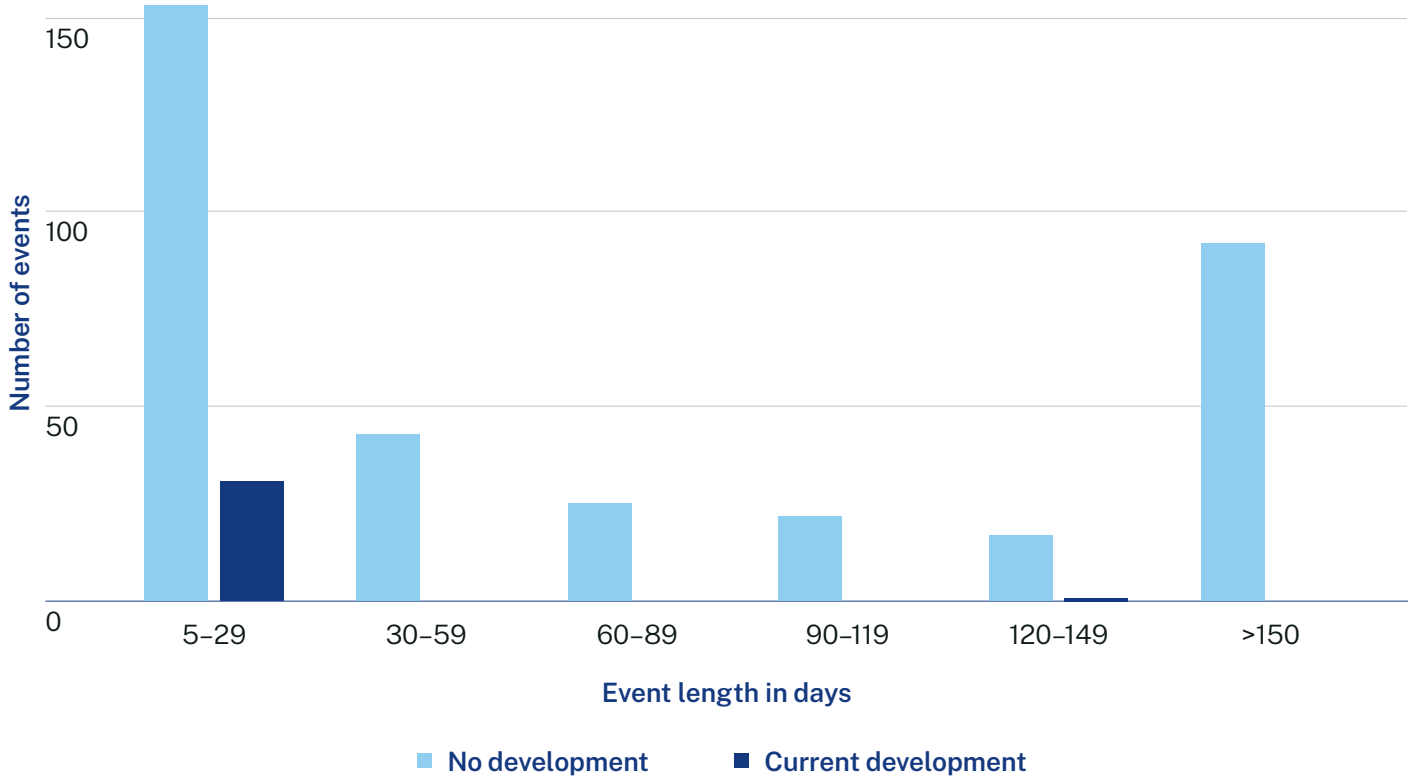
We have heard that the stock and domestic systems installed through irrigation networks such as in the Trangie Nevertire system, could be a good example to model these investments off. We also heard from councils that strategic lining of sections of the Albert Priest Channel followed by a further program of lining rest of the channel may be an option to consider.

This action would need to be supported by related ecological assessments and management actions, including a riparian fencing program. We have heard that many properties have come to rely on the creeks as 'fences' for stock movement, and for their aesthetic value in a dry landscape.

Changing the operation of Gunningbar, Duck and Crooked creeks could:

- save water that could be used for improved water supply reliability and flows into the Macquarie Marshes
- allow for more reliable water supplies for stock and domestic and high priority licences during times such as the recent drought when flows down the creeks had to be cut off.

**Figure 16. Modelled effect of development on frequency of no flow events in Gunningbar Creek**




There have been several previous investigations into this option that included technical analysis and consultation. There continues to be concerns from landholders about reduced access to creeks. Implementing this action will involve:

- identifying current stock and domestic users and needs for each creek, and evaluating potential alternative methods of supply (such as piping, bores, tanks and troughs)
- identifying the major stock users on each creek and determining the timing and volume of water they require
- identifying potential impacts, including environmental implications, and consulting with landholders, water users and key stakeholders
- upgrading the Macquarie River system model to more accurately estimate potential water savings from the options identified[49]
- confirming funding and ongoing operation and maintenance of any new works.

49. Initial hydrologic analysis of this option has been undertaken as part of the regional water strategy. However, the Macquarie River system model at the time of the analysis was not accurately analysing the changes in the flow regime at the extreme dry ends at the end of the river system. The model is in the process of being updated and this option will need to be reassessed with the upgraded model.

# Proposed action 2.3: Continue to investigate regional water security solutions for the lower Macquarie

In 2019, the NSW Government committed to progressing a final business case for a re-regulating weir on the mid Wambuul/Macquarie River to improve the efficiency of water deliveries along the river.

Since that time, the region has experienced the full effects of the worst drought on record, exposing the vulnerabilities of the businesses, towns and ecosystems to extreme droughts. Our new climate data has also highlighted that long-term options to improve water security for the lower Macquarie need to focus on:

- reducing water security risks for major regional cities such as Dubbo, as well the towns and high priority licences at the end of the Wambuul/ Macquarie system
- ensuring there is no significant reduction of water flowing into the Macquarie Marshes
- improving the drought security of water dependent industries that drive the economy.

Our strategic analysis has identified there are a number of shortlisted options that could help support long-term water security for users in the lower Macquarie and that merit further comparative analysis. These include:

- using some of the flood mitigation storage in Burrendong Dam for water supply
- a regional pipeline connecting Dubbo to Nyngan and other towns
- the proposed new weir for replacement of the aged and damaged Gin Gin Weir.

These options could be investigated as part of the business case considering the replacement of the Gin Gin weir.

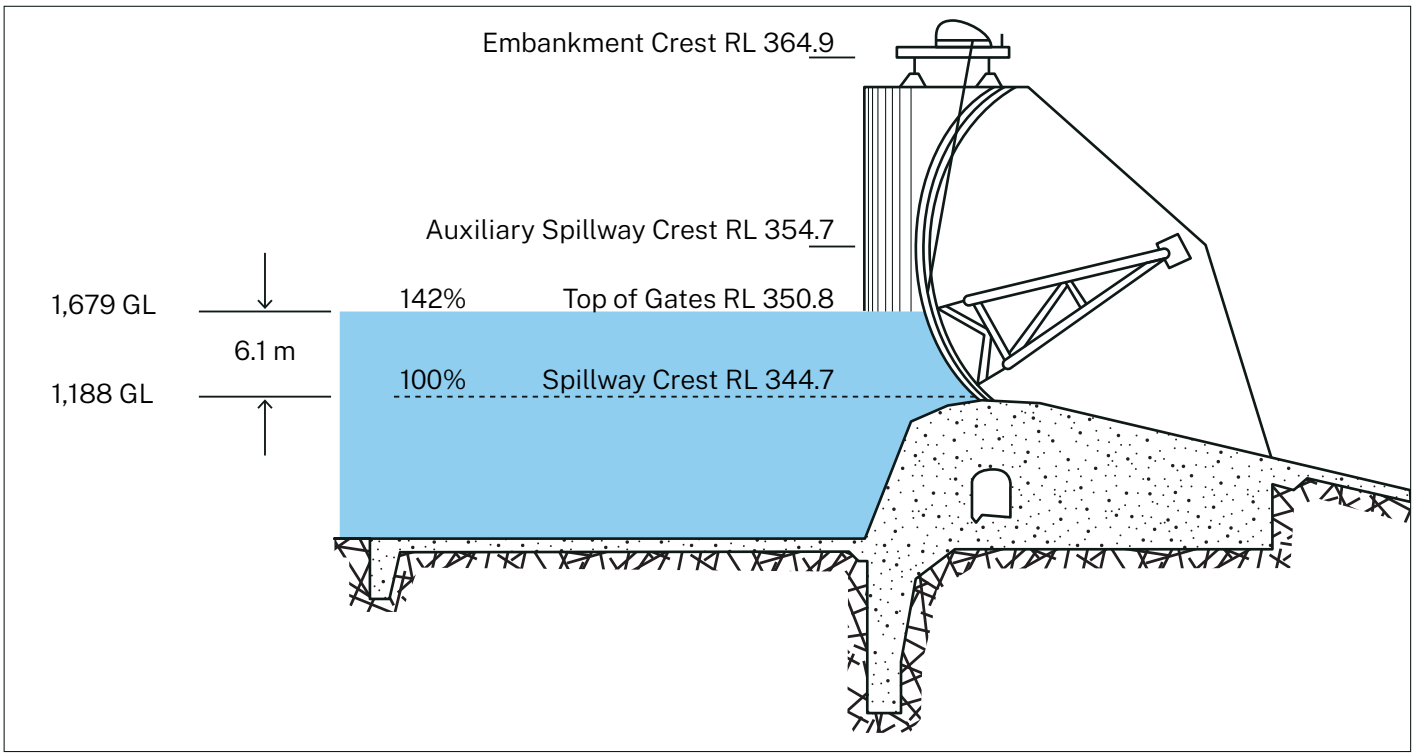
Each is an independent option and they are not presented in any prioritised order. The benefits that the options could provide will change if proposed actions 2.1 and 2.2 are implemented. Each option will include appropriate adjustments to water sharing rules so that the benefits can be realised, and the infrastructure can be operated in a way that benefits multiple water users and the environment, with any potential impacts avoided or mitigated as needed.

## Use some of the flood mitigation storage in Burrendong Dam for water supply

Burrendong Dam was built for the dual purposes of storing water to secure supply to a range of water needs and flood mitigation. The maximum amount allowed to be stored for water supply is called the full supply level. This volume is 1,188 GL. The storage capacity above the full supply level, 491 GL, is referred to as the Flood Mitigation Zone (Figure 17). Water is only stored in the Flood Mitigation Zone during times of flood and is released after the peak of the flood recedes. The purpose of doing this is to reduce the peak level of flooding downstream.

Since Burrendong Dam's completion in 1967, water has been stored in the flood mitigation zone on 20 separate occasions, with the longest being for 24 months in the early 1970s.

**Figure 17. Critical storage levels of Burrendong Dam**




Source: WaterNSW.

This proposed action is to repurpose some of the existing capacity of Burrendong Dam from flood mitigation to water supply. One proposal is to increase the water supply capacity by 13–15%. Different levels can be considered.

We have heard that if this action is implemented, the operation of the flood mitigation zone needs to be sensitive to the conditions on the ground. The benefits of pursuing this option will also need to be shared amongst different water users and the environment.

Our analysis (Table 4) using the historical climate dataset suggests that increasing the full supply level of Burrendong Dam by 13% could:

- improve water availability to general security water users (+3.7% in diversions) and supplementary water users (0.2% in diversions)
- reduce the time Burrendong Dam is sitting at low levels, and as a result, reduce the time that towns such as Dubbo is in severe water restrictions
- be operated to ensure there is no net reduction in water flowing into the Macquarie Marshes and end-of-system flows into the Barwon River (noting however that there may be implications fort eh effectiveness of these flows, such as changes to timing, duration and frequency of flow events downstream).

A reduction of the available flood mitigation zone could increase flood risk downstream (Table 4). However, there is potential for this to be mitigated by revised operating protocols.

**Table 4. Effects of increasing Burrendong Dam's water supply capacity by 13% under different climate scenarios**

| | Historical climate | | Dry future climate change scenario | |
|---|---|---|---|---|
| | Base case | 13% increase to Burrendong Dam Full Supply Level | Base case | 13% increase to Burrendong Dam Full Supply Level |
| General security use (GL/year) | 246.0 | 255.1 (+3.7%) | 133.1 | 137.2 (+3.1%) |
| Average end of year general security allocation (%) | 63.7 | 65.6 (+3.0%) | 35.5 | 36.4 (+2.4%) |
| Average annual flow into Macquarie Marshes[50] (GL) | 450.7 | 446.8 (-0.9%) | 239.9 | 238.2 (-0.7%) |
| Days active storage in Burrendong Dam falls below 10% at least once (%) | 9.8 | 9.2 (-6.4%) | 30.7 | 30.4 (-0.7%) |
| % days with floods above high flow (158,092 ML/day) at Narromine (%) | 0.0 | 0.1 (+13.0%) | 0.0 | 0.0 (Nil change) |

The results of this analysis suggest there is merit in further investigating this option. However, immediate tasks required to assess this action are:

- **Safety assessments** – an assessment of the infrastructure and safety of the dam is required under the Dams Safety NSW guidelines for Dam Safety Management System (DSMS) to understand whether the risks associated with changing the full supply level can be effectively mitigated. This assessment will identify any structural costs associated with changing the full supply level as well as the extent to which enhanced operating protocols and flood risk monitoring and warning systems could minimise the reduction in flood mitigation capacity. WaterNSW has indicated that the Burrendong Dam assessments have previously assumed there is water in the Flood Mitigation Zone at the commencement of the possible extreme flood events. However, the proposed changes to full supply level and operational procedures would need to be considered under the guidelines for DSMS and any changes in dam safety risk may lead to the need before upgrades to the dam structure. The detailed assessment is estimated to take approximately 2 years.
- **Ecological and biodiversity impacts** – our preliminary assessment suggested there are key protected fish species and properties immediately upstream of Burrendong Dam that are likely to be affected (mostly state-owned and a few in private ownership) from a decrease in the flood mitigation zone due to an increase in the dam's full supply level.

50. Assessed using the combined stream gauges of 421088 and 421090.

## Replacement of the aged and damaged Gin Gin Weir

The existing 120-year-old Gin Gin Weir is located on the Wambuul/Macquarie River north east of Trangie. The weir is damaged and presents a barrier for fish in the river. The current concrete structure was damaged by severe floods in 1903, reducing it from 9 m to its present overflow crest height of about 4 m. Locals use the sandy area on the riverbank near the weir, colloquially referred to as the 'beach', for fishing, camping and recreational purposes.

The NSW Government commenced a business case considering replacing the Gin Gin Weir with a new, modern gated 6 GL mid system weir and fishway 200 m downstream of the existing weir. The proposed weir could temporarily capture water that was ordered but then cancelled by water users, and then release it downstream for subsequent water orders.

We have heard concerns that the weir will reduce the water flowing into the Macquarie Marshes and capture water from tributary flows that otherwise flows down the river. If the weir is progressed, these concerns could be addressed through its operating procedures. The gate could be operated to allow for low flow events, tributary flows and floods to pass through.

Our analysis suggests that a new re-regulating weir could increase the long-term average annual amount of water taken by general security licences by 2.7% (6.6 GL)[51] under the observed historic record. The modelled benefits are slightly lower under the dry climate change scenario (Table 5).

A fishway on the weir could open up this section of the river to provide about 140 km of uninterrupted fish passage between Narromine and Warren, allowing fish to migrate upstream and downstream.

Community and stakeholder feedback has resulted in significant project design changes including reducing the storage capacity from 9 GL to 6 GL and improving the design of the fishway.

Further consultation will be needed to identify culturally significant sites, minimise impacts on the environment and nearby landowners, reduce project costs and improve river operations.

**Table 5. Effects of a new 6 GL re-regulating weir at Gin Gin under different climate scenarios**

| | Historical climate | | Dry future climate change scenario | |
|---|---|---|---|---|
| | **Base case** | **6 GL re-regulating weir** | **Base case** | **6 GL re-regulating weir** |
| General security use (GL/year) | 246.0 | 252.6 (+2.7%) | 133.1 | 136.4 (+2.5%) |
| Average end of year general security allocation (%) | 63.7 | 63.6 (-0.3%) | 35.5 | 35.5 (Nil change) |
| Average annual flow into Macquarie Marshes[52] (GL) | 450.7 | 445.7 (-1.1%) | 239.9 | 236.7 (-1.3%) |
| Days active storage in Burrendong Dam falls below 10% at least once (%) | 9.8 | 10.2 (4.5%) | 30.7 | 30.9 (+0.9%) |

51. A portion of this volume is licensed (held) environmental water.
52. Assessed using the combined stream gauges of 421088 and 421090.

## A regional pipeline connecting Dubbo to Nyngan and other towns

Dubbo Regional Council has proposed constructing a pipeline from Dubbo to Nyngan to improve the efficiency of how water is delivered to councils along the length of the river during droughts, and thereby improve water security for towns in the region. If progressed, this could also link in other urban centres such as Wellington and support centralised treatment of water.

Our initial analysis suggests that this option could have the potential to reduce the time Dubbo is in water restrictions and improve the water security for Nyngan, Cobar and nearby mines. The water that is saved from flowing down the river can be used for other purposes. This could slightly increase water available for general security licences or be put towards other needs.

Water flowing through pipes rather than down the river channel has trade-offs as the water in rivers supports the environment, fish and vegetation that need water to survive. It could also mean there is a slight reduction of flows into the Macquarie Marshes (less than 1% on average over the long-term).

There are opportunities to analyse this option in more detail to find ways to reduce the impacts on the environment while ensuring that water security for towns is prioritised during droughts. Given the costs associated with the pipeline, other shortlisted, lower-cost options that could improve Nyngan and Dubbo's water security, such as an additional off-river storage for Nyngan should be progressed first.

The NSW Government is developing a final business case for upgrading the existing pipeline and infrastructure between Nyngan and Cobar to ensure continued water supply reliability for the Cobar region. The proposed pipeline would improve long-term water security and reliability for Nyngan and Cobar. It would also increase water accessibility and reliability for agriculture and mining, including the Tritton mine, and improve the use of technology such as pipeline monitoring.

Image courtesy of Ines Richter, Department of Planning and Environment. Gin Gin Weir, NSW.

# Proposed action 2.4: Investigate ways to improve connectivity with the Barwon–Darling on a multi-valley scale

The Macquarie–Castlereagh catchment is one of several NSW and QLD catchments provides water to the Barwon–Darling River.

We have heard that many stakeholders outside of the Macquarie–Castlereagh region expect additional actions in the Macquarie–Castlereagh catchment to help meet needs downstream and improve connectivity. We have also heard that it may not be possible to improve connectivity when the river dries up naturally from time to time.

Within the Macquarie–Castlereagh catchment, we have heard from some stakeholders that assessing connectivity actions should not be based on average or median flows given the high level of variability within the system and that the majority of the flows from the Macquarie into the Darling occur during high flow periods and floods.

The NSW Government is reviewing if changes are needed to improve the flows of water between catchments at certain times. Importantly, this needs to consider whether we have the tools to deliver the intended outcomes without significant adverse impacts.

This work will be covered through a more coordinated system-scale approach as part of the Western Regional Water Strategy. Rule changes that significantly affect the amount of water available to water licence holders may trigger compensation under the *Water Management Act 2000*.

## What we have heard so far

Feedback provided in earlier consultation showed support for:

- restoration of river health and a commitment to reversing historic ecological damage, with connectivity considered a key component in the resilience of water-dependent ecosystems
- additional actions in the Macquarie–Castlereagh catchment to help meet downstream water needs
- consideration for what connectivity actions can feasibly be achieved.

## Have your say

- What are the relative benefits/impacts of options to improve connectivity with the Barwon–Darling?
- Are there other actions in the Macquarie–Castlereagh that we should analyse?

# Priority 3

## Support industry and community climate adaptation

Agriculture and mining will continue to be important to the regional economy in coming decades – however, potentially declining water availability could impact productivity and have flow-on impacts on the regional economy.

The actions shortlisted under this priority aim to support improved socio-economic resilience to climate-related challenges by:

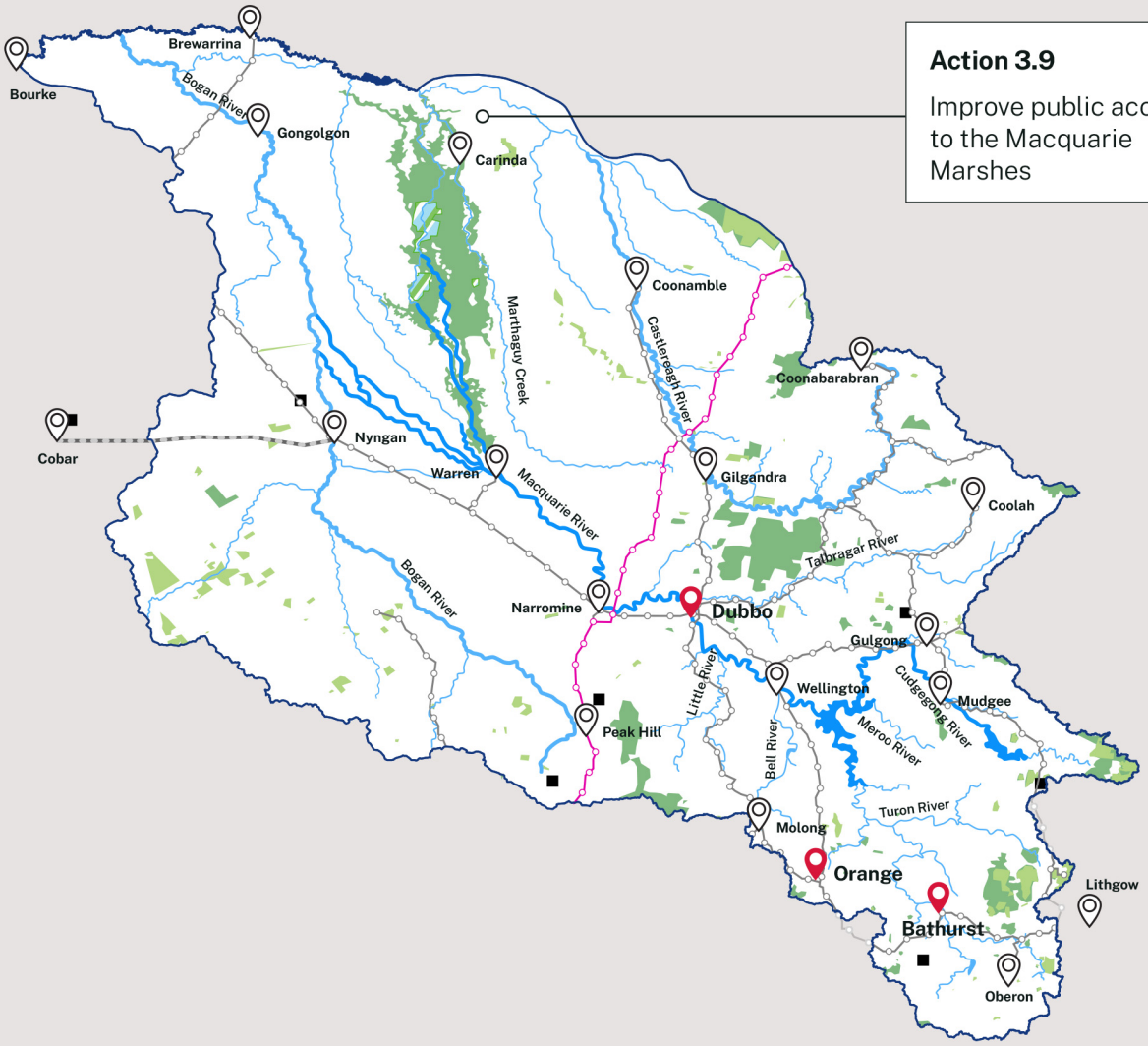
- exploring opportunities to make sure the water entitlement and access framework can cater to the development of emerging industries
- supporting Aboriginal people to be more involved in water management, by both sharing their traditional knowledge and enhancing their contribution to decision making.

### What we are already doing

There are existing NSW Government initiatives underway that the actions in this strategy will build off. These include:

- $3.9 million under Future Ready Communities to promote resilience and develop drought resilience plans which will assess drought impacts and responses. Individual plans can focus on intra- or inter-industry diversification, leadership and social capital building, and planning council works counter-cyclicality.
- The NSW Government is working with other jurisdictions to finalise a target for the ownership of water entitlements by Aboriginal people and organisations under the national Closing the Gap agreement.
- The NSW Government will partner with First Nations/Aboriginal People to co-design a state-wide Aboriginal Water Strategy that will identify a program of measures to deliver on First Nations' water rights and interests in water management and help address state-wide systemic issues to better enable the exercise of First Nations/Aboriginal People's rights and access to water.
- The $48 million expanded Farms of the Future program, will support on-farm connectivity and encourage farmers to adopt agtech to boost productivity, including water efficiency and drought preparedness.
- The Climate Change Research Strategy is supporting projects that help primary industry sectors adapt to climate change.
- The Future Ready Regions Strategy and Future Ready Communities Pilot Program includes a commitment to upgrade the Enhanced Drought Information System to provide farms with world-leading weather and climate data so they can make better business decisions, and support councils develop drought resilience plans.
- The Critical Minerals and High-Tech Metal's Strategy which aims to position NSW as a major global supplier and processor of critical minerals and high-tech metals well into the future.
- The 20-Year Economic Vision for Regional NSW is the NSW Government's plan to drive sustainable, long-term economic growth in regional NSW. It is the roadmap to unlock significant economic potential in regional NSW. It guides transformative, once-in-a generation investment in our regions through the $4.2 billion Snowy Hydro Legacy Fund, to create jobs now and into the future.
- The suite of Regional Plans, so the whole of NSW is covered by strategic land-use plans. The regional plans set a 20-year framework, vision and direction for strategic planning and land use to ensure regions have the housing, jobs, infrastructure, a healthy environment, access to green spaces and connected communities.
- The NSW Government has assisted local council to develop Regional Economic Development Strategies (REDS) based on the concept of a Functional Economic Region. The REDS provide a clear economic development strategy for the region and are currently under review.

**Figure 18. Priority 3: Support industry and community climate adaptation**




## Across the region

**Action 3.1**
Invest in continuous improvement to surface and groundwater modelling

**Action 3.2**
Improve public access to climate information and water availability forecasts

**Action 3.3**
Support adoption of farm climate adaptation and water efficiency measures

**Action 3.4**
Undertake research to inform reviews of groundwater extraction and condition limits

**Action 3.5**
Develop ongoing arrangements for participation of local Aboriginal people in water management

**Action 3.6**
Support place-based initiatives to deliver cultural outcomes for Aboriginal people

**Action 3.7**
Support the development of new water related Aboriginal business opportunities in the Macquarie–Castlereagh region

**Action 3.8**
Modernise the water management framework so it can continue to support sustainable economic diversification

**Legend**

Reducing water supply risks for regional cities, towns and villages

Supplying water to high priority needs in the lower river system and connected valleys

Supporting a growing regional economy in a future of potentially reduced water availability

Addressing barriers to Aboriginal water rights

Maintaining and improving the health and resilience of the region's aquatic and floodplain ecosystems

| Proposed action | Summary | Challenges addressed |
|---|---|---|
| **Action 3.1** Invest in continuous improvement to surface and groundwater modelling | Continue to improve the river and groundwater system models that underpin water management planning in the Macquarie–Castlereagh region. |  |
| **Action 3.2** Improve public access to climate information and water availability forecasts | Design and deliver suitable training and information products and communication platforms. |  |
| **Action 3.3** Support adoption of farm climate adaptation and water efficiency measures | Continue to invest in ways that support farm climate adaptation and improve water use efficiency. |  |
| **Action 3.4** Undertake research to inform reviews of groundwater extraction and condition limits | Increase our knowledge of groundwater resources to inform future decisions on sustainable groundwater extraction limits. |  |
| **Action 3.5** Develop ongoing arrangements for participation of local Aboriginal people in water management | Investigate ways to improve the participation of Aboriginal people in water management through new approaches, programs, partnerships and funding. |  |
| **Action 3.6** Support place-based initiatives to deliver cultural outcomes for Aboriginal people | Support the continued development of tailored, place-based initiatives to improve water and other outcomes for Aboriginal people in the Macquarie–Castlereagh region. |  |

| Proposed action | Summary | Challenges addressed |
|---|---|---|
| **Action 3.7** Support the development of new water related Aboriginal business opportunities in the Macquarie–Castlereagh region | Invest in Aboriginal run businesses and initiatives that address water access needs or identify new water-related business opportunities. | |
| **Action 3.8** Modernise the water management framework so it can continue to support sustainable economic diversification | Address regulatory and policy barriers for emerging industries. | |
| **Action 3.9** Improve public access to the Macquarie Marshes | Improve visitor experience and access to areas of the Macquarie Marshes that are part of the national parks reserve, and support development of ecotourism opportunities which could be led by local Aboriginal people. | |

Image courtesy of Peter Robey, Department of Planning and Environment. Farmland Cattle, Dubbo.

# Proposed action 3.1: Invest in continuous improvement to surface and groundwater modelling

The NSW Government uses water system models to help inform many of the decisions in regional water management. There are models for both surface water and groundwater systems:

- **surface water** – river system models are computer-based tools that simulate the way water flows and behaves in a system over time, the operation of infrastructure and the demands for and use of water by towns, irrigators and other water users. These models can produce detailed information on water availability and how changes in policy, rules or infrastructure can change the amount of water that flows in the river at different times, and the water available to different users. Recent improvements to the Macquarie Regulated River system model have included representation of water taken by floodplain harvesting and how environmental water managers use licensed water. The NSW Government has also developed a river system model for the region's unregulated river catchments, including the upper Macquarie and Castlereagh systems
- **groundwater** – groundwater system models simulate the behaviour of aquifers over time including recharge, the movement of water and the take of water through bores. They can also help us understand the potential risks to groundwater dependent ecosystems and to water quality. Groundwater levels fall and recover seasonally with annual pumping cycles and over multi-year periods where they decline in dry years and recover in wet years. These models are the only way we can assess the long term (decadal and multidecadal) trends in aquifer behaviour in the highly used aquifers, such as the Lower Macquarie Groundwater Sources.

The Government will continue to enhance the capability of the Macquarie–Castlereagh Valley river system model, as well as modelling of the Upper and Lower Macquarie aquifers. Continuing to improve and expand the capabilities of these models as new data and information becomes available will be particularly important for managing and sharing limited water resources and predicting and mitigating the impacts of increasingly variable and extreme conditions.

We have heard that sharing the models, particularly with Councils will help provide greater transparency and could support local level water security studies.

Improved modelling will give stakeholders and the broader community greater confidence that water sharing and management decisions are made using the latest scientific knowledge and a strong and credible evidence base.

## Collecting more data and better data

The NSW Government is undertaking a range of programs aimed at improving our understanding of water flows and water use in the Macquarie–Castlereagh region. The data collected by these programs will improve modelling capabilities.

### Non-urban water metering framework

Under the framework, water supply works in the Macquarie–Castlereagh region will be subject to the new metering rules to install meters on their pumps.

The non-urban water metering framework will be able to better collect and store data, through its cloud-based data acquisition service, to assist the Natural Resources Access Regulator, WaterNSW and the Department of Planning and Environment to undertake compliance and enforcement, billing, and other water management activities. Water users will also be able to access their water use data via a private online dashboard.

This program will help us better understand water use and behaviour in the system, and will include improved data on water use in unregulated river systems.

### Murray–Darling Basin Compliance Compact

NSW is currently reviewing its hydrometric (river gauge) network as part of the Murray–Darling Basin Compliance Compact. The review is looking at the coverage and data quality obtained from the existing hydrometric network and identifying ways to improve the information collected.

New gauging stations being delivered through the Compliance Compact will provide transparent, accurate and accessible data in real time to water users, communities and stakeholders, building on more than 1,300 monitoring sites already available in real time to the public. Information available from the new stations will include stream levels, flow volumes, and water quality.

This project will enhance the network so we can better manage stream connectivity, compliance, environmental water releases, and extreme events. The new stations will add even more localised data, helping us better understand local conditions so we can better balance the needs of water users and the environment, and better prepare for floods and droughts.

Water users can access the data through tools including WaterNSW's Water Insights portal and WaterLive App and the Bureau of Meteorology's Water Information Portal and Water Data Online.

# Proposed action 3.2: Improve public access to climate information and water availability forecasts

All parts of the community and government need access to reliable and timely information to make informed decisions and be effectively involved in water planning and decision making.

The NSW Government is committed to supporting better planning for droughts by providing more information and data to enable businesses to make the right decisions for their circumstances. Access to good climate information ahead of time, sound risk management and business planning are significant determining factors in the ability of businesses to weather prolonged droughts.

While the delivery of climate and water availability information by government has improved in recent years, more can be done to ensure water-related information products meet the expectations of water users.

The new climate data published in the regional water strategies is the first step in providing more information to water users on the future risks to water availability; however, tailoring the application of this data for industry and communities will deliver the greatest benefits.

Improving short- and long-term water availability forecasts will help the region's businesses plan with greater certainty and make informed decisions on managing their allocations. It will also support farm-level climate adaptation decisions. Ongoing maintenance and upgrading of gauges in the region can help inform real time data and decision making. Improving our understanding of the vulnerability of primary industries to climate change is critical for managing risks and making sound adaptation decisions.

Supporting new and diversified businesses to understand water licencing products and climate risks can help them to remain in the region over the long-term.

This action would build upon existing state and national information platforms and products, including the Water Insights and Water Information Dashboards. It will deliver suitable training and information products and platforms that:

- deliver upfront education and clarity to industry and government on potential water sources, given that all surface water sources, and some groundwater sources, are fully allocated and there is potential for reduced water availability in the future
- provide education on how continuous accounting and water markets can help individual water users create the mix of water products needed to support their businesses and risk appetites
- improve forecasting and better understand the movement of water across floodplains and within river channels during higher flow events. This requires continuous ongoing investment
- continue to fill gaps and maintain the gauging and monitoring network
- connect these forecasts across agencies to make it easier for users
- communicate potential implications of long-term climate data on:
  - surface water availability and water quality
  - the likelihood of consecutive years of low or no water availability
  - periods where access to water allocations may be restricted by delivery problems in the regulated river system
  - groundwater availability and quality
  - how future use may affect the condition of groundwater resources.
- develop a Drought and Flood River Index with the aim of providing early warning to water users on whether a regulated valley is at a higher risk of entering into drought or flood conditions.

## What we have heard so far

Feedback provided in earlier consultation showed support for:

- climate data and modelling being made available to assist communities and councils in their planning, including their development of integrated water cycle management strategies
- helping communities to understand what long-term climate assessments can tell us about future water availability. Communities also need an enhanced understanding of how the new climate data sets will be used in future water allocation decisions
- training for council staff in groundwater, as most are focused on river water and water quality treatment.

## Have your say

What kind of information and information products do you need to make decisions for your business or water use?

# Proposed action 3.3: Support adoption of farm climate adaptation and water efficiency measures

Industry associations, research institutions and government have worked together for decades to improve traditional crop and livestock production systems, including their water use efficiency and productivity. Grower-led irrigation research has been underway in the region for more than a decade and we heard during earlier consultation that new land use activities, including carbon and biodiversity farming, are increasing in some areas of the region.

Continuing critical research and development will set the industry up for the future and may go a significant way towards mitigating future climate risks and adapting to climate change.

Farm businesses in the Macquarie–Castlereagh region are considered early adopters of best practice management and new technology. On-farm water efficiency projects funded under the Murray–Darling Basin Authority's Private Irrigation Infrastructure Operators Program in the Macquarie–Castlereagh region included the Tenandra, Marthaguy, Trangie, Nevertire and Narromine Irrigation Board schemes in the lower Macquarie Valley. These schemes undertook different measures to reduce operational losses and improve delivery within their schemes, including:

- modernising irrigation channels through upgrading and decommissioning
- installing pumped pipeline systems
- constructing secure stock and domestic water delivery systems
- installing and operating fish-friendly diversion screens to achieve both ecological and operational outcomes.

Over 27 GL of water savings from the program was passed on to the Commonwealth as environmental water.

**The NSW Government's Climate Change Research Strategy** is supporting projects that help primary industry sectors adapt to climate change. For example, the Department of Primary Industries – Agriculture's is undertaking a Vulnerability Assessment Project to assess the vulnerability of 28 primary industries and 14 related biosecurity risks to climate change.

The assessment is being conducted in 2 stages:

- an impact assessment looking at how current production might vary under future climate conditions in 2050
- an adaptation assessment looking at how we might respond to negative impacts and provide direction for industry research and development; for example, developing crop varieties more suited to a drier climate.

The impact assessment for cotton, which is nearing completion, suggests that warmer temperatures could benefit cotton production and quality. The next steps are to assess water-related risks and possible responses to negative impacts. This could include developing new cotton varieties or other farming systems that are more suited to a drier climate.

The rangeland component of the vulnerability assessment project is looking at the impact on existing livestock production systems. The project will focus on the suitability of adaptation options, including changing management systems, shifting the focus of livestock enterprises to include carbon farming or adopting an increased focus on goat production.

This action would:

- integrate water data from the regional water strategies into the vulnerability assessment analysis for selected agriculture industries and investigating adaptation responses
- explore ways to reduce evaporation from on-farm storages and improve water use efficiency through the use of smart sensors and automated irrigation systems
- limiting deep drainage by increasing soil water holding capacity using novel compounds such as hydrophilic polymers.

In addition, research and development into new practices and enterprises that are best suited to warmer and drier conditions projected for regional NSW could be fast-tracked. This research will build on the Department of Primary Industry's climate vulnerability assessment to provide farm businesses with information on what types of crops could be best suited to the region in the context of a changing climate.

## What we have heard so far

Feedback provided in earlier consultation showed support for:

- the regional water strategy to focus on reducing and managing water demand and prioritising suitable efficiency measures to improve or maintain water reliability and deliverability
- managing land within the catchment to increase soil carbon and absorb more of the rain that falls, allowing it to be released more gradually to sustain streamflows, as well as enabling better production from those soils
- helping primary producers adapt farming systems to climate change.

## Have your say

What should be the focus of future water use efficiency research and investment?

Image courtesy of Destination NSW. Cattle grazing beside Lake Oberon, Oberon.

# Proposed action 3.4: Undertake research to inform reviews of groundwater extraction and condition limits

A better understanding of groundwater recharge rates, volumes, aquifer boundaries and their connectivity with ecosystems and other water sources can be used to refine our groundwater source extraction limits as we review the state's water sharing plans.

Additional considerations – such as the effects of climate change on groundwater recharge, changing user behaviour and demand, and socio-economic data – can also be incorporated into these new generation groundwater source extraction limits.

The NSW Government has already begun researching and assessing different methods to inform the definition of groundwater source extraction limits in NSW. This work is based on a review of the historical context for defining sustainable groundwater source extraction limits, as well as a comparative analysis of international best-practice cases. The draft method will consider groundwater risk assessments recently undertaken (where available), incorporate the most up-to-date hydrogeological and ecological information, and consider these in the context of new climate change data and risks.

The Murray–Darling Basin Plan will be revised in 2026 and we need to have a solid evidence base to support any suggested changes, such as increasing or decreasing the extraction limits. Several stakeholders considered improving our knowledge and understanding of groundwater sources and processes and recharge as a high priority to develop and implement long-term sustainable groundwater management plans in the Macquarie–Castlereagh region.

Also important is reviewing the resource conditions limits – that is, what is considered acceptable water levels and quality parameters. This is becoming more of a concern in the Talbragar Alluvium, Upper Macquarie Groundwater Source, and Lower Macquarie Groundwater Sources Zone 1, 2 and 6. In these areas, the concentration of groundwater extraction is increasing. For such areas, we need to look at not only the larger-scale extraction limits but also the smaller-scale resource condition limits. This action involves:

- undertaking field investigations and desktop analyses to provide up-to-date information on current and predicted long-term trends in water levels, recharge rates and connectivity (with surface water and between groundwater systems)
- considering the impacts of climate variability/change using new climate information and updated modelling
- establishing the groundwater extraction limits we will need to set in the future to ensure sustainable access to groundwater by consumptive users and the environment with consideration to the Murray–Darling Basin sustainable diversion limits
- establishing the groundwater condition limits we need to ensure fair and ongoing access to groundwater for towns, industries and the environment.

# Proposed action 3.5: Develop ongoing arrangements for participation of local Aboriginal people in water management

We heard from Aboriginal people that consultation with their communities on water issues has been infrequent and poorly executed. Community sentiment is that government agencies often come out to 'tick a box' and after they have got what they want they are never seen again.

To address this now and in the future, we need an approach that allows Aboriginal people in each local area and region to get the right people involved or appointed to seats where decisions about water are being made. Aboriginal people need to have a direct line of contact with regional water managers, compliance officers and decision makers. Aboriginal knowledge and science should be actively sought, respected and listened to.

In the Macquarie–Castlereagh region, we heard strong feedback that an effective Aboriginal water engagement committee needs to be the first step in fundamentally improving Aboriginal people's involvement in water management. For it to be successful, the makeup and function of groups engaged in water management need to be led by local communities – experience has shown that government dictated governance models for Aboriginal communities do not work.

The NSW Government will work with and fund existing or new Aboriginal groups to develop a governance approach for involvement in water management processes. The success of this action will be driven by the extent to which it enables self-determination and provides an adequate level of support for these groups.

This action supports Priority Reform 1 in the National Agreement for Closing the Gap – to enter formal partnerships and decision-making arrangements and develop place-based partnerships to respond to local priorities.

Local Aboriginal groups in the Macquarie–Castlereagh could be involved in:

- developing programs and initiatives to improve cultural competency within the water sector
- developing culturally appropriate water knowledge programs
- outlining a process that the NSW Government can follow to ensure water decisions have appropriately been considered by the community
- progressing on-ground initiatives
- compliance and monitoring programs.

# Proposed action 3.6: Support place-based initiatives to deliver cultural outcomes for Aboriginal people

The Draft Macquarie–Castlereagh Regional Water Strategy identified options to improve Aboriginal people's access to water and water rights. While there was a significant amount of support for these options, preferences on how they should be prioritised or implemented varied across communities. The needs and priorities of Aboriginal communities in different parts of the region are different.

The Australian Government's *Closing the Gap* report and *Local and Indigenous Voice program* have highlighted that Aboriginal people have expressed the desire for strong and inclusive partnerships, in which local communities set their own priorities and tailor services and projects to their unique situations. Programs with demonstrated successful initiatives are typically those that are tailored to local circumstances, are place-based, well resourced, locally driven and often cannot be scaled up.

This action would provide NSW Government support for Aboriginal organisations and communities to develop tailored projects for their communities. It aims to move away from central decision-making and develop a flexible program that is driven by the principle of self-determination – local communities 'speaking with their voice' to make decisions about which programs are needed for their community and their region.

In the Macquarie–Castlereagh region, this could include:

- developing **a cultural watering program** that identifies the specific sites or locations where water should be delivered at certain times to improve cultural, economic, social and recreational outcomes. We have heard that the Beemunnel Aboriginal site could be an important place to focus on. This could involve working with the Department of Planning and Environment – Water, WaterNSW and environmental water holders to identify whether cultural water access licences or water for the environment could help deliver water to these locations
- **improving access to Country**, including sites that have local significance. This would include opening up local parcels of public land that have access to waterways but are otherwise gated or locked – such as travelling stock reserves or Crown roads
- **a restoration reach**, which would use cultural knowledge and science to rehabilitate riparian land, through planting of native species and caring for Country
- **programs that engage Aboriginal youth** in water and landscape management, with the aim to build cultural awareness and give a sense of ownership and cultural connectivity
- locally run programs that **identify and record significant water-dependent sites** in the Macquarie and Castlereagh valleys. Information would be stored in a culturally appropriate way.

To receive government funding or support, these initiatives would need to have local champions, effective local governance arrangements and a strong capacity building component, such as activities that focus on water legislation, licensing structures, landscape management or knowledge activities for schools and youth programs.

## Have your say

How can Aboriginal place-based solutions be implemented in a way that creates opportunities for Aboriginal people and communities in the Macquarie–Castlereagh region, while also delivering positive outcomes for the broader community?

# Proposed action 3.7: Support the development of new water related Aboriginal business opportunities in the Macquarie–Castlereagh region

During our consultation on the Draft Macquarie–Castlereagh Regional Water Strategy, we heard about the need for economic development and business opportunities in the region that are led by Aboriginal communities and allow for local Aboriginal people to be employed.

Investing in regional Aboriginal businesses can help diversify incomes in the region, create employment for local Aboriginal youth and improve social and economic outcomes for Aboriginal people. Realising some of these opportunities may require access to surface water or groundwater resources.

This action will support Aboriginal business development opportunities in the Macquarie–Castlereagh region and will be led by the Department of Regional NSW. Through the Aboriginal Partnership Program, a dedicated Aboriginal Senior Regional Coordination officer will work with Aboriginal organisations, businesses and individuals to:

- identify and develop new business opportunities
- better manage existing businesses
- access support or grant funding.

Other support is also available through the Department of Aboriginal Affairs, the NSW Aboriginal Lands Council and the National Indigenous Australians Agency.


Image courtesy of Destination NSW. Indigenous Cultural Adventures, Orange.

# Proposed action 3.8: Modernise the water management framework so it can continue to support sustainable economic diversification

The NSW Government is making significant place-based investments in the region and surrounding areas to build strong communities and support industry development and diversification. Some of these key investments are the Central West Critical Minerals Hub, Inland Rail Project, upgrades to the Newell Highway, the new regional rail maintenance facility in Dubbo 'Mindyarra', and improvements to digital connectivity.

There are also a range of emerging opportunities and industries that can deliver new income streams that will be important for building regional resilience and spreading financial risk for individuals. Some of these include:

- carbon farming (carbon sequestration or emissions reduction) and biodiversity offsets, which can improve the resilience of farming systems and Aboriginal communities
- tourism – including eco-tourism, Aboriginal cultural tourism and agri-tourism – can generate year-round cash flow and reduce the impacts of seasonal and cyclical activities. Councils are working to expand nature-based adventure and cultural tourism places, leverage the area's environmental and iconic assets and enhance visitor experiences, and recreation and cultural facilities.

Many of the new industries will require access to water, which will need to come from trading of existing water entitlements, groundwater sources that are not fully allocated, or recycled and re-used water sources. We need to make sure our water entitlement and access framework can cater to these new industries by supporting sustainable access to water, and that additional access to water for new industries does not adversely impact the existing water security or pricing of urban centres.

This action will:

- address water-related policy and regulatory barriers around supporting new and diverse industries setting up in the region
- encourage new industries to have comprehensive drought management plans
- use evidence from this regional water strategy when informing future industrial and land use planning strategies, to ensure there are sustainable water sources available to support new industries
- investigate alternative water licences and products that could support new industries. This may include increasing the availability of high security licences by allowing some general security licences to be converted to high security licences.

## Converting general security licences to high security licences

General security water licences make up 61% of all water licences in the Macquarie–Castlereagh region. In drought, these licences typically receive no or very low allocations compared to high security licences.

Irrigated agriculture in the region has adapted to the highly variable availability of general security licences and supplementary and floodplain harvesting water by growing annual crops.

While the region's soils, climate and transport links create opportunities for higher-return agricultural or industrial enterprises, there are only a small number of high security (2.5%) surface water licences in the region. The ability to trade water enables it to be used for a higher value purpose, however, there are not enough permanent high security entitlements available to meet the needs of new high value enterprises. Some of these higher value uses include horticulture, intensive livestock or the growing minerals, metals and energy sector.

Provision could be made to allow some general security licences to be converted to high security licences. This would be a voluntary process initiated by the holder of the general security licence.

Licence conversion was permitted from 2004 to 2019 but there was limited interest, and it was discontinued across the Murray–Darling Basin in 2019 largely due to concerns about conversion rates leading to third party impacts.

Converting a proportion of general security licences to high security licences would reduce the overall volume of licensed water, but it would increase the availability of licences that can be allocated with high reliability each year.

Licence conversion processes would need to ensure no reduction in the reliability of any remaining general security licences. To prevent this from happening, a conversion ratio is used to determine how many general security licence shares become one high security licence share. Modelling indicates a conversion ratio of around 3:1 results in no material impacts on other licences and flows into the Macquarie Marshes. Further modelling is needed to refine the results, including taking into account the locations where water is taken. There may need to be restrictions on where new high security licences are used, as supplying high security water to the ends of the regulated system incurs much higher delivery losses than general security. This is due to the priority given to the supply of high security water.

Allowing the creation of additional high security licences from general security licences opens up a large pool of potential sellers of licences, that could help support alternative agricultural industries as well as the mining and energy sectors.

## Have your say

Do you see there being appetite for conversion of general security licences to high security licences?

# Proposed action 3.9: Improve public access to the Macquarie Marshes

Providing additional eco-tourism experiences can help to diversify the economic activity in the region. There are opportunities to improve visitor experience and access to areas of the Macquarie Marshes that are part of the national parks reserve.

Currently public access to the wetlands can occur once a year through NSW National Parks guided tours.

Over the coming decades, there are opportunities to handback title of parts of the Macquarie Marshes reserved as national parks to Traditional Owners. This is consistent with the aspirations in the Development of a new Aboriginal joint management model for NSW national parks.[53]

This action will:

- leverage existing access arrangements to maximise opportunities for commercial tourism and cultural access
- investigate future options to help enable access to sections of the Macquarie Marshes for Aboriginal people and the general public
- improve interpretation and understanding of the landscape at existing visitor areas
- expand Traditional Owner management and access to water and Country
- support development of ecotourism opportunities which could be led by local Aboriginal people.

Image courtesy of Nicola Brookhouse, Department of Planning and Environment. Ginghet Creek at Cresswell, Macquarie Marshes.

53. www.environment.nsw.gov.au/research-and-publications/publications-search/development-of-a-new-aboriginal-joint-management-model-for-nsw-national-parks


Image courtesy of Destination NSW. Streetscape, Orange.

# Priority 4

## Best use of existing water for the environment

The Macquarie–Castlereagh is richly endowed in environmental assets and ecosystems. As the region has a variable climate and the river system is long, environmental water managers use both preventative and responsive strategies to manage the needs of its aquatic ecosystems. Watering events target a range of outcomes; from building resilience and promoting ecological restoration when water is abundant, to minimising losses or damage by maintaining drought refuges when water is scarce. Where possible, environmental managers work with communities and Aboriginal people to take local actions that have catchment-wide outcomes and protect important environmental and cultural sites.

As water for the environment cannot always be used when it is needed or delivered to its best effect during dry and wet periods, this limits the ability of environmental water managers to build resilience in the system.

The actions under this priority focus on:

- limiting or removing pressures and impacts directly related to water infrastructure
- enabling water for the environment to be delivered to its best effect during wet and dry periods
- building knowledge of the region's water dependent ecosystems and assets, and the impacts of climate change on their health and resilience
- improving water resource health through better land management.

## What we are already doing

The NSW Water Strategy contains actions for improving environmental monitoring, evaluation and reporting programs. This includes:

- finalising a monitoring and evaluation framework for water sharing plans, and initially targeting locations with high environmental risk
- monitoring and reporting on environmental water delivery and management to inform adaptive management and reporting
- maintaining a water science strategy and prospectus that provides sector-wide guidance on future science, research and development
- initiating, developing and delivering science partnerships in support of enhanced water resource management outcomes with universities, research organisations, industry and the community.

These initiatives provide a strong foundation for actions taken in the Macquarie–Castlereagh Regional Water Strategy.

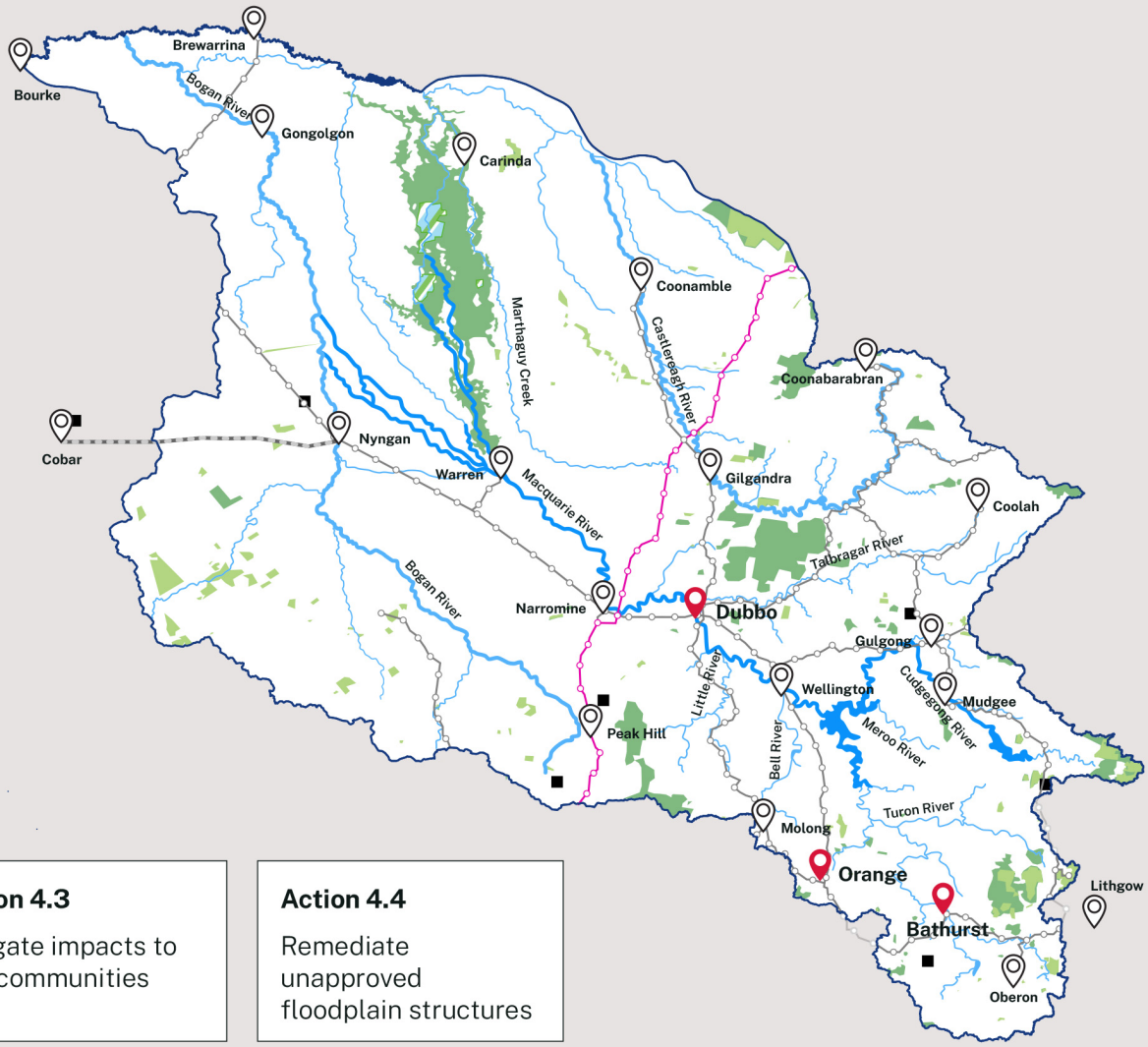
**Figure 19. Priority 4: Best use of existing water for the environment**

**Action 4.1**

Modify or remove barriers to delivering water for the environment

**Action 4.2**

Reinstate natural channel profiles in selected streams in the southern Macquarie Marshes




**Action 4.3**

Mitigate impacts to fish communities

**Action 4.4**

Remediate unapproved floodplain structures

## Across the region

**Action 4.5**

Provide clarity and certainty for environmental needs during drought operations

**Action 4.6**

Assess gaps in the flow regime and identify cooperative actions to improve ecological outcomes

**Action 4.7**

Fully implement the NSW Floodplain Harvesting Program

**Action 4.8**

Identify regionally significant riparian, wetland and floodplain areas to protect or rehabilitate

**Legend**

Reducing water supply risks for regional cities, towns and villages

Supplying water to high priority needs in the lower river system and connected valleys

Supporting a growing regional economy in a future of potentially reduced water availability

Addressing barriers to Aboriginal water rights

Maintaining and improving the health and resilience of the region's aquatic and floodplain ecosystems

| Proposed action | Summary | Challenges addressed |
|---|---|---|
| **Action 4.1**<br>Modify or remove barriers to delivering water for the environment | Implement the Macquarie Marshes Enhanced Watering Project.<br><br>In areas outside of the Macquarie Marshes Enhanced Watering Project, increase the flexibility of delivery of water to environmental assets by investigating the removal of physical barriers. |  |
| **Action 4.2**<br>Reinstate natural channel profiles in selected streams in the southern Macquarie Marshes | Undertake channel bed restoration works to allow reconnection with wetlands and floodplains. |  |
| **Action 4.3**<br>Mitigate impacts to fish communities | Mitigate the impact of water infrastructure on native fish by:<br>• installing fish passages at priority barriers in the Macquarie region<br>• progressing alternative cold water pollution mitigation measures for Burrendong Dam<br>• implementing diversion screens at priority pump sites in the Macquarie–Castlereagh to protect native fish. |  |
| **Action 4.4**<br>Remediate unapproved floodplain structures | Undertake an accelerated compliance program for unapproved floodplain structures in high-risk areas of the Macquarie floodplain. |  |
| **Action 4.5**<br>Provide clarity and certainty for environmental needs during drought operations | Clarify when, how and why drought operations are triggered. This will allow more accurate planning of environmental releases and more informed environmental management of the system. |  |

| Proposed action | Summary | Challenges addressed |
|---|---|---|
| **Action 4.6**<br>Assess gaps in the flow regime and identify cooperative actions to improve ecological outcomes | Identify gaps in the frequency and adequacy of different flow types under the current climate and future climate change scenarios and determine how to fill these flow gaps without significant impacts on water users. |  |
| **Action 4.7**<br>Fully implement the NSW Floodplain Harvesting Program | Finalise floodplain harvesting access licences and works approvals to regulate, measure and enforce limits on floodplain harvesting water take. |  |
| **Action 4.8**<br>Identify regionally significant riparian, wetland and floodplain areas to protect or rehabilitate | Strategically target on-ground activities at high-priority locations to restore, conserve and protect critical riparian, wetland and floodplain habitat and species, or areas of high cultural value in the Macquarie region. |  |

## What we have heard so far

Feedback provided in earlier consultation showed support for:

- restoration of river health and a commitment to reversing historical ecological damage, with connectivity considered a key component in the resilience of water-dependent ecosystems
- improving downstream connectivity to wetlands/waterbird breeding habitat.

# Proposed action 4.1: Modify or remove barriers to delivering water for the environment

The Murray–Darling Basin Authority's 2016 *Northern Basin Review* recognises the need to remove physical and operational barriers that constrain the delivery of water for the environment. Removing these barriers can help improve the ecological outcomes of water management in the northern Basin and support environmental objectives of the Basin Plan. This includes:

- enhancing habitat for aquatic organisms
- building ecological resilience
- protecting or enhancing the delivery of environmental water.

Through the Northern Basin Toolkit measures, the Australian Government has committed $2.9 million for the Macquarie Marshes Enhanced Watering Project. This project includes investigating the potential to deliver larger flows to the Macquarie Marshes, thereby assisting the connection of the river and wetlands to key areas of the floodplain. Funding will cover the construction of a regulator on Oxley Break, which includes a fish passage. It also covers a scoping study, and basic design and options assessment for treating a series of breaks immediately upstream of Marebone Weir.

Building on the Enhanced Watering Project, the NSW Government could investigate and seek funding to further reduce physical constraints that impact on the ability of water to move through rivers and across floodplains coupled with an analysis of the impacts on other water users at 3 locations:

- **Mumblebone Breaks** – while the Northern Basin Toolkit has funded a scoping study and basic design, funding for detailed design and the implementation of solutions is needed should these be viable and proceed.
- **Cudgegong River at Rocky Waterhole Bridge** – Cudgegong River flows are restricted to around 1,500 ML/day by the limited capacity of the Rocky Waterhole Bridge. The Cudgegong River crossing could be upgraded to allow higher flows.
- **Upper Crooked Creek** – investigation of options to reduce the channel constraint at the inlet to Crooked Creek.

Image courtesy of John Spencer, Department of Planning and Environment. Macquarie Marshes, NSW.

# Proposed action 4.2: Reinstate natural channel profiles in selected streams in the southern Macquarie Marshes

Changes to the shape of a river channel – such as its depth and width – affect how water moves through a river system. In-river erosion can cause channels to become so deep and wide that the surrounding floodplain and wetlands are disconnected from the river. Erosion is pronounced in the Southern Macquarie Marshes.

This action would support erosion mitigation and rehabilitation strategies such as river channel bed restoration works in the southern Macquarie Marshes.

Target areas for restoration of channels would include:

- **the Breakaway** – this project would comprise of one weir and 5 downstream structures along a 2 km stretch
- **Monkeygar Creek** – scoping study to determine locations, costs, justification and community perspectives on potential work along this creek
- **Oxley Break** – complementary works to the regulator and fish passage.[54]

This action could link to proposed action 4.8: Identify regionally significant riparian, wetland and floodplain areas to protect or rehabilitate. Restoration works such as revegetation can help stop erosion, stabilise banks and support a natural bank profile.

Image courtesy of Destination NSW. Murray Cod, Narrandera Fisheries Centre.

54. Informed by previous work for the Southern Macquarie Marshes Geomorphic Scoping Study.

# Proposed action 4.3: Mitigate impacts to fish communities

Many native fish species need free access within and between rivers and waterways to access food, avoid predators and find shelter, escape the impacts of drought, and seasonally to spawn, migrate and recruit. Enabling native fish to move within the Macquarie–Castlereagh region will help the resilience of fish species in a changing climate and can help maintain and replenish native fish stocks across the northern Murray–Darling Basin.

## Improve fish passage at priority sites

Physical barriers to fish passage such as weirs and dams can limit fish movement, leading to a decline in the health and viability of native fish populations. Removing barriers to fish movement and allowing fish to breed, find food and ideal habitat is critical to supporting native fish populations in the Macquarie–Castlereagh region.

Currently, native fish can only move through many parts of the Macquarie–Castlereagh system during high flow conditions when water overflows weirs and other in-stream barriers.

This action would improve fish passage at 7 priority sites in the Wambuul/Macquarie River:

- Dubbo North Weir
- Gin Gin Weir
- Marebone Break Regulator
- Bulgeraga Creek regulator at the Bifurcation
- Narromine Weir
- Warren Shire Council (town) Weir
- Gum Cowal regulator at the bifurcation.

Remediation of fish passage at the first 3 listed Wambuul/Macquarie River sites will restore waterway connectivity to nearly 150 km of the mainstem Wambuul/Macquarie River and significantly improve fish movement connectivity with the Ramsar listed Macquarie Marshes.

There are an additional 39 priority barriers to fish passage on mainstem rivers of the Macquarie–Castlereagh region that could be explored as part of future fish passage remediation programs.

## Implement fish diversion screens at priority sites

Every year an estimated 800,000 or more fish are extracted from rivers by unscreened pumps in the Murray–Darling Basin. Adult fish as well as juveniles, larvae and eggs are extracted by pumps and diverted into irrigation channels, along with debris such as sticks and leave. This impacts the sustainability of native fish populations and can also damage irrigation infrastructure.

Modern screens are available to solve these problems, by stopping fish and debris entering pumps and diversions. Screens can reduce fish losses at these sites by over 90%, protect native fish during upstream and downstream migrations, help more fish survive to maturity and boost native fish populations. This protection also extends to other aquatic species such as crayfish and turtles. As well as protecting fish, screening also improves pump operation, water delivery and extraction efficiency for asset owners through fewer blockages caused by debris.[55]

The NSW Government has announced $13 million to install 50 fish exclusion screens at 11 offtake points between Dubbo and the Macquarie Marshes. However, implementation is based on expression of interest and further ongoing funding might be needed.

### Have your say

Are there any additional measures that would improve native fish outcomes in the Macquarie–Castlereagh region?

55. Boys, C., Baumgartner, L., Rampano, B., Robinson, W., Alexander, T., Roswell, M., Fowler, T. and Lowry, M 2012, *Development of fish screening criteria for water diversions in the Murray–Darling Basin*, Fisheries Final Report Series No. 134, Department of Primary Industries, Sydney.

## Progress cold water pollution measures

The NSW Government has identified Burrendong Dam as a high-priority dam in the *NSW Cold Water Pollution Strategy*.

Cold-water pollution has damaging impacts on riverine ecological function, particularly in summer when biological cues such as fish spawning are disrupted. The water released from Burrendong Dam can be 10°C colder than the ambient river temperature, and the cold-water pollution can extend more than 300 km downstream.

In 2014, a prototype thermal curtain was installed around the intake tower of Burrendong Dam to assist in mitigating cold water pollution. Its purpose was to draw water from the upper warmer levels of the lake into the intake. However, the curtain was damaged twice and was only in operation for short periods. The thermal curtain has since been taken down and further action needs to be taken to manage cold-water pollution.

WaterNSW and Department of Primary Industries – Fisheries are undertaking preliminary investigations into alternative cold-water pollution mitigation options for Burrendong Dam. The presence of potentially toxic surface algae needs to be considered as it often impedes alternative mitigation measures.

Under this action, the NSW Government will:

- progress investigations into alternative infrastructure, new technologies and operational changes to arrive at a preferred solution for Burrendong Dam
- advance understanding of the improvements in fish populations that can be achieved by addressing cold water pollution.

# Proposed action 4.4: Remediate unapproved floodplain structures

Structures on the Macquarie Valley floodplain – such as levee banks, earthworks, on-farm storages, raised roads and water supply channels – constrain the movement of floodwaters. These flood works can significantly alter the flow of waters across the floodplain, and impact on the flood connectivity that is essential for sustaining ecological and cultural assets.

Some areas of ecologically important assets in the Macquarie–Castlereagh region rely on floodplain flows for their maintenance and survival. These assets include river red gum (*Eucalyptus camaldulensis*), coolabah (*E. coolabah*), black box (*E. largiflorens*), lignum (*Muehlenbeckia florulenta*) and non-woody wetland vegetation, such as reedbeds and water couch meadows.

This action would be delivered through the Improving Floodplain Connections Program (which commenced in January 2022). It will remediate or remove up to 24 priority unapproved works in the Macquarie Valley floodplain that are altering the flow of floodwaters in the region and potentially impeding the delivery of water to ecological assets.

The work will also aim to enhance Aboriginal cultural heritage sites and values and improve ecological balance in partnership with Aboriginal communities.

## Proposed action 4.5: Provide clarity and certainty for environmental needs during drought operations

During the most recent drought, the NSW Government altered normal regulated river operations in the Macquarie–Castlereagh region to adapt to the extreme dry conditions.

Regulated flows were ceased downstream of Warren Weir in September 2019 and environmental water provisions in the water sharing plans were suspended in July 2019. This was the first time that the regulated river system was cut at Warren since Burrendong Dam was constructed.

A changing climate could increase the likelihood that drought operations are required. Greater transparency and information about when these drought responses will be triggered will help water users and environmental water managers to plan and manage their water needs and use during these periods.

This action would improve transparency and certainty about how water will be managed during drought by:

- clarifying the measures that could be applied during increasing stages of drought. This would be done by updating the Incident Response Guide and developing a drought management plan for the Macquarie–Castlereagh region
- developing hydrological drought risk indicators
- identifying critical triggers and potential actions in relation to water quality events
- developing guidance on how to restart the river after dry times or cease-to-flow events to minimise the risk of fish deaths occurring from hypoxic blackwater events or the destratification of pools
- investigating the impact of drought management responses on alluvial groundwater sources and designing responses to account for this influence.

## Proposed action 4.6: Assess gaps in the flow regime and identify cooperative actions to improve ecological outcomes

All water, including natural events and consumptive (irrigation and town) water, has the potential to contribute to the ecological condition of rivers, wetlands and floodplains. The way the river is operated to deliver consumptive water can either enhance environmental outcomes or worsen environmental impacts.

There may be fewer opportunities to use environmental water to support environmental outcomes in the region under a more variable or changing future climate. We need to make sure the mechanisms are in place to allow water for the environment to go as far as possible.

This proposed action would investigate opportunities to provide flexibility to manage environmental flows in changing climate conditions, better coordinate the management of consumptive flows and water for the environment and achieve more natural flow patterns without impacts on water users.

### Investigate alternative operational rules for the use of tributary flows in the regulated Macquarie River

To run the regulated Macquarie River as an efficient delivery channel and reserve water in the dam, river operators use tributary flows in the regulated system to fulfill water orders and provide replenishment flows. Instead of releasing the ordered amount out of Burrendong Dam, tributary flows at the time of delivery are used to make up the order volume – reducing the amount of water that is released from storage. While this saves water in the dam, it impacts the natural flow characteristics in the regulated river.

Tributary flows are generally more environmentally valuable than dam water releases due to the connectivity, nutrient, natural timing and flow rates. Environmental benefits could be achieved by protecting tributary flows in-stream and letting them pass through the system without using them to fulfill water orders.

This action would improve the effectiveness of planned and held environmental water in the regulated Wambuul/Macquarie and Cudgegong rivers. This means that for the same amount of water there could be better environmental outcomes.

The NSW Government will investigate changes in operational and water sharing plan rules for the use of tributary flows. This action would need to specifically consider solutions that do not impact upon the reliability of general security licences.

## Proposed action 4.7: Fully implement the NSW Floodplain Harvesting Program

Floodplain harvesting happens when water is collected from floodplains during a flood or after a major or significant rain event (overland flows). It is a form of water take that has not been fully transitioned into the licensing framework provided by the *Water Management Act 2000*.

Floodplain harvesting is accounted for in the legal limits on surface water extractions as set out in the Murray–Darling Basin Agreement (the Cap), NSW water sharing plans (long-term average annual extraction limits) and the Basin Plan (sustainable diversion limits).

There has been growth in floodplain harvesting across the NSW northern Basin. Where this growth has resulted in total diversions in a water resource exceeding the legal limits, the floodplain harvesting reform will reduce take so that total diversions within each valley will not exceed legal limits.

Not implementing the NSW Healthy Floodplain Policy would mean continuing uncertainty for water users, the regulator and communities. Without implementing these reforms, we cannot measure or monitor floodplain harvesting and it may mean other licence categories are penalised in order to meet legal limits.

This action will ensure a regulatory framework is in place to regulate, measure and enforce floodplain harvesting water take in the Macquarie–Castlereagh catchment.

# Proposed action 4.8: Identify regionally significant riparian, wetland and floodplain areas to protect or rehabilitate

The health and resilience of rivers, and the ecosystems they support, are directly linked to the condition of waterways and their floodplains. Conserving remnant biodiversity and restoring degraded riverine and wetland ecosystems can strengthen their long-term resilience and improve ecological responses and benefits from environmental watering.

Land use changes and land clearing for urban and agricultural development have had adverse impacts on the health of the rivers throughout the Macquarie–Castlereagh region. Water now moves more quickly and with more energy through the catchment, eroding land and waterways, reducing water quality and leading to less water being stored in the landscape. The degradation of native riparian vegetation along water courses is recognised as a key threatening process under the *Fisheries Management Act 1994 (NSW)*.

This action would deliver targeted, on-ground activities at high priority locations to conserve and protect critical riparian, wetland and floodplain habitat and species, or areas of high cultural value in the Macquarie–Castlereagh region. This work will build on existing programs, such as Fencing the Northern Basin Riverbanks and other local initiatives, to support a whole-of-catchment program of works to improve river health, connectivity and ecosystem resilience. Works could include instream structures – for example, appropriately designed and approved large woody habitat structures – as well as improved instream vegetation, to slow and filter water flow. These works improve water quality by removing sediments and nutrients. Improved riparian management, including controlled stock access, could provide bank stability, protecting banks from erosion and reducing sediment loss during floods.

Delivering this more focused and prioritised approach would require:

- mapping existing programs and potential overlaps
- developing a system to prioritise areas to protect or rehabilitate – for example, based on detailed habitat mapping data, native fish conditions, threatened species distribution or the River Styles framework, severity of land degradation and environmental management outcomes
- establishing a program of management measures
- identifying funding models, including landholder incentives
- developing a clear governance framework for decision making and program delivery
- understanding and integrating local Aboriginal knowledge and expertise in delivering river improvement works – for example, through a River Ranger Program
- developing a monitoring and evaluation framework based on the outcomes and targets identified through the Macquarie–Castlereagh Long Term Water Plan.

## Fencing Northern Basin Riverbanks Program

The NSW Government is improved land management through the Fencing Northern Basin Riverbanks Program, which supports landholders to protect valuable ecological sites and improve native fish habitat across the Northern Basin. This includes off-stream stock watering points, control of exotic woody weeds, minor erosion control works, revegetation and river re-snagging to protect native fish, and stock-proof fencing along riverbanks. The mid and lower reaches of the Wambuul/Macquarie River, Little River and Bell River are priority reaches targeted in the program.

## Biodiversity Conservation Trust Tenders

The NSW Government has committed more than $350 million over 5 years to fund the Biodiversity and Conservation Trust to deliver its private land conservation programs guided by the Biodiversity Conservation Investment Strategy.

The Northern Inland floodplains tender resulted in 9 conservation agreements covering 27,821 ha. The new conservation areas contain important habitat for a number of threatened species, particularly wetland-dependent bird species such as the bush stone curlew and the barking owl. These agreements will help conserve threatened ecological communities.

Image courtesy of CSIRO. Waterbirds, Macquarie Marshes.

# How to have your say

5

Image courtesy of Department of Primary Industries.
Sunrise at Ben Chifley Dam, Bathurst.

# When will the actions be implemented?

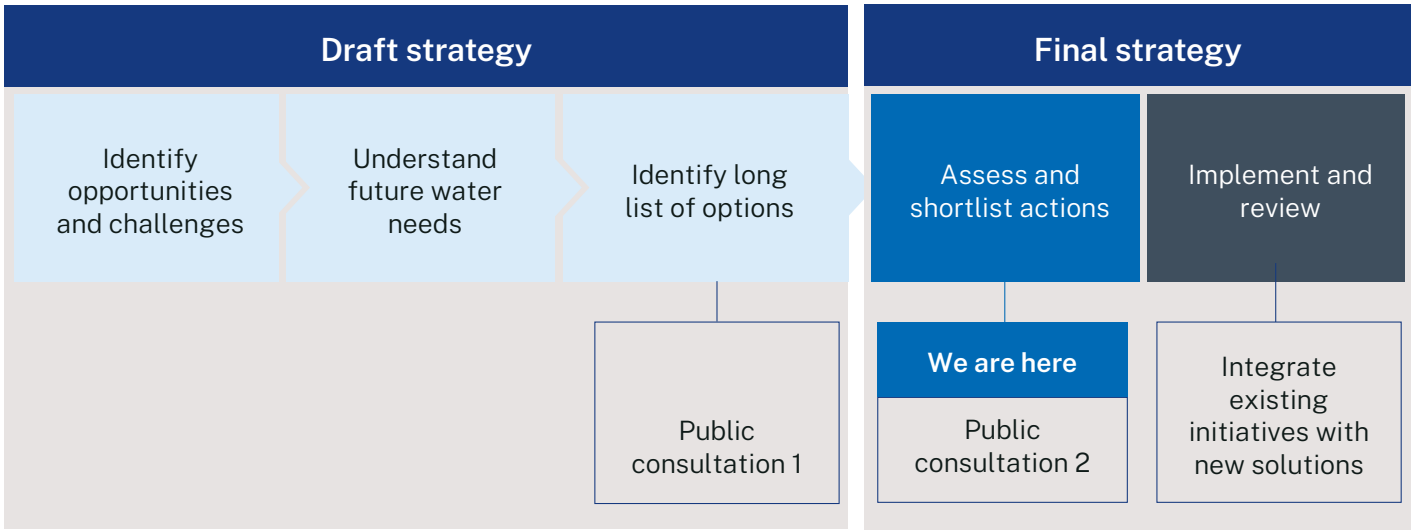
A critical feature of the final Macquarie–Castlereagh Regional Water Strategy is making sure we identify clearly what actions and investments are needed now and those that will or may be needed further into the future. The strategy considers a 20-year timeframe, aiming to chart a progressive journey that enables us to meet existing challenges, identify and prepare for foreseeable coming challenges and lay the groundwork for adapting to future uncertainties and changed circumstances.

After public consultation, we will develop an implementation plan that sets out when we will commence each action, and what we will achieve by when. The implementation plan will also identify key partners for delivering these actions, including local councils, government agencies, local community and industry groups and local Aboriginal communities.

Not all actions will commence at once. The availability of funding and the progress of existing government commitments will be a key consideration in planning when and how the actions will be implemented. The regional water strategies will be a key tool in securing funding as future opportunities arise.

We want your feedback on which actions should be prioritised for implementation over the next 3 to 5 years, and which ones should be implemented in the medium or longer term.

**Figure 20. Macquarie–Castlereagh Regional Water Strategy delivery timeline**




The water security actions in this strategy have a strong focus on drought security following the experience of the 2017–2020 drought. However, this drought has been closely followed by major flood events from 2020–2022.

Some of our proposed water security actions may also help mitigate low to moderate flooding events. A more detailed assessment of the flood mitigation benefits of these options will be vital to progressing the shortlisted actions from the strategy to on-ground implementation. Analysing the flood benefits of many of the proposed actions in this strategy will require enhanced investment by governments in flood modelling and mitigation works.

In the interim, the floodplain management plans being developed for northern NSW valleys provide the cornerstone for whole of catchment floodplain management in western NSW and will be extended into the southern NSW valleys over the coming years. The Office of Local Government and the Department of Planning and Environment – Environment and Heritage also take the specific lead role in flood risk management for towns and regional centres across the state.

Your voice is important. This consultation paper is on public exhibition in October – November. Supporting information is available at water.dpie.nsw.gov.au/plans-and-programs/regional-water-strategies/public-exhibition/macquarie-castlereagh-regional-water-strategy

You can also have your say on the preliminary options packages by providing written feedback to the Department of Planning and Environment via:

**Web:** water.dpie.nsw.gov.au/plans-and-programs/regional-water-strategies/public-exhibition/macquarie-castlereagh-regional-water-strategy

**Email:** regionalwater.strategies@dpie.nsw.gov.au

Throughout this consultation paper we have included focus questions that we'd like to hear your thoughts on. We would also be interested to know:

- whether any of the actions in this consultation paper should not be shortlisted, and why?
- how actions should be staged, and which should be implemented first?

Please note that all submissions will be published on the Department of Planning and Environment's website, unless you let us know in your submission that you do not wish the content to be released.

We will be holding community engagement sessions to give participants an understanding of the context for the regional water strategy and an overview of the proposed priorities and actions. Face-to-face sessions will be held subject to COVID-19 restrictions and risks; otherwise, they will be held online. Details of these sessions can be found at the website listed above.

Image courtesy of Peter Robey, Department of Planning and Environment. River landscape, Dubbo.

Image courtesy of Destination NSW. Lake Burrendong, Mumbil.

# Attachments

# 6

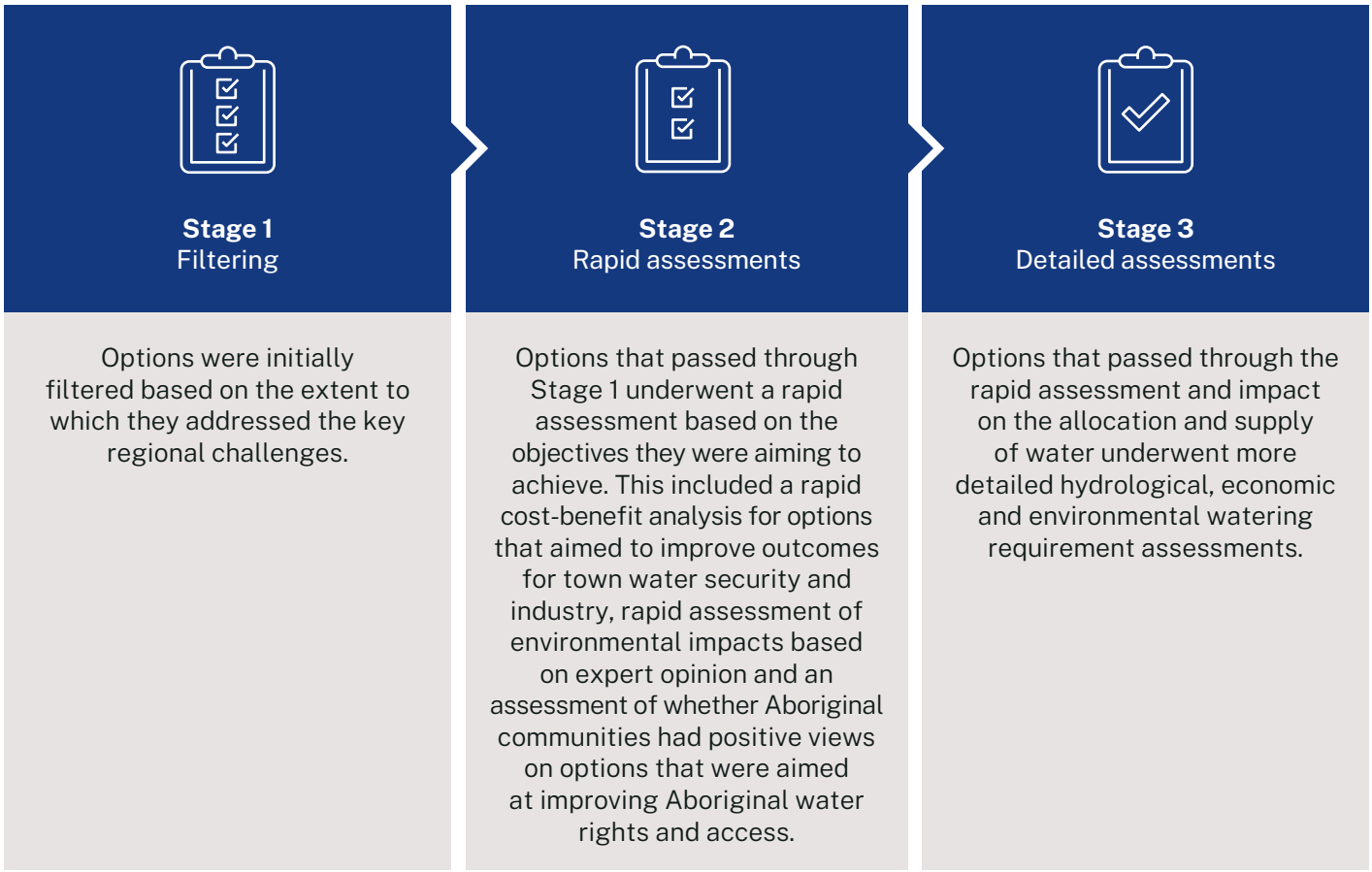
Image courtesy of Destination NSW. Newey Resevoir, Cobar.

# Attachment 1: Summary of the options assessment

The Draft Macquarie-Castlereagh Regional Water Strategy identified 49 draft options. During community consultation on this draft long list, we received feedback from a broad range stakeholder groups including councils, agriculture and industry groups, local communities, conservation groups and Aboriginal stakeholders. Based on this feedback as well as further analysis of the long list of options we have amended a number of options and developed new options to form the proposed shortlist.

The process we followed to move from the long list to the short list is summarised in Figure 21 and described in the *Options assessment process: Overview.*

**Figure 21. Going from a long list to a final strategy of actions**




At each step of the assessment, we narrowed down and filtered out the long list of options from the Draft Macquarie-Castlereagh Regional Water Strategy, based on the evidence we gathered and the analysis we undertook. Based on our analysis, several options were consolidated, refined and converted into actions. Others were not progressed.

This attachment summarises the outcomes of our options assessment. Results from the hydrological, cost-benefit and environmental watering requirement analyses is presented in Attachment 2.

The analysis we have undertaken is a high-level assessment process, appropriate for a strategic document, and is not designed to consider all possible impacts on the environment, water users or Aboriginal people in detail. However, it does provide enough detail to understand if an option is likely to make a net positive contribution to the regional water strategy's objectives. More detailed environmental, economic and cultural assessments are required and will be undertaken in any subsequent business case development or planning processes for options that proceed to implementation stage.

After community consultation, the recommended options for the regional water strategy will be sequenced, meaning, they will not all be progressed or implemented at the same time. Funding will play a role in the sequencing of options.

✓ Options progressed to next step

› To be considered in other NSW processes

× Option not progressed

**Table 6. Assessment of the long list of options**

| Long list option | Stage 1: Filtering | Stage 2: Rapid assessments | | Shortlisted | Comment |
|---|---|---|---|---|---|
| | Meets key regional challenge | Passes rapid cost-benefit analysis? | Rapid environmental assessment | | |
| **Government Commitment 1. A new mid system re-regulating weir on the Wambuul/ Macquarie River** | ✓ | ✓ | Major impact | ✓ | Incorporated into proposed action 2.3: Continue to investigate regional water security solutions for the lower Macquarie. |
| **Government Commitment 2. Access water from Burrendong Dam's deep storage** | × | × | Minor impact | › | This option has been identified as a drought contingency measure and partially completed in 2017–2020 drought. This option was not fully implemented as the drought conditions improved in March 2020. However, in the future, this option will still remain as a drought contingency measure and WaterNSW will re-activate the option when required. |
| **3. Managed aquifer recharge investigations and policy** | × | × | Minor impact | ✓ | See proposed action 1.5: Invest in innovative water supply options. |

| Long list option | Stage 1: Filtering | Stage 2: Rapid assessments | | Shortlisted | Comment |
|---|---|---|---|---|---|
| | Meets key regional challenge | Passes rapid cost-benefit analysis? | Rapid environmental assessment | | |
| **4. Improving town water security in the upper Macquarie Regulated River system** | ✓ | ✓ | Not assessed | ✓ | Incorporated into:<br>• proposed action 1.1: Confirm the level of water security needed to support regional cities<br>• proposed action 1.2: Establish a governance framework to coordinate actions under Priority 1<br>• proposed action 1.4: Adopt a stronger focus on urban water conservation and efficiency<br>• proposed action 1.5: Invest in innovative water supply options<br>• proposed action 1.6: Plan for the best long-term augmentation solution for the upper Macquarie. |
| **5. Drought protocols for Bathurst and Oberon town water supplies** | ✓ | Not assessed | No/little change | ✓ | See proposed action 1.3: Develop guidelines for managing extreme events in the upper Macquarie. |
| **6. Inter-regional connections project investigation** | ✓ | Not assessed | Minor impact | ✓ | Incorporated into proposed action 1.6: Plan for the best long-term augmentation solution for the upper Macquarie. |

| Long list option | Stage 1: Filtering | Stage 2: Rapid assessments | | Shortlisted | Comment |
|---|---|---|---|---|---|
| | Meets key regional challenge | Passes rapid cost-benefit analysis? | Rapid environmental assessment | | |
| **7. Reuse, recycle and stormwater projects** | ✓ | ✓ | No/little change | ✓ | Incorporated into:<br>• proposed action 1.4: Adopt a stronger focus on urban water conservation and efficiency<br>• proposed action 1.5: Invest in innovate water supply options. |
| **8. Burrendong Dam to Nyngan pipeline** | ✓ | Not assessed (modified option from Dubbo to Nyngan assessed) | Minor impact | ✓ | Amended and incorporated into proposed action 2.3: Continue to investigate regional water security solutions for the lower Macquarie. |
| **9. Pipeline from the proposed new mid system weir near Gin Gin to Nyngan** | ✓ | Not assessed | Minor impact | ✗ | Could be considered in future as part of option 8 (pipeline from Dubbo to Nyngan option). The assessment undertaken for this regional water strategy will inform any future work undertaken. |
| **10. Gunningbar Creek pipeline** | ✓ | ✓ | Minor impact | ✓ | Incorporated into proposed action 2.2: Create water savings through changed operation of regulated effluent creeks. |
| **11. Increase Burrendong Dam's Full Supply Level** | ✓ | ✓ | Major impact | ✓ | Incorporated into proposed action 2.3: Continue to investigate regional water security solutions for the lower Macquarie. |

| Long list option | Stage 1: Filtering | Stage 2: Rapid assessments | | Shortlisted | Comment |
|---|---|---|---|---|---|
| | Meets key regional challenge | Passes rapid cost-benefit analysis? | Rapid environmental assessment | | |
| 12. Increase valve capacity at Burrendong Dam | ✓ | Not assessed | Minor improvement | ✗ | Other constraints further downstream need to be addressed prior to considering this option. |
| 13. Reliable access to groundwater by towns | ✓ | Not assessed | Minor impact | ✓ | Incorporated into proposed action 1.7: Reduce uncertainty in groundwater security for the region's towns. |
| 14. Address channel constraints to delivering environmental flows to the Macquarie Marshes | ✓ | Not assessed | Minor improvement | ✓ | See proposed action 4.1: Modify or remove barriers to delivering water for the environment. |
| 15. *NSW Fish Passage Strategy* | ✓ | Not assessed | Minor improvement | ✓ | Incorporated into proposed action 4.3: Mitigate impacts to fish communities. |
| 16. Introduce flow variability in the distributary (effluent) creeks | ✓ | Not assessed | Minor improvement | ✓ | See proposed action 2.2: Create water savings through the changed operation of regulated effluent creeks. |
| 17. Determine the feasibility of delivering water to the Talga Wetland/ Overflow of the lower Crooked Creek | ✗ | Not assessed | Minor improvement | ✗ | This option did not meet a key regional challenge. |

| Long list option | Stage 1: Filtering | Stage 2: Rapid assessments | | Shortlisted | Comment |
|---|---|---|---|---|---|
| | Meets key regional challenge | Passes rapid cost-benefit analysis? | Rapid environmental assessment | | |
| 18. Undertake channel works to reinstate natural channel profiles in selected streams in the southern Macquarie Marshes | ✓ | Not assessed | Minor improvement | ✓ | See proposed action 4.2: Reinstate natural channel profiles in selected streams in the southern Macquarie Marshes. |
| 19. Formalise channel sharing arrangements | ✗ | Not assessed | No/little change | ✗ | The Water Sharing Plan for the Macquarie Cudgegong Regulated River Water Source 2016 was amended August 2022 to include provisions which specify the priority of delivery for water orders including Environmental Water Allowance water. |
| 20. Implement the Native Fish Restoration program | ✓ | Not assessed | Minor improvement | ✓ | Incorporated into proposed action 4.3: Mitigate impacts to fish communities. |
| 21. Diversion screens to prevent fish extraction at pump offtakes | ✓ | Not assessed | Minor improvement | ✓ | Incorporated into proposed action 4.3: Mitigate impacts to fish communities. |
| 22. Cold water pollution mitigation measures | ✓ | Not assessed | Major improvement | ✓ | Incorporated into proposed action 4.3: Mitigate impacts to fish communities. |
| 23. Modification and/or removal of exiting priority floodwork structures causing adverse impacts | ✓ | Not assessed | Minor improvement | ✓ | See proposed action 4.4: Remediate unapproved floodplain structures. |

| Long list option | Stage 1: Filtering | Stage 2: Rapid assessments | | Shortlisted | Comment |
|---|---|---|---|---|---|
| | Meets key regional challenge | Passes rapid cost-benefit analysis? | Rapid environmental assessment | | |
| **24. Relieve flow constraint on the Cudgegong River at Rocky Waterhole Bridge** | ✓ | Not assessed | Minor improvement | ✓ | Incorporated into proposed action 4.1: Modify or remove barriers to delivering water for the environment. |
| **25. Improved understanding of groundwater processes** | ✓ | Not assessed | Minor improvement | › | The action is being addressed at a state level in the NSW Groundwater Strategy and may recommend actions that will require implementation in the Macquarie–Castlereagh region. |
| **26. Sustainable access to groundwater** | ✓ | Not assessed | Minor impact | ✓ | See proposed action 3.4: Undertake research to inform reviews of groundwater extraction and condition limits. |
| **27. Improved clarity in managing groundwater resources sustainably** | ✓ | Not assessed | No/little change | ✓ | Incorporated into proposed action 3.4: Undertake research to inform reviews of groundwater extraction and condition limits. |
| **28. Investigation of water quality mitigation measures** | ✓ | Not assessed | Minor improvement | ✓ | Incorporated into:<br>• proposed action 4.8: Identify regionally significant riparian, wetland and floodplain areas to protect or rehabilitate<br>• proposed action 4.3: Mitigate impacts to fish communities. |

| Long list option | Stage 1: Filtering | Stage 2: Rapid assessments | | Shortlisted | Comment |
|---|---|---|---|---|---|
| | Meets key regional challenge | Passes rapid cost-benefit analysis? | Rapid environmental assessment | | |
| **29. River Ranger Program** | ✓ | Not assessed | No/little change | ✓ | Incorporated into proposed action 3.6: Support place-based initiatives to deliver cultural outcomes for Aboriginal people. |
| **30. Secure flows for Beemunnel Aboriginal Place** | ✓ | Not assessed | No/little change | ✓ | Incorporated into proposed action 3.6: Support place-based initiatives to deliver cultural outcomes for Aboriginal people. |
| **31. Connectivity with downstream systems** | ✓ | Not assessed | N/A | ✓ | Incorporated into proposed action 2.4: Investigate ways to improve connectivity with the Barwon–Darling on a multi-valley scale. |
| **32. End of system efficient stock and domestic delivery options** | ✓ | Not assessed | N/A | ✓ | Incorporated into proposed action 2.2: Create water savings through changed operation of regulated effluent creeks. |
| **33. Enterprise water use efficiency programs** | ✓ | Not assessed | N/A | ✓ | See proposed action 3.3: Support adoption of farm climate adaptation and water efficiency measures. |

| Long list option | Stage 1: Filtering | Stage 2: Rapid assessments | | Shortlisted | Comment |
|---|---|---|---|---|---|
| | Meets key regional challenge | Passes rapid cost-benefit analysis? | Rapid environmental assessment | | |
| **34. Market measures to support Dubbo's town water supply** | ✓ | Not assessed | No/little change | ✗ | This option has been superseded by the $30 million investment in additional groundwater bores for Dubbo.<br><br>See option 37 for surface water measures. |
| **35. Investigation of water access licence conversions** | ✓ | Not assessed | Major impact | ✓ | See proposed action 3.8: Modernise the water management framework so it can continue to support sustainable economic diversification. |
| **36. New drought operational rules (Wambuul/ Macquarie River)** | ✓ | Not assessed | Minor impact | ✓ | See proposed action 4.5: Provide clarity and certainty for environmental needs during drought operations. |
| **37. Review of regulated river water accounting and allocation process** | ✓ | Not assessed | Minor improvement | › | This will be progressed under the NSW Water Strategy's Action 4.2: Review water allocation and water sharing information in response to new climate information.<br><br>The assessment undertaken for this regional water strategy will inform work progressed through the NSW Water Strategy. Refer to Attachment 2 for details. |

| Long list option | Stage 1: Filtering | Stage 2: Rapid assessments | | Shortlisted | Comment |
|---|---|---|---|---|---|
| | Meets key regional challenge | Passes rapid cost-benefit analysis? | Rapid environmental assessment | | |
| **38. Improved data collection and information sharing** | ✓ | Not assessed | No/little change | ✓ | See proposed action 3.2: Improve public access to climate information and water availability forecasts. |
| **39. Capacity building program: - new climate data/ modelling – managing groundwater resources sustainability** | ✓ | Not assessed | No/little change | ✓ | Incorporated into proposed action 3.2: Improve public access to climate information and water availability forecasts. |
| **40. Investigation to maintain amenity for regional towns during drought** | ✓ | Not assessed | No/little change | › | This would be investigated as part of town Integrated Water Cycle Management Plans through Safe and Secure Water Program. |
| **41. Land use change impact on water resources** | ✓ | Not assessed | No/little change | › | This action will be progressed through the NSW Water Strategy Action 4.4: Better integrate land use planning and water management. |
| **42. Culturally appropriate water knowledge program** | ✓ | Not assessed | No/little change | › | This will be considered as part of the NSW Aboriginal Water Strategy. |

| Long list option | Stage 1: Filtering | Stage 2: Rapid assessments | | Shortlisted | Comment |
|---|---|---|---|---|---|
| | Meets key regional challenge | Passes rapid cost-benefit analysis? | Rapid environmental assessment | | |
| 43. Water-dependent cultural practices and site identification | ✓ | Not assessed | No/little change | ✓ | Incorporated into proposed action 3.6: Support place-based initiatives to deliver cultural outcomes for Aboriginal people. |
| 44. Shared benefit project (environment and cultural outcomes) | ✓ | Not assessed | Minor improvement | › | This will be considered as part of the NSW Aboriginal Water Strategy. |
| 45. Establish a Regional Aboriginal Water Advisory Committee | ✓ | Not assessed | N/A | ✓ | Incorporated into proposed action 3.5: Develop ongoing arrangements for participation of local Aboriginal people in water management.<br><br>It will also be considered as part of the NSW Aboriginal Water Strategy. |
| 46. Water portfolio project for Aboriginal communities | ✓ | Not assessed | No/little change | › | This will be considered as part of the NSW Aboriginal Water Strategy. |
| 47. Aboriginal cultural water access licence review | ✓ | Not assessed | No/little change | › | This will be considered as part of the NSW Aboriginal Water Strategy. |
| 48. Co-management investigation of Travelling Stock Reserves | ✓ | Not assessed | No/little change | › | This will be considered as part of the NSW Aboriginal Water Strategy. |

| Long list option | Stage 1: Filtering | Stage 2: Rapid assessments | | Shortlisted | Comment |
|---|---|---|---|---|---|
| | Meets key regional challenge | Passes rapid cost-benefit analysis? | Rapid environmental assessment | | |
| 49. Regional Cultural Water Officer employment program | ✓ | Not assessed | No/little change | → | This will be considered as part of the NSW Aboriginal Water Strategy. |
| (New option) Water security or small discrete communities | ✓ | Not assessed | Not assessed | → | Progressing through the Aboriginal Water and Sewerage Program. |
| (New option) Construction of a small Ulmarrah Dam | ✓ | ✓ | Not assessed | ✓ | Incorporated into proposed action 1.6: Plan for the best long-term augmentation solution for the upper Macquarie. |
| (New option) Improving town water security on the Castlereagh and Talbragar unregulated systems | ✓ | Not assessed | Not assessed | ✓ | Incorporated into:<br>• proposed action 1.2: Establish a governance framework to coordinate actions under Priority 1<br>• proposed action 1.4: Adopt a stronger focus on urban water conservation and efficiency<br>• proposed action 1.5: Invest in innovative water supply options<br>• proposed action 1.7: Reduce uncertainty in groundwater security for the region's town. |

| Long list option | Stage 1: Filtering | Stage 2: Rapid assessments | | Shortlisted | Comment |
|---|---|---|---|---|---|
| | Meets key regional challenge | Passes rapid cost-benefit analysis? | Rapid environmental assessment | | |
| (New sub option) Alternative to the pipeline from Burrendong to Nyngan is a pipeline from Dubbo weir to Nyngan | ✓ | ✓ | Not assessed | ✓ | Incorporated into proposed action 2.3: Continue to investigate regional water security solutions for the lower Macquarie. |
| (New option) Investigate alternative operational rules for the use of tributary flows in the regulated Macquarie River | ✓ | Not assessed | Not assessed | ✓ | Incorporated into proposed action 4.6: Assess gaps in the flow regime that are preventing achievement of environmental water requirements and identify cooperative. |
| (New option) Coordinate the management of irrigation water releases and water for the environment to improve ecological outcomes | ✓ | Not assessed | Not assessed | ✓ | Incorporated into proposed action 4.6: Assess gaps in the flow regime and identify cooperative actions to improve ecological outcomes. |
| (New option) Invest in continuous improvement to groundwater system modelling in the Macquarie-Castlereagh region | ✓ | Not assessed | Not assessed | ✓ | See proposed action 3.1: Invest in continuous improvement to surface and groundwater modelling. |

*Note: Originally identified as an option not to be progressed

# Attachment 2: Assessment of options that impact supply, demand or allocation of water

This attachment summarises the results of the hydrologic, economic and environmental assessment of options in the Draft Macquarie–Castlereagh Regional Water Strategy. It outlines the results of the rapid cost-benefit assessment (CBA) of the long-list of options. It also outlines the results of the detailed CBA that was conducted using the paleo-informed (stochastic) and climate-change adjusted (NARCliM) data sets. These results include the probability and timing of modelled water system failures for the towns and communities of the Macquarie–Castlereagh region. They also consider modelled changes to flow regimes and their environmental impacts.

The following options were subject to rapid and detailed quantitative assessments.

| Title | Rapid cost-benefit analysis | Detailed assessment |
|---|---|---|
| **Options for the upper Macquarie Valley** | | |
| Stormwater harvesting schemes for Bathurst and Orange<br>a. Bathurst stormwater harvesting scheme<br>b. Orange stormwater harvesting scheme (Stage 2)<br>(Option 7 in the Draft Macquarie–Castlereagh Regional Water Strategy) | ✓ | |
| Connect upper Macquarie towns to the Fish River Water Supply Scheme<br>a. Run-of-river supply of water to Bathurst from the Fish River Scheme<br>b. Pipeline supply of water to Bathurst and Orange from the Fish River Scheme<br>(Option 4 in the Draft Macquarie–Castlereagh Regional Water Strategy) | ✓ | ✓ (a. only) |
| Providing additional water from the Wambuul/Macquarie River for Orange<br>(New option) | ✓ | ✓ |
| Ulmarrah Dam<br>(New option) | ✓ | ✓ |

| Title | Rapid cost-benefit analysis | Detailed assessment |
|---|---|---|
| **Options for the Lower Macquarie Valley** | | |
| Off-river water storage at Nyngan<br><br>(New option) | ✓ | ✓ |
| Increase the Burrendong Dam Full Supply Level<br><br>(Option 11 in the Draft Macquarie–Castlereagh Regional Water Strategy) | ✓ | ✓ |
| A mid system re-reg weir on the Wambuul/Macquarie River<br><br>(Option 1 in the Draft Macquarie–Castlereagh Regional Water Strategy) | ✓ | ✓ |
| Dubbo to Nyngan pipeline<br><br>(Option 8 in the Draft Macquarie–Castlereagh Regional Water Strategy) | ✓ | |
| Increased essential needs reserve in Burrendong Dam<br><br>(Option 37 in the Draft Macquarie–Castlereagh Regional Water Strategy) | ✓ | ✓ |

High level results of the cost-benefit assessments are presented below.

A further 3 options were also hydrologically modelled using the historical climate dataset:

- reduced replenishment flows to Gunningbar Creek, Duck Creek and Crooked Creek
- reducing the Wambuul/Macquarie River cease-to-pump condition for Orange City Council
- no irrigation from the Campbells River as a bookend run to understand town water security risks.

## Rapid cost-benefit analysis

The rapid cost-benefit analyses were modelled against approximately 130 years of data. There were 2 key limitations of the rapid cost-benefit analysis (CBA) relevant to all options:

- the rapid cost-benefit analyses use the historic instrumental climate record (approximately 130-years). Although this period contains some periods of drought, the models showed very few instances of water supply shortfalls over this period. This will undervalue options aimed at improving reliability
- population growth was not considered in rapid cost-benefit assessment but was considered in the detailed assessment.

## Detailed economic and ecological analysis

In the past, water infrastructure and policy changes have been assessed against approximately 130 years of data – the historic set of instrumental data. Using the long-term paleoclimatic analysis developed for the regional water strategies, together with projections of a future dry climate change scenario gives us a much better understanding of the water risks that the region could face and how well different options could perform under different climate scenarios that we haven't seen in our observed past. The rapid cost-benefit analysis (CBA) was carried out using the historic instrumental data, while the detailed CBA and environmental assessments were carried out using the new long-term data sets.

The long-term climate data sets comprise:

- a 10,000-year synthetic data set based on the paleoclimatic analysis (referred to as the stochastic climate scenario in this document)
- a 'worst-case' dry climate change scenario, which is based on the paleoclimatic analysis and a set of scaling factors developed for the NARCliM project (referred to as the NARCliM climate scenario in this document).

For the purposes of the economic and environmental assessments, these data sets were broken down into 1,000 periods (termed realisations for the purposes of this assessment) of 40-year duration. This allows us to understand the economic and environmental impacts over the 40-year outlook of the regional water strategies. It also allows us to better plan for uncertainty by considering 1,000 different possibilities of what the climate may look like over the next 40 years.

The Macquarie–Castlereagh Regional Water Strategy is considering actions that address a wide range of objectives. The detailed CBA process focusses on those actions that address the reliability of water supply to towns and communities and water for agriculture and industry.

We know that population changes in the Macquarie–Castlereagh will have a large impact on future water security. To reflect variability of future population growth, local government area (LGA) population forecasts have been used in the detailed assessment. If no LGA population forecasts are provided, then the median and high growth common planning assumptions are used. These are the official NSW Government projections that are consistent with the NSW Treasury recommendations for estimating future populations across the state.

## Ecological assessment methodology

The ecological effects of the options were modelled and assessed at 23 sites across the Macquarie River catchment. The sites were selected to allow a reasonable representation of numerous freshwater habitat types across this catchment.

Flow metrics used for this report's assessment included the frequency and duration of cease-to-flow events and base flows; the frequency of freshes, large and infrequent bankful and overbank flows, and low flows (90th and 95th percentile flows); and the annual volume of flows. For this round of reporting environmental flow metrics are solely those derived from the department's risk assessments.[56]

These metrics were assessed for the stochastic and NARCliM scenarios. The results were then categorised as having an impact from extreme improvement to extreme impact. It uses a categorisation system to rate the potential impacts or benefits to the environment. The rapid environmental assessment uses a 5-category ranking (Stage 1) and the detailed assessment used an expanded 11-category ranking. Table 7 describes the impact categories used in the environmental assessments and their associated changes in hydrology.

The ecological effects of the options will also be assessed against metrics in the Long-Term Watering Plan for this valley in a subsequent, more detailed document.[57]

56. For this valley, see Department of Planning, Industry and Environment – Water 2018, *Risk Assessment for the Macquarie–Castlereagh Water Resource Plan Area (1),* Department of Planning, Industry and Environment – Water.
57. Department of Planning, Industry and Environment 2020, *Macquarie–Castlereagh Long Term Water Plan,* Parts a and b, as already cited.

**Table 7. Explanation of categories used in ecological assessment**

| Stage 1 category | Stage 2 category | Estimated percentage change in hydrology/ecology |
|---|---|---|
| Major/Extreme impact | Extreme impact | More than 30% change in a negative direction (i.e. < -30%) |
| | Major impact | More than 20% change in a negative direction (i.e. < -20%) |
| Minor/Moderate impact | Moderate impact | More than 10% change in a negative direction (i.e. < -10%) |
| | Minor impact | More than 3% change in negative direction (i.e. < -3%) |
| No/Little change | Little impact | Less than 3 % change in a negative direction (i.e.< 0%) |
| | No change | 0%, rounded to the nearest whole percentage point |
| | Little improvement | Less than 3% change in a positive direction (>0% and <3%) |
| Minor/Moderate improvement | Minor improvement | More than 3% change in a positive direction (i.e. >3%) |
| | Moderate improvement | More than 10% change in a positive direction (i.e. >10%) |
| Major/Extreme improvement | Major improvement | More than 20% change in a positive direction (i.e. >20%) |
| | Extreme improvement | More than 30% change in a positive direction (i.e. >30%) |

It is important to note that the environmental assessments presented below are based on generic flow metrics that describe typical components of the flow regimes upon which flow-dependent species and communities rely. Flow-dependent species and communities often have different and more complex environmental water requirements that cannot be represented with simple or generic metrics. There are also many external factors and long-term hydrological and ecological effects associated with river management that the models used for these assessments cannot capture which could affect the viability of aquatic species and populations. The metrics used for these assessments are designed to help eliminate unviable management options and to support identification of a shorter list of options that can undergo more detailed analysis at future stages of development if required.

## Orange and Bathurst stormwater harvesting

| | |
|---|---|
| **Purpose** | Reduce town water shortfall risk for the regional cities of Orange and Bathurst.<br><br>This was part of Option 7 in the Draft Macquarie–Castlereagh Regional Water Strategy. |
| **Description** | This option assessed the additional supply of water for each town from stormwater harvesting:<br>• Phase 2 of Orange's Stormwater Harvesting Scheme, which involves expansion of the Blackmans Swamp Creek Stormwater Harvesting Scheme to provide an additional 36 ML of air space for filling with harvested stormwater.<br>• Construction of 2 storage ponds (36 and 8 ML) to capture stormwater runoff and a replacement pipeline from Winburndale Dam to Bathurst.<br><br>The option also assumed reduced environmental releases from Orange's Suma Park Dam in drought.<br><br>These water harvesting schemes are already approved or underway. |
| **Results** | **Effective at meeting the main objective of reducing town water security risk.**<br><br>This option improves the town water supply security for Bathurst and Orange. It reduces the time spent in any level of restriction under the historic climate. It also reduces the risk of these towns running out of water but does not eliminate these risks or brings it down to acceptable standards, suggesting that additional actions are needed to secure water for Orange and Bathurst. |
| **Limitations** | The modelling is sufficient to demonstrate the effect of this option on Bathurst and Orange's water security. |

**Modelled effect of stormwater harvesting schemes on time in water restrictions or a supply failure for Bathurst and Orange under the historical climate.**

| Town | Base case | With stormwater harvesting |
|---|---|---|
| **Time under water restrictions** | | |
| Bathurst | 4.9% (1 in 20 years) | 3.9% (1 in 30 years) |
| Orange | 21.1% (1 in 5 years) | 19.9% (1 in 5 years) |
| **Time under severe water restrictions*** | | |
| Bathurst | 1.8% (1 in 60 years) | 1.4% (1 in 70 years) |
| Orange | 3.3% (1 in 30 years) | 2.1% (1 in 50 years) |
| **Time with a surface water failure**** | | |
| Bathurst | 1.7% (1 in 60 years) | 0.4% (1 in 250 years) |
| Orange | 1.9% (1 in 50 years) | 0.7% (1 in 140 years) |

*Severe restrictions are defined differently for each Council and depends on their restriction regime and water supply sources.
- Orange: Level 5 restrictions, which represents 62% of unrestricted demand, or worse
- Bathurst: Level 4 restrictions, which represents 67% of unrestricted demand, or worse.

**Failure is defined differently for each Council and depends on their restriction regime and water supply sources.
- Orange: Where water demands cannot be met under level 6 restrictions for Orange, which represents 60% of unrestricted demand
- Bathurst: Where water demands cannot be met under level 5 restrictions for Bathurst, which represents 52% of unrestricted demand.

**Summary model results for water users on the Macquarie Regulated River using the historical climate. These are compared to the base case (i.e. no change).**

| Change in long-term average water take under licences (GL/year) | | | Change in average end of year general security allocation (%) | Change in % of time Burrendong Dam <5% full supply level |
|---|---|---|---|---|
| General security | Supplementary | High security | | |
| 0.1 (0.1%) | No change | No change | +0.1 | No change |

**Summary of economic modelling results under the historical climate dataset.**

| Climate data | Average change in economic outcomes ($ million, over 40 years) | | | Option cost ($ million, over 40 years) | Average Net Present Value ($ million, over 40 years) | Average benefit to cost ratio |
|---|---|---|---|---|---|---|
| | Towns | Annual agriculture | Permanent crops | | | |
| Historical | 0.2 (0.6%) | 1.1 (0.1%) | 0 (0%) | 8.4 | -7.2 | <1 |

Image courtesy of David Roma, Destination NSW. Bathurst Winter Festival, Bathurst.

# Bathurst water supply from the Fish River (via pipeline)

| | |
|---|---|
| **Purpose** | Reduce town water shortfall risk for the regional city of Bathurst.<br><br>This was part of Option 4 in the Draft Macquarie–Castlereagh Regional Water Strategy. |
| **Description** | This option assessed the additional supply of water to Bathurst from the Fish River Supply Scheme. The option assumed an annual allocation to Bathurst, supplied as a constant year-round demand via a 24 ML/day pipeline to Chifley Dam at times when Chifley Dam is below 50% full. It also assumes a new 2 GL/year industrial demand near Bathurst. |
| **Results** | **Effective at meeting the main objective of reducing town water security risk and has been progressed to the short list, but requires further consultation, modelling and investigation.**<br><br>This option improves town water supply security. It results in positive outcomes for towns and communities in all 3 climate datasets. It also produces smaller benefits for annual agriculture.<br><br>In the historical dataset the benefit of maintaining a perpetual supply of water to towns and communities is almost $10 million compared to the base case. These average benefits would not offset the cost of infrastructure required.<br><br>Given the high-level nature of the assessment, it warrants further investigation given the importance of the benefits to Bathurst. Further investigation may reveal that those benefits are more significant than in the regional water strategy assessment.<br><br>The critical uncertainty around this option is the ability to secure entitlements from the Fish River catchment for urban supply in the short term. This will need concerted effort and investigation. |
| **Limitations** | The estimated cost of this option contains a high degree of uncertainty. It is likely that the cost of the infrastructure would increase in the event of further site-specific considerations and costings based on a progressed design.<br><br>This option could be considered more broadly to include benefits for Orange.<br><br>The cost of additional water from the Fish River Scheme could increase bills for local communities, and this analysis would need further investigation.<br><br>Securing entitlements in the short term could be a challenge. |

**Modelled effects of connecting Bathurst to the Fish River Water Supply Scheme on Bathurst's water security based on the historical climate.**

| | Bathurst's existing supply | Supply from Fish River Water Supply Scheme (via pipeline) |
|---|---|---|
| Time under water restrictions | 4.9% (1 in 20 years) | 2.8% (1 in 40 years) |
| Time under severe restrictions* | 1.8% (1 in 60 years) | 0.9% (1 in 110 years) |
| Time with a surface water failure** | 1.7% (1 in 60 years) | 0% (No simulated occurrences) |

*Severe restrictions are defined differently for each Council and depends on their restriction regime and water supply sources.
- Bathurst: Level 4 restrictions, which represents 60% of unrestricted demand, or worse.

**Failure is defined differently for each Council and depends on their restriction regime and water supply sources.
- Bathurst: Where water demands cannot be met under level 5 restrictions for Bathurst, which represents 52% of unrestricted demand.

**Summary model results for water users on the Macquarie Regulated River using the historical climate. These are compared to the base case (i.e. no change).**

| Change in long-term average water take under licences (GL/year) | | | Change in average end of year general security allocation (%) | Change in % of time Burrendong Dam <5% full supply level |
|---|---|---|---|---|
| General security | Supplementary | High security | | |
| 0.1 (+0.1%) | No change | No change | No change | No change |

**Summary of economic modelling results under the historical climate dataset.**

| Climate data | Average change in economic outcomes ($ million, over 40 years) | | |
|---|---|---|---|
| | Towns | Annual Agriculture | Permanent Agriculture |
| Historical | 9.4 (25.9%) | 2.7 (0.2%) | 0 (0%) |

# Bathurst supply from Fish River (via Fish River)

| | |
|---|---|
| **Purpose** | Reduce town water shortfall risk for the regional city of Bathurst.<br><br>This is Option 4 in the Draft Macquarie–Castlereagh Regional Water Strategy. |
| **Description** | This option assessed the additional supply of water to Bathurst from the Fish River Supply Scheme.<br><br>The option assumes an annual allocation to Bathurst, which is used to supply 50% of Bathurst's water demand when Chifley Dam is below 40% full. The water is supplied as a dam release.<br><br>The option also assumes a new high security demand of 2 GL/year upstream of Bathurst.<br><br>The modelling maintains the security of supply to other Fish River customers. |
| **Results** | **Effective at meeting the main objective of reducing town water security risk and has been progressed to the short list, but requires further consultation, modelling and investigation.**<br><br>This option improves water supply security for Bathurst without negatively impacting on annual or permanent agriculture. The time in any level of restriction is reduced by 2.5% under the stochastic climate dataset and by 6.7% under the NARCliM climate dataset.<br><br>Avoiding these restrictions and shortfalls improves the average economic outcomes for Bathurst over a 40-year period by $18 million under the stochastic climate dataset and by $74 million under the NARCliM climate dataset. Minor improvements are also experienced by agriculture.<br><br>Given the high-level nature of the assessment, it warrants further investigation given the importance of the benefits to Bathurst. Further investigation may reveal that those benefits are more significant than in the regional water strategy assessment.<br><br>The critical uncertainty around this option is the ability to secure entitlements from the Fish River catchment for urban supply in the short term. This will need concerted effort and investigation. |
| **Limitations** | The estimated cost of this option contains a high degree of uncertainty.<br><br>The economic benefits assigned to the new high security entitlements has not been estimated or included in the analysis.<br><br>This option could be considered more broadly to include benefits for Orange.<br><br>The cost of additional water from the Fish River Scheme could significantly increase bills for local communities, and this analysis would need further investigation.<br><br>Securing entitlements in the short term could be a challenge. |

**Modelled effects of supplying Bathurst from the Fish River Water Supply Scheme on Bathurst's water security based on the historical climate.**

| | Historical climate | | Long-term climate | | Dry climate change scenario | |
|---|---|---|---|---|---|---|
| | Base case | With option | Base case | With option | Base case | With option |
| Time under water restrictions | 4.9% (1 in 20 years) | 2.1% (1 in 50 years) | 3.8% (1 in 30 years) | 1.3% (1 in 80 years) | 13.8% (1 in 10 years) | 7.1% (1 in 14 years) |
| Time under severe water restrictions* | 1.8% (1 in 60 years) | 0.5% (1 in 200 years) | 1.6% (1 in 60 years) | 0.1% (1 in 1,000 years) | 7.6% (1 in 10 years) | 2.3% (1 in 40 years) |
| Time of surface water failure ** | 1.7% (1 in 60 years) | 0.4% (1 in 250 years) | 1.2% (1 in 120 years) | 0.1% (1 in 1,000 years) | 6.3% (1 in 16 years) | 1.7% (1 in 60 years) |

*Severe restrictions are defined differently for each Council and depends on their restriction regime and water supply sources.
- Bathurst: Level 4 restrictions, which represents 67% of unrestricted demand, or worse.

**Failure is defined differently for each Council and depends on their restriction regime and water supply sources.
- Bathurst: Where water demands cannot be met under level 5 restrictions for Bathurst, which represents 52% of unrestricted demand.

**Summary model results for water users on the Macquarie Regulated River using historical, long-term climate and dry climate change datasets. These are compared to the base case (i.e. no change).**

| | Change in long-term average water take under licences (GL/year)* | | | Change in end of year general security allocation (%) | Change in % of time Burrendong Dam <5% full supply level |
|---|---|---|---|---|---|
| | General security | Supplementary | High security | | |
| Historical | 1.1 (+0.4%) | No change | No change | 0.3 | -0.1% (-12.7%) |
| Long-term climate | 1.1 (+0.4%) | No change | No change | 0.2 | -0.1% (-7.9%) |
| Dry climate change scenario | 1.0 (+0.7%) | No change | No change | 0.3 | -0.5% (-5.3%) |

*These figures demonstrate general security usage and not annual reliability.

**Summary of economic modelling results under the historical, long-term climate and dry climate change datasets.**

| Climate data | Average change in economic outcomes ($ million, over 40 years) (% change from base case) | | |
|---|---|---|---|
| | **Towns** | **Annual agriculture** | **Permanent agriculture** |
| Historical | 12.8 (35.3%) | 4.2 (0.3%) | 0 (0%) |
| Long-term climate | 18.2 (33.2%) | 2.9 (0.2%) | 0.1 (1.6%) |
| Dry climate change scenario | 74.2 (24.5%) | 0.9 (0.1%) | 0.6 (29.3%) |

Image courtesy of Destination NSW. Windamere Dam, Mudgee.

## Environmental effects of the Bathurst supply from Fish River (via Fish River) option

The option affects the Fish River, which is a priority asset within the Macquarie Headwaters water source within the Macquarie–Castlereagh Long-Term Water Plan. Historical accounts suggest a very diverse and healthy instream community comprising of 'black bream' (Macquarie Perch), river blackfish, silver perch, golden perch, Murray Cod, trout cod freshwater catfish, and platypus.[58] As a probable result of habitat change, stocking and droughts, the fish community is now largely naturalised brown and rainbow trout, and the native Mountain galaxias.[59] The river's health as a trout fishery is therefore of social and recreational value. However, the Fish River is still considered to have a valuable natural flow-dependent community under the Surface Water Risk Assessment,[60] which is currently attributed to the presence of several species of threatened frogs, which probably includes the Booroolong Frog.[61] This risk assessment considered the Fish River is already at a high risk of not receiving its required environmental flows for zero and fresh flows and for smaller overbank flows. All other environmental flow categories were classified as at medium risk.

This option was associated with 2 moderate improvements in zero flow events and one minor improvement in very low flow rates under the stochastic climate scenario. In this analysis the improvements in zero flow events were driven by extreme improvements at 4 gauges (Macquarie River at Bathurst, Fish River at Tarana, Dixons Point and Burrendong Dam inflows). The improvements in duration of zero flow spells were all less than a day, while the number of years with zero flow events was greatest at Bathurst where it declined from one in 32 years to one in 118 years.

There were moderate improvements in the Fish River and for the Wambuul/Macquarie River at Bathurst in the order of an increase around 2 to 3 ML/day.

The climate change (NARCliM) modelling revealed similar effects on zero flows but an extreme improvement in very low flows and minor improvement in base flows. There was also a moderate improvement for median days below low flow and a minor change to low flow standard deviation. Macquarie at Bathurst (8 to 13 ML/day) and Fish River (9 to 12 ML/day) and 2 other gauges also had extreme improvements. There was also a decrease in low flow standard deviation which was largest at Bathurst and in the Fish River which may be due to improvements in very low flows and base flows but is more likely due to regulation to supply water to Bathurst.

Overall, the changes in flow, while in some instances were proportionately large are relatively minor from an environmental perspective. Given that this data is averaged over time at a site level, the proportional differences and ecological effect could be much larger or smaller than these averages for specific flow events. The increases in very low flows in the Fish River and Macquarie River at Bathurst are likely to increase the amount of habitat available and maintain water quality for native fish during stressful periods.

58. Trueman, W. T 2011, *True tales of the trout cod: River histories of the Murray–Darling Basin,* Murray–Darling Basin Authority, and Grant, T. R., & Temple–Smith, P. D 1998, *Field biology of the platypus (Ornithorhynchus anatinus): historical and current perspectives,* Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences, 353(1372), pp 1081-1091. Baumgartner, L., Cameron, L., Faragher, B., & Pogonoski, J 2008, *An assessment of the trout fishery in Oberon Dam and the Fish River,* Transactions of the American Fisheries Society, 120, pp 582-588.
59. Baumgartner, L., Cameron, L., Faragher, B., & Pogonoski, J 2008, *An assessment of the trout fishery in Oberon Dam and the Fish River*, Transactions of the American Fisheries Society, 120, 582-588.
60. Department of Planning, Industry and Environment – Water 2018, *Risk Assessment for the Macquarie–Castlereagh Water Resource Plan Area (SW11),* Department of Planning, Industry and Environment – Water.
61. Hansen, N., & Crosby, K 2016, *Habitat use of the threatened Booroolong Frog (Litoria booroolongensis) in the Central West Catchment Management Area,* Australian Zoologist, 38(2), pp 161-170.

**Predicted environment effects of the Bathurst supply from Fish River (via Fish River) option using long-term climate and dry climate change dataset.**

| | Long-term climate | Dry climate change scenario |
|---|---|---|
| **Metric** | **Average (Min-Max)** | **Average (Min-Max)** |
| Number of years with greater or equal to one zero flow spell in 130 years | 0 (-0.1 to 0.1) | 0 (-0.3 to 0.2) |
| Average duration of zero flow spells (days) | -18 (-96 to 0.7) | -15 (-74 to 0) |
| Number of zero events per 130 years | -15 (-93 to 1.1) | -13 (-69 to 0.1) |
| Very low flow rate (ML/day) measured as the 95th percentile discharge of daily flows | 9 (0 to 100) | 37 (0 to 162.9) |
| Low flow rate (ML/day), measured as the 90th percentile discharge of daily flows | 2.3 (0 to 15) | 9 (0 to 35.4) |
| Median annual low flow days | 0.8 (0 to 6) | 1.1 (0 to 7) |
| Median days below low flow | -2.1 (-33 to 0) | -18 (-100 to 0) |
| Low flow standard deviation | -2.6 (-23 to 0) | -5.8 (-34 to 0) |
| Low flow days below the 75th percentile | -0.9 (-14 to 0) | -2.3 (-17 to 0) |
| Base flow rate (ML/day), measured as the 80th percentile discharge of daily flows | 1.2 (0 to 13) | 3.8 (-1.2 to 30) |
| Mean annual discharge (ML/year) | 0.6 (0 to 4.8) | 0.9 (0 to 7) |
| Fresh flow rate (ML/day), measured as discharge of daily flows | 0.9 (0 to 7) | 1.1 (0 to 8) |
| Average number of freshes per year | 0 (0 to 0) | 0 (0 to 0.4) |
| Average duration of freshes (number of days) | 0.3 (-0.4 to 3.1) | 0.2 (-0.9 to 2.9) |
| High flows – discharge for 2.5-year Annual Return rate (ML/day) | 0.2 (0 to 2.1) | 0.3 (0 to 1.5) |
| High flows - discharge for 5-year Annual Return rate (ML/day) | 0 (-0.4 to 0.7) | 0.1 (-0.5 to 1.8) |
| Very high flows - discharge for 10-year Annual Return rate (ML/day) | 0.1 (0 to 0.6) | 0 (-1.7 to 0.6) |
| Monthly flow coefficient of variation | -0.7 (-3.8 to 0.5) | -2.1 (-9 to 0.3) |
| Daily flow coefficient of variation | -0.7 (-4.6 to 0.4) | -2.2 (-10 to 0.2) |
| Weekly flow coefficient of variation | -0.7 (-4 to 0.3) | -2.2 (-11 to 0.2) |

Note: The environmental effect is calculated as the percentage change against the base case. Cells are shaded following Table 7. Explanation of categories used in ecological assessment.

# Increased water access to the Wambuul/Macquarie River by Orange City Council

| | |
|---|---|
| **Purpose** | Reduce town water shortfall risk for the regional city of Orange.<br><br>This was identified during Public Exhibition 1 of the Draft Macquarie–Castlereagh Regional Water Strategy. |
| **Description** | This option removes Orange's current annual limit on water taken from the Wambuul/Macquarie River and allows unlimited access, while still adhering to the cease-to-pump threshold of 108 ML/day.<br><br>This has the effect of increasing the average annual take from 611 ML/year under the historic base case to 1,091 ML/year. |
| **Results** | **Effective at meeting the main objective of reducing town water security risk and has been progressed to the short list.**<br><br>This option improves water supply security for Orange with only minor impacts on annual or permanent agriculture. The time in any level of restriction is reduced by 3.5% under the stochastic climate dataset and by 5% under the NARCliM climate dataset. This option helps reduce (but not eliminate) the risk of Orange running out of surface water under current conditions, but its effectiveness is reduced under a dry climate change scenario as the scenario assumes significantly less inflows into the Wambuul/Macquarie River. This suggests that the option may be worth pursuing in the short term but cannot in itself secure Orange's long term water needs.<br><br>Avoiding restrictions and shortfalls improves the average economic outcomes for Orange over a 40-year period by $7.8 million under the stochastic climate dataset and by $34 million under the NARCliM climate dataset.<br><br>Under the NARCliM dataset, this option produces benefits that outweigh the costs, resulting in a positive net present value, and a benefit cost ratio greater than one. Under the stochastic dataset, the option produces benefits, but they are slightly less than the estimated cost. The result is that net present value is slightly negative and the benefit to cost ratio is less than one.<br><br>Given the benefits that are produced under any circumstances, and particularly the climate change forecasts, this option is worth considering further. |
| **Limitations** | The modelling is sufficient to demonstrate the effect of this option.<br><br>Further analysis could better define costs and impacts on water users in the unregulated section of the Wambuul/Macquarie River. |

**Modelled effects on Orange's water security using historical, long-term climate and dry climate change datasets.**

| | Historical | | Long-term climate | | Dry climate change scenario | |
|---|---|---|---|---|---|---|
| | **Base case** | **With option** | **Base case** | **With option** | **Base case** | **With option** |
| Time under water restrictions | 21.1% (1 in 5 years) | 17.8% (1 in 6 years) | 17.3% (1 in 6 years) | 13.8% (1 in 10 years) | 46.5% (1 in 2 years) | 41.5% (1 in 2 years) |
| Time under severe water restrictions* | 3.3% (1 in 30 years) | 1.3% (1 in 80 years) | 1.7% (1 in 6 years) | 0.9% (1 in 110 years) | 14.7% (1 in 7 years) | 10.9 (1 in 9 years) |
| Time of surface water failure ** | 1.9% (1 in 50 years) | 0.4% (1 in 250 years) | 1.1% (1 in 90 years) | 0.5% (1 in 200 years) | 11.8% (1 in 10 years) | 8.5% (1 in 10 years) |

*Severe restrictions are defined differently for each Council and depends on their restriction regime and water supply sources.
- Orange: Level 5 restrictions, which represents 62% of unrestricted demand, or worse.

**Failure is defined differently for each Council and depends on their restriction regime and water supply sources.
- Orange: Where water demands cannot be met under level 6 restrictions for Orange, which represents 60% of unrestricted demand.

**Summary model results for water users on the Macquarie Regulated River using the historical, long-term climate and dry climate change datasets. These are compared to the base case (i.e. no change).**

| | Change in long-term average water take under licences (GL/year)* | | | Change in end of year general security allocation (%) | Change in % of time Burrendong Dam <5% full supply level |
|---|---|---|---|---|---|
| | **General security** | **Supplementary** | **High security** | | |
| Historical | -0.2 (-0.1%) | No change | No change | No change | No change |
| Long-term climate | -0.1 (-0.1%) | No change | No change | No change | No change |
| Dry climate change scenario | -0.1 (-0.1%) | No change | No change | No change | +0.1 (+1%) |

*These figures demonstrate general security usage and not annual reliability.

**Summary of economic modelling results under the long-term climate and dry climate change datasets.**

| Climate data | Average change in economic outcomes ($ million, over 40 years) | | | Option cost ($ million, over 40 years) | Average Net Present Value ($ million, over 40 years) | Average benefit to cost ratio |
|---|---|---|---|---|---|---|
| | Towns | Annual Agriculture | Permanent Agriculture | | | |
| Long-term climate | 7.8 (14.2%) | -0.5 (0%) | 0 (-0.4%) | $8 | -$1 | <1 |
| Dry climate change scenario | 33.9 (11.2%) | -0.6 (-0.1%) | -0.2 (-10.2%) | $8 | $25 | >1 |

## Environmental effects of increased water access to the Wambuul/ Macquarie River by Orange City Council

Increasing Orange City Council's access to water under this option showed almost no environmental impact.

The exception was that the climate change modelling identified a minor impact on very low flows. Changes equated to losses in discharge of less than 1 ML/day.

However, this is based on time averaged data at each site, and the option has the potential to impact all these areas that are considered of environmental significance under the Long-Term Watering Plan. Hence, if this option was pursued then the effects during low flow sequences requires further investigation.

**Predicted environment effects of increased water access to the Wambuul/Macquarie River by Orange City Council using long-term climate and dry climate change scenario modelling.**

| | Long-term climate | Dry climate change scenario |
|---|---|---|
| **Metric** | **Average (Min-Max)** | **Average (Min-Max)** |
| Number of years with greater or equal to one zero flow spell in 130 years | 0 (-0.2 to 0) | 0 (-0.1 to 0) |
| Average duration of zero flow spells (days) | -0.2 (-5.4 to 0.9) | 0.5 (0 to 1.4) |
| Number of zero events per 130 years | 0 (-3.5 to 1.8) | 0.2 (-0.1 to 1.2) |
| Very low flow rate (ML/day) measured as the 95th percentile discharge of daily flows | 0 (-0.4 to 0.8) | -3.8 (-29 to 0) |
| Low flow rate (ML/day), measured as the 90th percentile discharge of daily flows | -0.1 (-1.2 to 0.3) | -0.8 (-2.5 to 0) |
| Median annual low flow days | 0 (-0.2 to 0.1) | 0 (-0.3 to 0) |
| Median days below low flow | 0 (0 to 0) | 0 (0 to 0) |
| Low flow standard deviation | 0 (-0.1 to 0.3) | 0.2 (0 to 0.5) |
| Low flow days below the 75th percentile | 0.8 (0 to 12) | 0 (0 to 0) |
| Base flow rate (ML/day), measured as the 80th percentile discharge of daily flows | -0.2 (-1.9 to 0) | -0.3 (-2.1 to 0) |
| Mean annual discharge (ML/year) | 0 (0 to 0.2) | 0 (-0.1 to 0) |
| Fresh flow rate (ML/day), measured as discharge of daily flows | 0 (0 to 0) | 0 (-0.2 to 0) |
| Average number of freshes per year | 0 (0 to 0) | 0 (-0.3 to 0) |
| Average duration of freshes (number of days) | 0 (-0.3 to 0.2) | 0 (-0.2 to 0.3) |
| High flows – discharge for 2.5-year Annual Return rate (ML/day) | 0 (0 to 0.7) | 0 (0 to 0.1) |
| High flows – discharge for 5-year Annual Return rate (ML/day) | 0 (-0.3 to 0) | 0 (0 to 0.2) |
| Very high flows – discharge for 10-year Annual Return rate (ML/day) | 0 (-0.2 to 0.4) | 0 (-0.8 to 2.4) |
| Monthly flow coefficient of variation | 0 (-0.3 to 0.3) | 0.2 (0 to 0.6) |
| Daily flow coefficient of variation | 0 (0 to 0.2) | 0.1 (0 to 0.4) |
| Weekly flow coefficient of variation | 0 (0 to 0.2) | 0.1 (0 to 0.4) |

Note: The environmental effect is calculated as the percentage change against the base case. Cells are shaded following Table 7. Explanation of categories used in ecological assessment.

# A new dam on the Wambuul/Macquarie River at Dixons Long Point Crossing (Ulmarrah Dam)

| | |
|---|---|
| **Purpose** | Reduce town water shortfall risk for the regional city of Orange.<br><br>This is a new option included in the long list following public consultation on the draft strategy. |
| **Description** | Construct a new 30 GL dam on the Wambuul/Macquarie River at Dixons Long Point Crossing, which is 65 km upstream of Burrendong Dam.<br><br>The option assumes:<br>• that Orange's current town water supply pipeline from the Macquarie River would directly access the dam<br>• standard environmental dam releases and an Environmental Water Allowance<br>• the water supply is solely used by Orange. |
| **Results** | **Effective at meeting the main objective of reducing town water security risk and has been progressed to the short list.**<br><br>This option can help reduce water security risks for towns in the upper Macquarie. |
| **Limitations** | The modelling is sufficient to demonstrate the effect of this option on water availability.<br><br>Further analysis and engagement would be required to understand optimum dam size, environmental and cultural impacts, water sharing arrangements, preferred owner and operator arrangements, dam operating rules and final hydrology modelling.<br><br>The construction of a greenfield dam is also expected to generate a range of environmental, cultural and social impacts within the inundation area and downstream, requiring further detailed investigations to understand the full extent of impacts.<br><br>The estimated cost of this option contains a high degree of uncertainty. It is likely that the cost of the infrastructure would significantly increase in the event of further site-specific considerations and costings based on a progressed design.<br><br>Recent experiences suggest that new dams could cost more than $1 billion. |

**Changes to surface water availability for Orange.**

| | Historical | | Long-term climate | | Dry climate change scenario | |
|---|---|---|---|---|---|---|
| | **Base case** | **With option** | **Base case** | **With option** | **Base case** | **With option** |
| Time under water restrictions | 21.1% (1 in 5 years) | 5.0% (1 in 20 years) | 17.3% (1 in 6 years) | 4.8% (1 in 21 years) | 46.5% (1 in 2 years) | 19.1% (1 in 5 years) |
| Time under severe water restrictions* | 3.3% (1 in 30 years) | 0.0% (No simulated occurrences) | 1.7% (1 in 60 years) | 0.0% (No simulated occurrences) | 14.7% (1 in 7 years) | 0.4% (1 in 250 years) |
| Time of surface water failure ** | 1.9% (1 in 50 years) | 0.0% (No simulated occurrences) | 1.1% (1 in 90 years) | 0.0% (No simulated occurrences) | 11.8% (1 in 10 years) | 0.1% (1 in 1,000 years) |

*Severe restrictions are defined differently for each Council and depends on their restriction regime and water supply sources.
- Orange: Level 5 restrictions, which represents 62% of unrestricted demand, or worse.

**Failure is defined differently for each Council and depends on their restriction regime and water supply sources.
- Orange: Where water demands cannot be met under level 6 restrictions for Orange, which represents 60% of unrestricted demand.

**Summary model results for water users on the Macquarie Regulated River using the historical, long-term climate and dry climate change datasets. These are compared to the base case (i.e. no change).**

| | Change in long-term average water take under licences (GL/year)* | | | Change in end of year general security allocation (%) | Change in % of time Burrendong Dam <5% full supply level |
|---|---|---|---|---|---|
| | **General security** | **Supplementary** | **High security** | | |
| Historical | -1.7 (-0.7%) | No change | No change | -0.3 | +0.1 (13.1%) |
| Long-term climate | -1.7 (-0.7%) | No change | No change | -0.4 | +0.1 (15.2%) |
| Dry climate change scenario | -1.5 (-1.2%) | No change | No change | -0.3 | +0.9 (10.8%) |

*These figures demonstrate general security usage and not annual reliability.

**Summary of economic modelling results using historical, long-term climate and dry climate change datasets.**

| Climate data | Average change in economic outcomes ($ million, over 40 years) | | |
|---|---|---|---|
| | Towns | Annual Agriculture | Permanent Agriculture |
| Historical | 15.4 (42.5%) | -10.5 (-0.7%) | -0.1 (0%) |
| Long-term climate | 23.3 (42.5%) | -8.9 (-0.6%) | -0.3 (-5.8%) |
| Dry climate change scenario | 123.1 (40.7%) | -8.1 (-1%) | -1.9 (-92.8%) |

## Environmental effects of a new dam at Dixons Long Point Crossing (Ulmarrah Dam)

The construction of a new dam is forecast to lead to a minor improvement in the number of days below low flow and minor impacts on the frequency of 5-year and 10-year annual return flows under the stochastic scenario. The improvement in days below low flow was driven by an extreme improvement at 2 gauges, Dixons Point and upstream of Burrendong Dam. At Dixon's Point the reduction was from 37 to 30 days, with a similar reduction for inflows to Burrendong Dam.

The impacts that reduced the size (ML/day) of high flows associated with 5-year and 10-year annual return flow rates were mostly influenced by an extreme impact at Dixons Point and a moderate impact on inflows to Burrendong Dam. The reduction in 5-year high flows at Dixons Point was from 59 to 31 GL/day, with similar proportional reductions in the 2.5 and 10 ARI (Average Recurrence Interval) flows.

The climate change scenario revealed similar effects on days below low flow and high flows. In addition, there was a major impact on the very low flow rate and minor impacts on low flow rate and duration of zero flow events.

The changes in high flows could have long-term impacts on channel morphology in the reach from Dixon's Point to Burrendong Dam. With such flow changes vegetation can gradually encroach on the channel.

The significance of changes in very low flows are difficult to determine given the very low volumes forecast. There were also few impacts on the number of zero flow days, which suggests that this option does not greatly increase risks to low flow regimes.

This assessment is not able to fully determine the effect of impeded movement of aquatic organisms, and transportation of organic material and nutrients, which are also critical to stream function, caused by an instream structure. These impacts have been well documented,[62] and, for example, could isolate fish communities from river refuges that would otherwise enable survival and recolonisation. Conversely, exotics such as carp more often benefit from weirs and flow regulation.[63] Partial mitigation of these effects can be enabled through construction that allows fish passage.

62. (i) Department of Primary Industries 2006, *Reducing the Impact of Weirs on Aquatic Habitat – New South Wales*, Department of Primary Industries. (ii) Kingsford 2000, as previously cited. (iii) Bunn, S. E., & Arthington, A. H 2002, *Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity,* Environmental management, 30(4), pp 492-507.
63. Driver, P. D., Harris, J. H., Closs, G. P., & Koen, T. B 2005, *Effects of flow regulation on carp (Cyprinus carpio L.) recruitment in the Murray–Darling Basin,* Australia. River Research and Applications, 21(2-3), pp 327-335.

**Predicted environment effects of a new dam at Dixons Long Point Crossing (Ulmarrah Dam) using long-term climate and dry climate change scenario modelling.**

| | Long-term climate | Dry climate change scenario |
|---|---|---|
| **Metric** | **Average (Min-Max)** | **Average (Min-Max)** |
| Number of years with greater or equal to one zero flow spell in 130 years | -0.2 (-2.1 to 0.2) | -0.3 (-3.9 to 0.2) |
| Average duration of zero flow spells (days) | 2.3 (-6.4 to 15) | 9.4 (-7 to 62) |
| Number of zero events per 130 years | 0.8 (-6.6 to 11) | 2.4 (-4.3 to 14.6) |
| Very low flow rate (ML/day) measured as the 95th percentile discharge of daily flows | -1.1 (-11 to 17) | -20 (-100 to 16) |
| Low flow rate (ML/day), measured as the 90th percentile discharge of daily flows | -0.4 (-10.4 to 15.2) | -6 (-22 to 17) |
| Median annual low flow days | 0 (-0.8 to 1.7) | -0.4 (-1.8 to 0.6) |
| Median days below low flow | -7.2 (-100 to 4.5) | -6.3 (-50 to 4.3) |
| Low flow standard deviation | 1.1 (-8.3 to 3.1) | 3 (-4 to 9.7) |
| Low flow days below the 75th percentile | 0.9 (0 to 14) | 0 (0 to 0.6) |
| Base flow rate (ML/day), measured as the 80th percentile discharge of daily flows | -0.8 (-3.7 to 0) | -1.8 (-20 to 14) |
| Mean annual discharge (ML/year) | 0 (-0.3 to 0.5) | -0.3 (-1.1 to 0.4) |
| Fresh flow rate (ML/day), measured as discharge of daily flows | 0.7 (-0.2 to 5.1) | -0.1 (-0.8 to 1.2) |
| Average number of freshes per year | 0 (0 to 0) | 0 (-0.9 to 0) |
| Average duration of freshes (number of days) | 2.3 (-0.9 to 38) | 3.7 (-1.2 to 58) |
| High flows – discharge for 2.5-year Annual Return rate (ML/day) | -2.6 (-45.7 to 0.2) | -2.2 (-44.1 to 2.9) |
| High flows – discharge for 5-year Annual Return rate (ML/day) | -3.3 (-47.7 to 0) | -2.7 (-48 to 0.3) |
| Very high flows - discharge for 10-year Annual Return rate (ML/day) | -5.8 (-47.5 to 0) | -3.7 (-49 to 0) |
| Monthly flow coefficient of variation | 1.1 (0 to 4.1) | 2.8 (0 to 7.5) |
| Daily flow coefficient of variation | 0.5 (-0.5 to 2.4) | 1.6 (-0.9 to 4.6) |
| Weekly flow coefficient of variation | 0.6 (0 to 3) | 2 (0 to 5.1) |

Note: The environmental effect is calculated as the percentage change against the base case. Cells with numbers are shaded following Table 7. Explanation of categories used in ecological assessment.

# Reducing the Macquarie River cease-to-pump condition for Orange City Council

| | |
|---|---|
| **Purpose** | Reduce town water shortfall risk for the regional city of Orange.<br><br>This was identified during Public Exhibition 1 of the Draft Macquarie–Castlereagh Regional Water Strategy. |
| **Description** | This option reduced the cease-to-pump threshold for Orange City Council and permitted pumping from the Wambuul/Macquarie River at times when river flow exceeded 38 ML/day (instead of the current access rule of 108 ML/day). |
| **Results** | The analysis demonstrates that this option does not have a significant benefit to Orange's water security over the long term but may be worthwhile considering during extreme dry periods for short periods of time. |

**Modelled effect of reduced cease to pump conditions on time in water restriction for Orange under the historic climate record.**

| | Base case | With option |
|---|---|---|
| Time under water restrictions | 21.1% (1 in 5 years) | 20.5% (1 in 5 years) |
| Time under severe water restrictions* | 3.3% (1 in 30 years) | 3.2% (1 in 30 years) |
| Time of surface water failure** | 1.9% (1 in 50 years) | 1.9% (1 in 50 years) |

*Severe restrictions are defined differently for each Council and depends on their restriction regime and water supply sources.
- Orange: Level 5 restrictions, which represents 62% of unrestricted demand, or worse.

**Failure is defined differently for each Council and depends on their restriction regime and water supply sources.
- Orange: Where water demands cannot be met under level 6 restrictions for Orange, which represents 60% of unrestricted demand.

# No irrigation from the Campbells River as a bookend run to understand town water security risks

| | |
|---|---|
| **Purpose** | Reduce town water shortfall risk for the regional city of Bathurst.<br><br>This was identified during Public Exhibition 1 of the Draft Macquarie–Castlereagh Regional Water Strategy. |
| **Description** | This option assumed there was no water take for irrigation on the Campbells River.<br><br>It was modelled to understand drought security risks for Bathurst in greater detail. It was not intended to become a shortlisted action. |
| **Results** | This analysis demonstrates that it does not significantly reduce Bathurst's water security risk and comes at a significant broader economic impact. As a result, it was not considered in more detail. |

**Modelled effect of no irrigation from the Campbells River on time in water restriction for Bathurst under the historic climate record.**

| | Base case | With option |
|---|---|---|
| Time under water restrictions | 4.9% (1 in 20 years) | 1.3% (1 in 80 years) |
| Time under severe water restrictions* | 1.8% (1 in 60 years) | 0.6% (1 in 170 years) |
| Time of surface water failure** | 1.7% (1 in 60 years) | 0.2% (1 in 500 years) |

*Severe restrictions are defined differently for each Council and depends on their restriction regime and water supply sources.
- Bathurst: Level 4 restrictions, which represents 67% of unrestricted demand, or worse.

**Failure is defined differently for each Council and depends on their restriction regime and water supply sources.
- Bathurst: Where water demands cannot be met under level 5 restrictions for Bathurst, which represents 52% of unrestricted demand.

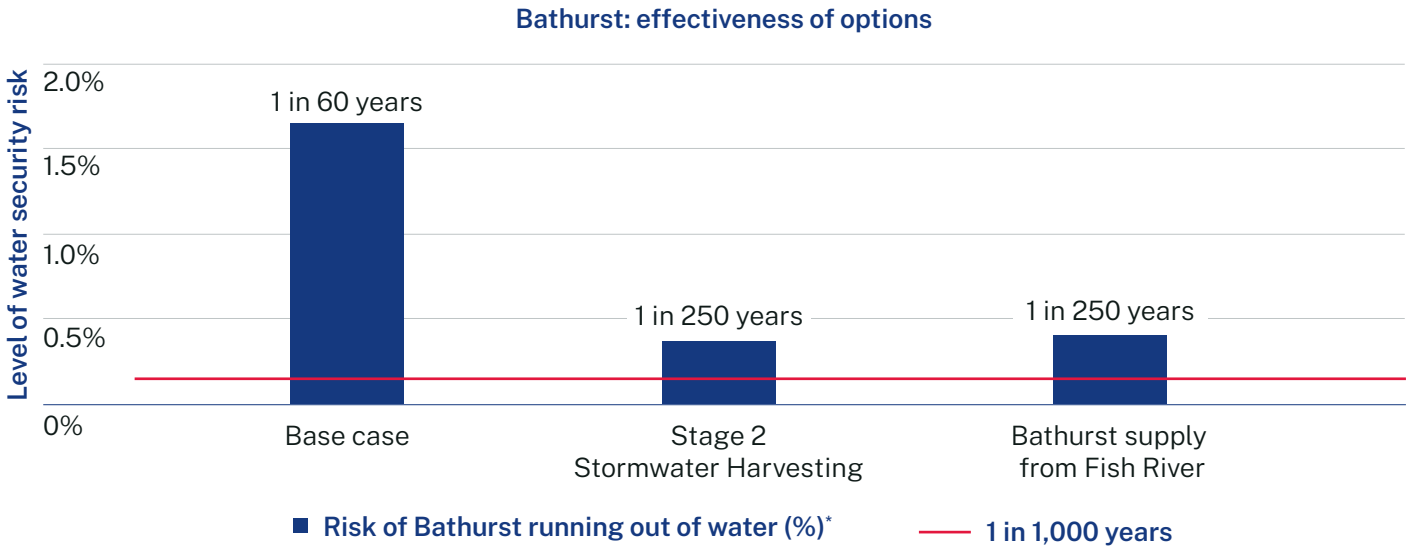
## Comparison of upper Macquarie options

The options analysed for the upper upper Macquarie Valley are primarily focussed on reducing water security risks for Orange, Bathurst and surrounding communities.

All options require further work and investigation, and a combination of options may be required in order to reduce town water security risks below the current acceptable risk guideline. Existing NSW Government guidelines suggest town water supplies should meet a minimum service level. This roughly correlates to town water supplies being able to withstand a drought that has the probability of occurring one in 1,000 years. While this level of risk may not be appropriate for large regional towns, as discussed in action 1.1, it does help provide a benchmark when assessing the effectiveness of options in meeting their desired outcomes.

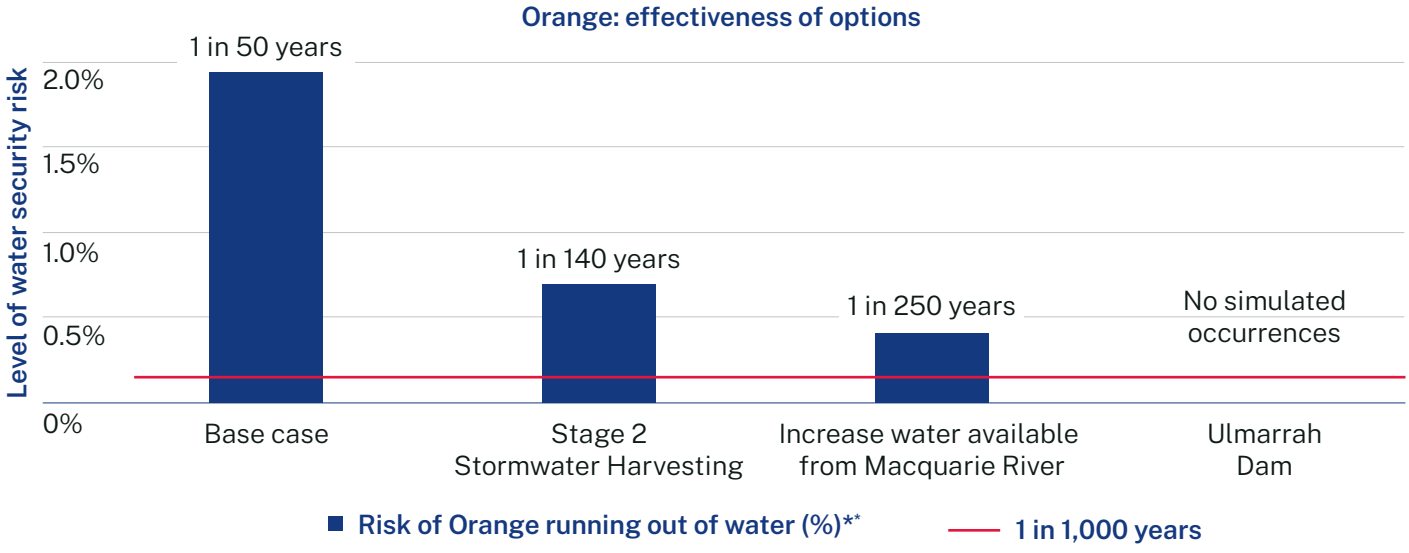
The graphs below show how effective the stormwater harvesting, water from the Fish River, additional water from the Wambuul/Macquarie River for Orange and a new Ulmarrah Dam are at reducing town water security risks when compared against each other under the historical climate. The graphs below demonstrates that shorter term options such as water harvesting and additional water from the Wambuul/Macquarie River will help in recuing some risks, they will need to be combined or paired up with other options to reduce risks down to an acceptable level. Over the long term, additional infrastructure may be needed to support large regional towns if we start to see a worst-case dry climate change scenario.

**Figure 22. Effectiveness of options in reducing water security risks for Bathurst assuming our future climate is similar to our historical climate**




*Risk of running out of water is defined as when water demands cannot be met under level 5 restrictions for Bathurst, which represents 52% of unrestricted demand

**Figure 23. Effectiveness of options in reducing water security risks for Orange assuming our future climate is similar to our historical climate**




*Risk of Orange running out of water is defined as where water demands cannot be met under level 6 restrictions for Orange, which represents 60% of unrestricted demand

# Options for the lower (western) Macquarie Valley

## Dubbo to Nyngan pipeline

| | |
|---|---|
| **Purpose** | Reduce water shortfall risks for towns and mines supplied by Burrendong Dam by improving delivery efficiency to towns, communities and industries in the regulated system.<br><br>This is modified from Option 8 in the Draft Macquarie–Castlereagh Regional Water Strategy. |
| **Description** | This would involve construction of a new pipeline along the length of the catchment from Dubbo to Nyngan that supplies Nyngan, Cobar and all mines. The modelling assumes that the pipeline replaces Albert Priest Channel. |
| **Results** | **This option requires further analysis and comparison with other lower Macquarie options.**<br><br>The analysis in the historical database suggests a small benefit to annual agriculture, and a very small decline for permanent agriculture, the net benefits are less than the estimated cost of the option, but further work needs to be undertaken to confirm the quantum of water savings. |
| **Limitations** | Analysing the benefits or impacts of options during extreme dry periods in river system models can be challenging as these are at the extremes of the river system model capabilities.<br><br>The modelling does not capture any changes to access to water that may be occurring for mining activity. |

**Modelled effect of Dubbo to Nyngan pipeline on the time Dubbo is in water restrictions or with a surface water failure under the historical climate record.**

| | Base case | With option |
|---|---|---|
| Time under water restrictions | 9.8% (1 in 10 years) | 8.5% (1 in 10 years) |
| Time under severe water restrictions* | 0.2% (1 in 500 years) | 0.1% (1 in 1,000 years) |
| Time of surface water failure** | 0.0% (No simulated occurrences) | 0.0% (No simulated occurrences) |

*Severe restrictions are defined differently for each Council and depends on their restriction regime and water supply sources.

- Dubbo: Level 2 restrictions, which represent 70% of unrestricted demand, or worse.

**Failure is defined differently for each Council and depends on their restriction regime and water supply sources.

- Dubbo: When water demands cannot be met under level 3 restrictions for Dubbo, which represents 50% of unrestricted demand.

^Further work and model upgrades are needed to better understand the risks of Dubbo experiencing extended water restrictions. The Macquarie River system model at the time of the analysis was not accurately analysing the changes in the flow regime and drawdown of Burrendong Dam at the extreme dry ends at the end of the catchment. The model is being updated and this analysis will be reassessed with the upgraded model.

**Summary model results for water users on the Macquarie Regulated River using the historical climate dataset. These are compared to the base case (i.e. no change).**

| Change in long-term average water take under licences (GL/year) | | | Change in end of year general security allocation (%) | Change in % of time Burrendong Dam <5% full supply level | Change in average flow into the Macquarie Marshes (GL/a) |
|---|---|---|---|---|---|
| General security | Supplementary | High security | | | |
| 3.2 (+1.2%) | Nil | Nil | +0.6 | -8.8% | -3.5 (-0.7%) |

**Summary of economic modelling results using the historical climate dataset.**

| Average change in economic outcomes ($ million, over 40 years) | | | Option cost ($ million, over 40 years) | Average Net Present Value ($ million, over 40 years) | Average benefit to cost ratio |
|---|---|---|---|---|---|
| Towns | Annual Agriculture | Permanent Agriculture | | | |
| 0 (0%) | 14.1 (0.9%) | -0.2 (-0.1%) | 920 | -906 | 0 |

# A new mid-system re-regulating weir on the Wambuul/ Macquarie River

| | |
|---|---|
| **Purpose** | To improve delivery efficiency and supply reliability for industry, towns and basic landholder rights under all climate conditions by capturing regulated water order rejections.<br><br>This was Government Commitment 1 in the Draft Macquarie–Castlereagh Regional Water Strategy. |
| **Description** | • A new 6,000 ML re-regulating weir near the existing weir at Gin Gin to assist with delivery efficiency to the lower reaches of the Wambuul/Macquarie River.<br>• Additional general security entitlements and use was maximised without reducing the average end of year effective allocation for existing general security licence holders. |
| **Results** | **This option requires further analysis and comparison with other lower Macquarie options.**<br><br>The option provides an increase in general security water, and could be operated in a way to maintain flows into the Macquarie Marshes, but needs further comparative analysis with other lower Macquarie options. |
| **Limitations** | The model is not performing well for the extreme dry ends at the end of the river system and needs further improvement. These models are not designed to fully represent year-to-year operational and environmental water delivery details, and such practices have continued to change in recent years because of increasing impacts of drought.<br><br>The estimated cost of this option contains a high degree of uncertainty. |

**Modelled effect of a new mid-system re-regulating weir on the Wambuul/Macquarie River on the time Dubbo is in water restrictions or with a surface water failure under the historical climate, long-term climate and dry climate change scenario datasets.**

| Time under water restrictions | | | | | |
|---|---|---|---|---|---|
| **Historical** | | **Long-term stochastic** | | **Dry climate change scenario** | |
| **Base case** | **With option** | **Base case** | **With option** | **Base case** | **With option** |
| 9.8% (1 in 10 years) | 10.3% (1 in 10 years) | 10.6% (1 in 10 years) | 10.8% (1 in 10 years) | 30.7% (1 in 3 years) | 31.0% (1 in 3 years) |
| **Time under severe water restrictions*** | | | | | |
| **Historical** | | **Long-term stochastic** | | **Dry climate change scenario** | |
| **Base case** | **With option** | **Base case** | **With option** | **Base case** | **With option** |
| 0.2% (1 in 500 years) | 0.2% (1 in 500 years) | 0.2% (1 in 500 years) | 0.2% (1 in 500 years) | 2.7% (1 in 40 years) | 2.7% (1 in 40 years) |
| **Time with a surface water failure for Dubbo**** | | | | | |
| **Historical** | | **Long-term stochastic** | | **Dry climate change scenario** | |
| **Base case** | **With option** | **Base case** | **With option** | **Base case** | **With option** |
| 0.0% (No simulated occurrences) | 0.0% (No simulated occurrences) | 0.1% (1 in 1,000 years) | 0.1% (1 in 1,000 years) | 1.2% (1 in 100 years) | 1.2% (1 in 100 years) |

*Severe restrictions are defined differently for each Council and depends on their restriction regime and water supply sources.

- Dubbo: Level 2 restrictions, which represent 70% of unrestricted demand, or worse.

**Failure is defined differently for each Council and depends on their restriction regime and water supply sources.

- Dubbo: When water demands cannot be met under level 3 restrictions for Dubbo, which represents 50% of unrestricted demand.

^Further work and model upgrades are needed to better understand the risks of Dubbo experiencing extended water restrictions. The Macquarie River system model at the time of the analysis was not accurately analysing the changes in the flow regime and drawdown of Burrendong Dam at the extreme dry ends at the end of the catchment. The model is being updated and this analysis will be reassessed with the upgraded model.

**Summary model results for water users on the Macquarie Regulated River using the historical, long-term climate and dry climate change datasets. These are compared to the base case (i.e. no change).**

| | Change in long-term average water take under licences (GL/year)* | | | Change in end of year general security allocation (%) | Change in % of time Burrendong Dam <5% full supply level | Change of average flows (GL/year) into Macquarie Marshes |
|---|---|---|---|---|---|---|
| | General security | Supplementary | High security | | | |
| Historical | +6.6 (+2.7%) | No change | No change | -0.1 | No change | -5 (-1.1%) |
| Long-term climate | +6.4 (+2.4%) | No change | No change | -0.1 | No change | -4.8 (-1%) |
| Dry climate change scenario | +3.3 (+2.5%) | No change | No change | No change | No change | -3.2 (-1.3%) |

*These figures demonstrate general security usage and not annual reliability.

**Summary of economic modelling results using the historical, long-term climate and dry climate change datasets.**

| Climate data | Average change in economic outcomes ($ million, over 40 years) | | | Option cost ($ million, over 40 years) | Average Net Present Value ($ million, over 40 years) | Average benefit to cost ratio |
|---|---|---|---|---|---|---|
| | Towns | Annual Agriculture | Permanent Agriculture | | | |
| Historical | -0.5 (-1.2%) | 31.4 (2%) | 0 (0%) | $60 | -$28 | <1 |
| Long-term climate | -0.4 (-0.7%) | 27.7 (1.9%) | -0.1 (-1.4%) | $60 | -$32 | <1 |
| Dry climate change scenario | 0.8 (0.3%) | 14.9 (1.9%) | -0.2 (-10.9%) | $60 | -$44 | <1 |

# Environmental effects of a re-regulating weir on the Wambuul/Macquarie River

The installation of a mid-river regulating weir was generally associated with only minor impacts on the size (ML/day) of the very low flow rate and the frequency of days below the 75th percentile. However, the underlying hydrological model might not be sufficiently calibrated to properly test these effects.

The modelling showed extreme impacts at specific locations:

- An extreme impact on the size of very low flows (95th percentiles) at Gunningbar Creek downstream of the Weir (from 6 to 5 ML/day) and a major impact on the Wambuul/Macquarie River at the Oxley gauge (from 0.3 to 0.2 ML/day).
- An extreme impact on the frequency of days below the 75th percentile at the Wambuul/Macquarie River at Oxley (3 to 4 days) and moderate impacts at Warren Weir and Marebone Weir (7 to 8 days).

The climate change modelling forecast similar outcomes with a slight increase in the minor impact on very low flows and no impact on the frequency of flows below the 75th percentile. The impact on very low flows was driven by a 99% reduction of Wambuul/Macquarie River flows at Oxley from an initial 0.003 ML/day, which appears trivial.

The environmental impact of this scenario would appear to be minimal, but impacts would require further assessment if this option was to progress. As noted previously, these are time-averaged effects for each gauge, and so, for example there could be periods of very low flows driving the impacts of average very low flow discharge and days below the 75th percentile.

Any potential impacts associated with this option needs to be considered against the background of existing flow risks. That is, the Wambuul/Macquarie River from the wall of Burrendong Dam to Gin Gin Weir is at risk of having insufficient water for the environment and capacity to achieve base flows, fresh flows, bank-full flows (1.5-year) and overbank flows (2.5-year ARI, and 5-year ARI). Additionally, the Wambuul/Macquarie River from Narromine to Oxley (including at Gin Gin) is at risk of having insufficient water to avoid zero flows.[64]

This assessment is not able to fully determine the effect of impeded movement of aquatic organisms, and transportation of organic material and nutrients, which are also critical to stream function, caused by an instream structure. The low flow effects could have a detrimental effect on the resilience of already impacted vegetation[65] and waterbird communities with the Ramsar-listed Macquarie Marshes.[66] For fish, the river at the existing Gin Gin Weir has high conservation value, in part because it is within the expected distribution of numerous threatened species, including silver perch, olive perchlet, purple spotted gudgeon and an endangered river snail (Notopala sublineata).[67] Additionally, the river between Gin Gin Weir to Warren is a key river section for Murray Cod recruitment, although the river from Burrendong Dam to above the Macquarie Marshes, and then below the Macquarie Marshes also support significant levels of native fish recruitment.[68]

64. Department of Planning, Industry and Environment – Water 2018, *Risk Assessment* for the *Macquarie–Castlereagh Water Resource Plan Area* (SW11), Department of Planning, Industry and Environment – Water.
65. Flood dependent woody and non-woody vegetation communities have significantly declined in extent, and flood dependent woody vegetation communities have declined in condition in the Macquarie Marshes, as described in Bowen, S. M 2019, *Quantifying the water needs of flood-dependent plant communities in the Macquarie Marshes*, south-eastern Australia (Doctoral dissertation).
66. As discussed earlier, in the section on 'Challenge: Maintaining and improving the health and resilience of the region's aquatic and floodplains ecosystems'.
67. Department of Primary Industries 2006, *Reducing the Impact of Weirs on Aquatic Habitat - New South Wales*, Department of Primary Industries.
68. Stocks et al 2015, *Short-term intervention monitoring of a fish community response to an environmental flow in the mid and lower Macquarie River: 2014/2015 watering year*, Commonwealth of Australia 2015, and Stocks 2021, *Monitoring Murray Cod spawning & recruitment in response to spring 2020 Macquarie River environmental water flows*, A report prepared for the Commonwealth Environmental Water Office by Department of Primary Industries – Fisheries.

**Predicted environment effects of re-regulating weir on the Wambuul/Macquarie River using long-term climate and dry climate change scenario modelling.**

| | Long-term climate | Dry climate change scenario |
|---|---|---|
| **Metric** | **Average (Min-Max)** | **Average (Min-Max)** |
| Number of years with greater or equal to one zero flow spell in 130 years | 0 (-0.1 to 0.2) | -0.1 (-0.9 to 0.5) |
| Average duration of zero flow spells (days) | 2.1 (0 to 5.8) | 1.1 (0 to 3.3) |
| Number of zero events per 130 years | 1.2 (0 to 4.5) | 1 (-0.9 to 5.1) |
| Very low flow rate (ML/day) measured as the 95th percentile discharge of daily flows | -6 (-50 to 0) | -9 (-100 to 0) |
| Low flow rate (ML/day), measured as the 90th percentile discharge of daily flows | -2.4 (-14.9 to 0) | -2.2 (-10.4 to 0) |
| Median annual low flow days | -0.5 (-2.9 to 0.1) | -0.5 (-2.1 to 0.2) |
| Median days below low flow | 2.1 (-6.2 to 16.6) | 1.5 (0 to 10) |
| Low flow standard deviation | 0.7 (0 to 2.5) | 0.4 (0 to 2.1) |
| Low flow days below the 75th percentile | 4.4 (-14.2 to 33.3) | 0.2 (0 to 1.9) |
| Base flow rate (ML/day), measured as the 80th percentile discharge of daily flows | -0.9 (-5.4 to 0) | -1.4 (-6.9 to 0.1) |
| Mean annual discharge (ML/year) | -0.3 (-1 to 0) | -0.4 (-1.4 to 0) |
| Fresh flow rate (ML/day), measured as discharge of daily flows | -0.7 (-3.7 to 0) | -0.6 (-3.5 to 0.2) |
| Average number of freshes per year | 0 (0 to 0) | 0 (-0.4 to 0) |
| Average duration of freshes (number of days) | -0.3 (-3.7 to 0.9) | -0.1 (-1.3 to 1.8) |
| High flows – discharge for 2.5-year Annual Return rate (ML/day) | -0.1 (-1.3 to 0.1) | -0.2 (-3.2 to 0.1) |
| High flows – discharge for 5-year Annual Return rate (ML/day) | 0 (-0.3 to 0) | 0 (-1.1 to 0) |
| Very high flows - discharge for 10-year Annual Return rate (ML/day) | 0 (-0.1 to 0.2) | -0.3 (-3.1 to 0) |
| Monthly flow coefficient of variation | 0.4 (0 to 1.4) | 0.4 (0 to 1.3) |
| Daily flow coefficient of variation | 0.4 (0 to 1.4) | 0.4 (0 to 1.2) |
| Weekly flow coefficient of variation | 0.4 (0 to 1.3) | 0.4 (0 to 1.1) |

Note: The environmental effect is calculated as the percentage change against the base case. Cells with numbers are shaded following Table 7. Explanation of categories used in ecological assessment.

# Increase Burrendong Dam's Full Supply Level

| | |
|---|---|
| **Purpose** | To improve water security and supply reliability for towns and improve drought resilience for industry in the regulated Macquarie River without reducing flows in the Macquarie Marshes under all climate conditions.<br><br>This is Option 11 in the Draft Macquarie-Castlereagh Regional Water Strategy. |
| **Description** | Changing the operation of the Burrendong Dam to increase the Full Supply Level by 151.5 GL to 1,306.5 GL (13%) and use a portion of the flood mitigation zone to increase storage capacity (without requiring major construction). |
| **Results** | **This option requires further analysis and comparison with other lower Macquarie options.**<br><br>This option produces a positive net present value and a benefit-cost ratio greater than one under the historical and stochastic climate datasets. The majority of the benefits go to annual agriculture while towns and communities experience minor disbenefits. |
| **Limitations** | This modelling includes assumptions that there will be very limited capital and infra-structure costs associated with this option. These costings need to be confirmed once a thorough dam safety risk assessment is undertaken on the option. Increases in capital costs will reduce the cost-benefit ration of the option.<br><br>Further fine tuning of the modelling could be done to examine a range of climate change consequences as the NARCliM dataset assumes one of the worst climate change outcomes.<br><br>No mines have been included in this assessment, however the benefit to any mines would need to be significant to create a net positive economic outcome.<br><br>This option needs further refinement around how the benefits would be shared, and impacts would be mitigated. |

**Modelled effect of increasing Burrendong Dam's Full Supply Level on the time Dubbo is in water restrictions or with a surface water failure under the historical climate, long-term climate and dry climate change scenario datasets.**

| Time under water restrictions | | | | | |
|---|---|---|---|---|---|
| **Historical** | | **Long-term stochastic** | | **Dry climate change scenario** | |
| **Base case** | **With option** | **Base case** | **With option** | **Base case** | **With option** |
| 9.8% (1 in 10 years) | 9.2% (1 in 10 years) | 10.6% (1 in 10 years) | 10.2% (1 in 10 years) | 30.7% (1 in 3 years) | 30.5% (1 in 3 years) |
| **Time under severe water restrictions*** | | | | | |
| **Historical** | | **Long-term stochastic** | | **Dry climate change scenario** | |
| **Base case** | **With option** | **Base case** | **With option** | **Base case** | **With option** |
| 0.2% (1 in 500 years) | 0.1% (1 in 1,000 years) | 0.2% (1 in 500 years) | 0.2% (1 in 500 years) | 2.7% (1 in 40 years) | 2.7% (1 in 40 years) |
| **Time with a surface water failure for Dubbo**** | | | | | |
| **Historical** | | **Long-term stochastic** | | **Dry climate change scenario** | |
| **Base case** | **With option** | **Base case** | **With option** | **Base case** | **With option** |
| 0.0% (No simulated occurrences) | 0.0% (No simulated occurrences) | 0.1% (1 in 1,000 years) | 0.1% (1 in 1,000 years) | 1.2% (1 in 100 years) | 1.2% (1 in 100 years) |

*Severe restrictions are defined differently for each Council and depends on their restriction regime and water supply sources.

- Dubbo: Level 2 restrictions, which represent 70% of unrestricted demand, or worse.

**Failure is defined differently for each Council and depends on their restriction regime and water supply sources.

- Dubbo: When water demands cannot be met under level 3 restrictions for Dubbo, which represents 50% of unrestricted demand.

^Further work and model upgrades are needed to better understand the risks of Dubbo experiencing extended water restrictions. The Macquarie River system model at the time of the analysis was not accurately analysing the changes in the flow regime and drawdown of Burrendong Dam at the extreme dry ends at the end of the catchment. The model is being updated and this analysis will be reassessed with the upgraded model.

**Summary model results for water users on the Macquarie Regulated River using the historical, long-term climate and dry climate change datasets. These are compared to the base case (i.e. no change).**

| | Change in long-term average water take under licences (GL/year)* | | | Change in end of year general security allocation (%) | Change in % of time Burrendong Dam <5% full supply level | Change of average flows (GL/year) into Macquarie Marshes |
|---|---|---|---|---|---|---|
| | General security | Supplementary | High security | | | |
| Historical | +9.1 (+3.7%) | +0.1 (+0.2%) | No change | +1.9 | -0.1 (-14.8%) | -3.9 (-0.9%) |
| Long-term climate | +8.4 (+3.2%) | -0.2 (-0.8%) | No change | +2.0 | -0.1 (-3.4%) | -4 (-0.9%) |
| Dry climate change scenario | +4.1 (+3.1%) | No change | No change | +0.9 | -0.1 (-1.0%) | -1.7 (-0.7%) |

*These figures demonstrate general security usage and not annual reliability.

**Summary of economic modelling results using the historical, long-term climate and dry climate change datasets.**

| Climate data | Average change in economic outcomes ($ million, over 40 years) | | | Option cost ($ million, over 40 years) | Average Net Present Value ($ million, over 40 years) | Average benefit to cost ratio |
|---|---|---|---|---|---|---|
| | Towns | Annual Agriculture | Permanent Agriculture | | | |
| Historical | -0.2 (-0.5%) | 44.3 (2.8%) | -0.1 (0%) | $8 | $36 | >1 |
| Long-term climate | -4.2 (-7.7%) | 32.6 (2.3%) | 0 (1%) | $8 | $20 | >1 |
| Dry climate change scenario | -11.1 (-3.7%) | 15.2 (1.9%) | 0 (1.2%) | $8 | -$4 | <1 |

# Environmental effects of increasing Burrendong Dam's Full Supply Level

The increase in Burrendong Dam's Full Supply Level was associated with an extreme improvement in the size (ML/day) of very low flow rates (95th percentile) and minor improvements in (90th percentile) low flow rates. There were also minor improvements with reductions in the frequency of days below low (75th and 95th percentile) flows. The extreme improvement in very low flows, and the extraordinarily high ratio between the option and base case, was driven by the 95th percentile increasing from 0.000053 to 7 ML/day at Gunningbar Creek downstream of the weir. In contrast, one of the other 3 gauges that showed an extreme improvement was Gunningbar Creek downstream of the weir where very low flows had a modest increase from 6 to 11 ML/day.

The minor improvement in the frequency (90th percentile) low flows was driven by an extreme improvement at Crooked Creek, and a moderate improvement in Wambuul/Macquarie River flows at Oxley Station.

The improvements in days below 75th and 95th percentile low flows were influenced by 6 gauges ranging from Dubbo (-11%) to Oxley (-33%), which were in the order of a reduction by one day in the 75th percentile flows.

The climate change modelling revealed only 2 minor improvements, the number of days below 90th percentile low flow and the very low flow rate. The improvement was again driven by a large proportional increase in a very small number at Oxley Station.

These preliminary results indicate that an increase in full supply level is unlikely to affect flow risks to the Macquarie River system, given that most of the effects were minor improvements and the only extreme improvement arose largely as an artifact of a change from a very small number.

**Predicted environment effects of increasing Burrendong Dam's Full Supply Level using long-term climate and dry climate change scenario modelling.**

| | Long-term climate | Dry climate change scenario |
|---|---|---|
| **Metric** | **Average (Min-Max)** | **Average (Min-Max)** |
| Number of years with greater or equal to one zero flow spell in 130 years | 0.4 (-0.5 to 1.3) | 0 (-0.2 to 0.3) |
| Average duration of zero flow spells (days) | -2.5 (-6.3 to 0.1) | -0.3 (-1.1 to 1.5) |
| Number of zero events per 130 years | -1.4 (-5.7 to 1.4) | 0.1 (-2.3 to 9.7) |
| Very low flow rate (ML/day) measured as the 95th percentile discharge of daily flows | 2,340,183 (-3.2 to 46,803,515) | 7 (0 to 79) |
| Low flow rate (ML/day), measured as the 90th percentile discharge of daily flows | 3.5 (-2.6 to 30) | 0.7 (0 to 3) |
| Median annual low flow days | 0.6 (-0.6 to 2.4) | 0.4 (-0.4 to 1.6) |
| Median days below low flow | -5.8 (-33 to 7.1) | -1.4 (-10 to 0) |
| Low flow standard deviation | -0.5 (-1.4 to 0.5) | 0 (-0.4 to 0.3) |
| Low flow days below the 75th percentile | -7 (-33.3 to 0) | -9 (-50 to 0) |
| Base flow rate (ML/day), measured as the 80th percentile discharge of daily flows | 0.7 (-4.3 to 6) | 0.5 (-2.7 to 3) |
| Mean annual discharge (ML/year) | -0.3 (-2.7 to 0.6) | -0.3 (-2.8 to 0.3) |
| Fresh flow rate (ML/day), measured as discharge of daily flows | -0.9 (-4.1 to 0.3) | 0.4 (-1.8 to 1.9) |
| Average number of freshes per year | 0 (0 to 0) | 0 (0 to 0.5) |
| Average duration of freshes (number of days) | -2.7 (-7.9 to 4) | -0.7 (-3.9 to 1.7) |
| High flows – discharge for 2.5-year Annual Return rate (ML/day) | 0.3 (-1.1 to 2.3) | 0.4 (0 to 2.8) |
| High flows – discharge for 5-year Annual Return rate (ML/day) | 2.3 (-0.1 to 24) | 0 (-1.4 to 1.3) |
| Very high flows - discharge for 10-year Annual Return rate (ML/day) | 1.9 (-0.1 to 8.1) | 1.8 (-0.4 to 18) |
| Monthly flow coefficient of variation | -0.7 (-1.5 to 0.2) | -0.2 (-0.5 to 0) |
| Daily flow coefficient of variation | -0.8 (-2.2 to 0.2) | -0.2 (-0.7 to 0) |
| Weekly flow coefficient of variation | -0.9 (-2.5 to 0.2) | -0.2 (-0.6 to 0) |

Note: The environmental effect is calculated as the percentage change against the base case. Cells with numbers are shaded following Table 7. Explanation of categories used in ecological assessment

# An additional off-river water storage for Nyngan

| | |
|---|---|
| **Purpose** | To improve the drought security for Nyngan and Cobar, and nearby mines. |
| **Description** | This option involves construction of a 3 GL off-river storage at Nyngan and Tritton mine being supplied by Cobar.<br><br>The modelling assumes that the storage is filled from the Wambuul/Macquarie River (if necessary) when Burrendong Dam falls below 270 GL and is used either when supply from Burrendong Dam ceases, or once Burrendong Dam returns above 270 GL if unused. |
| **Results** | **Option has been shortlisted as it could help reduce water security risks for towns at the end of the system.**<br><br>It is worth noting that the benefits generated are relatively robust across the 3 climate datasets. While the amount of benefit generated for annual agriculture is lower in the NARCliM dataset, it also produces benefits for towns and communities as well as very small benefits for permanent agriculture.<br><br>Given the high-level nature of this assessment, while the option may produce a benefit cost ratio less than one, it may warrant further investigation given the importance of the benefits generated. The further investigation may reveal that those benefits are more significant than in the regional water strategy assessment. |
| **Limitations** | The model is not performing well for the extreme dry ends at the end of the river system and needs further improvement. These models are not designed to fully represent year-to-year operational and environmental water delivery details, and such practices have continued to change in recent years because of increasing impacts of drought.<br><br>The costs of this option could be refined. |

**Modelled effect of an additional off-river storage at Nyngan on the time Dubbo is in water restrictions or a surface water failure for Dubbo under the historical climate, long-term climate and dry climate change scenario datasets.**

| Time under water restrictions | | | | | |
|---|---|---|---|---|---|
| **Historical** | | **Long-term stochastic** | | **Dry climate change scenario** | |
| **Base case** | **With option** | **Base case** | **With option** | **Base case** | **With option** |
| 9.8% (1 in 10 years) | 9.3% (1 in 10 years) | 10.6% (1 in 10 years) | 10.3% (1 in 10 years) | 30.7% (1 in 3 years) | 30.0% (1 in 3 years) |
| **Time under severe water restrictions*** | | | | | |
| **Historical** | | **Long-term stochastic** | | **Dry climate change scenario** | |
| **Base case** | **With option** | **Base case** | **With option** | **Base case** | **With option** |
| 0.2% (1 in 500 years) | 0.1% (1 in 1,000 years) | 0.2% (1 in 500 years) | 0.2% (1 in 500 years) | 2.7% (1 in 40 years) | 2.7% (1 in 40 years) |
| **Time with a surface water failure for Dubbo**** | | | | | |
| **Historical** | | **Long-term stochastic** | | **Dry climate change scenario** | |
| **Base case** | **With option** | **Base case** | **With option** | **Base case** | **With option** |
| 0.0% (No simulated occurrences) | 0.0% (No simulated occurrences) | 0.1% (1 in 1,000 years) | 0.1% (1 in 1,000 years) | 1.2% (1 in 100 years) | 1.1% (1 in 100 years) |

*Severe restrictions are defined differently for each Council and depends on their restriction regime and water supply sources.

- Dubbo: Level 2 restrictions, which represent 70% of unrestricted demand, or worse.

**Failure is defined differently for each Council and depends on their restriction regime and water supply sources.

- Dubbo: When water demands cannot be met under level 3 restrictions for Dubbo, which represents 50% of unrestricted demand.

^Further work and model upgrades are needed to better understand the risks of Dubbo experiencing extended water restrictions. The Macquarie River system model at the time of the analysis was not accurately analysing the changes in the flow regime and drawdown of Burrendong Dam at the extreme dry ends at the end of the catchment. The model is being updated and this analysis will be reassessed with the upgraded model.

**Summary model results for water users on the Macquarie Regulated River using the historical, long-term climate and dry climate change datasets. These are compared to the base case (i.e. no change).**

| | Change in long-term average water take under licences (GL/year)* | | | Change in end of year general security allocation (%) | Change in % of time Burrendong Dam <5% full supply level | Change of average flows (GL/year) into Macquarie Marshes |
|---|---|---|---|---|---|---|
| | General security | Supplementary | High security | | | |
| Historical | +2.2 (+0.9%) | +0.1 (+1.0%) | No change | +0.5 | No change | -0.9 (-0.2%) |
| Long-term climate | +1.9 (+0.7%) | No change | No change | +0.4 | -0.1 (-3.8%) | -0.9 (-0.2%) |
| Dry climate change scenario | +1.5 (+1.1%) | No change | No change | +0.4 | -0.2 (-2.2%) | -0.6 (-0.1%) |

*These figures demonstrate general security usage and not annual reliability.

**Summary of economic modelling results using the historical, long-term climate and dry climate change datasets.**

| Climate data | Average change in economic outcomes ($ million, over 40 years) | | | Option cost ($ million, over 40 years) | Average Net Present Value ($ million, over 40 years) | Average benefit to cost ratio |
|---|---|---|---|---|---|---|
| | Towns | Annual Agriculture | Permanent Agriculture | | | |
| Historical | -0.2 (-0.5%) | 10.3 (0.6%) | 0 (0%) | $40 | -$30 | <1 |
| Long-term climate | 0 (-0.1%) | 8.4 (0.6%) | 0.1 (1.3%) | $40 | -$30 | <1 |
| Dry climate change scenario | 1.9 (0.6%) | 6.8 (0.9%) | 0.3 (12.3%) | $40 | -$30 | <1 |

# Environmental effects of an additional off-river water storage for Nyngan

This option was associated with a very extreme improvement in the size of very low flows (the 95th percentile), a moderate impact on days below 75th percentile low flows and a minor impact on days below 90th percentile low flow. As with other scenarios, the extreme improvement in very low flows was driven by a large proportional change in a very small number. At Gunningbar Creek, downstream of the weir, the very low flow discharge went from 0.000015 to 4.74 ML/day. The only other extreme improvement for very low flow discharge was also in Gunningbar Creek at Fairview Dam, where very low flows increased from 6 to 9 ML/day.

Impacts on the frequency of low flow days below the 75th percentile followed a similar pattern to with the greatest effect in Gunningbar Creek (18 to 26 days) and at Oxley (3 to 4 days). For median days below low flow (90th percentile flows), the greatest impact was at Carinda (6 to 8 days) followed by Gunningbar Creek (30 to 35 days).

The environmental effects of this option are focused on Gunningbar Creek with the only impact on the Bogan River being an increase in the average number of days below 75th percentile at a site increasing from 21 to 22 days. The increased number of days below the low flow thresholds could create an increased risk for fish and riparian vegetation within Gunningbar Creek. This might be offset by the large very low flow value and some minor reductions in the duration of zero flow days. Under heat-wave conditions this could lead to stratification of pools, high temperatures and low oxygen levels, which would all place stress on the fish community. If this proposal were to proceed, this risk would need to be managed, potentially through increased flows for Gunningbar Creek.

**Predicted environment effects of an additional off-river water storage for Nyngan using long-term climate and dry climate change scenario modelling.**

| | Long-term climate | Dry climate change scenario |
|---|---|---|
| **Metric** | **Average (Min-Max)** | **Average (Min-Max)** |
| Number of years with greater or equal to one zero flow spell in 130 years | 0 (-0.5 to 0.4) | 0 (-2.2 to 0.4) |
| Average duration of zero flow spells (days) | -1.6 (-5.5 to 1.6) | -0.7 (-5.2 to 9.2) |
| Number of zero events per 130 years | -0.7 (-4.7 to 3.4) | -0.6 (-2.9 to 3.9) |
| Very low flow rate (ML/day) measured as the 95th percentile discharge of daily flows | 1,555,103 (-2.1 to 31,101,989) | 12.3 (0 to 155.7) |
| Low flow rate (ML/day), measured as the 90th percentile discharge of daily flows | 0.4 (-10 to 29) | 2.3 (-11 to 18) |
| Median annual low flow days | -0.2 (-1.7 to 0.7) | -0.2 (-2.6 to 1) |
| Median days below low flow | 5 (-13 to 33) | 4.1 (0 to 30.4) |
| Low flow standard deviation | -1.1 (-2.9 to 0.3) | -0.9 (-3.1 to 0.3) |
| Low flow days below the 75th percentile | 15 (0 to 44) | 21 (0 to 78) |
| Base flow rate (ML/day), measured as the 80th percentile discharge of daily flows | -0.6 (-3.9 to 4.2) | 1.2 (-6.1 to 18) |
| Mean annual discharge (ML/year) | 0 (-1.1 to 0.7) | -0.1 (-1.9 to 1.3) |
| Fresh flow rate (ML/day), measured as discharge of daily flows | -0.2 (-1.6 to 0.3) | -0.3 (-2.7 to 0.2) |
| Average number of freshes per year | 0 (-0.3 to 0) | 0 (0 to 1.5) |
| Average duration of freshes (number of days) | -0.2 (-1.6 to 0.6) | -0.4 (-4.8 to 0.5) |
| High flows – discharge for 2.5-year Annual Return rate (ML/day) | 0 (-0.8 to 0.8) | 0 (-1.3 to 0.7) |
| High flows – discharge for 5-year Annual Return rate (ML/day) | 0 (-0.4 to 0.3) | 0 (-0.6 to 0.5) |
| Very high flows - discharge for 10-year Annual Return rate (ML/day) | 0.1 (-0.5 to 1) | 0 (-0.9 to 1.2) |
| Monthly flow coefficient of variation | 0 (-2.3 to 2.6) | 0.3 (-1.7 to 9.1) |
| Daily flow coefficient of variation | 0 (-1.9 to 0.6) | -0.1 (-2.1 to 2.4) |
| Weekly flow coefficient of variation | -0.1 (-1.9 to 0.5) | 0 (-1.8 to 4.2) |

Note: The environmental effect is calculated as the percentage change against the base case. Cells with numbers are shaded following Table 7. Explanation of categories used in ecological assessment

# Increased essential needs reserve in Burrendong Dam

| | |
|---|---|
| **Purpose** | Improve security of supply for critical needs in dry periods.<br><br>This was Option 37 in the Draft Macquarie–Castlereagh Regional Water Strategy. |
| **Description** | When allocating water to users in the Macquarie-Cudgegong Regulated River, the NSW Government first ensures, as far as practicable, that 2 years of essential requirements can be met from Burrendong Dam before allocating to lower priority (general security) licence categories. This volume must include the amount of water required for town water supplies, high security licences, minimum dam releases, stock and domestic replenishment needs and water conveyancing volumes, which are based on average transmission and evaporation losses. The allocation set aside for high-priority purposes is called the reserve.<br><br>We have undertaken a preliminary assessment to understand the benefits and impacts of increasing the reserve volume in Burrendong Dam by 108 GL to provide an additional year of essential needs reserve. Most of the extra water is needed to deliver the water down the river.<br><br>We know that actual volumes to convey water down the system can be higher during dry times and that the use of drought contingency measures has been driven by higher-than-average river conveyancing volumes. There may be benefits to setting aside more water for transmission losses during droughts for basic landholder rights, environmental needs and replenishment flows to the lower system. |
| **Results** | **This option needs discussion with community about risk appetite and purpose of the option which will occur through the NSW Water Strategy implementation.**<br><br>The detailed assessment found that the option has a negative net present value and low benefit cost ratio under all scenarios which is driven by the reduction in water available to general security licence holders.<br><br>The assessment has also shown that an increase in the reserve would reduce the time that Burrendong Dam sits at low levels, but it would not eliminate the risk.<br><br>This analysis only looked at one option around changing the essential needs reserve in Burrendong Dam. A broader assessment of whether changing the essential needs reserve is an effective way to secure water for critical needs in dry periods compared to alternative options needs to be considered through a risk framework and will be assessed as part of the work program implementing the NSW Water Strategy.<br><br>Using this analysis as a basis, the NSW Water Strategy work program will consider:<br>• options for redefining the period of lowest inflows to the water source<br>• whether different periods should apply to different categories of access licences<br>• whether the reserve level should be increased during a sequence of dry years and reduced during a sequence of wet years<br>• the impact of any options for change on planned environmental water and each category of access licence.<br><br>The results of the investigation would help to determine whether a change to water allocation rules in the regulated Wambuul/Macquarie River is warranted in response to new extremes in water availability. Any decision on whether to implement a change in the policy on reserves depends on the level of risk that the community is willing to bear around running out of surface water in droughts and associated impacts on licence holders and the environment. |

# Increased essential needs reserve in Burrendong Dam (continued)

| | |
|---|---|
| **Limitations** | The modelling is sufficient to demonstrate the water availability and reliability impact of this option on water users throughout the Macquarie–Castlereagh region; however, its operational (water delivery) benefits to minimising the time the system is in drought operation could not be assessed by the existing hydrologic model and, therefore, could not be valued by the rapid cost–benefit analysis method.<br><br>The model does not perform well at the extreme dry ends and so further refinement is needed of the model and the analysis to better understand the benefits and impacts. |

**Modelled effect of increasing the essential needs reserve in Burrendong Dam on the time Dubbo is in water restrictions or a surface water failure for Dubbo under the historical climate, long-term climate and dry climate change scenario datasets.**

| **Time under water restrictions** | | | | | |
|---|---|---|---|---|---|
| **Historical** | | **Long-term stochastic** | | **Dry climate change scenario** | |
| **Base case** | **With option** | **Base case** | **With option** | **Base case** | **With option** |
| 9.8%<br>(1 in 10 years) | 6.0%<br>(1 in 15 years) | 10.6%<br>(1 in 10 years) | 7.4%<br>(1 in 13 years) | 24.5%<br>(1 in 4 years) | 30.5%<br>(1 in 3 years) |
| **Time under severe water restrictions*** | | | | | |
| **Historical** | | **Long-term stochastic** | | **Dry climate change scenario** | |
| **Base case** | **With option** | **Base case** | **With option** | **Base case** | **With option** |
| 0.2%<br>(1 in 500 years) | 0.1%<br>(1 in 1,000 years) | 0.2%<br>(1 in 500 years) | 0.1%<br>(1 in 1,000 years) | 2.7%<br>(1 in 40 years) | 2.2%<br>(1 in 45 years) |
| **Time with a surface water failure for Dubbo**** | | | | | |
| **Historical** | | **Long-term stochastic** | | **Dry climate change scenario** | |
| **Base case** | **With option** | **Base case** | **With option** | **Base case** | **With option** |
| 0.0% (No simulated occurrences) | 0.0% (No simulated occurrences) | 0.1%<br>(1 in 1,000 years) | 0% (No simulated occurrences) | 1.2%<br>(1 in 100 years) | 1.0%<br>(1 in 100 years) |

*Severe restrictions are defined differently for each Council and depends on their restriction regime and water supply sources.

- Dubbo: Level 2 restrictions, which represent 70% of unrestricted demand, or worse.

**Failure is defined differently for each Council and depends on their restriction regime and water supply sources.

- Dubbo: When water demands cannot be met under level 3 restrictions for Dubbo, which represents 50% of unrestricted demand.

^Further work and model upgrades are needed to better understand the risks of Dubbo experiencing extended water restrictions. The Macquarie River system model at the time of the analysis was not accurately analysing the changes in the flow regime and drawdown of Burrendong Dam at the extreme dry ends at the end of the catchment. The model is being updated and this analysis will be reassessed with the upgraded model.

**Summary model results for water users on the Macquarie Regulated River using the historical, long-term climate and dry climate change datasets. These are compared to the base case (i.e. no change).**

| | Change in long-term average water take under licences (GL/year)* | | | Change in end of year general security allocation (%) | Change in % of time Burrendong Dam <5% full supply level | Change of average flows (GL/year) into Macquarie Marshes |
|---|---|---|---|---|---|---|
| | General security | Supplementary | High security | | | |
| Historical | -18.0 (-7.3%) | No change | No change | -4.5 | -0.1 (-20.3%) | +4.7 (+1.1%) |
| Long-term climate | -17.7 (-6.8%) | No change | No change | -4.4 | -0.4 (-36.0%) | +4.9 (+2.1%) |
| Dry climate change scenario | -14.6 (-10.9%) | +0.1 (0.3%) | No change | -3.9 | -1.7 (-19.7%) | +3.0 (+0.7%) |

* These figures demonstrate general security usage and not annual reliability.
**The variability in the hydrologic record can result in a wide range of benefit cost ratios. Understanding what portion of the hydrologic dataset results in a positive result, or a poor outcome, is important to appreciating how likely the option will add economic value to the region.

**Summary of economic modelling results using the historical, long-term climate and dry climate change datasets.**

| Climate data | Average change in economic outcomes ($ million, over 40 years) | | | Option cost ($ million, over 40 years) | Average Net Present Value ($ million, over 40 years) | Average benefit to cost ratio |
|---|---|---|---|---|---|---|
| | Towns | Annual Agriculture | Permanent Agriculture | | | |
| Long-term climate | 2 (3.6%) | -78.7 (-5.5%) | 0.8 (16.8%) | $4 | -$80 | <0 |
| Dry climate change scenario | 8.7 (2.9%) | -65.3 (-8.2%) | 3.2 (154.4%) | $4 | -$58 | <0 |

# Environmental effects of an increased essential needs reserve in Burrendong Dam

Increasing the essential needs reserve in Burrendong Dam is forecast to provide extreme improvements in low and very low flows, major improvements in the frequency of zero flows, days below the 75th and 90th percentile low flow thresholds and moderate improvements in base flows (80th percentile) and the number of years with zero flows. There was also one moderate and 3 minor decreases in flow variability, over daily to monthly timescales.

The improvement in very low (95th percentile) flows was driven by a 104 million percent increase at Gunningbar downstream of the weir. This increase was driven by a change from 0.00002 to 16 ML/day. While this appears to be a staggeringly large change, it is just showing the regime has become more dominated by 16 ML/day flows at the low flow end of the flow distribution curve. Similar, but more modest increases occurred at 9 gauges from Oxley and downstream, influencing Crooked and Marra Creeks, and along the Macquarie River to Carinda.

The improvement in low (90th percentile) flows was influenced by large increases at Oxley and Crooked Creek. The largest increase was in Crooked Creek, where low flows increased from 14 to 52 ML/day.

There were major improvements to duration of zero and low flows:

- Zero flows: The improvement was influenced by extreme improvements at 13 gauges starting with Carinda, peaking at Warren weir, and influencing Gunningbar, Duck, Crooked, Billybingbone and Bulgeraga Creeks. At Warren the decrease was from 1.4 to 0.7 days, while the largest reduction in of number of days was at Gum Cowal (164 to 153 days). The overall pattern of reduced zero flows, rather than the specific numbers is the key message here. This is because the specific effects on the creeks would depend on the operational assumptions in the model, which would be more consistent than occurs. In particular, WaterNSW delivers environmental water on advice from the Environmental Water Advisory Group. As a large portion of this water delivery is determined by deliberative decision making within this stakeholder-based committee rather than rigid rules.[69]
- Days below low flow: The improvement was influenced by extreme improvements at 6 gauges with the largest changes at Carinda and the end of the Bogan River. In both cases, the reduction was from 37 to 23 days. The largest reduction in terms of number of days was again Gum Cowal (162 to 151 days).
- Low flow days below 75th percentile: There were extreme improvements at 4 gauges, Oxley and Marebone D/S Weir on the Macquarie River, Billybingbone Creek and Crooked Creek. At Oxley, the reduction was from 3 to 0 days. A 5-day reduction was the largest in terms of days.

Flow variability decreased for low flows, and daily, weekly and monthly time periods. Given the changes in low and zero flows it is likely these minor reductions are due to modifications in low flows. Flow variation can be important in its role in sustaining littoral (edge) habitats, nutrient and organic matter cycling. In this instance it is likely that the reduction would be associated with better protection of aquatic and riparian health during low flows and improved water quality conditions. To better assess how much the environment benefits from these releases would, however, require testing during specific events and months, and using the Long-Term Watering Plan metrics.

The climate change modelling revealed a similar pattern of flow change with minor changes in the category or magnitude of improvement. The extreme improvement in very low flows was once again driven by an increase from 0.003 to 0.3 ML/day.

69. Department of Planning, Industry and Environment 2020, *Macquarie–Castlereagh Long Term Water Plan,* Parts a and b, as already cited and Department of Planning and Environment 2022, *How Environmental Water Advisory Groups work with communities*, Department of Planning and Environment (April 2022, file BD2774).

**Predicted environment effects of an increased essential needs reserve in Burrendong Dam using long-term climate and dry climate change scenario modelling.**

| | Long-term climate | Dry climate change scenario |
|---|---|---|
| **Metric** | **Average (Min-Max)** | **Average (Min-Max)** |
| Number of years with greater or equal to one zero flow spell in 130 years | -0.2 (-4 to 0.8) | 0.2 (-1.7 to 1.4) |
| Average duration of zero flow spells (days) | -23.1 (-53.4 to 4.2) | -17 (-37.5 to 0.7) |
| Number of zero events per 130 years | -18 (-50 to 6) | -14 (-34 to 0) |
| Very low flow rate (ML/day) measured as the 95th percentile discharge of daily flows | 5,215,856 (-1 to 104,315,249) | 644.8 (0 to 9642) |
| Low flow rate (ML/day), measured as the 90th percentile discharge of daily flows | 33 (-7.6 to 268.5) | 47 (0 to 180.4) |
| Median annual low flow days | 0.1 (-2.9 to 4.5) | -0.2 (-5 to 7) |
| Median days below low flow | -21 (-100 to 7.1) | -12 (-70 to 2.3) |
| Low flow standard deviation | -10 (-19 to 0.9) | -6 (-14 to 0.6) |
| Low flow days below the 75th percentile | -24 (-100 to 0) | -22 (-100 to 5.2) |
| Base flow rate (ML/day), measured as the 80th percentile discharge of daily flows | 8.5 (-4.7 to 54.1) | 19 (-2.6 to 106.8) |
| Mean annual discharge (ML/year) | 1 (0 to 5) | 1.3 (-0.2 to 7.8) |
| Fresh flow rate (ML/day), measured as discharge of daily flows | 0 (-1.8 to 0.6) | -1.4 (-7.5 to 0) |
| Average number of freshes per year | 0 (0 to 0) | 0 (0 to 2.1) |
| Average duration of freshes (number of days) | 0.5 (-5.5 to 11.3) | -1.3 (-18 to 7.2) |
| High flows – discharge for 2.5-year Annual Return rate (ML/day) | 0 (-0.4 to 0.2) | -0.5 (-7.1 to 0.6) |
| High flows – discharge for 5-year Annual Return rate (ML/day) | 0.6 (0 to 7.4) | 0 (-1 to 1.8) |
| Very high flows - discharge for 10-year Annual Return rate (ML/day) | 0.6 (0 to 3.3) | 0.4 (0 to 2.1) |
| Monthly flow coefficient of variation | -5.5 (-20 to 0.9) | -5.5 (-12.4 to 0.3) |
| Daily flow coefficient of variation | -5.7 (-20 to 1) | -6.1 (-14.2 to 0.4) |
| Weekly flow coefficient of variation | -6.3 (-20 to 1.1) | -6.3 (-13.6 to 0.5) |

Note: The environmental effect is calculated as the percentage change against the base case. Cells with numbers are shaded following Table 7. Explanation of categories used in ecological assessment

# Reduced replenishment flows to Gunningbar Creek, Duck Creek and Crooked Creek

| | |
|---|---|
| **Purpose** | Increase water security and reliability in the Regulated Macquarie River by reducing operational losses in regulated supply to effluents.<br><br>This was Option 32 in the Draft Macquarie–Castlereagh Regional Water Strategy. |
| **Description** | The option assessed returning of Gunningbar, Duck and the upper part of Crooked Creeks to a more natural regime with occasional periods of no flow.<br><br>The modelling simulated water being passed down these creeks for 2 reasons<br>• as a portion of uncontrolled flows<br>• when there were no uncontrolled flows to meet water orders under licences or stock and domestic demands. |
| **Limitations** | The results for this option may be over-estimated.<br><br>The Macquarie River system model at the time of the analysis was not accurately analysing river operations at the extreme dry ends at the end of the catchment and as a result, the analysis should be treated with caution.<br><br>However, the analysis is sufficient to demonstrate that this option could provide benefits and should be investigated further.<br><br>The model is being updated and this analysis will be reassessed with the upgraded model. |

**Summary model results for water users on the Macquarie Regulated River using the historical climate dataset. These are compared to the base case (i.e. no change).**

| | Change in long-term average water take under licences (GL/year)* | | | Change in end of year general security allocation (%) | Change in % of time Burrendong Dam <5% full supply level | Change of average flows (GL/year) into Macquarie Marshes |
|---|---|---|---|---|---|---|
| | General security | Supplementary | High security | | | |
| Gunningbar Creek | 15.7 (6.3%) | 0.0 (Nil) | 0.0 (Nil) | 5.5% | -8% | -6.6 (-1.4%) |
| Duck Creek | 7.4 (2.9%) | 0.0 (Nil) | 0.0 (Nil) | 2.5% | 1.8% | -4 (-0.9%) |
| Crooked Creek | 23.9 (9.6%) | 0.1 (1%) | 0.0 (Nil) | 8% | -22.1% | -0.8 (-0.2%) |

*These figures demonstrate general security usage and not annual reliability.

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