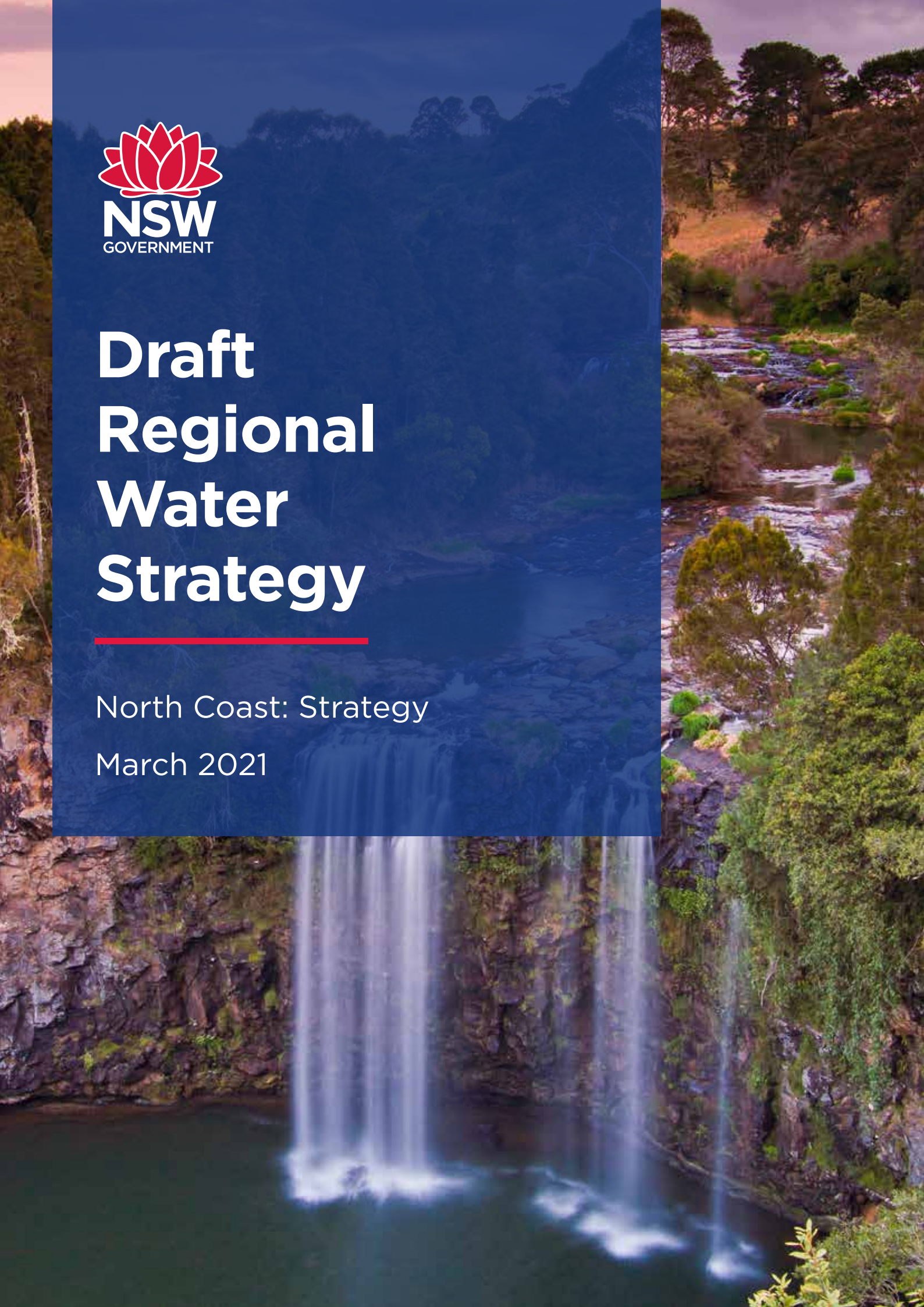

NSW GOVERNMENT

Draft Regional Water Strategy

North Coast: Strategy

March 2021

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Acknowledging Aboriginal people: The NSW Government acknowledges Aboriginal people as Australia's first people practising the oldest living culture on earth and as the Traditional Owners and Custodians of the lands and waters.

We acknowledge that the people of the Anaiwan, Biripi, Bundjalung, Dunghutti, Githabul, Gumbaynggirr and Yaegl Nations hold a significant connection to the lands in which the North Coast Regional Water Strategy falls upon.

The North Coast Region holds areas of great spiritual, cultural and economic importance to Aboriginal people and the NSW Government recognises the connection of the water to the people of these nations.

We recognise the intrinsic connection of Traditional Owners to Country and acknowledge their contribution to the management of the North Coast Regional Water Strategy area landscape and natural resources.

NSW Department of Planning, Industry and Environment understands the need for consultation and inclusion of Traditional Owner knowledge, values and uses in water quality planning to ensure we are working towards equality in objectives and outcomes.

NSW Department of Planning, Industry and Environment is committed to continuing future relationships and building strong partnerships with Aboriginal people. We thank the Elders, representatives of the Anaiwan, Biripi, Bundjalung, Dunghutti, Githabul, Gumbaynggirr and Yaegl Nations and Aboriginal community members who provided their knowledge throughout the regional water strategy development process.

Image courtesy of Destination NSW.

Minister's foreword

The NSW Government made a commitment before the last election to undertake comprehensive modelling that would enhance the management of water to improve water security and better prepare our communities for future droughts.

Water is our most precious and valuable resource—for our towns and industries and maintaining our natural and cultural assets.

Our water management and understanding has improved considerably in recent times—if you can't measure it, you can't manage it.

The knowledge we have garnered in the development of these draft regional water strategies will underpin future investments through a better understanding of optimum water management.

Engaging with our Aboriginal communities is vital, given water is an essential part of their connection to Country and culture, and their cultural water holdings will be vital to creating local jobs into the future. While COVID-19 has impacted our ability to engage with Aboriginal communities in a culturally appropriate way, we are committed to including their voices in the North Coast Regional Water Strategy.

I appreciate the engagement by local government in the development of the draft strategies. Their continued partnership is very important to ensure the strategies respond to the needs of catchments that may extend across many local government boundaries.

Australia is no stranger to extremes; we have always had to manage our water resources through prolonged floods and droughts.

In preparing these strategies, we've engaged leading academics at a number of universities. The paleoclimate-informed rainfall and evaporation modelling was largely undertaken by the University of Newcastle and the University of Adelaide to help understand and mitigate risk in the most extreme circumstances.

The climate modelling in this draft strategy is based on a deliberately conservative scenario that is intended to 'pressure test' the effectiveness of these strategies in a worst-case scenario. They do not account for changes in how we operate the system moving forward, where in reality we will respond actively to ongoing drought conditions to prolong the availability of water for critical human needs.

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 if they arise.

The recent drought has taught us a great deal about managing our water resources and we need to put these lessons to good use in preparing for possible future extreme weather events.

In short, the better 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, and I encourage all stakeholders to take part in giving us your views on how to improve these draft strategies to ensure our water management policies support the future of NSW.

Melinda Pavey
Minister for Water,
Property and Housing

Image courtesy of Destination NSW.

Contents

Snapshot

The North Coast region

302,000
population

42,000
km² area

Aboriginal Nations:
Anaiwan, Biripi, Bundjalung, Dunghutti, Githabul, Gumbaynggirr and Yaegl Nations

Regional centres include:
Grafton, Armidale, Coffs Harbour, Kempsey and Port Macquarie

Smaller towns include:
Guyra, Bellingen, Maclean, Yamba, Wauchope, Macksville and Nambucca Heads

Main rivers:
Clarence, Macleay, Bellinger, Nambucca, Hastings, Camden Haven as well as adjoining coastal catchments and many unregulated rivers

Major town water storages:
Shannon Creek Dam with a storage capacity of 30 GL
Karangi Dam with a storage capacity of 5.6 GL
Malpas Dam with a storage capacity of 13 GL
No state-owned dams

Critical State Significant Infrastructure:
Oven Mountain Pumped Hydro Energy Storage project

Groundwater sources:
Alluvial, coastal sands, porous and fractured rock
Key sources: Comboyne Basalt Groundwater Source, Stuarts Point Groundwater Source and Macleay Coastal Sands

Key environmental assets:
Nearly 16,000 km² of national park and wilderness area, including the Gondwana Rainforest World Heritage Area and Oxley Wild Rivers National Park as well as nationally important wetlands.
Threatened native species including the endangered Eastern Freshwater Cod, the Green-thighed Frog and the vulnerable Bellinger River snapping turtle.

Gross Regional Product: **$1.6 billion**

Image courtesy of Destination NSW.

Overview

Across NSW, our valuable and essential water resources are under pressure. Changing industry and employment patterns, and a more variable climate mean we face difficult decisions and choices about how to balance the different demands for this vital resource and manage our water efficiently and sustainably into the future.

The NSW Government is preparing comprehensive regional water strategies that will 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 North Coast Regional Water Strategy is one of 14 strategies (12 regional strategies, a Greater Sydney Water Strategy and a NSW Water Strategy) the Department of Planning, Industry and Environment is developing in partnership with water service providers, local councils, Aboriginal peak bodies, communities and other stakeholders across NSW.

Image courtesy of Jaime Plaza Van Roon, Department of Planning, Industry and Environment.

The North Coast region

The North Coast region (Figure 1) covers approximately 42,000 km^2.[1] The region neighbours the Northern Rivers area of the Far North Coast, the Greater Hunter Region to the south and the Gwydir, Namoi and Border Rivers regions to the west. It incorporates seven local government areas—Clarence Valley Council, Coffs Harbour City Council, Kempsey Shire Council, Armidale Regional Council, Bellingen Shire Council, Port Macquarie-Hastings Council and Nambucca Valley Council.[2] The Traditional Owners and ongoing custodians of these lands are the people of the Anaiwan, Biripi, Bundjalung, Dunghutti, Githabul, Gumbaynggirr and Yaegl Nations.

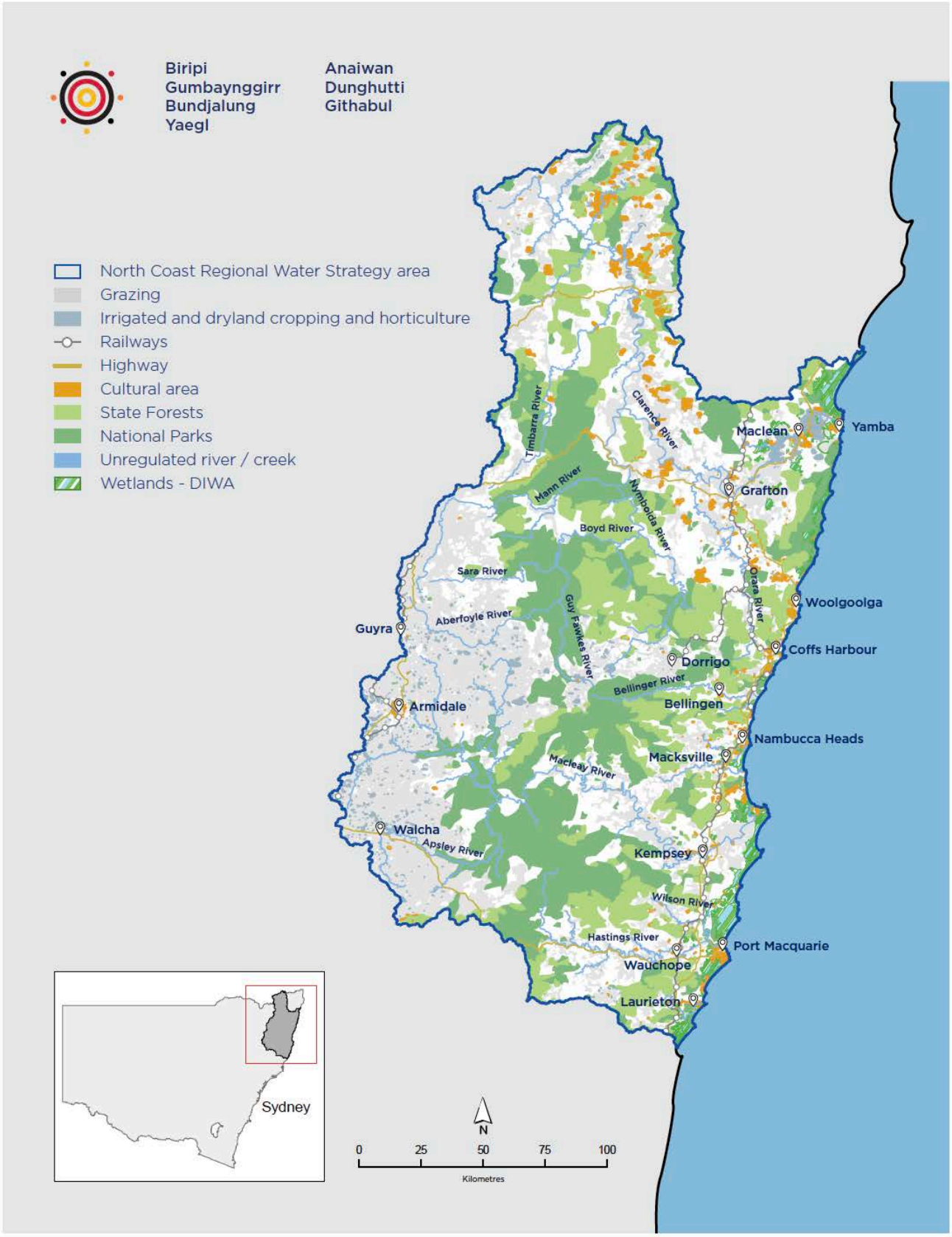
The North Coast region is renowned for its spectacular and diverse natural environment. The landscape transitions from the expansive New England Tablelands at its western periphery, descending sharply through rugged gorge country to undulating foothills, lowlands and floodplains before reaching the coast and its plethora of coastal lagoons, wetlands and estuaries. Almost 40% of the region is classified as national park, declared wilderness area or nature reserve,[3] including the Gondwana Rainforest World Heritage Area and Oxley Wild Rivers National Park. Large sections of the coast contain nationally important wetlands and estuaries, the most extensive being contained within Limeburners Creek Nature Reserve.

The region is home to around 300,000 people and the main towns of Grafton, Port Macquarie, Coffs Harbour, Armidale and Kempsey, which serve as important employment and service hubs. There are several smaller towns in the region with populations ranging from around 3,000 to 7,000,[4] including Bellingen, Nambucca Heads, Macksville, Wauchope and Yamba.[5]

The region's riverine and coastal environment, as well as its rural landscape, support one of the state's strongest economies (third in size following Greater Metropolitan Sydney and the Greater Hunter regions). The region (along with the Far North Coast[6]) is one of the most popular Australian tourist destinations, receiving an average of over five million visitors annually. Bananas have long been an iconic crop for the region and, more recently, blueberries and other berries have been growing in importance. Cattle and sheep grazing, and dairy farming continue to be mainstays of the regional economy. Other key sectors include health care and, in some parts of the region, education and construction.

1. The boundary for the North Coast region is based on surface water catchments. It has been separated from the catchments of the Far North Coast Regional Water Strategy due to previous work by Infrastructure NSW on the State Infrastructure Strategies (2014 and 2018), which considered regulated surface water catchments only. It is noted that the boundaries for the North Coast region do not align with the North Coast Region declared under the provisions of s.3.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).
2. The boundaries of the North Coast Regional Water Strategy also include parts of Tenterfield Shire Council, Kyogle Shire Council, Glen Innes Severn Shire Council and Walcha Shire Council. These local government areas source their main town water supplies from neighbouring regions. Options to address future water security for these councils are discussed in the Border Rivers, Gwydir, Namoi or Far North Coast regional water strategies respectively.
3. Data compiled by the Department of Planning, Industry and Environment.
4. Department of Planning, Industry and Environment 2020, *Population Projections*, www.planning.nsw.gov.au/Research-and-Demography/Population-projections/Projections
5. The North Coast Plan 2036 describes towns as either a *regional city*, *strategic centre* or *centre*. Coffs Harbour and Port Macquarie are described as *strategic centres* and Grafton as a *regional city*. All other towns mentioned are described as important *centres*.
6. This refers to the area defined in the Far North Coast Regional Water Strategy: www.industry.nsw.gov.au/water/plans-programs/regional-water-strategies/public-exhibition/far-north-coast

Figure 1. Map of the North Coast region



Water in the North Coast region

The many interconnected rivers, creeks, groundwater aquifers and estuaries define the North Coast region. Water supports the region's liveability and appeal to tourists, protects and conserves ecological assets and Aboriginal cultural heritage, and underpins key industries and local employment.

The North Coast region consists of six independent river catchments—the Clarence, Macleay, Bellinger, Nambucca, Hastings and Camden Haven—as well as the coastal waterways of the Coffs Harbour area. These catchments all have numerous tributaries in the tablelands and plateaus of the upper catchments which 'cut into this flesh of earth'[7] as they descend through steep, rugged gorges. The rivers broaden as they emerge onto the coastal floodplain before terminating in an extensive system of coastal lagoons, wetlands and estuaries. The tablelands and plateaus (particularly in the Clarence and Macleay River catchments) include small but important swamps and lagoons. The tidal pool for each catchment is extensive, extending up to 100 km into the catchment. The region's two largest river catchments are the Clarence and Macleay rivers, with the Clarence River being the longest coastal river catchment in eastern Australia.

Thirteen groundwater sources lie partially or in total beneath the surface water boundaries of the region. These groundwater sources are found in coastal sands, extensive coastal alluvial floodplains and porous and fractured rocks, as well as smaller alluvial aquifers adjacent to rivers and creeks (upriver alluvials). Groundwater on plateau areas such as the Comboyne provide baseflows to surface waters, while alluvial groundwater and surface water systems can have a high degree of connectivity in the lower river reaches, in estuaries and in coastal riverbeds. This means that the depletion of surface water sources—either during extended dry periods or from over extraction—can impact groundwater recharge and groundwater levels. Similarly, the depletion of groundwater can impact streamflow.

The water resources of the North Coast region support extremely high species and habitat diversity, many of which are endemic or threatened. Freshwater flows are critical to the ecosystems of the coast, providing nutrients and triggering breeding cycles for aquatic species such as the commercially important local Sydney Rock Oyster industry (worth nearly $7 million).[8] A number of these coastal systems are nationally important and support breeding, roosting and foraging sites for migratory birds.

7. Skrzynecki, Peter 2020, Styx River, *To the river that has no name*, Sydney Review of Books, www.sydneyreviewofbooks.com/essay/to-the-river-that-has-no-name
8. Based on 2018/19 gross value of production

It's a bosker big river, the Clarence,
Have you ever been on it, my boy?
It's bonny, it's broad, and it's bonzer,
It's something to see and enjoy.

The blue hills away in the distance,
The islands, the bends, and the bays,
And the cane growing ripe in the sunlight,
And miles of green, succulent maize.

The poddy, the colt, and the filly,
All seem to be getting their fill,
And the pelican out in the current,
Is busy at work with his bill.

There's a steamer come up from
the southward,
She crossed the bar yonder at dawn,
She's loading up pigs and potatoes,
And butter and sugar and corn.

They are swinging the axe in the timber,
There's a log for the bullocky still
To dump in the lugger that's hugging
The stringybark wharf at the mill.

The swim after school hours, remember,
With Billy, with Ben, and with Bert,
And the dive from the little old springboard,
And the dry with the little old shirt?

Think of the row on the water,
In the moon's soft, silvery gleam,
And the lights on the ferryboat crossing
That glitter like gold in the stream.

When they talk of their beautiful rivers,
That are racing away to the seas,
My thoughts go back to the Clarence,
And Grafton, the City of Trees.

Jack Moses, The Clarence

The land and waters of the North Coast region are also of great importance to the Aboriginal people of the North Coast. They are central to their spiritual and religious belief system, and are often celebrated in ritual, ceremony, story, dance and artwork. We have heard in consultation processes across the state that Aboriginal people rely on water for their health, wellbeing and connection to Country, and that Aboriginal people seek more opportunities to manage water using their cultural knowledge and to create improved economic opportunities. The Department of Planning, Industry and Environment is committed to continuing our engagement with communities, Aboriginal Elders and nation representatives across the North Coast region through to the release of the final strategy to ensure we capture their views and fully understand their water needs and aspirations.

Unlike other regions across the state, there are no state-owned dams. The rivers are all unregulated and large stretches of the region's waterways have had little or no disturbance (mainly due to the large expanses of national park and the rugged topography).[9] In the 1950s, drainage infrastructure was built to better control some of the region's large rivers—particularly the Clarence River and the Macleay River—as they travel through the lowland and floodplain areas to support farming on the extremely fertile, alluvial soils.

Each local council in the region is responsible for the provision of town water to their local government area. Rainfall across the region (and consequently, surface water flows and groundwater levels) is sufficient to meet town water demands during most years. However, some councils have constructed small

9. An unregulated river or stream is not controlled by releases from a major state-owned dam or through the use of weirs or gated structures. Water users (and the environment) are reliant on climatic conditions and rainfall.

emergency storages to provide water security during dry times. Three of the most significant local council storages within the region are Malpas Dam (13 GL),[10] Shannon Creek Dam (30 GL) and Karangi Dam (5.6 GL).

Malpas Dam (10 km south of Guyra) was built in 1968 as the major water supply storage for Armidale. Armidale Regional Council, with the financial support of the state government, recently constructed a pipeline to connect Malpas Dam and the Guyra Water Treatment Plant. This project was undertaken to secure future water supply to residents and businesses in Guyra, particularly during times of severe drought.[11] Construction was fast-tracked due to the unprecedented dry period at the beginning of 2019 and the project was completed in October 2019.

Shannon Creek Dam (18 km south of Grafton) and Karangi Dam (15 km west of Coffs Harbour) form part of the Clarence-Coffs Harbour *Regional Water Supply Scheme*. This scheme was developed in 2009 to secure town water supplies for the rapidly growing populations of Grafton and Coffs Harbour. It involved the construction of Shannon Creek Dam and a bi-directional pipeline that allows transfer of water between Shannon Creek and Karangi Dam (built in 1980). Water is diverted at the Nymboida weir to each dam during high flows in the Nymboida River (as well as from the Orara River for Karangi Dam) and is taken from each dam only when flows in the rivers are too low to allow extraction for town water use. Shannon Creek Dam is owned and operated by Clarence Valley Council, and Karangi Dam is owned and operated by Coffs Harbour City Council.

The region's industries are diverse and many depend either indirectly (tourism) or directly (agriculture) on water.

Tourism is driven largely by the attractiveness of the region, and new residents are also drawn to the region by its 'clean and green' lifestyle and many natural amenities.

The North Coast appeals to many different industries, including livestock and livestock products, fruit and nuts (particularly intensive horticulture), nurseries, cut flowers and turf, and broadacre crops such as sugar cane (although this is only grown in the Clarence River floodplain). Most crops are rain-fed and, given that rainfall across the region is generally reliable, irrigation is often not necessary or only required during the drier months of spring. When required, water for irrigation is sourced from unregulated rivers and creeks, shallow aquifers and farm dams (both harvestable rights and licensed). However, this reliance on rainfall and unregulated water supplies has made the region particularly susceptible to extended dry periods.

Urban and rural land use practices have affected the health of the region's waterways. Many sections of the region's rivers and creeks have been classified as being under high or medium hydrologic stress,[12] with those sections not under hydrological stress typically within catchments composed largely of national park or state forest. While there is generally enough water in the region to meet urban and rural water demands on an annual basis, competition over low flows during the drier spring months places many of the region's rivers and creeks under increased hydrologic stress. This affects the river's flora and fauna, as well as downstream water users.

10. Malpas Dam is the main water supply storage for Armidale Regional Council. Unlike the other local council storages, water is stored in Malpas Dam as part of the main town water supply system.
11. Armidale Regional Council 2019, *Guyra Pipeline Fact Sheet*, www.armidaleregional.nsw.gov.au/environment/water-usage-and-supply/water-supply
12. High hydrologic stress: 70–100% flow extracted; Medium hydrologic stress: 40–60% flow extracted. See Department of Land and Water Conservation 1998, *Stressed Rivers Assessment Report*, NSW State Summary

Many of the water sources in the region also suffer from poor water quality. Water quality issues are largely a result of historic mining operations,[13] poor agricultural practices,[14] diffuse pollution from urban centres[15] and issues including drainage of shallow acid groundwater and tidal floodgate operation (particularly in the Clarence and Macleay tidal areas).[16] In 2019, heavy rainfall following bushfires had a devastating impact on water quality, increasing nutrient and sediment levels and reducing oxygen levels, which led to rivers turning toxic, fish deaths and reduced access to water by towns and communities.[17]

The last 20 to 30 years have seen a significant shift in the agricultural profile of the region. For example, many of the banana plantations along the coast have been converted to high-value irrigated crops such as berries (particularly blueberries) and avocado plantations, while horticulture has replaced many of the dairy and cattle farms in the tablelands. These crops cannot rely solely on rainfall and, as a consequence, have placed further hydrological pressure on the region's water resources. This pressure on water resources is likely to increase as the horticultural industry expands, new mining operations potentially commence and more industries consider a move to the coastal regions due to the allure of more reliable rainfall.

The summer of 2019/20 highlighted the vulnerability of many of the region's town water supplies and agricultural users to an extended dry period. River flows were some of the lowest ever recorded, and for many councils such as Kempsey, Port Macquarie-Hastings, Nambucca and Bellingen, this made extraction of water difficult.

The North Coast Regional Water Strategy provides an opportunity to better understand the risks and pressures, such as the extremely dry conditions of the summer of 2019/20, on the region's vital water resources. It also provides an opportunity to consider what steps can be taken now to create greater resilience and set up the region to make the most of emerging opportunities.

Some of the exciting opportunities for the region relate to supporting renewable energy production. Many systems such as hydro-electric power, depend on water. The NSW Government recently announced the $1 billion 600 MW Oven Mountain Pumped Hydro Energy Storage project, located between Armidale and Kempsey, as Critical State Significant Infrastructure in meeting the state's future energy needs.[18] The project also has the potential to secure some of the region's future water needs by providing a water source for firefighting and an additional source of town water for Kempsey.[19]

13. Ashlet et al. 2006, Antimony and arsenic dispersion in the Macleay River catchment, *New South Wales: a study of the environmental geochemical consequences*
14. www.scu.edu.au/research/research-impact/impact-case-studies/blueberries-and-water-quality/
15. NSW Marine Estate Management Authority 2017, *NSW Marine Estate Threat and Risk Assessment—background environmental information* (978-1-74256-983-3), www.marine.nsw.gov.au
16. North Coast Region State of the Environment Report Working Group 2016, *State of the Environment Report*
17. www.abc.net.au/news/2019-12-06/ash-rain-threatens-quality-of-drinking-water-and-aquatic-life/11774076
18. Critical State Significant Infrastructure (CSSI) projects are high priority infrastructure projects that are essential to NSW for economic, social or environmental reasons. The CSSI process involves a declaration by the Minister for Planning that a State Significant Infrastructure project is critical. The Secretary of the Department of Planning, Industry and Environment is required to issue environmental assessment requirements (SEARs) for CSSI projects and—in doing so—is required to consult with relevant government agencies, as well as the community, if deemed necessary by the Minister. Being declared Critical State Significant Infrastructure does not automatically result in government funding support.
19. www.mattkean.com.au/news/media-release/%E2%80%98critical%E2%80%99-status-billion-dollar-regional-pumped-hydro-project

Definitions

We are using the following definitions in the regional water strategies:

Water security in the context of regional water strategies refers to the acceptable chance of having town water supplies fail. This requires community and government to have a shared understanding of what is a 'fail event' (for example, no drinking water or restrictions below a defined level for longer than a defined period, or unacceptable water quality) and the level of acceptability they will pay for.

The NSW Government's guidance around an appropriate security of supply for sizing town water supply head-works is the 5/10/10 rule. Under this approach, the total time spent in drought restrictions should be no more that 5% of the time, restrictions should not need to be applied in more than 10% of years and when they are applied there should be an average reduction of 10% in water usage. This allows full demand to be met in most years and also allows for water restrictions to be implemented infrequently to conserve supplies.

Water reliability refers to how often an outcome is achieved. It is often considered to be the likelihood, in percentage of years, of receiving full water allocations by the end of a water year for a licence category. For example, a 60% reliability means that in 60% of years a licence holder can expect to receive 100% of their licensed entitlement by the end of the water year. Other measures of volumetric reliability could also be used. For example, the percentage allocation a licence holder could expect to receive at a particular time of the year as a long-term average. Reliability may also refer to how often an acceptable water quality is available. A reliable water supply gives some clarity to water users and helps them plan to meet their water needs.

Resilient water resources means water users are able to withstand extreme events, such as drought and flood, and/or adapt and respond to changes caused by extreme events.

Image courtesy of Destination NSW.

Image courtesy of Destination NSW; Coffs Coast Marketing.

Future climate risks

The NSW Government has invested in new climate datasets and built new hydrologic models for the Clarence, Macleay, Bellinger-Coffs Harbour and Hastings surface water catchments that provide a more sophisticated understanding of historic climate variability in the North Coast region, as well as likely future climate risks. This means that we have moved from making decisions that are based largely on a single 'worst-case' scenario to a much more comprehensive understanding of natural variability and potential extreme events.

We can now better predict and plan for plausible future climate scenarios (such as the likely frequency, duration and severity of extended droughts), better understand the climate risks faced by water users and the environment across NSW and better manage our water resources over the medium- and long-term to mitigate these risks.

This new information is the basis for preparing robust new water strategies for our regions and offers fresh evidence for examining our existing water policies, operational rules and management plans.

Existing climate studies, as well as the new climate data and hydrological modelling developed for this draft regional water strategy, suggest that the North Coast region will continue to be dominated by wet and dry periods and there is a risk of:

- more frequent prolonged droughts that receive less total rainfall than those in the observed record for the North Coast region (such as the Federation Drought and the World War II Drought)
- more frequent short, sharp droughts, similar to the conditions experienced over the last two to three years
- a reduction in the total annual volume of water flowing down the major rivers, impacting the full range of flows
- potentially less frequent, but higher magnitude large flow events
- a likely reduction in the recharge of alluvial aquifers during dry periods due to reduced surface water flow volumes
- sea level rise, which will push high tides further upstream and increase river and groundwater salinity. Over time, this may also have impacts on land available for agriculture and other purposes.

These risks could become more severe due to likely changes in climate across north eastern NSW in both the near future and longer term. These changes include higher temperatures, more frequent hot days and changes to the seasonality of rainfall. It also means that regular flows in rivers may reduce and some smaller creeks may stop flowing more often than they do now. Droughts that occur in closer succession and hotter, drier conditions may mean catchments require higher rainfall to generate runoff into rivers and creeks.

Making choices for the future

Like most regions across Australia, the North Coast faces choices and challenges in balancing different water uses, both current and emerging, as climatic conditions change. The region is particularly vulnerable to protracted dry periods—the major rivers and creeks are perennial and support ecosystems that depend on a range of flow conditions, while storage is minimal and designed to manage relatively short dry periods.

Communities and local governments have already demonstrated an awareness of the need for action to secure water in a drier, more variable climate. This will put the region in a good position to deal with greater climate variability and tackle future challenges by:

- providing reliable and safe town water supplies for the growing population in the North Coast region
- maintaining and improving flows for the environment, aquatic habitats and fish passage
- sustaining and improving the productivity of the region's agricultural industries
- providing a better understanding of the demands on water
- mitigating the impacts of urban and rural land management activities on water quality
- maintaining domestic water availability during extended dry periods for the region's population who source their drinking and domestic water from unregulated rivers, groundwater aquifers and farm dams
- having systems in place to ensure a planned and consistent approach to managing water resources during extended dry periods
- improving the region's capacity to manage the impacts of sea level rise and higher-magnitude flooding
- giving Aboriginal people better representation in decision making processes around water management.

To address these challenges, we may need to rethink how the region's towns, industries and rural communities access water and which water resources they rely on. We may also need to find ways to use water more efficiently, improve how we manage groundwater and water quality, and make more use of recycled wastewater and stormwater. Importantly, we need to better understand the current demands of rural users on the region's precious water resources to support the needs of these users and new industries.

A new, comprehensive water strategy for the North Coast region

The North Coast Regional Water Strategy will guide how we address future water resource challenges, make the right policy and infrastructure choices and open up new opportunities for the region.

The strategy will bring together all the tools we have—policy, planning, behavioural, regulatory, technology and infrastructure solutions—in an integrated package. This package will be based on the best evidence, respond to the region's growth and balance different water needs.

The strategy will aim to provide choices to better use, share, store and deliver water to avoid having to ride the highs and lows of water availability. It will cover the whole North Coast region and all water types, and it will change how we manage water in the future.

In line with the objectives we have set for all regional water strategies, the North Coast strategy has a strong focus on working closely with communities to deliver healthy, reliable and resilient water resources that:

- deliver and manage water for local communities
- enable economic prosperity
- recognise and protect Aboriginal water rights, interests and cultural values
- protect and enhance the environment
- are affordable.

The final strategy will set out clear and accountable actions for the NSW Government, local councils and industries to tackle the challenges facing the North Coast region. The strategy will seek to maximise opportunities that support expected population growth, synergies between water and future energy generation, and the growing agribusiness and tourism sectors. It will also aim to expand on opportunities presented by investment in the health of the NSW marine estate, the Oven Mountain Pumped Hydro Energy Storage project and in transport and community infrastructure, such as the upgrades to the Pacific Highway and Coffs Harbour airport.

The final strategy will also help to improve the sequencing and integration of water reforms and water planning actions across the North Coast region to ensure they are implemented effectively.

The Department of Planning, Industry and Environment will develop an implementation plan that identifies actions and timeframes.

Our vision for the strategy

Our vision for the North Coast Regional Water Strategy is to support the delivery of healthy, reliable and resilient water resources for a liveable and prosperous region. To achieve this, we need to position the region so there is the right amount of water of the right quality available for people, Aboriginal communities, towns, industries and the environment.

Image courtesy of Jaime Plaza Van Roo,
Department of Planning, Industry and Environment.

The options

A long list of potential options is presented as part of this draft strategy.

These options build on the NSW Government's current and planned investment in water planning and infrastructure in the region, including the recently completed pipeline connection between Malpas Dam and Guyra Water Treatment Plant, investments in critical water treatment plant upgrades, and funding to support integrated water cycle management planning and secure yield analysis. They also complement and build on state-wide reforms to introduce non-urban water metering, improve compliance with water sharing rules and review harvestable rights for all coastal draining catchments.

To identify and develop appropriate options for the draft strategy, we have drawn from a range of sources including previous studies, community engagement, experiences of the dry period over the summer of 2019/20 and existing government programs. We have aligned our approach with regional development and land use strategies to ensure that all options can be integrated and sequenced with state-wide and local plans.

The options cover actions, projects, reforms and investments that focus on:

- **maintaining and diversifying water supplies** during dry times, including expanding existing regional town water supply schemes, increasing on-farm storage and new water sources such as desalination, wastewater reuse and stormwater projects
- **protecting and enhancing natural systems**, including long-term planning to better support healthy waterways and catchments (including native and threatened aquatic species), policy changes to ensure future sustainable water extraction, and wetland and catchment management works
- **supporting water use and delivery efficiency and conservation**, including water efficiency measures, regional drought response planning, improved data collection, and water market reviews.

Ongoing engagement with Aboriginal communities in the North Coast will be vital to developing options that improve the recognition of Aboriginal people's water rights, interests and access to water. Although COVID-19 has impacted our ability to engage with Aboriginal communities in a culturally appropriate way, we have heard suggestions around reviewing the framework for cultural water access licences and involving Aboriginal people more in water management. We are committed to having ongoing conversations with Aboriginal communities to ensure their views are reflected in the final North Coast Regional Water Strategy.

This strategy considers how government and local councils can adopt a more integrated approach to managing surface water, groundwater and their catchments. It also acknowledges that end of system flows are fundamental for a biologically diverse marine estate, which provides a range of social, economic and cultural opportunities for the North Coast's communities, including its Aboriginal people, and visitors.

Many of the options are inter-related. This means that to get the most benefit out of these options—and make the best use of the region's water resources—they may need to be combined into packages.

Not all options will be progressed, and most have not been costed. Following feedback on the draft strategy, we will conduct an evidence-based assessment to identify the best actions for the North Coast region. These will form the final, comprehensive North Coast Regional Water Strategy.

The Draft North Coast Regional Water Strategy is accompanied by a more detailed description of the long list of options and an overarching explanatory guide that outlines the broader context for the development of regional water strategies across NSW (Figure 2).

Figure 2. Draft North Coast Regional Water Strategy

Regional Water Strategies Guide

Describes the state-wide context for regional water strategies, gives information about how the strategies are being developed, provides more detail about new climate modelling and data, and shows how the strategies fit with current water management policies and plans, ongoing water reforms and regional development and land use strategies. The Guide also outlines the options assessment process, community and Aboriginal communities engagement approaches and the existing studies and programs that have informed the strategies.

↓ ↓

Draft North Coast Regional Water Strategy	**Long list of options for the North Coast region**
Sets out the regional context for the strategy, presents the results of new climate modelling and data, describes the North Coast region, its water resources and current and future water needs, and outlines the options under consideration.	Describes each option being considered for the strategy, including its objectives, challenges addressed, potential combinations with other options and further work required to progress the option.

Chapter 1

Context

Image courtesy of Destination NSW.

Snapshot

We are preparing comprehensive regional water strategies across NSW, bringing 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 strategies will aim to understand how much water a region will need to meet future demand, identify the challenges and choices involved in meeting needs and set out the actions we can take to manage risks to water security and reliability.
- Through better strategic planning the NSW Government aims to support safe and secure water for towns and communities, support regional industries, boost economic prosperity and safeguard and enhance the environment. The strategies will also recognise and protect Aboriginal rights, interests and access to water.
- The North Coast Regional Water Strategy is one of 14 strategies (12 regional water strategies, a Greater Sydney Water Strategy, and a NSW Water Strategy) the Department of Planning, Industry and Environment is developing in partnership with water service providers, local councils and Aboriginal peak bodies. The final strategies will also be informed by communities and other stakeholders across NSW.

New climate data and modelling, plans, studies and investments have also influenced the direction of the North Coast Regional Water Strategy.

- A significant amount of work has occurred since the Millennium Drought to improve our understanding of the risks affecting water resource management across regional NSW. Community engagement over the last few years has also given insights into the best way to prepare for future droughts and floods in the region.
- The NSW Government has invested in new climate datasets and new modelling to provide a more robust and sophisticated understanding of future risks to water availability in the North Coast region.
- The regional water strategies will build on existing NSW Government commitments to improve water security, resilience and reliability across regional NSW, including investment in water infrastructure, a range of state-wide water reforms and a new streamlined approval process for drought-related projects.
- The strategy also aligns with existing policies and plans that are improving the management of water resources across NSW, as well as being integrated with strategic and local land use planning.

1.1 Purpose of regional water strategies

Regional water strategies bring together the most up-to-date information and evidence with a wide range of tools and solutions to plan and manage each region's medium and long-term water needs.

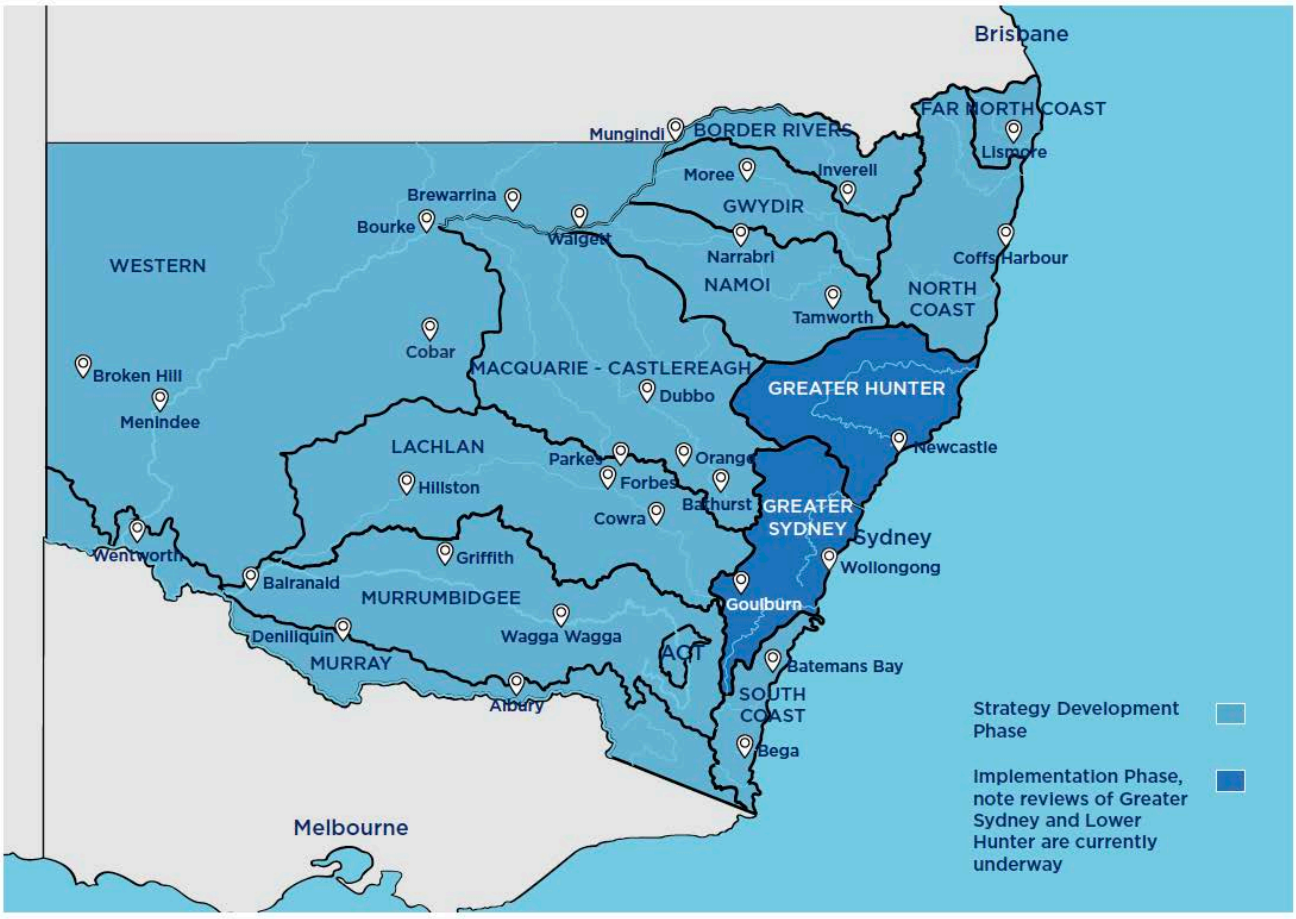
The strategies look out over the next 20 to 40 years and identify the challenges and choices involved in meeting the region's future water needs. They also determine the actions we can take to manage risks to water availability and to secure healthier, more reliable water sources.

The strategies also explore new solutions to tackle these issues. These solutions have the potential to add value to the way we manage water, to generate greater community-wide benefits and to create new economic opportunities for each region.

With improved strategic planning around water, the NSW Government aims to achieve resilient water resources for towns and communities, industry, Aboriginal people and the environment.

The North Coast Regional Water Strategy is one of 14 strategies (12 regional water strategies, a Greater Sydney Water Strategy, and a NSW Water Strategy) the Department of Planning, Industry and Environment is developing in partnership with local councils, Aboriginal peak bodies, communities and other stakeholders across NSW (Figure 3).

Figure 3. Map of NSW regional water strategy regions



1.2 Objectives of regional water strategies

Regional water strategies will set out a long-term 'roadmap' of actions to deliver five objectives (Figure 4). Options selected for inclusion in the final strategy for each region will need to address at least one of these objectives.

Our aim is for the North Coast Regional Water Strategy to include a comprehensive, balanced package of options that is also aligned with and delivers on the goals, directions and actions of the *North Coast Regional Plan 2036.*[20]

Figure 4. NSW regional water strategies: objectives

Deliver and manage water for local communities

Improve water security, water quality and flood management for regional towns and communities.

Enable economic prosperity

Improve water access reliability for regional industries.

Recognise and protect Aboriginal water rights, interests and access to water

Including Aboriginal heritage assets.

Protect and enhance the environment

Improve the health and integrity of environmental systems and assets, including by improving water quality.

Affordability

Identify least cost policy and infrastructure options.

20. www.planning.nsw.gov.au/Plans-for-your-area/Regional-Plans/North-Coast/Plan

The goals of the regional plan cover similar themes to the North Coast Regional Water Strategy, including protecting and enhancing the environment, building the economy and building vibrant and engaged communities. These goals are supported by a series of directions and actions that include managing and enhancing biodiversity and water catchments, sustainably managing resources for industry, partnering with Aboriginal communities and coordinating cost efficient local infrastructure delivery.

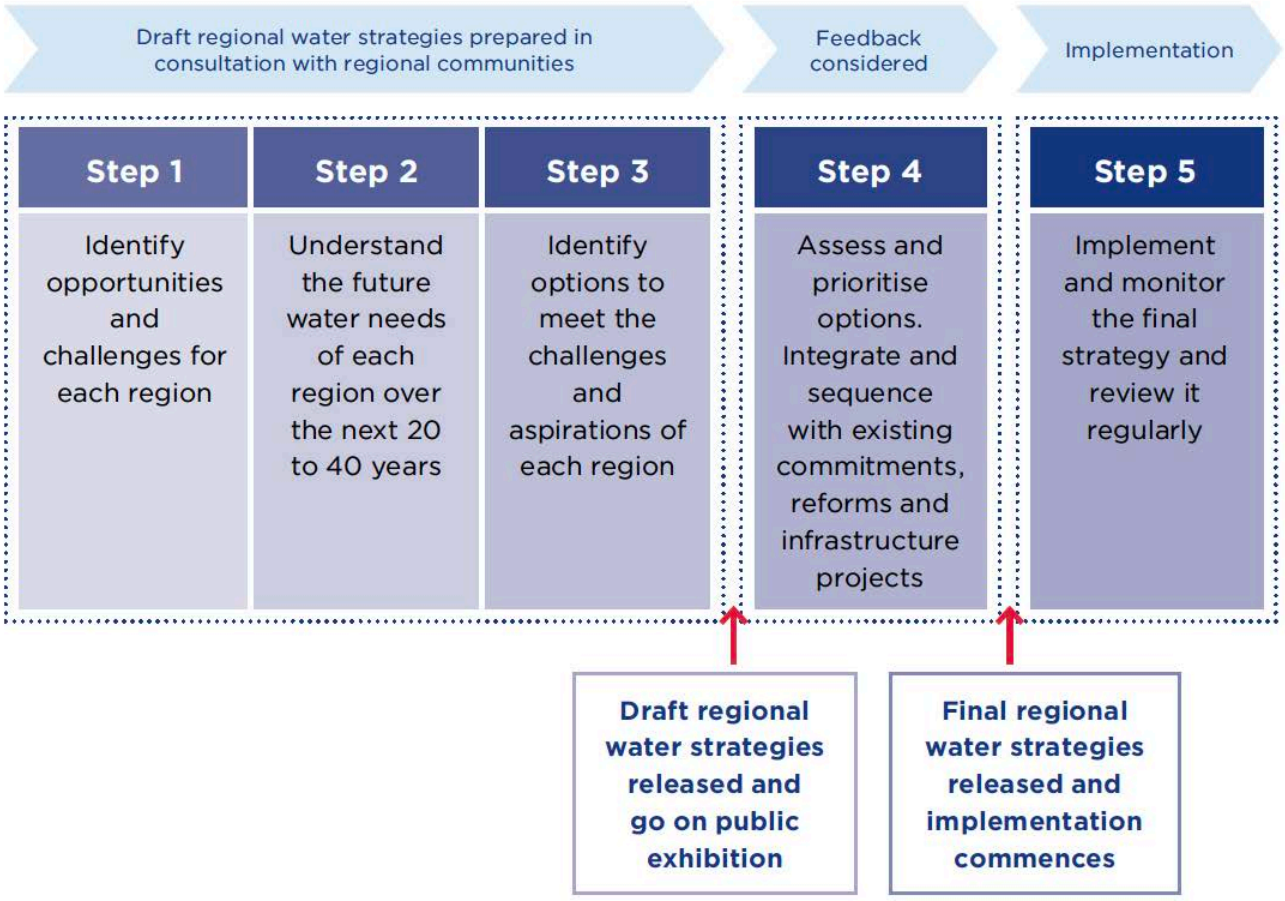
During extreme events, such as the 2019/20 drought, our focus is on securing basic landholder rights (including Native Title rights) and essential town water supplies. Outside of these extreme events, we have greater flexibility to deliver across all of the objectives, including providing water for the environment.

It is also important to note that when formulating water sharing plans, the NSW Government must take all reasonable steps to prioritise the protection of the water sources and their dependent ecosystems.[21]

Through the regional water strategies, we aim to better manage these extreme events for all water users in the future.

The NSW Government is taking a five-step approach to preparing and implementing regional water strategies, as shown in Figure 5 below.

Figure 5. Five step approach to NSW regional water strategies



21. Subsections 9(1)(b), 5(3)(a) and 5(3)(b) of the NSW *Water Management Act 2000*

1.3 What has informed the draft regional water strategies?

To ensure we are using the best evidence and most recent data, and fully consider ideas and options from each region, we have used a wide range of sources to inform each strategy.

1.3.1 Improved climate modelling and data

Until now, water management in NSW has been based on historical data and observations going back to the 1890s. This has provided a limited understanding of extreme events. The NSW Government has invested in new climate datasets and modelling to develop a more sophisticated depiction of past and future climatic conditions. These improved datasets integrate recorded historical data with paleoclimate data (data reconstructed from before instrumental records began, using sources such as tree rings, cave deposits and coral growth), to give a modelling tool that generates 10,000 years of synthetic climate data. When combined with other sources of climate data (such as climate change projections), this has helped us to better understand natural climate variability, including the probability of wet and dry periods in each region, and estimate risks to future water availability.

This new method is an important advance on previous climate datasets and models. The improved modelling means that we have moved from making decisions based heavily on a single 'worst case' scenario drawn from a short climatic record to a much more comprehensive understanding of the distribution, length and frequency of past wet and dry periods. Through this work, we can now assess and plan for the impacts of changes in flows and water security over a much wider range of climatic conditions than if we had only considered the observed historical records.

Chapter 2 sets out the results from analysis of the new climate data for the North Coast region. This updated climate information has been used to develop the draft regional water strategy for the North Coast and will help to assess and compare the effectiveness of the long list of options. It will also support all water users in making more informed decisions to better plan and prepare for climate risks.[22]

Ongoing analysis will yield more specific and robust results, giving an updated understanding of risks to town water supply, irrigation and environmental water security in the North Coast region. The final North Coast Regional Water Strategy will use this new data to identify the best ways to share, manage and use water to manage these risks.

1.3.2 Existing studies

Key foundational work that has informed the Draft North Coast Regional Water Strategy and the long list of options includes the review and audit of existing water sharing plans, EcoHealth Reports and the NSW Government's *NSW Marine Estate Management Strategy 2018–2028*.

Many of the North Coast water sharing plans have been gazetted or are due for review. The background material prepared to support these plans, as well as recent audit reports, has provided important context for water management in the region and highlighted key areas where future work is required.

22. More information about this modelling is provided in the *Regional Water Strategies Guide.*

The *Marine Estate Management Strategy* sets out actions to tackle priority threats to the NSW marine estate. Many of these threats also pose risks to the health of upstream waterways and our ability to meet our objective to deliver resilient water resources in the North Coast region. Priority threats were identified in the Marine Estate Community Survey Final Report and the NSW Marine Estate Threat and Risk Assessment Final Report.

Other important work has informed the Draft North Coast Regional Water Strategy (and will continue to inform the final strategy), including:

- *The North Coast Regional Plan 2036*[23]— sets out planning directions for the NSW Government, councils and other organisations to realise the potential for growth across the North Coast and Far North Coast regions

- Regional Economic Development Strategies—completed by the NSW Government in consultation with local councils. Strategies have been developed for the Hastings-Macleay, Nambucca, Coffs Coast, Clarence Valley and the Southern and Northern New England High Country regions[24]

- EcoHealth Reports— developed between 2009 and 2018 as part of a catchment-based estuarine and freshwater monitoring and reporting program by the University of New England in collaboration with NSW Government agencies and local councils. The reports cover some 400 sites across the region's major river catchments (as well as the waterways of the Coffs Harbour area)

- Integrated water cycle management strategies—although many of the North Coast councils are still developing or updating their integrated water cycle management strategies, these documents will be important sources of information for the final North Coast Regional Water Strategy.

Unlike other NSW regions, the North Coast was not part of the catchment needs assessment that accompanied the *2014 State Infrastructure Strategy* (a key driver for the Regional Water Strategy program). In addition, the focus on NSW inland catchments in response to Murray-Darling Basin Plan requirements has limited the attention given to coastal water-related issues and has slowed the development of an integrated local, regional and state-wide planning approach in the region.

The work done in NSW's inland regions is an important stepping stone for future work in the state's coastal regions and—together with the North Coast Regional Water Strategy—will provide the basis for a better understanding of the risks to water resources and water users, as well as the opportunity to develop options that will prepare the region against climate extremes. As highlighted in the September 2020 NSW Auditor-General's report, Support for regional town water infrastructure, the North Coast Regional Water Strategy also provides the opportunity to better coordinate strategic water planning, program funding and engagement with local councils in the region.[25]

These and other studies will be important sources of information as we assess options for the final North Coast Regional Water Strategy.

23. www.planning.nsw.gov.au/Plans-for-your-area/Regional-Plans/North-Coast
24. www.nsw.gov.au/regional-nsw/regional-economic-development-strategies
25. Audit Office of NSW 2020, *Support for regional town water infrastructure*, www.audit.nsw.gov.au/our-work/reports/support-for-regional-town-water-infrastructure

1.3.3 Community engagement

The NSW Government has been consulting widely—and is continuing to consult—on water sharing plans, metering reforms, coastal harvestable rights, environmental water management and drought. Stakeholder engagement is also underway on coastal agricultural drainage management issues. Through these processes, we have heard many ideas about how to be better prepared for future droughts and floods and a more variable climate.

Due to the COVID-19 pandemic we have had to redesign our engagement program, replacing some face-to-face consultation with virtual, online and contactless methods.

We have continued to talk with local councils, other NSW Government agencies and water users about their thoughts on what the North Coast Regional Water Strategy could cover. Face-to-face engagement with the Aboriginal communities on the North Coast was slightly delayed. Engagement recommenced in July 2020 and will continue as we progress through the options assessment process and final strategy preparation.

Further information about the outcomes of these initial meetings and discussions with local councils, other NSW Government agencies and water users, and our engagement approach with Aboriginal communities during the COVID-19 pandemic is in Attachment 1.

What local councils and other groups have told us so far:

- People are seeking meaningful engagement during the development of the strategy.
- Councils don't just want another strategy—they want something that will lead to action.
- Opportunities exist for better alignment between state, regional and local plans, and better coordination of catchment management activities.
- Many of the local government areas have independent water supply systems that source water from completely separate water sources and do not lend themselves to cross-connection between areas.
- Most local councils consider their town water supply secure, even with projected population growth. The main exception is Armidale Regional Council, with Port Macquarie-Hastings Council and Bellingen Shire Council also noting concern over supply security based on experience from the summer of 2019/20.
- The drought and bushfire conditions of 2019 exposed the vulnerability of some town water supply networks to extended dry periods. The heavy rainfall events of early 2020 exacerbated security issues, elevating turbidity levels. The dry conditions also affected local agriculture, which led to job losses.
- Many councils have already put measures in place—mainly emergency storages—to manage dry periods. Further 'drought security' options being investigated include desalination plants, additional small, off river storages and the recommissioning of old bores.
- Complexity of town water licences makes it difficult to maximise extraction and secure demand for some local towns.

- The use of town water by rural customers is an issue. Rural customers are using water for stock, as well as for larger horticultural plantings. This is a legacy of previous planning decisions and is not the intent of the urban water supply system. This rural demand is of most concern during drought when demand tends to increase and restrictions in use are more difficult (compared to residential water restrictions) to impose.
- When drought hits, the water demands of rural users on council water supplies increases further with water carters taking water to supply rural users not connected to the town water system.
- Access to town water can be impacted by high turbidity following high rainfall events.
- Council emergency storages are prone to algal growth and the build-up of heavy metals, affecting water quality and the ability to use the stored water during dry times. Many councils already have projects underway to improve water disinfection, including dam aerators and additional disinfection.
- Saltwater intrusion to water supplies is a concern for many councils and is likely to become more of an issue into the future as sea levels rise.
- There is concern regarding non-compliance amongst new horticultural users and the impact this is having on town water security, particularly during dry periods.
- Existing and new local intensive horticultural industries are looking to local councils for water security.
- Many councils would like to support wastewater reuse by industry but current regulations and costs, as well as physical constraints (such as storage and sporadic demands), make this expensive and difficult to implement. For some local government areas (particularly in low socio-economic areas), the perceived environmental benefits are unlikely to outweigh the cost to implement.
- We need to shift our approach to managing extreme events—such as drought—from reactive to proactive.
- There needs to be consistent messaging in our approach to managing droughts.
- Local councils need support to deliver integrated water cycle management planning. The audits of end user recycled wastewater management plans was noted as a considerable drain on council resources.
- The social, cultural and environmental values of water are important to many of the North Coast communities. Water management options need to take these values into account.

These early insights have been considered in developing this draft strategy.

1.4 Building on existing commitments and reforms

The NSW Government has made significant commitments to improve water resilience and reliability across the state. Much of our current work addresses the risks facing regional NSW and sets our regions up for the future. For the North Coast region, this includes investing in water treatment plant upgrades and supporting studies and business case development for a range of projects aimed at securing water supplies and providing sewerage services.

We are implementing a range of state-wide water reforms, including improving water and sewerage services for Aboriginal communities, improving compliance and transparency around water use and access.

We are also implementing the NSW Government's coastal management framework to manage the risk of coastal hazards on communities and the health of our estuaries. This is being done through the preparation and implementation of coastal management plans by councils, together with their local communities. We are also implementing the *Marine Estate Management Strategy* to protect and enhance NSW's marine estate over the next 10 years. Coastal management plans will link to—and be able to integrate actions with—this strategy.

The North Coast Regional Water Strategy will integrate with and build on the *Marine Estate Management Strategy* initiatives and outcomes of coastal management plans, such as improving water quality, planning for climate change and rehabilitation of degraded coastal waterways.

We continue to work towards a state-wide Aboriginal water policy to better represent the interests of Aboriginal cultural values and rights in water management.

More information about these reforms is in the *Regional Water Strategies Guide*.

The North Coast Regional Water Strategy will build on these commitments and reforms. It will seek to enhance and leverage them where possible and address any outstanding gaps.

Providing for community water supplies

The Safe and Secure Water Program is a $1 billion regional infrastructure co-funding program established in 2017. The Safe and Secure Water Program has committed over $38 million in the past three years to co-fund eligible water and sewerage projects across the North Coast region. Previous versions of this program have supported the delivery of the *Regional Water Supply Scheme*—the only system that connects and coordinates the supply of town water to more than one local government area.

This has improved public health, water security and environmental outcomes, and delivered social benefits.

When regional town and village supplies are threatened by a major event such as an extreme dry period or extreme water quality event, the NSW Government also provides technical and financial assistance to ensure critical human water needs are met. During the recent drought, the Emergency Relief for Regional Town Water Supplies program provided over $21 million to local councils in the North Coast.

Image courtesy of Annette Corlis.

1.5 Policy and planning context

Each regional water strategy sits within a broader policy and planning context. This includes policies and plans that guide the management of regional water resources in coastal NSW (Figure 6).

The NSW Government is also developing a 20-year NSW Water Strategy. This will establish overarching directions for managing water resources and services to ensure future water security, reliability and resilience and address long-term challenges such as greater climate variability and population changes. The NSW Water Strategy will set high-level outcomes and actions to achieve these across public and environmental health, service delivery, liveability, economic development and technology, and for Aboriginal people.

Regional water strategies provide an opportunity to explore how we can better integrate and shape these plans and policies to deliver improved water outcomes. In particular, the strategies will play a key role in the ordering, sequencing and integration of water reforms in each region.

The strategies also align with the NSW Government's strategic planning hierarchy and will be integrated with current land use and regional plans.[26] This includes the *North Coast Regional Plan 2036*, which sets out the land use planning directions for the region.[27]

26. More information about how the strategies relate to strategic, regional and water planning is in the *Regional Water Strategies Guide.*
27. www.planning.nsw.gov.au/Plans-for-your-area/Regional-Plans/North-Coast/Plan

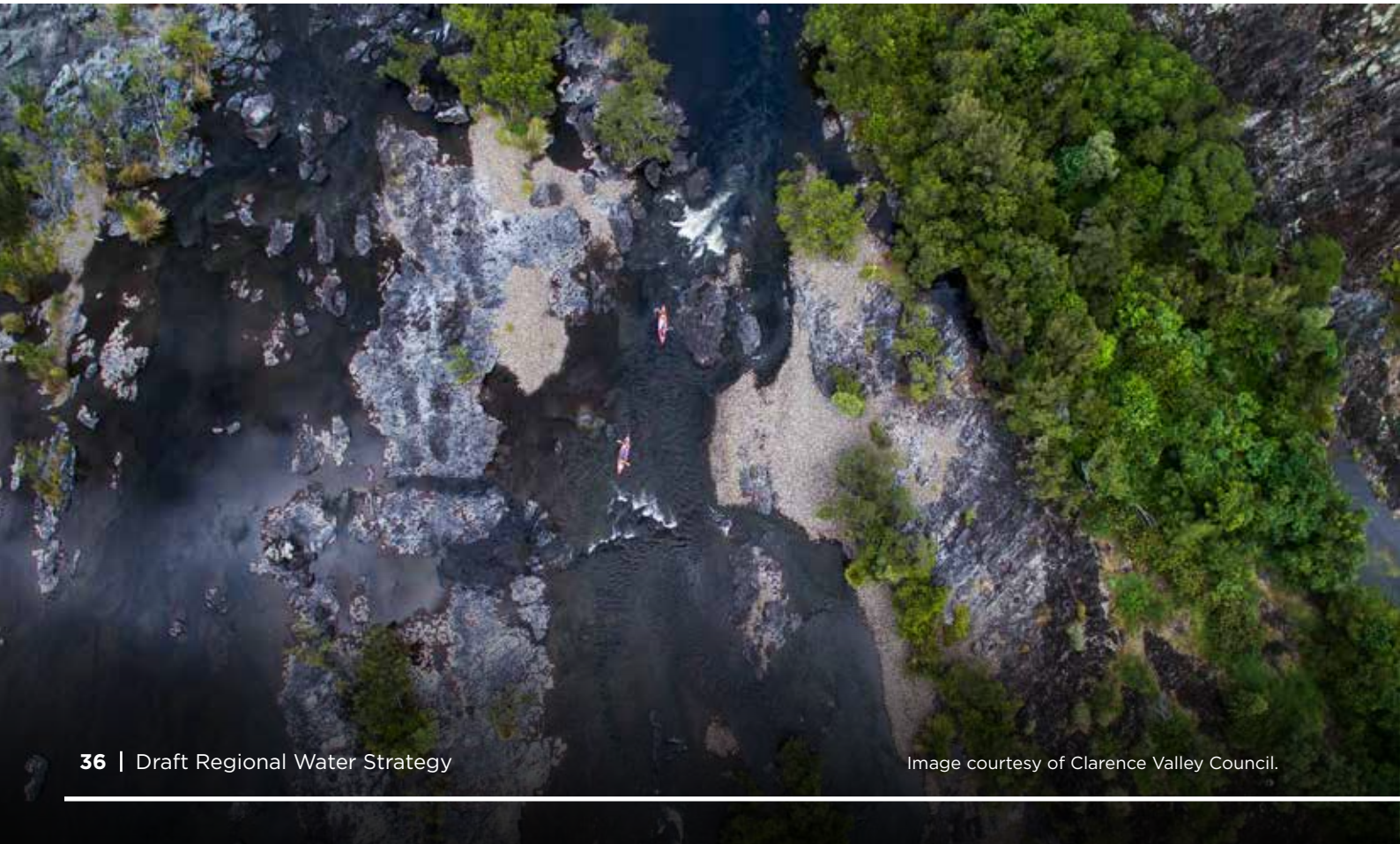
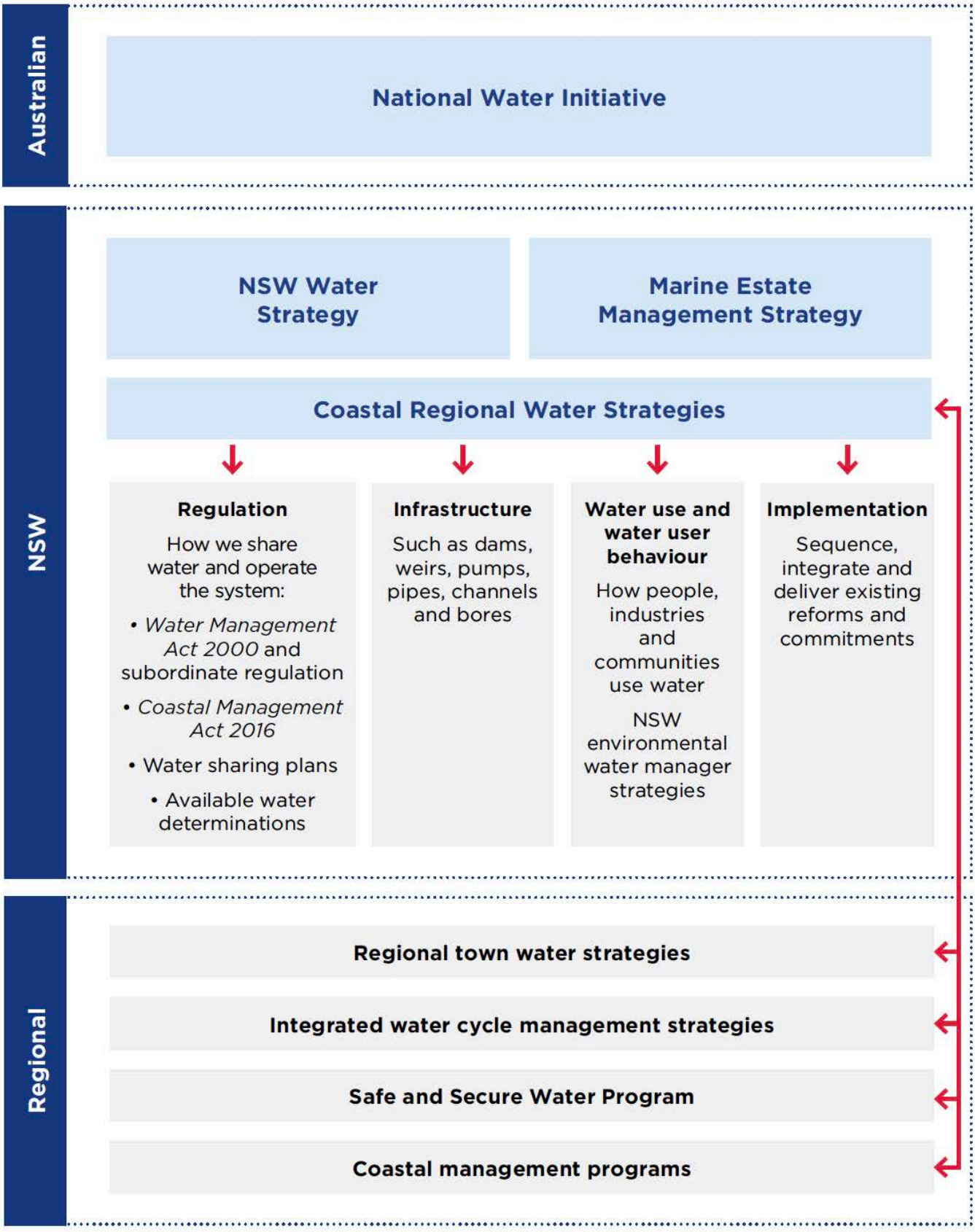


Image courtesy of Clarence Valley Council.

Figure 6. Regional NSW water policy and planning context for coastal catchments



Chapter 2

The North Coast region, its opportunities and challenges

Image courtesy of Destination NSW.

Snapshot

The North Coast region has minimal water infrastructure to capture, store or divert flows and is the only region where all the rivers are completely unregulated. Users generally rely on high, reasonably reliable rainfall and small local storages to meet their demands.

- The region has six independent river catchments as well as the waterways of the Coffs Harbour area, with towns, communities and other water users dispersed across the catchments.
- The region's local councils source town water directly from the region's rivers, upriver alluvials or coastal sands groundwater sources. Many local councils have constructed small town water storages to provide water supply during dry times when river flows are too low to permit extraction. These dams range from 2.5 GL to 30 GL and typically service a single town or community.
- Historically, demand for water from agriculture has been small, with crops mainly being rain-fed. Irrigation is typically only required during drier spring months or extended drought.
- Shifts towards intensive horticulture in many parts of the region have changed the demand for water by agriculture. These crops require regular irrigation and cannot rely on rainfall alone.
- Individual licensed farms dams and harvestable rights dams have been constructed to secure water for drier times. There are currently over 450 licensed farms dams across the region, with the total volume of these dams roughly equal to 30% of the region's total licensed entitlement.

Most local councils have already taken steps to protect town water supplies against dry periods. However, some towns are still vulnerable.

- During 2019 and 2020, flows in many of the region's rivers, particularly the Bellinger and Macleay rivers, were extremely low or ceased completely, preventing extraction of critical town water.
- In response, many councils are investigating new or additional local storage, recommissioning old bores or desalination to improve water security. Unlike other regions, there are few options to connect different local council town water supply systems, due to the distances between regional towns.
- Our new climate data show that the 12 month period of 2019/20 was the driest on record for the region, and that short, dry periods similar to that experienced over the last two to three years are likely to become more frequent. Based on our new modelling, climate change could potentially increase the average number of days per year that cease-to-take conditions on town water licences are triggered.
- Sea level rise and saline intrusion is an additional risk to future town water security, which is unique to coastal towns. Many councils extract water immediately upstream of the tidal limit. Even a small increase in the tidal footprint could affect the water quality for towns and communities and could increase the costs to treat water to adequate standards.

Some councils have already commenced investigations into the potential impacts of sea level rise on town water security.

- The NSW Government recently announced the Oven Mountain Pumped Hydro Energy Storage project as Critical State Significant Infrastructure. Located between Armidale and Kempsey, the project will play a key role in using renewable energy to meet future energy demands, but also has the potential to help secure town water for Kempsey.

Many of the region's rivers are under high hydrologic stress and are affected by poor water quality. Continued shifts towards intensive horticulture, as well as potential future reductions in critical low flows, could worsen these impacts.

- Competition for water is typically highest during spring when rainfall and flows in the river are low and demands for irrigation greatest. This places significant pressure on the region's rivers and creeks.

- A shift from predominately rain-fed crops to high value horticulture over the last 20 to 30 years has placed additional stress on these waterways. These crops have a much higher and regular demand for water irrespective of the prevalent climate conditions.

- New climate modelling shows these pressures could increase. According to our modelling the total annual volume of water flowing in rivers across the North Coast may reduce by around 24% and may impact the full range of flows in these rivers. Low flows will be impacted the greatest, with reductions as high as 36%.

- Managing water for the environment can be challenging, particularly during these periods of low flows and increased competition across water users. Protecting low flows and reducing the stress on the region's rivers relies on all water users complying with the cease-to-take rules. However, very few pumps are metered, making it difficult to ensure water is extracted legally and shared equitably during these periods. Additionally, these rules and extraction limits are premised largely on historic licensed extraction, rather than risk assessments of high priority environmental needs.

- Water quality is also a concern in many parts of the region. Water quality ratings for the major rivers vary from fair to very poor. Poor water quality was found to be worse at the tidal limit but in some catchments, it was also very poor in the tablelands. Past and present rural and urban land use practices, as well as the impacts of legacy mining operations, are key sources of poor water quality in the region.

Maintaining a healthy riverine and estuarine environment is not only important to the region's unique and diverse ecosystems, it is also critical to supporting one of the state's strongest economies.

- Nearly 40% of the region is protected within national parks, declared wilderness areas and nature reserves, including the Gondwana Rainforest World Heritage Area and Oxley Wild Rivers National Park. The region has many coastal lagoons, wetlands and estuaries that are nationally important, such as Limeburners Creek Nature Reserve and the Clarence River Estuary, and support endangered habitat and species.
- These natural assets are key attractions for the five million or more people that visit the region, annually. Tourism is the second highest valued industry in the region at $1,800 million (based on 2019 data). Local tourism campaigns focus on the environment—heavily promoting nature-based experiences—as well as locally produced products. The focus of future investment in the region is to capitalise on the region's natural endowments to make the region the 'best place to live, work and play' in Australia.
- In 2018/19, the commercial estuarine wild harvest and Sydney Rock Oyster industry for the North Coast was worth around $17 million. Flow on business from these industries has been estimated at over $200 million. Aquaculture such as oysters have very high water quality requirements, which are heavily influenced by freshwater inflows and catchment activities.

Greater knowledge and information are needed to ensure groundwater is managed sustainably and innovatively across the region.

- Groundwater in the region is found in fractured and porous rocks, coastal sands and smaller alluvial aquifers around rivers and creeks. This groundwater provides essential flows to ecosystems, baseflow to rivers and creeks and provides water for stock and domestic users, agriculture and town water supplies.
- Groundwater and surface water are often highly interconnected. If river flows are low—due to extended dry periods, over extraction or a combination of both—groundwater stores will also be depleted.
- Groundwater entitlements in the region are considerably less than surface water and since 2017, allocations have been made available for new licences.
- Studies have highlighted that the region's coastal sands groundwater sources and smaller alluvial aquifers have been impacted by saline intrusion, most likely linked to changes induced by groundwater extraction.

- There is limited data on groundwater use. Like surface water, very few bores are metered and extraction is monitored at a limited number of locations.
- Improving knowledge around groundwater sources can help councils, industries and other water users to make informed strategic planning and groundwater management decisions.
- The opportunity for the next 20 to 40 years is to ensure sustainable access to groundwater resources by all water users.

The land and waters of the North Coast region contain places of deep significance to Aboriginal people. Incorporating traditional knowledge into water management could help better understand and manage the region's water resources.

- Aboriginal people have a strong connection to the region's land and water resources. Stories from the Dreaming tell of the creation of the rivers, and in the case of the Clarence, the river's defiance to being dammed.
- Enabling Aboriginal people access to water and Country is key to supporting their social, cultural, economic and spiritual needs. Communities need better information on how the region's rivers, creeks and groundwater systems are managed.
- Aboriginal people—as recognised traditional custodians of the lands and water resources in the region—would like more direct input to water management decisions. Aboriginal people also have concerns about the impact of extraction and land uses on river flows and water quality.
- We are committed to having an ongoing dialogue with Aboriginal people in the region to ensure that their rights, interests and concerns are heard and included in the strategy.

There are significant opportunities to improve how we manage and use water in the North Coast.

- **Improve data collection**—a better understanding of how changing water needs may impact the region's water resources is critical to ensuring these resources are managed sustainability into the future.
- **Ensure existing infrastructure is fit for purpose**—with limited options for interconnections, individual local councils will largely need to provide towns, communities and industry with a secure water supply during dry periods.
- **Support long-term planning for healthy waterways**—building on the work completed in NSW inland regions, there are opportunities to develop long-term water plans that provide a single, coordinated framework to sustain and improve the health of priority environmental assets and ecosystem functions across the region.
- **Protect and bring back critical riverine habitats and species**—continued improvement in land use and water management practices are essential to maintain and improve the natural beauty and diversity of the region's riverine environment and the species that depend on it. This will also provide important cultural flows for local Aboriginal people.

- **Review and clarify rules and procedures**—sustainable use of the region's water resources requires rules that are based on the best available science, recognise longer term climate variability and are clear to those who need to follow them.
- **Provide transparency and confidence to water users**—to be better prepared for future droughts, regions will need guidance on what actions should be taken to protect critical water needs during these extreme conditions.
- **Support more flexible water access arrangements**—with no new surface water licences available across the region, we need to think of more innovative ways to provide access to water, particularly during dry times and in catchments that are already under hydrologic stress.
- **Encourage innovation**—in how we collect water data and encourage more efficient water use.
- **Build capacity to support water stewardship and local decision making**—to support the equitable and sustainable take of water, the community needs access to the right information and support. Councils also need skilled local staff to develop and implement their integrated water cycle management strategies.
- **Support further research**—investment in foundational research is essential to fully understand some of the risks to the region's water resources. This includes impacts from saline intrusion on the region's coastal aquifers.
- **Give Aboriginal people a voice in decision making around water**—we need to support local Aboriginal people to navigate the complexities of water management legislation and provide options for better representation in how water is managed.

2.1 What we know about the North Coast region's climate

2.1.1 Today's climate

The North Coast region's climate exhibits characteristics of both the Border Rivers region to the west and the Far North Coast region to the north.

The region's climate varies from temperate in the higher country of the west to sub-tropical on the coast. Average annual rainfall is around 790 mm in the tablelands (near Armidale) compared to between 1,400 and 1,500 mm along the coast. Portions of the region around and inland from Coffs Harbour and Port Macquarie experience some of the highest annual rainfall in NSW, with up to 2,500 mm on the tablelands around Dorrigo and up to 2,200 mm on the Comboyne Plateau. The volume, as well as the pattern, of rainfall in these areas is very similar to the Far North Coast region. Rainfall along the coast is highly variable and seasonal, with the highest falls during summer and early autumn. August to October are typically the driest months.[28] Along the tablelands, seasonal rainfall is more uniform and more akin to the north-west slopes of the Border Rivers region.

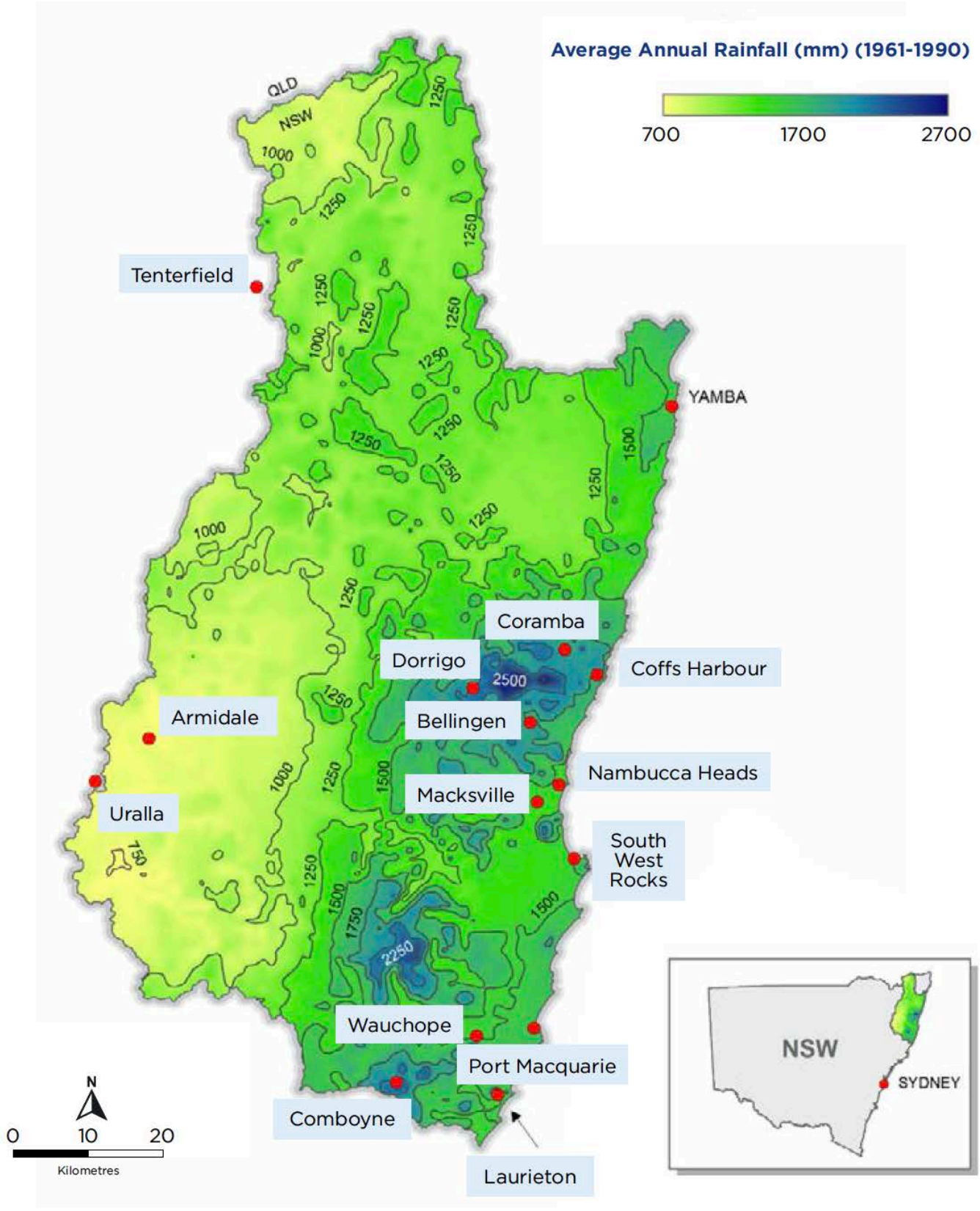
January and February are the hottest months in the region with mean maximum temperatures of around 27°C. Mean winter temperatures can range from 6°C to 19°C on the coast and from below zero to 13°C in the west near Armidale. Long-term records indicate that temperatures in the region have been increasing since the 1950s.[29]

Annual potential evapotranspiration is lowest in the inland south western parts of the region (1,100 mm), increasing to 1,400-1,500 mm along the coast. Monthly potential evapotranspiration peaks during the summer at around 190 mm and drops to between 45 to 60 mm in the winter.[30]

Recent trends in the region's climate show the last 30 years (1989 to 2018) have been drier and hotter than the previous 30 years (1959–1988). Annual rainfall has decreased by 7%, but was within the range of natural variability. While summer rainfall was moderately reliable, autumn and particularly winter rainfall was unreliable. There have also been more days above 35°C.[31]

28. Australian Government, Bureau of Meteorology, *Climate data online*, www.bom.gov.au/climate/data/stations/
29. Bureau of Meteorology, *Climate change—trends and extremes*, www.bom.gov.au/climate/change/
30. Bureau of Meteorology, *Climate data online*, www.bom.gov.au/jsp/ncc/climate_averages/evapotranspiration/
31. Bureau of Meteorology, *Climate guides*, www.bom.gov.au/climate/climate-guides/

Figure 7. North Coast region observed average annual rainfall (1961–1990)



Source: Department of Planning, Industry and Environment—Water 2020, regional rainfall data

2.1.2 A better understanding of current climate variability and future climate change

As outlined in section 1.3.1, new climate datasets and improved modelling are providing a better understanding and more realistic picture of the natural variability of the North Coast's climate beyond the observed historical records.

Recent climate projections indicate that the climate along the coast will change in coming years and is likely to be hotter and have more extreme events. New data and modelling suggest that the natural variability of the climate system is much greater than we have seen in recent history and that this variability will continue to be an important driver of the system as the climate changes.

This new analysis shows that the differences between wet periods and dry periods in the historical record relate mostly to rainfall (rather than evaporation).[32] Average annual rainfall during wet periods is roughly 143 mm higher than during dry periods. By comparison, annual evapotranspiration in dry periods is only 22 mm higher on average than during wet periods. Rainfall is highly variable year-to-year, whereas evapotranspiration is much more consistent. The analysis also found that while the cycles of wet/dry periods usually last between four and 18 years on average, it is possible for dry periods to last up to 60 years.

Our improved modelling also incorporates recognised climate change forecasts, which suggest that in the North Coast region we are likely to see:[33]

- **changing rainfall patterns**—the most dramatic change in rainfall is projected for the historically driest months of winter, with a potential seasonal decrease of around 30 mm for both the near and far future. Generally, autumn rainfall is also projected to decrease, while the months of spring and early autumn are projected to receive slightly more rainfall. Figure 8 shows the average rainfall scaling factor we used to model climate change projections for the North Coast region
- **higher evapotranspiration**—potential evapotranspiration is expected to increase by between 5% to 6% for most months by 2060 compared to levels between 1990 and 2009. The cumulative effect of higher evapotranspiration rates during extended low rainfall periods will reduce soil moisture and make droughts worse than previously experienced. Figure 9 shows the potential evapotranspiration scaling factor we used to model climate change projections
- **higher temperatures**—long-term records indicate the region's temperatures have been increasing since the 1960s. Future projections show this trend will continue across all seasons. Maximum temperatures are expected to increase in the eastern coastal parts by 0.4–1.0°C by 2030, and by 1.5–2.4°C by 2070, while minimum temperatures are expected to increase by 0.4–1.0°C by 2030, and by 1.6–2.5°C by 2070. For the western tablelands, the far future projections show even greater change, with the maximum and minimum temperature expected to increase by as much as 2.7°C. This is a key driver of the expected evapotranspiration increase

32. The wet period refers to the negative phase of Interdecadal Pacific Oscillation; dry period refers to the positive phase of the Interdecadal Pacific Oscillation.
33. Office of Environment and Heritage 2014, *North Coast: Climate change snapshot,* climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Climate-projections-for-your-region/North-Coast-Climate-Change-Downloads

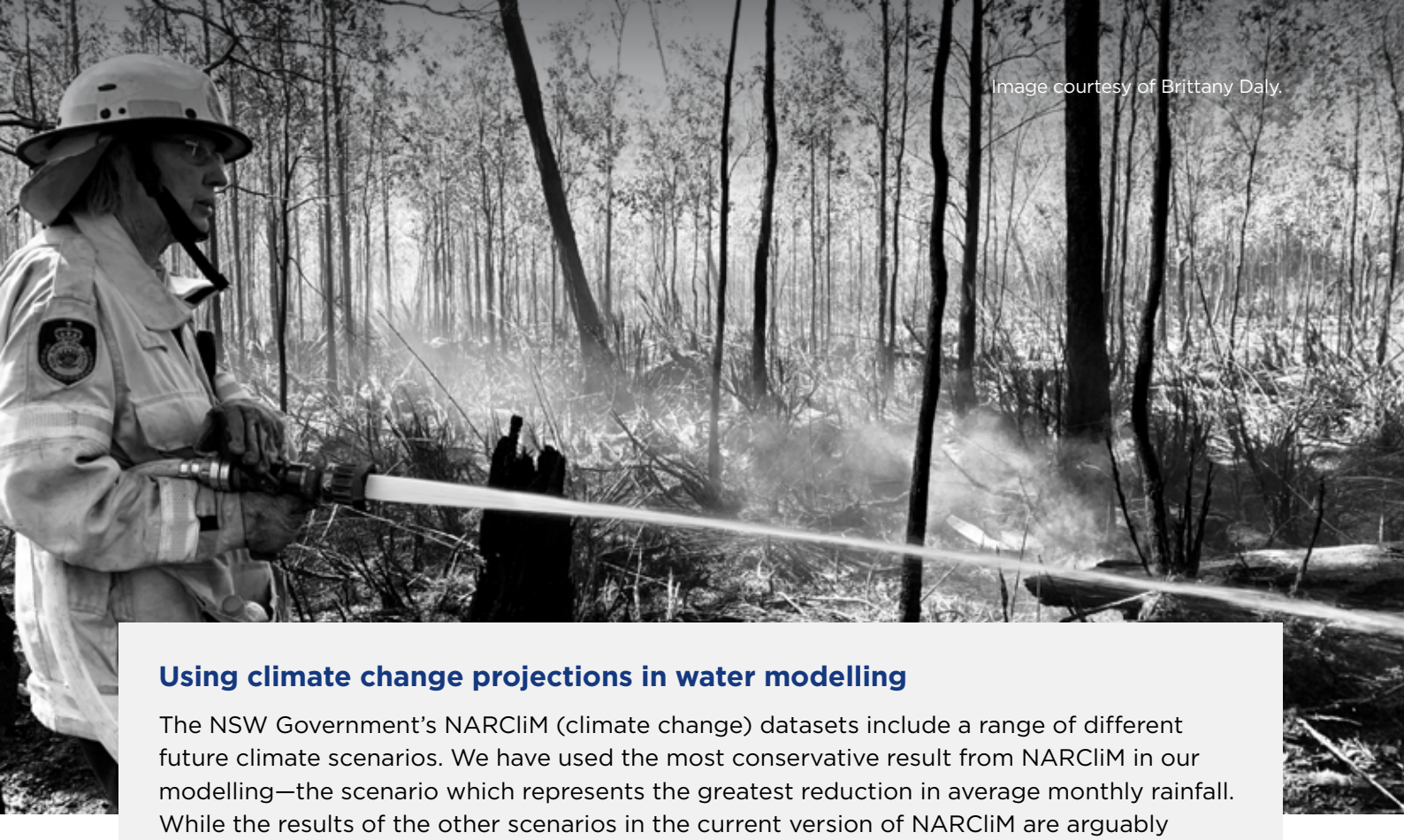


Image courtesy of Brittany Daly.

Using climate change projections in water modelling

The NSW Government's NARCliM (climate change) datasets include a range of different future climate scenarios. We have used the most conservative result from NARCliM in our modelling—the scenario which represents the greatest reduction in average monthly rainfall. While the results of the other scenarios in the current version of NARCliM are arguably equally appropriate and probable, we intend to stress test the water system and understand the worst-case climate scenario for strategic water planning. This will test the resilience of options proposed in the regional water strategies, particularly options that go towards securing water for critical human needs.

- **more hot days and warm spells**— on average, an additional three hot days (maximum above 35°C) are projected by 2030 and an additional nine hot days by 2070. The number of hot days in the western tablelands is projected to be slightly higher
- **decrease in the number of frosts and cold nights**—although there is likely to be little change in the number of cold nights along the coast, along the mountains there may be 10–20 fewer cold nights (defined as below 2°C) by 2030, and over 40 fewer cold nights by 2070
- **increased intensity of extreme events**—the region is likely to be subject to more intense storm events, although it is uncertain if the severity of associated flooding will increase[34]
- **rising mean sea level**—sea level relative to the coast is projected to rise in the region between 0.09 m and 0.18 m by 2030, and between 0.19 m and 0.42 m by 2070.[35, 36] The height of extreme sea-level events (storm surges) will also increase. Consequently, inundation will become more common in low-lying areas along the coast
- **harsher fire-weather** climate in the future.

34. Wasko, C., & Sharma, A. 2017, *Global assessment of flood and storm extremes with increased temperatures. Scientific Reports*, 7(1), 7945-7945, doi.org/10.1038/s41598-017-08481-1
35. The projection of sea level rise relative to the coast reported is averaged for the NSW Coast based on a very low greenhouse gas scenario (RCP2.6). This average is the same as that projected for the coastal local government areas in the North Coast region, with the exception of the far future projections for Port Macquarie–Hastings, which are 0.2-0.43 m.
36. www.climatechange.environment.nsw.gov.au/-/media/NARCLim/Files/Climate-Change-Impact-Reports/Sea-Level-Rise-Science-and-Synthesis-for-NSW.PDF?la=en&hash=E3608D4BA290AEC7EFB6C07630977055362BC473

Figure 8. Average monthly changes in rainfall for the North Coast region for the periods 2020 to 2039 and 2060 to 2079 compared to the period 1990 to 2009 from NARCliM projections

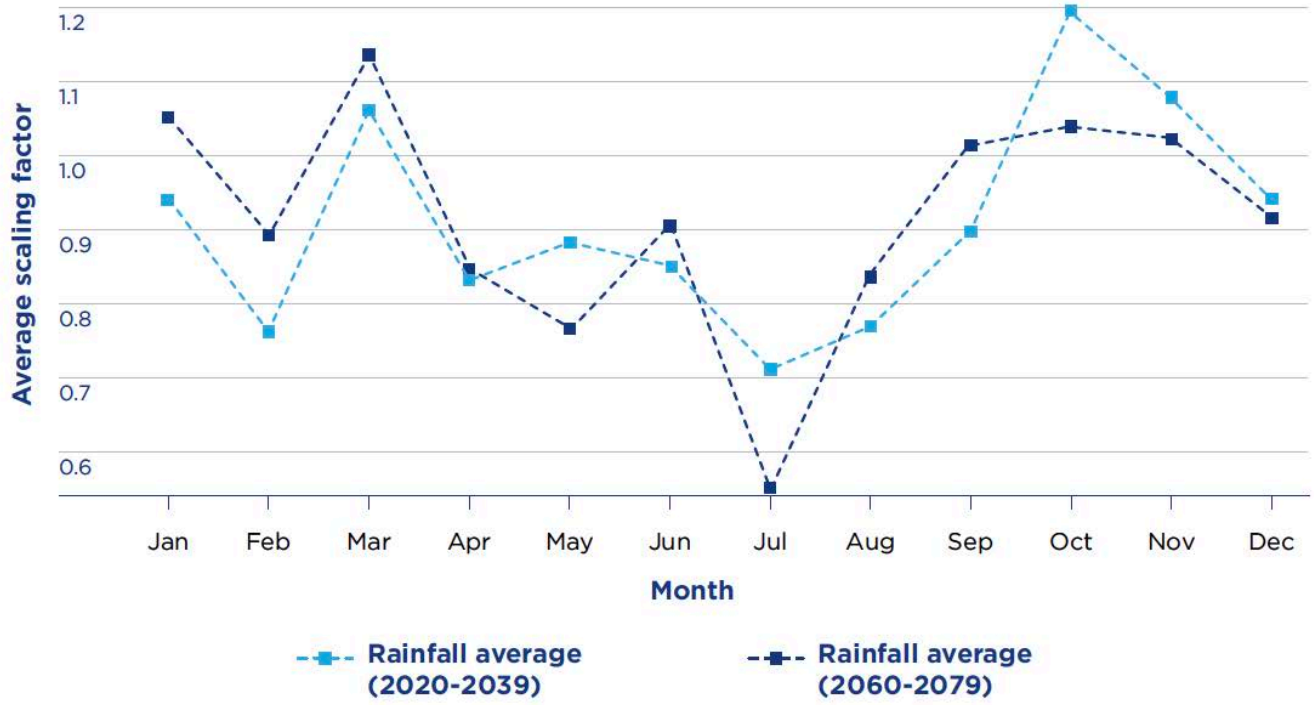
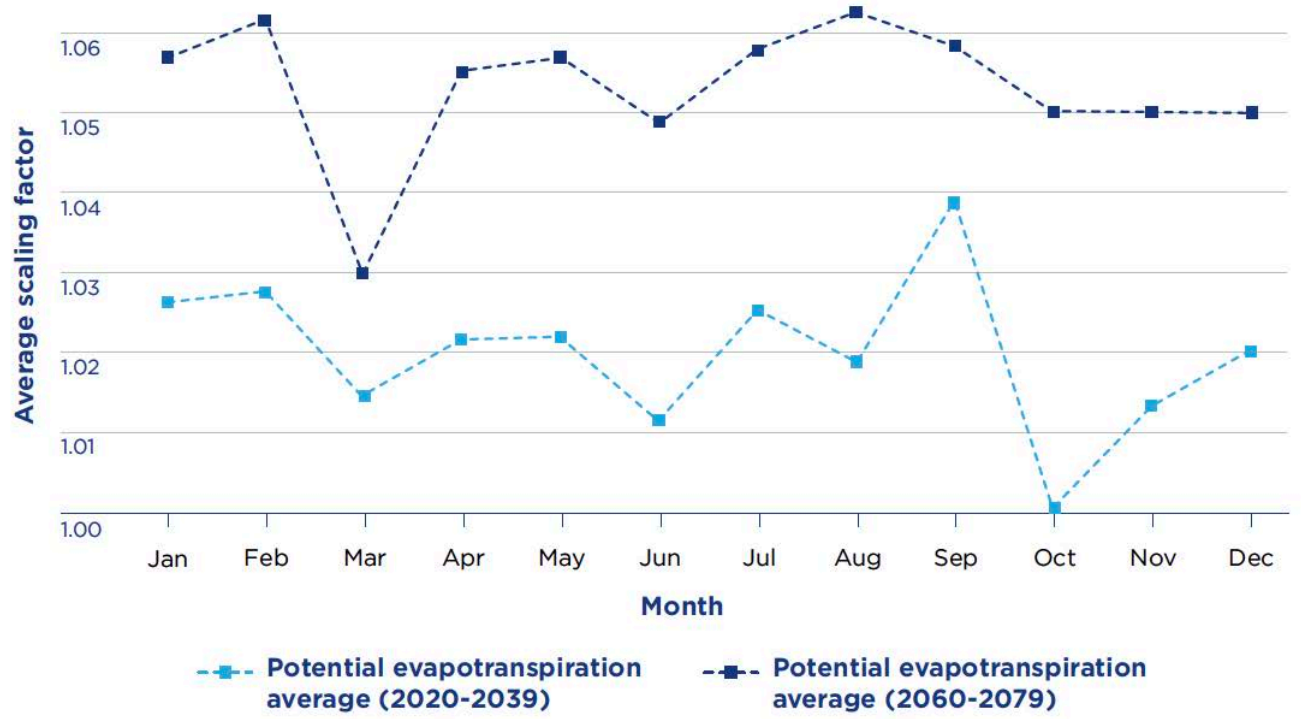


Figure 9. Average monthly changes in potential evapotranspiration for the North Coast region for the periods 2020 to 2039 and 2060 to 2079 compared to the period 1990 to 2009 from NARCliM projections



Source: Department of Planning, Industry and Environment—Water 2020, region climate data

Drivers of climate variability in the North Coast region

The North Coast region experiences relatively consistent long-term annual rainfall, with intermittent and occasionally intense dry and wet periods. Climate variability in the region is related to changes in sea surface temperatures of neighbouring oceans. Two main climate drivers influence rainfall and temperature in the region at the annual and decadal scales. These are the El Niño Southern Oscillation (ENSO) and the Inter-decadal Pacific Oscillation (IPO).

Year-to-year variability is most strongly influenced by the ENSO. The ENSO cycle can be in a negative phase (El Niño) or in a positive phase (La Niña). El Niño conditions refer to warming of the central and eastern Pacific Ocean and are associated with a higher probability of drier conditions.[37] La Niña conditions refer to cooling of the central and eastern Pacific Ocean and are associated with a higher probability of wetter conditions.[38]

Larger-scale, multi-decadal variability in the region is primarily influenced by 15- to 30-year cycles of the IPO. The IPO is caused by fluctuations in the sea surface temperature and mean sea level pressure of the north and south Pacific Ocean.[39] Positive phases of the IPO are characterised by a warmer than average tropical Pacific Ocean and drier conditions in south eastern Australia (that is, less rainfall than average). Negative phases are characterised by cool tropics and result in wetter conditions across south eastern Australia. In the North Coast region, long-term wet and dry periods in the observed recorded data have been shown to correlate to the recorded IPO, with the IPO affecting rainfall more significantly than evaporation.[40] On this basis, the IPO method for stochastic data generation was adopted for the NSW North Coast region.[41]

37. Bureau of Meteorology 2020, *Climate glossary: El Niño*, accessed 24 August 2020, www.bom.gov.au/climate/glossary/elnino.shtml
38. Bureau of Meteorology 2020, *Climate glossary: La Niña*, accessed 24 August 2020, www.bom.gov.au/climate/glossary/lanina.shtml
39. Dowdy et al. 2015, East Coast Cluster Report. In Ekström et al. (Eds.), *Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports*, CSIRO and Bureau of Meteorology, www.climatechangeinaustralia.gov.au/
40. Leonard et al. 2020, *Methodology Report for Multisite Rainfall and Evaporation Data Generation of the Northern Basins—Far North Coast Region Stochastic Evaluation,* University of Adelaide
41. Stochastic climate datasets are extended climate sequences that are synthesised using statistical methods applied to observed rainfall and evapotranspiration data (and can also include paleoclimatic data). These sequences give a more complete picture of climate variability. The new climate datasets developed for the regional water strategies are explained in gretaer detail in the *Regional Water Strategies Guide*.

The region has experienced persistent droughts, as well as intense shorter droughts

The North Coast has experienced several protracted droughts[42] over the past 130 years of observed records. The region experienced severe impacts during the extended dry conditions of the Federation Drought (1895 to 1903) and World War II Drought (1939 to 1945), both of which also affected much of inland NSW. The Millennium Drought (1997 to 2009) affected the North Coast to a much lesser extent.

The region's lowest ten-year rainfall total on record occurred during the Federation Drought from 1900 to 1910 (compared to 1910 to 1920 for the Far North Coast and 1935 to 1944 in the Border Rivers region).[43] This occurred during a period of sustained El Niño activity characterised by a reduction in the number of rainfall days and a significant decline in spring and summer rainfall along the coast.[44] During this drought, extended periods of low or no flow were interspersed with one large flood in 1903 and several small to medium freshes,[45] which may have been sufficient to reset the system and dampen the overall impact on ecosystem function and water security. The Macleay River experienced twice as many days with low flow[46] than the long-term average and 107 cease-to-flow days, which is around six times more than the long-term decadal average. Our new datasets and modelling suggest that dry periods of 10 years are not unique; nor is it the longest dry period the region is likely to have experienced. Our new extended dataset suggests that similar events—and even much more severe ones—have occurred in the longer climate record, meaning they could happen again. Based on long-term historical climate variability, there is a 57% chance that drier ten-year minimum rainfall than that seen in the Federation Drought could occur in any 129-year period.[47]

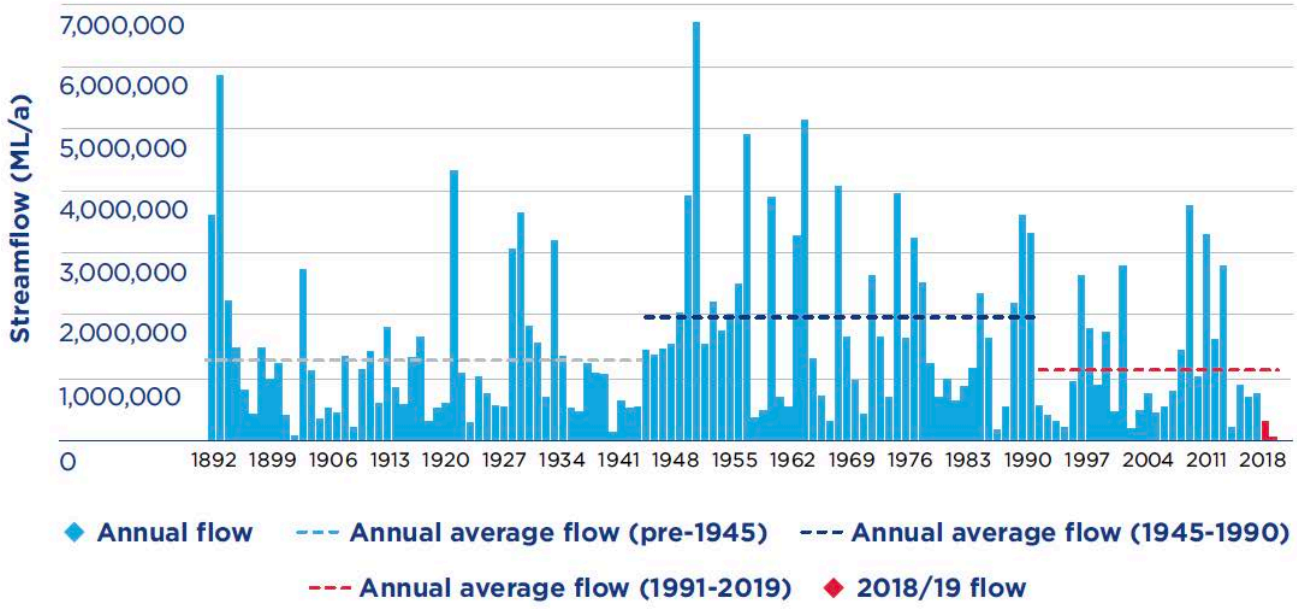
The response to extended dry periods for a region like the North Coast with completely unregulated rivers will differ to regulated systems, particularly those of inland NSW. In the North Coast, a dry period as short as one or two years could severely impact ecosystem function and water security for towns, communities and industries. In contrast, a regulated system can potentially dampen these shorter term impacts by delivering stored water to downstream users. However, an unregulated system is also likely to be more responsive to freshes than a regulated system. In general, the rivers of the North Coast are short and steep and a moderate rainfall event is likely to be sufficient to reset important ecosystem functions (as well as access arrangements for water users). In comparison, inland regions typically need multiple, large rainfall events to raise storage levels, and water can take more than a month to be delivered to the users at the end of the system.

42. Drought is defined in terms of periods of rainfall deficit (meteorological drought), low catchment streamflow (hydrological drought) and soil moisture depletion (agricultural drought). This strategy discusses meteorological and hydrological drought.
43. Leonard, L, Devanand, A, Westra, S.,2020, *Northern Basin Method Report Stochastic Generation—Annex E North Coast Region Stochastic Evaluation*, University of Adelaide.
44. Verdon Kidd and Kiem 2009, *Nature and causes of protracted droughts in southeast Australia: Comparison between the Federation, WWII, and Big Dry droughts*, www.aph.gov.au/DocumentStore.ashx?id=e75d2425-4bb3-425b-ba4f-dc640c258804
45. Freshes define a surface water flow that is of suitable magnitude and duration to have the capacity to reset river reaches. Resetting includes improving water quality, clearing sediment build-up to enhance instream habitat, redistributing sediment to enable normal geomorphic processes, redistributing nutrients to enable normal levels of instream productivity and encouraging instream biota to disperse and/or breed.
46. Low-flow is defined as mean daily flow less than the 95th percentile mean daily flow. Flow is at Macleay River at Turners Flat (gauge 206011)
47. Leonard, L, Devanand, A, Westra, S., 2020, *Northern Basin Method Report Stochastic Generation—Annex E North Coast Region Stochastic Evaluation*, University of Adelaide.

As a region, the North Coast has recently experienced its driest 24 months on record (2018/2019). While severe, our new climate datasets suggest that the region may have experienced lower two-year rainfall totals in the past. This means that similar and even more severe droughts may occur in the future.

Climate patterns vary across the region and consequently, drought patterns for each of the distinctly different catchments will also vary. For example, the conditions experienced between 2018 and early 2020 had the greatest impact on streamflow in the Clarence River and Macleay River catchments. This was largely due to higher rainfall deficits and greater mean monthly temperature anomalies across the north-west of the catchment compared to the coast. Streamflow for 2018/2019 in both the Macleay and Clarence rivers was around 12% of the long-term average, compared to 46% of the long-term average in the Bellinger River and 50% in the Hastings River.[48] The historical variability of streamflow in the Macleay River is shown in Figure 10, illustrating the extended dry periods interspersed with years of high streamflow, and lower average annual streamflow in the region since 1991.

Figure 10. Annual streamflow in the Macleay River over the instrumental period[49]



48. The worse 24-month stream flows for the Bellinger and Hastings rivers were experienced during March 1901 to March 1903 and May 1901 to June 1903, based on data recorded at gauges 205002 (Bellinger River @ Thora) and 207004 (Hastings River at Ellenborough (Kindee Bridge))
49. Based on data generated for gauge 206011 at Turners Flat

A note of caution: the scenarios in these models will not necessarily eventuate. They are potential scenarios and there is always a level of uncertainty with this type of modelling, which needs to be taken into account as part of any water decision making and planning. In some instances, this may mean managing risks to our water security by being prepared and resilient, rather than relying on firm predictions and hard numbers.

As the science develops further, we will be able to reduce or quantify some of these uncertainties.

Floods are a feature of the past, and the future

Floods are a vital, natural process that supports the North Coast region's environmental, agricultural and ecological productivity, and facilitates longitudinal and lateral connectivity along river systems. They form part of the environmental flows required to connect wetlands and floodplains with the river (for example, Everlasting Swamp in the Clarence River floodplain) and open lagoons (such as Hearnes Lake[50]) to the sea. Floods distribute nutrient rich deposits that form the highly productive soils of the region's floodplains. Flood pulses flush floodplains and estuaries of any build-up of organic matter, salinity and nutrients that accumulate during dry and prolonged low-flow periods. They can limit saltwater intrusion into freshwater reaches of rivers and are important reproductive cues for many fish and invertebrates. Floods also assist groundwater recharge.

However, due to the degree of development on floodplains, floods can also have significant detrimental impacts on people and businesses—damaging infrastructure, creating safety risks and causing financial and economic loss.

Poor catchment management, inappropriate development, vegetation clearing and flood control exacerbates the negative impact of floods. Floods that occur following extended dry periods can also cause land degradation and soil erosion, damage to riverbank vegetation due to rapid wetting of the banks and in some instances flushing of dead organic matter into streams, causing potentially hypoxic 'blackwater' events that pose a risk to threatened fish species.

The North Coast region has a long history of flooding. Clarence Valley Council has recorded 120 floods since records began in 1839[51] and Kempsey has recorded 41 floods for a similar period.[52] In the early 20th century, the devastating impacts of flooding in the Clarence River floodplain forced farmers to abandon this fertile and highly valuable agricultural land. In response, the predecessor of the current Clarence Valley Council was formed in 1959 to coordinate flood mitigation measures across the separate shires in the river's catchment,[53] supporting the return of agriculture in the region.

Image courtesy of Kempsey Shire Council.

50. These lakes are located in the catchments of the Coffs Harbour area, Hastings River and Macleay River respectively.
51. www.clarence.nsw.gov.au/
52. Manly Hydraulics Laboratory 2020, *Kempsey Shire Council Flood Information: Annex A to the Kempsey Shire Local Flood Plan*
53. www.clarence.nsw.gov.au/

Major floods in the region typically occur in the summer and autumn months, due to one of the following weather events:[54]

- east coast low pressure systems
- rain depressions originating as tropical cyclones
- monsoonal low-pressure systems
- sequence of fronts (phenomenon most likely during winter months)
- high intensity, short duration, convective thunderstorms (particularly in the summer months).

Flooding patterns are often sporadic. Several severe floods can occur in short succession. For example, the floods of 1949 and 1950—the worst two floods recorded at Kempsey Traffic Bridge—occurred within eight months of each other. Conversely, there have been periods more recently of around 10 years without any major flooding.[55]

Many of the region's major urban centres are located in the floodplain. Local councils have constructed a range of flood mitigation works to reduce the impacts of flooding and protect people, communities and businesses in these urban areas. Examples include extensive levee systems, flood detention basins and flood warning systems.

Flood mitigation and drainage works put in place to address frequent and prolonged inundation of agricultural areas in the Lower Macleay River and Clarence River floodplain can have significant water quality impacts. During flood events, this infrastructure can exacerbate the risk of deoxygenation and 'blackwater' events. These impacts were experienced last summer when a major flood event in the Macleay River, followed by high temperatures, led to the reported deaths of hundreds of thousands of fish in the Macleay estuary.[56] Councils are continually seeking solutions to improve water quality in drains and creeks, reviving floodplain watercourses and wetlands, and increasing the diversity and abundance of wildlife.

Climate change may affect future flood behaviour. Climate change has the potential to influence sea levels and tidal and entrance conditions in lower coastal waterways, flood-producing rainfall events (such as East Coast Lows), and catchment and floodplain conditions before an event.

Sea level rise will influence flooding in lower coastal waterways by reducing the capacity of waterways to contain higher flows. Sea level rise can further exacerbate flooding by changing the morphology of the river mouth.

Climate change research suggests the scale of larger flood producing rainfall events, typically produced by East Coast Lows, is likely to increase. However, the impact will depend on the antecedent conditions relative to the size of the rainfall event, and the interplay with other climate drivers.[57] For example, if the catchment is dry at the time of the storm, a large proportion of the event will be absorbed by the soil, reducing the potential flood impacts. However, if there are multiple, high intensity storms in short succession—or if the storm is large enough to override the ability for the storm to be absorbed by the soil—the impacts are likely to be far worse.

54. NSW Government 2016, *Eastern Seaboard Climate Change Initiative*, www.climatechange.environment.nsw.gov.au/Impacts-of-climate-change/East-Coast-Lows/Eastern-Seaboard-Climate-Change-Initiative
55. Manly Hydraulics Laboratory 2020, *Kempsey Shire Council Flood Information: Annex A to the Kempsey Shire Local Flood Plan*, www.mhlfit.net/users/KempseyShireCouncil-FloodInformation
56. www.dpi.nsw.gov.au/fishing/habitat/threats/fish-kills
57. El Niño and IPO phases can dampen the effects of East Coast Lows.

Councils work closely with the Department of Planning, Industry and Environment—Environment, Energy and Science and with the State Emergency Service to ensure that land use planning and emergency management processes are in place to protect the community from the impact of flooding. Flood investigations consider the potential impacts of climate change on flood risk in a manner that is fit for purpose for each location.

The North Coast Regional Water Strategy is an opportunity to reaffirm the importance of understanding the relevance of flooding to achieving regional objectives, the appropriateness of the current flood management framework and the delineation of responsibilities between the NSW Government and local councils.

Sea levels are rising

Global sea levels are rising, predominantly as a result of increasing greenhouse gas concentrations in the atmosphere and associated glacial and ice sheet melt.[58] As a coastal region, the North Coast is particularly susceptible to the impacts of rising sea levels. Low-lying areas may become inundated and sandy shorelines will recede landwards. Sea level rise is likely to exacerbate flood impacts in the region as it will reduce the ability of ocean outlets such as the Clarence, Macleay and Hastings rivers to quickly discharge flood waters. Rising sea levels will also cause tidal limits in estuaries to move further upstream and saltwater to intrude into groundwater sources. This poses a threat to regional water security because increases in salinity will restrict what these water sources can be used for or require higher levels of treatment for consumptive uses.

Local geological factors, ocean currents and local thermal expansion or contraction of oceans all affect sea level rise projections in different locations. The extent to which sea levels will rise is also highly dependent on how significantly greenhouse gas emissions are reduced in the coming years (Table 1). Sea levels in the North Coast region are projected to increase between 0.19 m and 0.42 m by 2070. The average projections for coastal NSW are for 0.30 m increase for a low emissions scenario and 0.45 m for a very high emissions scenario.[59]

Larger rises are possible beyond these median scenarios. The Intergovernmental Panel on Climate Change suggests that these projections could be up to tens of centimetres higher if marine-based sectors of the Antarctic ice sheet collapse. Other research suggests that the upper estimate of global mean sea level rise could be as high as 2 m to 2.7 m. More frequent and intense low pressure systems can also contribute to higher sea levels during these events.

58. Oppenheimer et al. 2019, Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities. In Pörtner et al. (Eds.), *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*, Intergovernmental Panel on Climate Change
59. CoastAdapt 2017, *Sea-level rise and future climate information for coastal councils*, accessed 14 July 2020, www.coastadapt.com.au/sea-level-rise-information-all-australian-coastal-councils

Table 1. Sea level rise projections for the North Coast region (relative to an average recorded between 1986 and 2005)*

Year	Low emissions scenario (RCP4.5) (m)	Very high emissions scenario (RCP8.5) (m)
2030	0.13 (0.09-0.18)	0.14 (0.09-0.18)
2050	0.22 (0.14-0.29)	0.27 (0.19-0.36)
2070	0.30 (0.19-0.42)	0.45 (0.31-0.59)

*Note: Values are average values with likely range provided in brackets

Source: CoastAdapt, 2017

Opportunistic freshwater extraction from below the tidal limit occurs in the tidal pools of Bellinger, Clarence, Hastings and Macleay rivers, and accounts for approximately 1% to 8% of each river's total water access entitlement volume.[60] The footprints of the maximum high tide for many of these rivers already extend at least 20 km upstream into the catchment and are likely to increase with sea level rise. As many towns extract water from rivers and alluvial groundwater systems immediately upstream of the existing high tide limit, even a small rise in sea level may have serious impacts on the water security of towns and communities along the coast.[61]

Many coastal sands, floodplain alluvials and some upriver alluvials are vulnerable to saltwater intrusion (the encroachment of saltwater from adjacent sea water bodies into coastal aquifers).[62] This can significantly degrade water quality and reduce freshwater availability over the medium to long term. The increasing demands for fresh water in coastal areas and the anticipated impacts of climate change (such as sea level rise and variations in rainfall recharge) may result in increases in the incidence and severity of saltwater intrusion.

The management of saltwater intrusion is based around ensuring over-extraction of these coastal aquifers does not occur through both limiting overall extraction volumes and monitoring and managing water level heights in areas of intensive extraction. However, our current understanding of the impact and the potential vulnerability of the region's groundwater sources, and the appropriate management response, is severely constrained by limited hydrochemical and water pressure data across the region.[63]

Sea level rise will also threaten the management, operation and maintenance of low-lying gravity agricultural drainage, stormwater infrastructure and sewerage infrastructure.

60. Internal Department of Planning, Industry and Environment—Water data
61. Based on data presented through the tool www.coastalrisk.com.au/
62. The process of saltwater intrusion takes place when groundwater is over-extracted and/or groundwater levels are reduced during drought periods, resulting in the ingress of saltwater to replace the depleted groundwater. This process brings salts into the aquifer, which require long-term natural flushing to reduce the salt concentration.
63. Ivkovic et al. 2012, *National-scale vulnerability assessment of seawater intrusion: summary report,* Waterlines Report Series No 85, Issue August 2012

Image courtesy of Destination NSW.

2.2 The landscape and its water

Water is critical to the North Coast region—to the health of its environment, the social fabric and liveability of its towns and communities, and to its economic prosperity.

The region, with a total area of almost 42,000 km^2, includes six river catchments (the Clarence River, Macleay River, Bellinger River, Nambucca River, Hastings River and Camden Haven River) and the waterways of the Coffs Harbour area. All of the rivers have numerous tributaries, and unlike the rivers of inland NSW, are typically fast flowing with relatively small catchments. After descending through steep (and often rugged) country, the rivers join wide, flat floodplains that terminate in an extensive system of coastal lagoons, wetlands and estuaries.

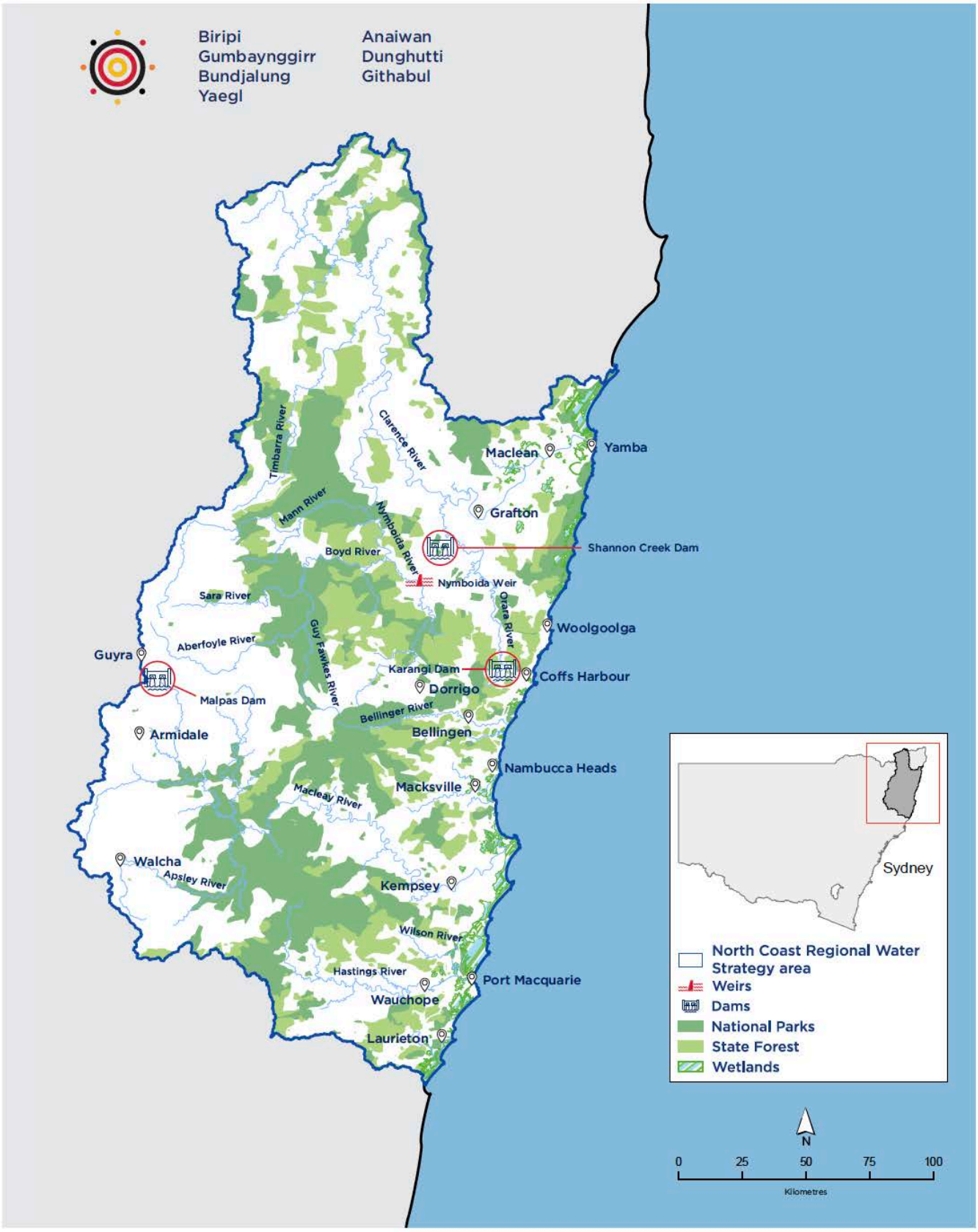
The region also has numerous groundwater sources found in extensive coastal alluvial floodplains, coastal sands, porous and fractured rocks, as well as smaller alluvial aquifers adjacent to rivers and creeks.

2.2.1 Water resources in the region

The region's towns, communities and industries use water from multiple sources (shown in Figure 11):

- six main unregulated, perennial and unconnected river systems: the Clarence River, Macleay River, Bellinger River, Nambucca River, Hastings River and Camden Haven River, all of which have a network of smaller river systems and creeks
- smaller coastal catchments, including the waters of the Coffs Harbour area
- 13 groundwater sources including the Comboyne Basalt Groundwater Source, Stuarts Point Groundwater Source, and Macleay Coastal Sands Groundwater Source
- local runoff from rainfall captured in farm dams
- recycled wastewater and stormwater harvesting.

Figure 11. The North Coast region: key surface water sources and infrastructure



Major rivers and local storages

Major rivers

The Clarence River, at nearly 400 km, is the longest river in the region. It rises in the McPherson Range near the Queensland border,[64] travelling south to Grafton and then north-east before joining the Pacific Ocean near Yamba. The river's catchment transitions from high tableland areas in its western extremities, falling away to a large and relatively flat coastal floodplain.[65] Around 33% of the river's catchment lies within national parks and nature reserves (compared to 40% of the entire region). These include Bandjalung National Park, Iluka Nature Reserve and the Yuraygir National Park. Large flows are typical of the Clarence—as for all the region's rivers—and are critical to the diverse and unique ecosystems of the North Coast. About 2,340,000 ML water runs through the Clarence River annually,[66] but can be nearly three times larger or two thirds smaller.[67] Roughly 70% of this flow happens between January and April.

The Macleay River begins at the confluence of the Gara River, Bakers Creek and Salisbury Waters, between Guyra and Armidale on the New England Tablelands[68] and travels approximately 300 km to the sea, mainly through extensive tableland areas and rugged gorge country. Before terminating north of South West Rocks,[69] the river is joined by 26 tributaries, the major ones being the Apsley River, Chandler River, Styx River, Tia River, Dyke River, Yarrowitch River and Commissioners Waters.[70] Like the Clarence River, annual flows can be highly variable from year to year.

The Nambucca River headwaters are within the Gumbayniggirr National Park on the border of the New England tablelands. The river traverses through mainly cleared floodplain, terminating at the Nambucca River estuary. The Nambucca River estuary covers around 20% of the catchment area. The tidal waterways of the estuary extend upstream along the Nambucca River to Bowraville, along Taylors Arm to Boat Harbour at Utungun, and along Warrell Creek to the Pacific Highway near the hamlet of Warrell Creek. The average annual flow in the river is around 88,000 ML, with 50% of flow occurring from January to March.[71]

The Bellinger River catchment includes both the Bellinger and Kalang rivers. The Bellinger River (109 km) flows from the Dorrigo Plateau before entering the ocean at Urunga; the Kalang River joins the Bellinger River just upstream. The river has one of the smallest catchments of the region's major rivers. Flows in the river are still large—on average, around 450,000 ML/yr occurring mainly between January and April.[72] Most of the catchment is mountainous, with only small areas of flat land along the river and creek valleys and on the coastal floodplain. Over 60% of the catchment is either national park or state forest, including

64. www.britannica.com/place/Clarence-River-New-South-Wales
65. Department of Primary Industries—Water 2016, *Water Sharing Plan for the Clarence River Unregulated and Alluvial Water Sources: Background document*
66. Average annual long term historical river flow over 130 years of instrumental record for the Lilydale gauge (204007)
67. Based on 10th and 95th percentile flows generated from the new hydrological model at the gauge 204007.
68. www.oroh.com.au/our-rivers/macleay-river/
69. Ashley et al. 2007, *Antimony and arsenic dispersion in the Macleay River Catchment, New South Wales; a study of the environmental geochemical consequences*, Australian Journal of Earth Sciences, 54, p.83-103, www.researchgate.net/publication/248955277_Antimony_and_arsenic_dispersion_in_the_Macleay_River_catchment_New_South_Wales_A_study_of_the_environmental_geochemical_consequences#pf3)
70. Department of Primary Industries—Water 2016, *Water Sharing Plan for the Macleay Unregulated and Alluvial Water Sources: Background document*
71. Average annual flow data for Nambucca River upstream of Bowraville, realtimedata.waternsw.com.au
72. Average annual long term historical river flow over 130 years of instrumental record for Bellinger at Boggy Creek (205005)

Dorrigo National Park and Bellinger River National Park. The tidal limit extends upstream of the township of Bellingen.

The southern extent of the region includes the catchments of the Hastings River and the Camden Haven River. The Hastings River begins in the steep gorges of the Great Dividing Range and flows to the coast through an extensive floodplain area before entering the sea at Port Macquarie. The river's source is within the Werrikimbe National Park in the northwest of the catchment. It flows for 165 km before being joined by its major tributaries: the Forbes, Ellenborough and Throne rivers, Pappinbarra River and finally the Wilson River. Annual flow in the Hastings River is around 650,000 ML[73] and, like the other rivers, is concentrated in the early few months of the year. The Camden Haven River is much smaller than the Hastings River and supports extensive floodplains, wetlands and coastal lakes including Watson Taylors lake and Queens Lake and flows out to sea at North Haven.

The Coffs Harbour waterways are all short catchments. The coastal catchments from Bundageree Creek to Station Creek begin at the coastal range of hills in the west. The upper parts of each catchment have steep, dramatic topography, flattening out as the creeks become estuaries and flow to the ocean. The most distinctive features of these coastal catchments are the estuaries and lagoons, with impressive headlands and many beaches. Like the Nambucca River and Bellinger River catchments, there is a significant amount of land tenure under state forest.

Diverting eastern flows to inland catchments

There have been several suggestions for inland diversion schemes involving the eastern rivers, including flows from the Clarence River. The option of an 'inland diversion scheme from the east' was listed in WaterNSW's 20-year infrastructure options study and has been incorporated into the draft Border Rivers Regional Water Strategy.

In previous investigations, WaterNSW had eliminated options to divert water from the Clarence and Macleay River catchments due to excessive costs and marginal benefits.

The investigations also highlighted potentially significant environmental implications, including impacts on threatened species and biosecurity in the Clarence Valley.

Work undertaken for the North Coast Regional Water Strategy, including the new climate datasets and modelling, will also inform the impact and risk analysis of draft options included in the draft Border Rivers and Namoi regional water strategies that have implications for towns, communities, industries and the environment in the North Coast region.

73. Average annual long term historical river flow over 130 years of instrumental record for Hastings River at Kindee Bridge (207004)

Table 2. Fast facts

Major river	River length (km)	Catchment area (km²)	National park, nature reserve and/or wilderness area	Extent of tidal influence[74]
Clarence	398	22,654	33%, including Bundjalung, Yuraygir and Yaegl National Parks	110 km from ocean (tide stopped by rocky rapids at Copmanhurst)
Bellinger	109	1,000	67%, including Dorrigo National Park	26 km from ocean (1.6 km upstream of Bellinger Bridge, Bellingen)
Nambucca	87	1,426	18%, including Gaagal Wanggan (South Beach), Dungirr and Gumbaynggirr National Parks	31 km from ocean (250 m upstream of Lanes Bridge at Bowraville)
Macleay	298	11,450	41%, including Hat Head, Oxley Wild Rivers and Cunnawarra National Parks	57 km from ocean (between the upstream side of Belgrave Falls, and 80 m downstream of Dungay Creek)
Hastings	165	4,500	47%, including Werrikimbe National Park and Limeburners Creek Nature Reserve	36 km from ocean (upstream of Cameron Falls at Wauchope)
Camden Haven	72	589	16%, including Crowdy Bay National Park	26 km from ocean (to Logans Crossing) near Kew

74. Manly Hydraulics Laboratory 2006, *Survey of Tidal Limits and Mangrove Limits in NSW estuaries 1996 to 2005*

Image courtesy of Clarance Valley Council.

Local town water storages

The North Coast region has no state-owned water storages. Major storages in the region are generally all off-river and are owned by local councils. The three most significant storages are Malpas Dam, Karangi Dam, and Shannon Creek Dam.

Shannon Creek Dam (18 km south of Grafton) and Karangi Dam (15 km west of Coffs Harbour) form part of the Clarence-Coffs Harbour *Regional Water Supply Scheme*. The Clarence-Coffs Harbour *Regional Water Supply Scheme*, completed in 2009, was designed to provide water security to the Clarence Valley and Coffs Harbour. It involved the construction of Shannon Creek Dam, as well as a bi-directional pipeline linking Shannon Creek and the existing Karangi Dam (built in 1980). Construction of the project was fast-tracked due to the impact of the Millennium Drought on water access for Clarence Valley Council.[75]

Shannon Creek Dam is owned and operated by Clarence Valley Council. Although technically an on-river storage, the dam is filled only from water extracted from the Nymboida River and by-passes all flows from the creek of the same name. The dam has been designed for future augmentation (to a capacity of 75 GL). Karangi Dam is owned by Coffs Harbour City Council and is an off-river storage that can be filled from water diverted from either the Orara River or the Nymboida River. The diversion weir and associated infrastructure used by both councils to extract from the Nymboida River is a legacy of previous hydro-electric operations in the area.

The bi-directional pipeline between the two storages enables both councils to draw from either reserve when flows in the Nymboida River (or Orara River, in the case of Coffs Harbour City Council) are too low for extraction.

Malpas Dam is a 13 GL storage used to supply water security to the Armidale region. In 2019, Armidale Regional Council built a pipeline connecting Malpas Dam to the Guyra Water Treatment Plant (which treats water stored in the significantly smaller Gara Dam). This project, envisaged after the 2014 drought, was completed to ensure water supply security to residents and businesses in Guyra, particularly during times of severe drought.[76] Construction of the pipeline, with the help of NSW Government funding, was fast-tracked given the severe shortages experienced by Guyra from June 2019. In response to those same dry conditions, Armidale Regional Council is now considering augmenting Malpas Dam from 13 GL to 26 GL as part of its integrated water cycle management planning.

Most of the remaining councils in the region also have off-river storages, constructed to provide an emergency supply in response to the impact of previous droughts on town water security. These storages—which include Cowarra Dam (Port Macquarie-Hastings Council), Steuart McIntyre Dam (Kempsey Shire Council) and Bowra Dam (Nambucca Valley Council)—are typically between 2,500 and 10,000 ML. A few councils have decommissioned some of their storages as alternative, typically larger storages have been constructed.

75. www.abc.net.au/news/2009-03-26/shannon-creek-dam-project-completed/1631580
76. Armidale Regional Council 2019, *Guyra Pipeline Fact Sheet*, www.armidaleregional.nsw.gov.au/environment/water-usage-and-supply/water-supply

Farm dams

Farm dams are constructed to provide storage for individual use, with water either pumped from a surface or groundwater source (licensed dam) or harvested from rainfall runoff (harvestable rights dam). Farm dams require licensing under the *Water Management Act 2000* unless they are defined as a basic right (harvestable right). Harvestable rights dams allow landholders to collect 10% of the average annual runoff from their properties and store it in one or more farm dams up to a certain size.

Farm dams are a common feature of the North Coast region. There are over 450 licensed dams, with the greatest number being in the Clarence catchment. The licensed storage capacity linked to these dams is around 30% of the total entitlement for each of the region's major catchments.[77] These dams provide an important source of water for local farmers during drier periods in the absence of any regional, large scale storage.

Increasingly, farm dams are being constructed to meet intensive horticulture water demands, particularly around Coffs Harbour, the Clarence Valley and the Nambucca area. Recent case studies have shown that the uptake of harvestable right dams is nearly 50% of the permissible volume for some catchments.[78] However, due to the nature of harvestable rights—which do not require metering or a licence for dam construction or water take—there is no data available on how much water is collected or used from harvestable rights sources across the entire North Coast.

A significant number of harvestable rights dams being constructed across the North Coast region are non-compliant. In 2020, the Natural Resources Access Regulator inspected 50 properties in the Coffs Harbour area, 34 of which had dams that were non-compliant. For those properties that didn't meet harvestable right rules, dams exceeded the legal volumetric limit by up to 20 times (or around 2.9 times on average).[79]

As part of the recent compliance campaign, the Natural Resources Access Regulator has engaged with industry groups and water users in the region to help users achieve compliance. The Natural Resources Access Regulator will continue targeted engagement and field inspections to encourage the industry to act in a way that sees a notable improvement in levels of compliance with water laws in the region.

77. Derived from internal Department of Planning, Industry and Environment—Water data
78. Derived from internal Department of Planning, Industry and Environment—Water data
79. www.industry.nsw.gov.au/water/news/nrar-finds-non-compliance-in-17-coffs-horticulture-operations

Image courtesy of Natural Resources Access Regulator.

Groundwater

The coastal sands groundwater sources within the region are Bellinger-Nambucca, Coffs Harbour, Macleay, Stuarts Point, Hastings, Clarence and, in part, Manning Camden Haven (Figure 12). These sources often have a high degree of connection with surface waters. In many areas, there is a direct relationship between increases in surface water levels, such as coastal lakes, and increases in water levels in associated monitoring bores, with surface water levels and groundwater levels showing a rapid increase with associated rainfall events.

There are four fractured rock groundwater sources[80] spanning the region—the Dorrigo Basalt and the Comboyne Basalt, as well as part of the New England Fold Belt Coast and the North Coast Volcanics. Groundwater from these sources is typically recharged by direct rainfall infiltration, typically resulting in good to excellent quality water. Within these hard rock groundwater sources, stream and spring flow is reliant on groundwater discharge during dry periods. As a result, groundwater dependent ecosystems associated with stream discharge and shallow aquifers can be common. Yields from these groundwater sources are generally moderate; however, within the basalts, yields can be high and within the New England Fold Belt Coast, yields are generally low.

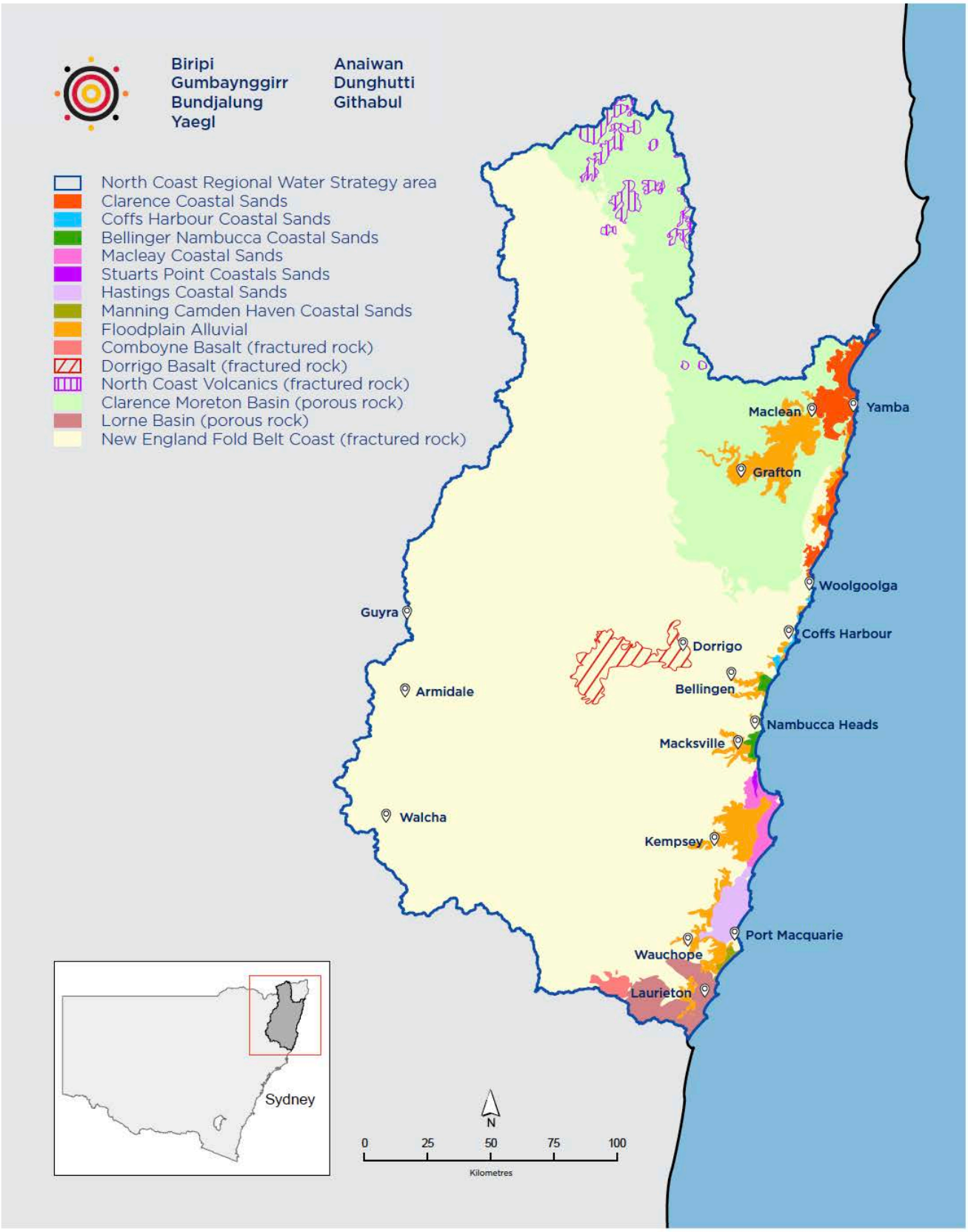
The porous rock groundwater sources[81] of the Clarence Moreton Basin and the Lorne Basin lie partially within the North Coast region's boundaries. Like the fractured rock groundwater sources, these systems are rainfall fed; however, water quality is typically poor or marginal, and can have a high salt content. Use of this water is largely limited to stock water use.

Extensive floodplain alluvial aquifers exist within the boundary of the region, the largest of which are in the Clarence and Macleay catchments. These aquifers consist of fluvial and tidal deposited sediments and are typically comprised of finer grained sands, silts and clays, allowing only for low potential yields. As well, due to their association with an estuarine environment deposition, they typically have low water quality due to acid sulfate soils and residual deposition salts. As such, these aquifers are generally limited for irrigation use and are usually only used for stock and domestic supplies.

The North Coast region contains a large number of groundwater dependent ecosystems (GDEs). These ecosystems have inherent environmental value, supporting a range of species by providing water for ecosystem services such as habitats. Limeburners Creek Nature Reserve is the most extensive GDE in the region. Other GDEs include the wetlands within Hat Head National Park and Fisherman's Bend in the Macleay sub-region, Camden Haven Wetlands and Lake Cathie in the Hastings sub-region, and the Nambucca River wetlands and Warrell Creek wetlands in the Nambucca sub-region.

80. Groundwater that is contained within, and moves through, fractures in the rock that are present due to the folding and faulting of the rock formations
81. Groundwater that is contained within, and moves through, pores in the rock (small holes in the rocks or the spaces between grains of soil)

Figure 12. Groundwater sources in the North Coast region



Recycled water

Recycled wastewater is already being used across a wide range of applications in the region. These include non-potable demands such as sportsground and golf course irrigation, toilet flushing and vehicle washdown, irrigation of fodder crops, and—for Coffs Harbour City Council—irrigation of horticultural crops. The volume used varies across the region from less than 10% to nearly 50% of the volume produced.

Planning for future use of treated wastewater is a prominent feature of integrated water cycle management. Drivers for the North Coast region include managing discharge conditions on wastewater treatment plants (when discharge is to an estuary), supporting local horticulture and improving town water supply security for future population growth. However, there are many challenges to any future implementation: the cost of treatment, community demand and acceptance, the type of demand (for example, ongoing versus seasonal as well as water quality requirements), regulatory and audit obligations, and storage considerations. Understanding these constraints will be important in identifying and scoping future opportunities.

Recycled water is currently not used for drinking water supply. The regional water strategies provide an opportunity to explore whether purified recycled water can be used more effectively to supplement drinking water supplies or to be made more accessible to water users.

Coffs Harbour City Council: recycling water to support the needs of local horticulture

Coffs Harbour City Council has invested heavily in upgrading its wastewater treatment facilities to provide an alternative water source for local horticulture businesses. The treatment facilities produce around 13 ML per day of treated wastewater. Currently, 70 agricultural properties use this treated wastewater, mainly for growing blueberries, tomatoes and cucumbers.

Image courtesy of Destination NSW.

2.2.2 Water and the regional environment

The natural environment of the North Coast is recognised for its high density of waterways, wide and fertile floodplains, and the rich aquatic and terrestrial biodiversity that the rivers, creeks and groundwater systems support. These features reflect the presence of both sub-tropical and temperate climates, as well as the remarkable complexity in the evolution of the region's landscape.

Nationally important wetlands are located within the estuaries and tidal areas of the North Coast region. These include the Limeburners Creek Nature Reserve in the Hastings, the Solitary Islands Marine Park in the Coffs Harbour waterways, and the Clarence River estuary in the Clarence.

The region also includes Little Llangothlin Nature Reserve Ramsar Site. Little Llangothlin Nature Reserve is a permanent lake, two metres deep and 105 ha in size, located on the New England Tablelands. The lake is a closed basin and generally contains water in all years, except periods of prolonged drought, and hence is an important refuge for water dependent fauna, including birds.[82] The reserve also includes part of the Billy Bung Lagoon.

The major rivers and creeks across the region are perennial, and many of the dependent ecosystems are highly sensitive to variations in the flow regime. Freshwater inflows also impact the characteristics and health of the region's estuaries, including salinity gradients, estuarine circulation patterns, water quality, flushing, productivity and the distribution and abundance of many species of fish and animals.

Extraction by industry, particularly during periods of low-flow, has put a number of these rivers and creeks under medium to high hydrologic stress. The most widespread impacts have been observed in the Coffs Harbour waterways.[83]

Many native fish and other aquatic species are found in the region, including freshwater bass, the short- and long-finned eel, multiple species of gudgeon and freshwater catfish, as well as frogs and turtles.[84] Some of these species have recreational fishing value and are important culturally to local Aboriginal communities. Some species, such as freshwater mullet, eels and freshwater herring, migrate downstream from freshwater to estuarine or oceanic waters to spawn.[85] The annual mullet run was an integral part of local Aboriginal culture and is now a much anticipated event by recreational fishing enthusiasts.

A number of species found in the region are also listed as threatened in NSW. Examples include a known population of the endangered *Oxleyan Pygmy Perch*, *Eastern Freshwater Cod*,[86] the *Green-thighed Frog* and the vulnerable *Bellinger River Snapping Turtle*. As part of the NSW Government's *Saving our Species* program, 16 healthy *Bellinger River Snapping Turtles* were retrieved from the Bellinger River in 2015, when the population was at risk of extinction from a novel virus that infiltrated the river. Since then, a breeding program at Taronga Zoo (Sydney) has produced nearly 100 turtles, of which 20 have successfully been released back into the Bellinger River.[87]

82. www.environment.gov.au/water/wetlands/publications/little-llangothlin-nature-reserve-ramsar-site-ecological-character-description
83. Derived from report cards and background documents of the North Coast water sharing plans
84. Butler et al 2012, *Relative condition of the freshwater fish community in the Hastings Basin: North Coast New South Wales EcoHealth Program*
85. Butler et al 2012, *Relative condition of the freshwater fish community in the Hastings Basin: North Coast New South Wales EcoHealth Program*
86. Department of Primary Industries—Water 2016, *Water Sharing Plan for the Clarence River Unregulated and Alluvial Water Sources: Background document*
87. www.taronga.org.au/media-release/2020-03-16/baby-boom-bellinger-river-snapping-turtle

Image courtesy of Taronga Zoo, Taronga Conservation Society Australia.

The North Coast has a number of threatened ecological communities—naturally occurring groups of native plants, animals and other organisms living in a unique habitat. Similar to the Far North Coast, these include freshwater wetlands in coastal floodplains, swamp oak and swamp sclerophyll forest.

The Clarence, Hastings and Macleay river catchments have large expanses of estuarine ecosystems. The Clarence River, being the largest estuary along the north coast, contains the largest proportion of mangroves of the northern NSW coast (including the Far North Coast region). The Hastings River and Camden Haven estuaries have by far the greatest extent of seagrass (1.4 km^2 in the Hastings and 10.2 km^2 in Camden Haven).[88] However, significant cover loss of seagrass has been observed in both estuaries.[89] Poor catchment practices, leading to elevated nutrient levels and high turbidity in the estuary, are key contributing factors.[90]

Between 40% and 60% of the region's coastal sands groundwater sources are in areas of high environmental value, with examples including Bundjalung and Yuraygir National Parks (Clarence), Bongil Bongil National Park (Coffs Harbour) and Hat Head National Park (Macleay).[91]

88. Department of Environment, Climate Change and Water NSW 2010, Northern Rivers Regional Biodiversity Plan
89. EcoHealth report for Hastings, www.pmhc.nsw.gov.au/files/assets/public/services/environment/environmental-reporting/ecohealth/2017-une-final-hastings-ecohealth-report.pdf. Note. The report states that caution should be taken in interpreting the results due to potential shortcomings in data collection.
90. Department of Primary Industries 2007, *Seagrasses: Primefact 629*
91. Bellingen-Nambucca Coastal Sands Groundwater Source is the one exception, with around 11% of the source classified as high environmental value. High environmental value areas include national parks, nature reserves, historic sites, Aboriginal sites, State conservation areas and karst conservation areas.

Water quality and health

Many of the region's rivers, creeks and estuaries are in fair to very poor health.[92] Water quality issues are largely a result of historic mining, logging and gravel extraction operations, poor agricultural land management practices, diffuse pollution from urban centres, water extraction during low flows and, in the tidal areas of the Clarence and Macleay rivers, drainage issues associated with shallow acid sulfate soils and tidal floodgate operation.

Poor water quality in the region mainly originates in the tablelands and upper to mid-river tributaries due to land clearing for agriculture and rural industries, stock access to waterways, poor land management, the removal of riparian vegetation and the subsequent erosion of streambanks.[93] There is a general trend towards increasing turbidity, nutrient concentration and bacterial contamination with distance down the catchment as cumulative inputs increase. In most river systems in the region, the greatest impacts (particularly in terms of sedimentation, turbidity and elevated nutrient loads) are felt in the lower reaches of the rivers and estuaries by aquatic ecosystems, aquaculture industries, recreation and tourism. The impacts of these land use practices on water quality have been observed in the waterways of the Coffs Harbour area, particularly Coffs Creek and Willis Creek,[94] some sections of the Hastings River,[95] tableland areas[96] and varying reaches on the Nymboida River in the Clarence.[97]

The impact of blueberry farming is of growing concern to the health of the region's waterways. Many new farms (particularly around Coffs Harbour and Woolgoolga) are replacing banana crops on lands with very steep slopes (between 10% and 20% gradient). The steeper lands are challenging for managing crop fertigation and watering, which has led to over-fertilisation.[98] This has been detrimental to water quality, but also to soil health and productivity. In response, the Department of Regional NSW - Department of Primary Industry has been working with local producers to support better practices through research, publications and workshops.

Bacterial contamination in the estuary and lower floodplains impacts the health of fish, shellfish and crustaceans and impacts oyster-growers in the Nambucca, Bellinger, Hastings and Macleay rivers. This issue, largely attributed to cattle accessing the rivers, also impacts other industries such as irrigated agriculture, aquaculture and tourism.

Riparian vegetation is important for maintaining good water quality, stabilising riverbanks and providing habitat for animals including macroinvertebrates and fish. Outside of protected or forested areas, riparian condition across the region is generally low. This is due to weeds and vegetation clearing, which has lead to large areas that are devoid of native vegetation or vegetation that has poor diversity, reduced structure or that occurs in small isolated patches that are poorly connected to other native vegetation patches.

92. North Coast Region State of the Environment Report Working Group 2016, *State of the Environment Report*
93. Ecohealth 2016, Macleay Catchment Report Card 2016; *NSW Water Quality and River Flow Objectives*, www.environment.nsw.gov.au/ieo/
94. Ecohealth 2012, Coffs Harbour Region Ecohealth Project, *Assessment of River and Estuarine Condition: Final Technical Report to the Coffs Harbour City Council*
95. Ecohealth 2017, *Hastings and Camden Haven Catchments Ecohealth Project: Final Technical Report*
96. Ecohealth Reports for the Macleay River 2016 and Clarence Catchment 2014
97. Ecohealth 2014, *Clarence Catchment Ecohealth Project: Assessment of River and Estuarine Condition: Final Technical Report*
98. www.dpi.nsw.gov.au/content/archive/agriculture-today-stories/ag-today-archives/april-2007/growing-better-blueberries

Estuarine reaches are generally dominated by riverbanks with little or no vegetation. Poor riverbank stability (geomorphic condition) is primarily linked to agricultural and urban land use practices across the region.[99]

The extreme rainfall and flooding that is typical of the region can impact the health of rivers and estuaries. Runoff generated during these events is typically high in nutrients and sediment, causing smothering of vegetation and elevated nutrient loading. Heavy rainfall following bushfires can exacerbate these impacts, leading to rivers turning toxic, leading to fish deaths. It can also impact town water supply, as many of the region's councils cannot treat water when turbidity is high, thus limiting extraction during these events.

The opposite is also true. Declining river flows reduce hydraulic flushing of freshwater and estuarine systems. If rivers and estuaries are inadequately flushed, the build-up of organic matter, sediment, nutrients, pollutants and salinity levels can have a negative impact on the ecology and native fauna of those systems. Inadequate hydrologic flushing may be a key contributing factor to the significant loss of sea grass beds observed in the Coffs Harbour estuaries.[100]

Many coastal floodplain alluvials in the region are underlain by acid sulfate soils. These soils release sulfuric acid on contact with air. This may be caused from localised groundwater drawdown or excavation of acid sulfate material due to the construction and maintenance of works for drainage and flood management purposes (for urban development and agriculture), as well as over-extraction of groundwater. These issues impact the water quality of estuarine and lower floodplain areas across the region.[101] Many of the region's coastal councils have already completed, or are in the process of commencing, remediation works for acid sulfate soils areas of high concern: examples include 230 drains (with a total length of 100 km) in the lower Clarence, Gumma Swamp in the Nambucca and Clybucca Swamp on the Macleay River.[102] In addition, the NSW Government is investigating options for managing these issues through a review of coastal drainage management in NSW. The review—undertaken through Initiative 1 of the *NSW Marine Estate Management Strategy*—will contribute to improvements in estuarine water quality over the long term.

As the climate changes, projected lower flows and higher temperatures may further increase risks to water quality. Higher temperatures and elevated nutrient concentrations create more favourable environments for potentially harmful algal blooms. Under the right conditions these algal blooms can spread significant distances downstream. Sea level rise may also reduce the effectiveness of floodgates and drains in estuarine areas.

99. North Coast Region State of the Environment Report Working Group 2016, *State of the Environment Report*
100. Ecohealth 2012, Coffs Harbour Region Ecohealth Project, *Assessment of River and Estuarine Condition: Final Technical Report to the Coffs Harbour City Council*
101. Particularly the Hastings and Camden Haven Rivers, Macleay River, Nambucca River, Bellinger River as well as including Pine, Bonville, Boambee, Newports, Coffs and Moonee Creeks
102. North Coast Region State of the Environment Report Working Group 2016, *State of the Environment Report*

Bushfires and water quality

The 2019/20 bushfire season that burnt over one million hectares of vegetation across the North Coast and Far North Coast raised awareness of bushfire impacts to water quality and coastal and marine environments. In small headwater systems or creeks, or on wetlands, bushfires can directly impact the mortality of native fauna and fish.

Bushfires can remove riparian vegetation cover and affect its structure, thereby reducing shade, nutrient input and a source of food for in-stream animals including fish. Removing shade can lead to higher water temperatures. In summer, without shade, water temperatures can reach lethal thresholds for many aquatic biota, including fish. The loss of litter fall and inputs of other nutrient sources (such as insects) undermines the riparian food web. Bushfires can also destroy riparian vegetation, which can then take generations to recover.

Bushfires result in the build-up of large amounts of ash in catchments. A lack of vegetation cover increases the erosive force of even moderate rainfall. Rainfall after bushfires can wash debris, ash and sediment into rivers and streams. This sludge can clog the gills of fish and smother other animals such as mussels. Bushfire ash is made of organic material that supports rapid bacterial growth that quickly uses up oxygen in the water. Increased nutrients can encourage the growth of bacteria and algae that consume oxygen and lead to 'blackwater' events, leading to fish deaths and loss of other aquatic invertebrates.

Ash and sediments also contain contaminants such as nutrients and metals that may work their way up the food chain, while turbid water reduces the ability of aquatic plants to photosynthesise. Bushfire debris can also change the shape of rivers through landslides, filling holes that are preferred fish habitats and clogging feeding and breeding areas.

These impacts will persist until sufficient regrowth of trees, shrubs and ground cover prevents ash and sediment from entering the water. The long-term impacts of a loss of habitat and food web to support native fish while bushfire impacted areas recover are significant.

After rain fell in January and February in bushfire-hit areas (such as within the Clarence and Macleay catchments), there were numerous reports of fish deaths after ash and charcoal washed into river systems and reduced oxygen levels. Fish deaths were reported in Sportsmans Creek on the Clarence River. Hundreds of thousands of fish, including Mullet, Bream, Estuary Perch and other small estuary fish and prawns, were reported dead along a 70 km stretch of the Macleay River upstream of Kempsey.

On 30 January 2020, the NSW Premier announced an inquiry into the 2019/20 bushfire season to make recommendations in relation to bushfire preparedness and response. The focus of the inquiry (and report) was to provide analysis and recommendations for change to ensure that, when bushfires like this happen again, there is less damage to property and our environment and, as much as possible, there are no lives lost.[103]

103. www.nsw.gov.au/nsw-government/projects-and-initiatives/nsw-bushfire-inquiry

Image courtesy of NSW Rural Fire Service.

As discussed in section 2.1.2, sea level rise, combined with reduction in freshwater flows, will cause tidal limits to move further upstream and saltwater to intrude into groundwater sources. The tidal limit extends far into many of the region's catchments, and hence impacts on surface water systems may be less severe than other parts of the coast. Saltwater intrusion will also impact water security for local water utilities and water users who currently access freshwater water sources located close to, or within, current tidal limits. Forming a clearer regional picture of this issue is critical to developing appropriate local responses.

Improving water quality in the marine estate

The NSW Marine Estate Threat and Risk Assessment Final Report identified water pollution as the number one threat to both the environmental assets and the social, cultural and economic benefits derived from the marine estate. Initiative 1 of the NSW Marine Estate Management Strategy targets improving water quality through 14 management actions aimed at improving habitat, addressing litter, and reducing land-based runoff:

- clean coastal catchments
- fish friendly workshops for local government
- oyster reef restoration
- riverbank vegetation rehabilitation
- coastal wetland rehabilitation
- reducing erosion from roads and tracks
- biodiversity offsets
- marine litter campaign
- risk-based framework for waterway health
- estuarine water quality monitoring
- coastal floodplain study
- coastal drainage management
- construction sediment management
- review of the NSW Water Quality Objectives.

Supporting local fish populations in the future

Existing studies indicate that the fish communities of the North Coast region's rivers are generally in good condition[104]—and for some catchments, there has been little change in the structure of native fish communities since European settlement. However, these studies represent a point in time and all pre-date the recent drought and bushfire season that would have likely affected fish communities in the region. For example, populations of threatened and endangered species such as the *Oxleyan Pygmy Perch* and the *Eastern Freshwater Cod* are expected to be in poor condition as a consequence of the recent bushfires.[105]

Recruitment (breeding) of native fish is impacted by the way we manage water and is reported to be poor to very poor in some river reaches across the region.[106] Factors affecting recruitment include freshwater flows, in-stream barriers to fish passage, cold water pollution, water pumping (of licensed entitlement) and loss of habitat, as well as the water quality impacts (such as 'blackwater' events) discussed above.

Australian native fish require unimpeded access along waterways to survive and reproduce. In-stream structures such as weirs, floodgates, causeways and bridges impact native fish in two ways: through the physical presence of the structure and by the manner in which the structure is operated. Barriers to fish passage prevent the migration of native fish populations and interfere with growth, development and reproduction of native fish. Barriers can limit the resilience of fish populations that rely on connectivity to respond to stressful events such as droughts. Operation of infrastructure alters the natural pattern, timing and volumes of flows that trigger key events and life stages for native fish. Impacts include a reduction in connectivity from tributaries to main channels and from the channel to the floodplain. The *NSW Fish Passage Strategy* aims to address the highest priority fish barriers remaining in NSW. Four sites have been identified for the North Coast Region: the Nymboida Weir, a bridge on Timbarra River off Upper Rocky Creek Road, a bridge/box culvert on Dowlings Falls Road and a bridge on Ewingar Road.

Cold water pollution is the term given to the lowering of river temperatures due to the release of cold water from in-channel storages such as dams and weirs. Cold water pollution affects the lifecycles of native fish in four ways: it reduces body growth and condition; changes the range and distribution of species; reduces the opportunity for effective reproduction; and reduces recruitment success. There has been very little monitoring of cold water pollution linked to council storages across the North Coast region. Malpas Dam was assessed in 2004 and was found to have negligible cold water impacts downstream.[107] Emergency supply systems, such as Puddledock Dam, are also likely to have minimal impact as releases from the storage are rare. However, further monitoring is required to clearly understand the potential impact of cold water pollution in the region.

Pumping water can have a large impact on native fish. Studies in Australia have shown that pumps can remove anywhere from one to over 800 native fish per megalitre of water extracted. With over 4,500 licensed pumps

104. Freshwater fish communities within the Bellingen Shire Council's portion of the Bellinger and Kalang rivers were found to be poor, while the number of native freshwater fish species were found to be less than pre-European settlement. See Ryder et al. 2011, *Bellinger-Kalang Rivers Ecohealth Project: Assessment of River and Estuarine Condition 2009-2010 Final Technical Report to the Bellingen Shire Council*
105. www.dpi.nsw.gov.au/fishing/threatened-species/current-threatened-species-projects
106. Butler et al. 2012, *Relative condition of the freshwater fish community in the Hastings Basin: North Coast New South Wales Ecohealth Program*
107. Preece, R. 2004, *Cold Water Pollution Below Dams in New South Wales: A Desktop Assessment*

in NSW alone, the cumulative impact of this ranges from hundreds of thousands of fish a day up to as much as hundreds of billions per day. Installing screens on pump intakes can prevent entrainment of adults, larvae and eggs—thereby reducing fish mortalities and supporting population growth. Research by then Department of Primary Industries—Fisheries in 2013 found that well designed and installed screens can reduce fish deaths by up to 90%, as well as mortalities for other aquatic species.[108]

Loss of habitat is also a major concern and can be caused by changes to flow regime and patterns, as well as impacts from land use practices (such as clearing of riparian vegetation and nutrient and sediment runoff).

For example, much of the Clarence River and its tributaries is reported to be highly disturbed and have poor bank condition, both of which directly affect habitat condition.[109] Tree clearing and stock access (due to lack of exclusion fencing) are two key contributing factors.

The North Coast Regional Water Strategy provides an opportunity to consider a number of options to improve the conditions for native, local fish populations in the region. For example, development of a long-term plan to guide the management of water resources, installation of screens on pumps, the construction of fish passages and the new *Bringing Back Threatened Species* program would all support the protection of native and threatened aquatic species in the North Coast.

108. Boys et al. 2013, *Influence of Approach Velocity and Mesh Size on the Entrainment and Contact of a Lowland River Fish Assemblage at a Screened Irrigation Pump*
109. Ryder et al. 2014, *Clarence Catchment Ecohealth Project: Assessment of River and Estuarine Condition. Final Technical Report to the Clarence Valley Council*

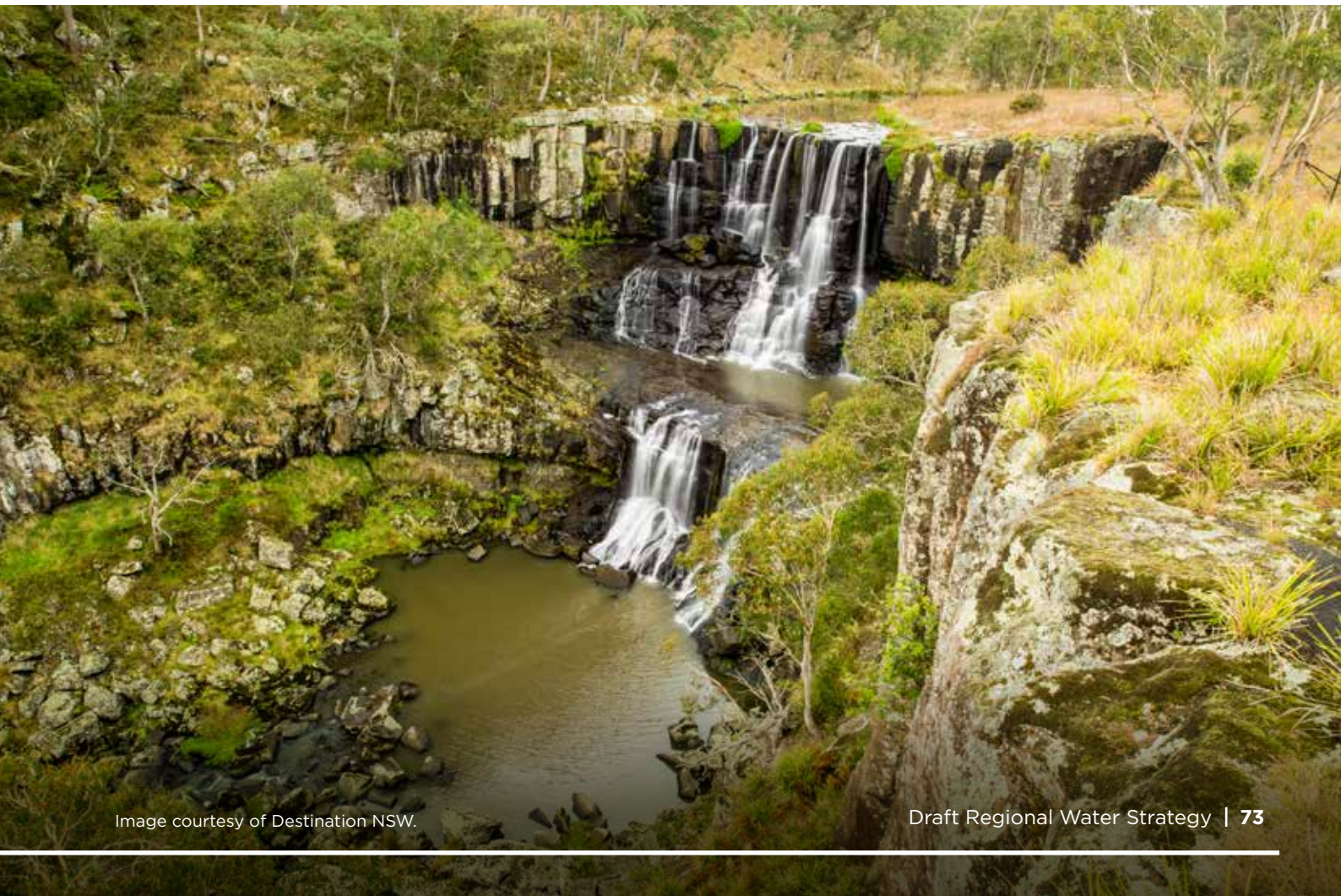


Image courtesy of Destination NSW.

Future impacts on water for the environment

Higher temperatures, increased evaporation, increased fire risk, changes to rainfall patterns and associated flows, sea level rise and potentially more intense dry and wet periods could all significantly impact water-dependent ecosystems that have evolved over millennia to thrive in natural cycles that are now changing.

Modelling the effects of long-term climate change on hydrology in the North Coast region indicates the potential for significant changes to river flows in the next 40 years, with associated impacts on riverine and estuarine ecosystems.

In general, our modelling shows the total annual volume of water flowing in the North Coast catchments may reduce by a median of 24% and may impact the full range of flows in these rivers. On a catchment average basis, the largest median reduction is predicted in the Macleay catchment (42%) and the smallest in the Hastings and Bellinger-Coffs catchments (19%) (Figure 13). The range of potential impacts to annual average flows is larger than the adjacent Far North Coast region,[110] but similar to that of the Border Rivers region. This is attributed to the variety of landscapes, river sizes and climatic variations across the North Coast region.

The magnitude of medium- to high-flow events[111] could decrease by 22% in the unregulated rivers across the region, with the most significant reductions most likely in the Macleay (47%). This may limit the number of events that trigger fish movement and spawning. It may also reduce the larger tributary flows that stimulate riverine productivity by transporting dissolved carbon and organic detritus, micro-organisms and small plankton animals into the system.

High-flow events in rivers and streams that flow directly into estuaries may also reduce in magnitude by about 22%. Reductions in the size of events flowing to estuaries will have similar impacts to freshwater systems in terms of the availability of organic carbon and other food for organisms low in the food web. These reductions may also impact salinity gradients and circulation patterns—detrimentally impacting the estuarine ecology, particularly in the tidal pools at the upper limits of the estuaries.

Low flows[112] are important as they prolong the availability of the high velocity flow areas within riffle habitats that many aquatic organisms rely upon to breathe, feed and reproduce. Low flows in unregulated systems may reduce in magnitude by 36% under the projected climate change scenario. A similar reduction could occur to low flows entering the region's estuaries.

When rivers and streams stop flowing, this results in the drying of flowing water habitats, increased sedimentation, water quality deterioration (elevated water temperatures and low dissolved oxygen levels) and the loss of connectivity throughout the river system. These are called 'cease-to-flow' events and they can have damaging effects on the region's aquatic ecosystems. There could be an increase in the number of years in which a cease-to-flow event occurs across all unregulated and estuary inflow systems. The most pronounced increase is likely to be at the inflow to the Macleay River estuary, where cease-to-flow events could increase from about 14% (14 out

110. The reduction in total annual flow for catchments of the Far North Coast ranges between 3% and 9% and the median for Border Rivers region is 45%.
111. Flows with an Average Recurrence Interval of 2.5 years. Average Recurrence Interval is the likelihood of occurrence, expressed in terms of the long-term average number of years, between flow events as large as or larger than the specified event. For example, flows with a discharge as large as or larger than the 2.5-year Average Recurrence Interval flood will occur on average once every 2.5 years.
112. Flows in the 95th percentile

of every 100 years) to about 24%. In other parts of the region, the occurrence of cease-to-flow events may increase by as low as 2% to as high as 8%. Although it is likely that cease-to-flow events will be more frequent under a changing climate, the average duration of these events is unlikely to change significantly.

During low-flow and cease-to-flow events, salinity gradients in tidal pools change as freshwater flows entering estuaries reduce or stop. This allows the salt wedge that usually sits below freshwater in tidal pools to move further upstream. The impacts of the changing salinity gradients will be amplified by salinity changes due to sea level rise.

Figure 13. Impacts of climate risks on the flow regime—unregulated flows

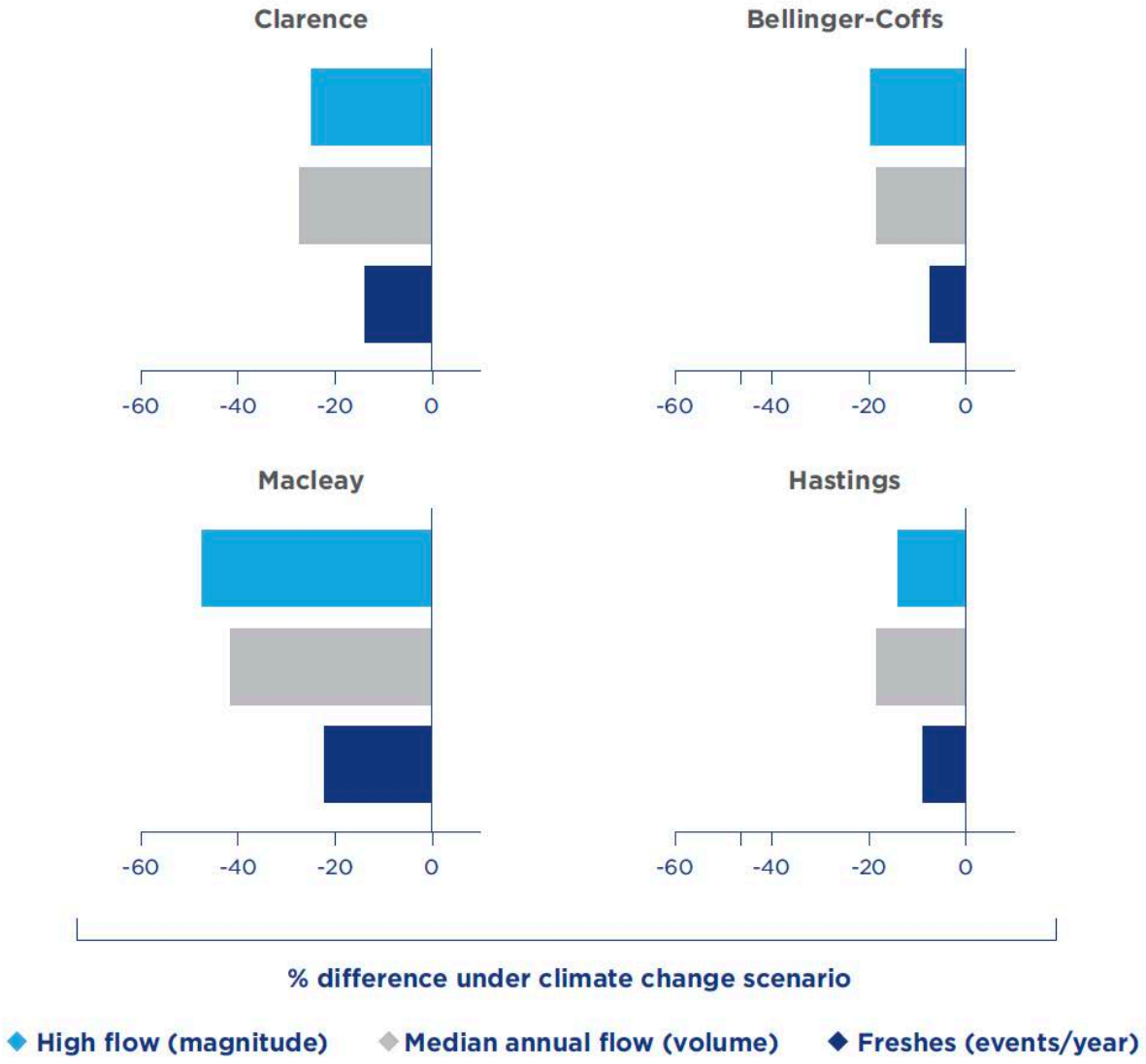


Figure 14. Impacts of climate risks on the flow regime—estuary inflows

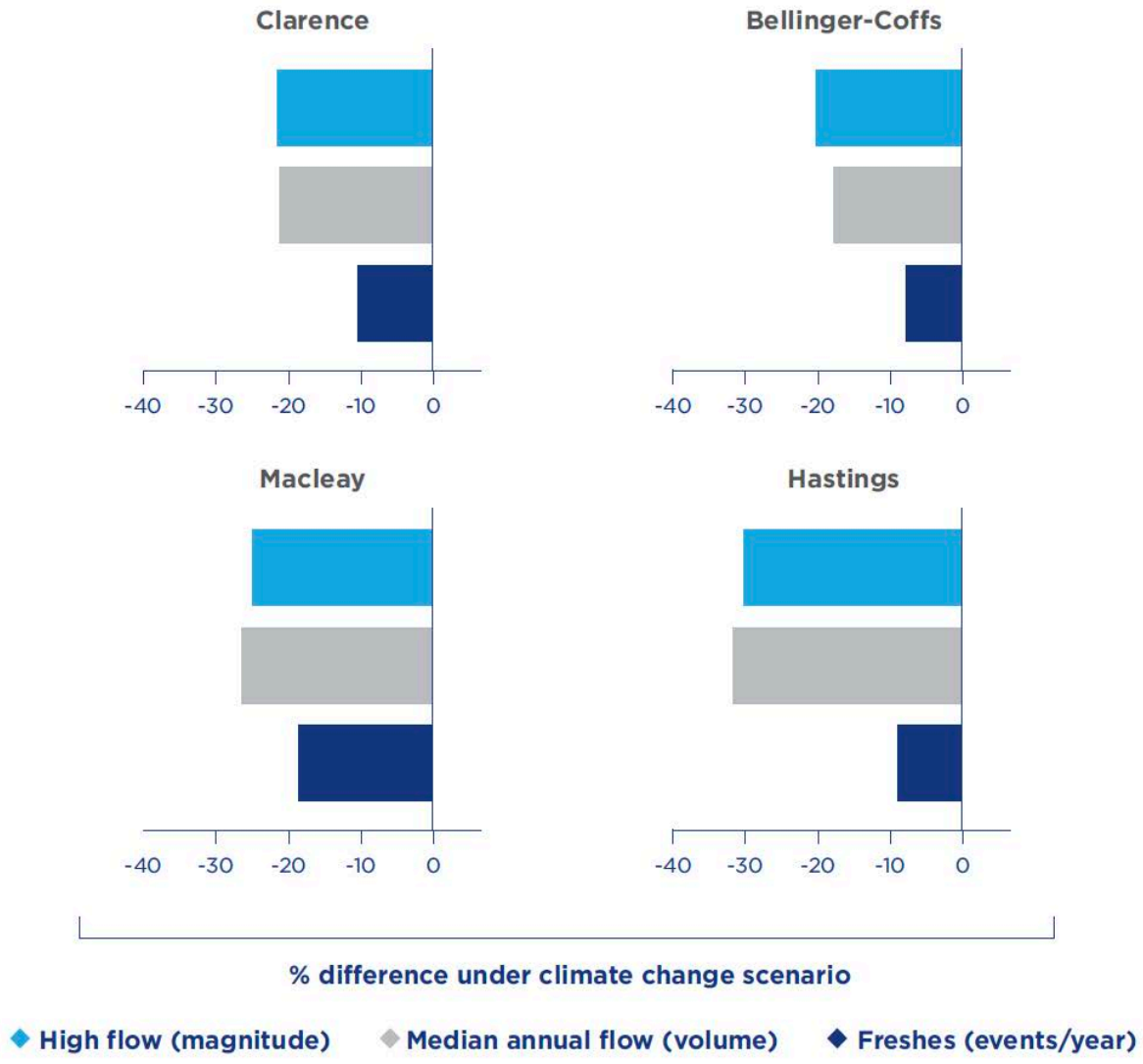
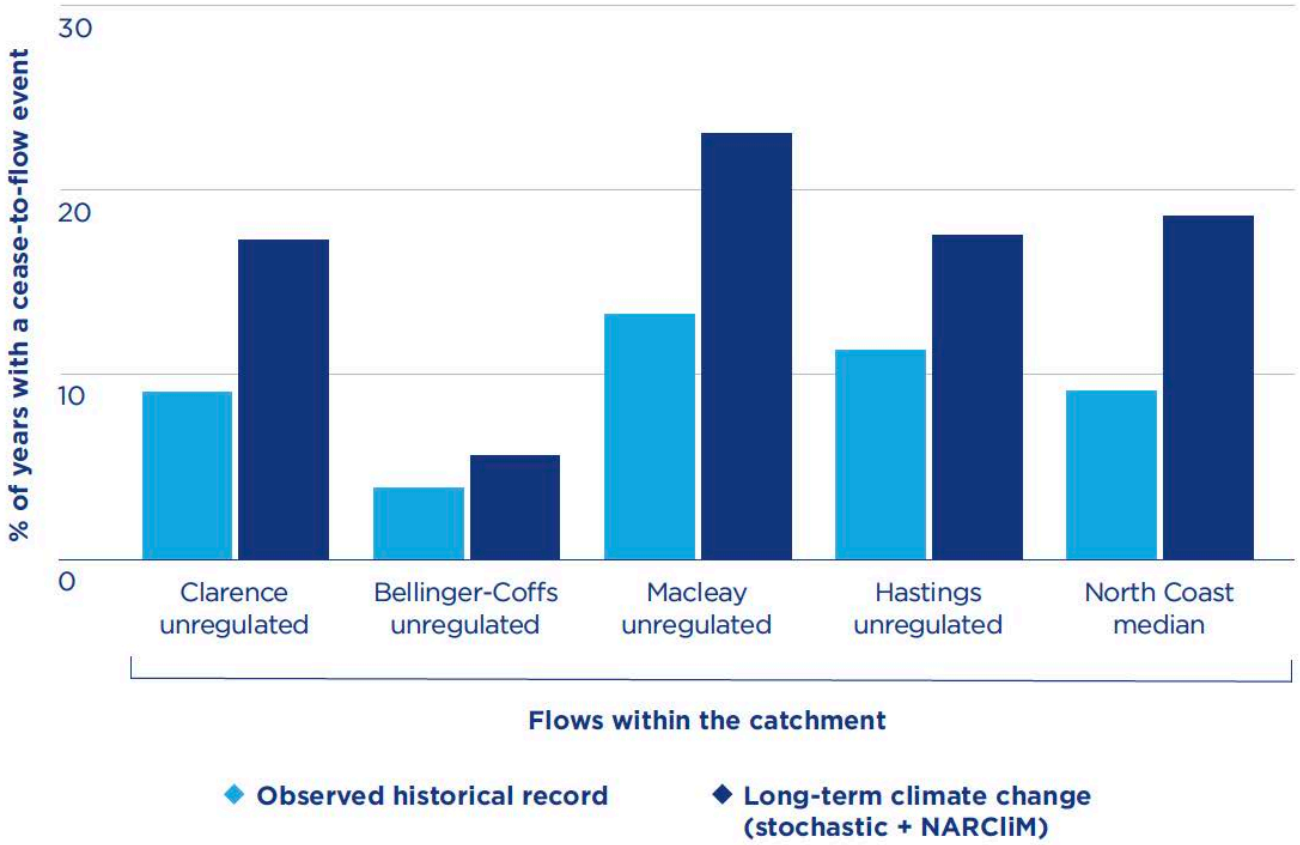


Figure 15. Impacts of climate risks on the flow regime—cease-to-flow events



These potential changes to river flows will not occur in isolation, but are likely to coincide with other changes such as irrigation demand increasing due to climate change, land use and agriculture changes and associated changes to water management, and may lead to further competition for water at low flows. This presents a long-term risk to river, wetland and floodplain health. It also makes it more difficult to manage our landscapes and ecosystems and the human activities that depend on and benefit from them.

Current environmental water arrangements (rules and triggers) may not be fit-for-purpose under hotter and drier climate scenarios with declining inflows and more frequent drought periods. The impact of a change in inflow timing and volumes on riparian ecology will be exacerbated by increased regulation, storage and extraction. The imminent review of the region's water sharing plans, as well as the options in this strategy aimed at setting sustainable long-term extraction limits and developing long-term water plans, provide an opportunity to assess the effectiveness of these rules in a drier climate.

A more variable climate means that concerted and coordinated efforts will be required to protect and enhance the region's vital environmental, economic, social and cultural assets into the future. To this end, opportunities exist to not only embed and build on water metering reforms, but to adopt innovative methods to better understand the impacts of water extraction on waterway and aquifer health and facilitate water user compliance with the rules. With access to better information, there is also an opportunity to consider the long-term sustainability of existing extraction limits and cease-to-take rules through upcoming water sharing plan reviews.

The other future impact on the region's water-dependent environment is sea level rise. As discussed in section 2.1.2, sea level rise—combined with reductions in freshwater flows—will cause tidal limits to move further upstream. An increase in surface water or groundwater salinity, combined with higher water levels, will potentially alter existing freshwater dependent habitats for numerous North Coast water sources and change the current day conditions and characteristics of many of the region's wetlands and estuaries. It is also broadly anticipated that marine conditions will move landwards as the sea level rises. The NSW Government is taking action to identify estuarine and marine environments and species at threat from climate change through Initiative 3 of the *Marine Estate Management Strategy* and the preparation of coastal management programs.

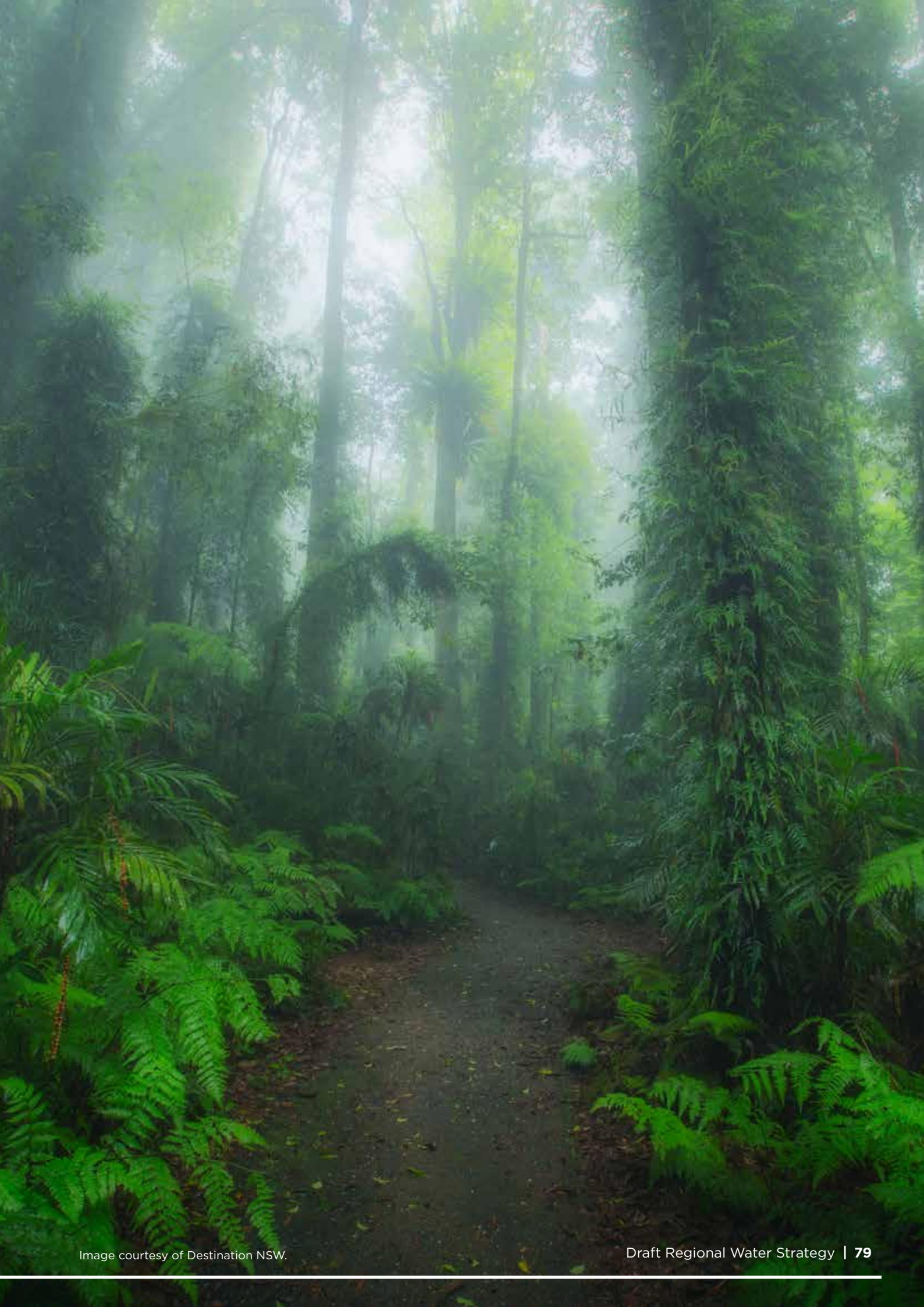


Image courtesy of Destination NSW.

2.2.3 Managing water in the North Coast region

Water in NSW is managed and shared under the *Water Management Act 2000*, with specific water sharing rules set out in water sharing plans.

Managing water extraction

Water sharing plans set the limits on the amount of water that can be extracted from surface water and groundwater sources in the North Coast region. The annual sharing of water is managed through long-term average annual extraction limits (LTAAELs), while daily sharing is managed through cease-to-take rules,[113] which can vary for different categories of licence. Extractions rules aim to balance reliable access to water with protecting the environment.

LTAEELs for North Coast water sources are implemented through the following water sharing plans:

- *Water Sharing Plan for the Bellinger River Area Unregulated and Alluvial Water Sources 2020*[114]
- *Water Sharing Plan for the Clarence River Unregulated and Alluvial Water Sources 2016*
- *Water Sharing Plan for the Coffs Harbour Area Unregulated and Alluvial Water Sources 2009*
- *Water Sharing Plan for the Hastings Unregulated and Alluvial Water Sources 2019*
- *Water Sharing Plan for the Macleay Unregulated and Alluvial Water Sources 2016*
- *Water Sharing Plan for the Nambucca Unregulated and Alluvial Water Sources 2016*
- *Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources 2016*
- *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016.*

Water sharing plans are valid for ten years from their commencement. Plans are amended throughout their life to ensure they comply with changing legislation and to facilitate their implementation. At the end of the ten-year terms, a formal review occurs to identify necessary amendments. Upon review, the plan is either extended or replaced.[115]

The *Water Sharing Plan for the Bellinger River Area Unregulated and Alluvial Water Sources* has recently been replaced, while the *Water Sharing Plan for the Coffs Harbour Area Unregulated and Alluvial Water Sources* is due for replacement this year. The review (extension or replacement) of all other water sharing plans for the North Coast region is not scheduled until 2026 at the earliest.[116]

113. Water sharing plans for unregulated rivers require licence holders to stop pumping when the river flow falls below a certain volume or salinity levels in tidal pool or estuary water sources increase above certain thresholds. These rules are referred to as cease-to-take rules. Cease-to-take rules apply to surface water licences in all unregulated water sources, excluding licences held by local water utilities, licensed stock and domestic users, and licences used for food safety and essential dairy care.
114. LTAAELs for floodplain alluvials are being incorporated into the remake of the coastal unregulated and alluvial water sources water sharing plans.
115. Amendments to water sharing plans can be made by the Minister for Regional Water, with the concurrence of the Minister for the Environment. More information on this process can be found at www.industry.nsw.gov.au/water/plans-programs/water-sharing-plans/review-process
116. Department of Planning, Industry and Environment 2020, *Water sharing plan status—North Coast region*, accessed 24 August 2020, www.industry.nsw.gov.au/water/plans-programs/water-sharing-plans/status/north-coast-region

Dealing with extraction limits

The region's surface water LTAAELs reflect the sum of licensed volumes and estimated basic landholder rights at the time the water sharing plan was made. While the LTAAELs in all six water sharing plan catchments are considerably less than their total annual flows (for example, about 2% of median annual flow in the Bellinger River, 4% in the Clarence River and 6% in the Hastings River), competition for water between consumptive users and the environment is high when streamflows are low. Cease-to-take[117] rules in water sharing plans are in place to manage competition for water during these periods.

Cease-to-take rules were developed based on risk assessments completed as part of the development of the original water sharing plans.[118] The rules consider the in-stream ecological values of a water source and the level of hydrologic stress (that is, the level of extractions). Cease-to-take rules based on tidal pool salinity levels were developed based on the risks posed by applying saline water on adjacent land.

Cease-to-take rules are sometimes based on the presence or absence of a 'visible flow' rather than an established flow rate. These conditions are in place for water sources that either do not have high extractive demands or where there is a physical constraint to monitoring flow. Consequently, at some locations, cease-to-take rules only come into effect once a water source has stopped flowing. The recent review of the *Water Sharing Plan for the Coffs Harbour Area Unregulated and Alluvial Water Sources* raised concerns that cease-to-flow conditions may not be effective in protecting the area's characteristic pool and riffle sequences. Riffles, which support macrophyte communities, re-oxygenate water and promote biogeochemical filtration and nutrient cycling, were noted as particularly prone to drying out during droughts.[119]

As discussed in section 2.1.2, our new modelling suggests that the frequency of low-flow periods is likely to increase in the future. The average number of days per year when cease-to-take conditions are reached may also increase in some parts of the region, particularly in the water sources of the Clarence and Macleay rivers. This means that competition between water users, and between water users and the environment, may increase if projected long-term decreases in rainfall and streamflow occur.

The regional water strategies provide an opportunity to review the LTAAELs and water access rules to ensure they reflect sustainable levels of extraction. Sustainable extraction limits would consider the ecological, economic, social and cultural water needs of the region. The review may result in higher or lower LTAAELs. Higher LTAAELS would support economic growth because more water access licences could be issued for productive use. Lower LTAAELs would identify where the NSW Government should prioritise reducing the impact of water extraction on the environment and between water access licence types. Irrespective of the outcome, the process should ensure greater confidence that extraction limits are sustainable and protect the key needs of the environment.

117. The terms 'cease-to-take' and 'cease-to-pump' are sometimes used interchangeably. The *Water Act 1912* has generally referred to 'cease-to-pump' conditions or rules. For the purpose of the draft North Coast Regional Water Strategy, the term 'cease-to-take' has been adopted throughout the document.
118. The first water sharing plan gazetted in the North Coast was the *Bellinger River Area Unregulated and Alluvial Water Sources in 2008*. This plan has been recently replaced.
119. Natural Resources Commission 2020, *Final Report Review of the Water Sharing Plan for the Coffs Harbour Area Unregulated and Alluvial Water Sources 2009*

Like surface water resources, LTAAELs have been determined for groundwater resources (Table 3).[120] These limits consider factors such as current and likely future demand, recharge rates and the sustainability of continued extraction. Estimated future demands are largest for residential and commercial dewatering and sand mining dewatering in the coastal sands groundwater sources, and agriculture in the fractured and porous rock groundwater sources.[121]

Monitoring take of groundwater is also difficult due to a lack of metering. Coastal sands aquifers are particularly vulnerable to excessive pumping due to the low amounts of groundwater storage relative to rainfall recharge. This makes them vulnerable to vertical or lateral seawater intrusion.[122] Without adequate metering, it can be difficult to gauge when these limits are reached.

The interconnectivity between surface water and some of the region's groundwater sources means that the depletion of surface water sources—from over-extraction or from changes to rainfall during periods of drought—can also impact groundwater recharge and groundwater levels. The urbanisation common in coastal areas has resulted in modified surface water drainage, runoff and changes to areas where aquifer recharge occurs. This can impact groundwater recharge patterns and increase pollution risks.

Unassigned water exists in all coastal sands, porous and fractured rock sources in the North Coast, except for Stuarts Point, because the LTAAEL far exceeds the current requirements for water. Acknowledging this, the NSW Government made 2,689 unit shares of controlled allocations from coastal sands groundwater sources in the North Coast available in 2018 under the 2017 controlled allocation order[123] and 1,094 unit shares in 2020.[124] Controlled allocations for porous and fractured rock groundwater sources were 500 unit shares and 265 unit shares in 2018 and 2020.[125]

Future controlled allocations will be made in accordance with the *Strategy for the controlled allocation of groundwater*.[126] Investment in better understanding groundwater processes would provide more information to consider ongoing sustainable access to these groundwater resources. This would help to identify opportunities to increase LTAAELs to support economic growth or prioritise locations where levels of water extraction are unsustainable over the long term.

Preparation of the regional water strategies offers an opportunity to consider whether the current rules for managing extraction from the region's surface and groundwater resources are sustainable, particularly in relation to new climate data, regional shifts in demand and other contemporary information.

120. Department of Primary Industries—Water 2016, *Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources: Background document* and Department of Primary Industries—Water 2016, *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources: Background Document*, www.water.nsw.gov.au/
121. According to feedback from stakeholders, future water dependence of sand mining is likely to be low despite information to the contrary in the background document for the *Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources.*
122. Many of these resources are beneath large areas of national parks and nature reserves, contain groundwater-dependent ecosystems or are affected by the presence of potential acid sulfate soils, which has limited the demand on these resources.
123. www.industry.nsw.gov.au/water/allocations-availability/controlled/table-one
124. NSW Government 2020, Controlled Allocation Order (Various Groundwater Sources) 2020
125. This only includes groundwater sources that fall entirely within the North Coast Regional Water Strategy boundary.
126. Department of Primary Industries—Water 2017, *Strategy for the controlled allocation of groundwater*, NSW Government, www.industry.nsw.gov.au/water/licensing-trade/licences/controlled

Table 3. Total current requirements and the corresponding long-term average annual extraction limits (LTAAEL) for coastal sands, porous and fractured rock groundwater sources across the North Coast region

Water source	Total current requirements (ML/yr)**	Long-term average annual extraction limits (ML/yr)
Clarence Coastal Sands	150	4,206
Coffs Harbour Coastal Sands	128	3,110
Bellinger–Nambucca Coastal Sands	105	1,175
Macleay Coastal Sands	3,361	11,300
Stuarts Point Coastal Sands	3,755	4,188
Hastings Coastal Sands	1,169	7,099
Manning–Camden Haven Coastal Sands*	236	3,280
Comboyne Basalt	809	2,600
Dorrigo Basalt Plateau	769	5,000
North Coast Volcanics*	5,907	13,000
Clarence Moreton Basin*	4,562	300,000
Lorne Basin*	357	9,500
New England Fold Belt Coastal*	35,468	60,000

* These groundwater sources span the North Coast into adjoining regions. The LTAAEL and total current requirement is for the entire water source.

** Total current requirements include licensed entitlements and an estimate of basic rights as documented in Department of Primary Industries—Water 2016, *Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources: Background document*

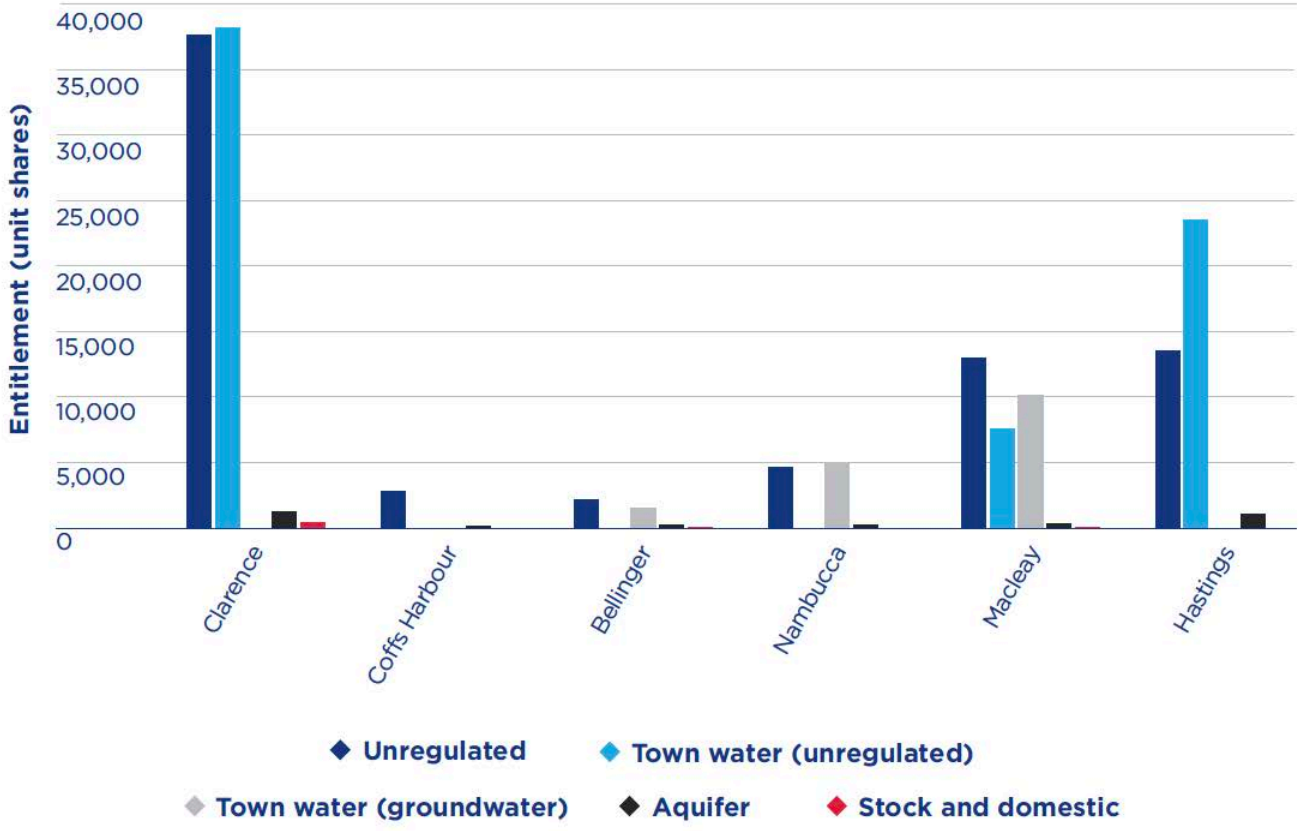
Water take in the North Coast

The rivers and creeks of the North Coast are not controlled by major dams or weirs and, as such, are considered unregulated. Licensed extraction from these sources is for stock and domestic use, unregulated access (primarily used for agriculture) and local town water. Water is also provided for basic rights, including Native Title rights, as defined under the *Water Management Act 2000*. More information on Native Title rights in relation to water is provided in section 2.3.1.

Current records show a total of 164,422 ML of water from surface water (rivers and creeks) and alluvial water sources is licensed for use across the region (Figure 16). Nearly 50% of this volume is licensed from the surface and alluvial water sources within the Clarence River catchment. The smallest volume of licensed entitlement is for the water sources of the Coffs Harbour and Bellinger River catchments.

There are no entitlements held by the NSW or Australian Governments to provide environmental water in the North Coast region. Currently, the environmental needs of these water sources can only be met from water that is not taken for other purposes, as protected under the rules set out in the water sharing plans.

Figure 16. Licensed entitlement from unregulated surface water and associated alluvial water sources by licence category and catchment



As discussed in section 2.2.1, harvestable rights allow landholders in coastal draining catchments to collect 10% of the average annual rainfall runoff from their properties and store it in one or more farm dams up to a certain size, without a water access licence, water supply work approval or water use approval. Harvestable rights dams can only be constructed on non-permanent mapped minor streams and gullies, or unmapped streams. 'Minor streams' are first and second order streams, as defined using the Strahler stream order.[127] The water captured in a harvestable rights dam can be used for any purpose, but it cannot be supplied to any other property or traded.

Review of harvestable rights

The Department of Planning, Industry and Environment has recently published a discussion paper and detailed supporting information on its review of harvestable rights in all coastal draining catchments.

The purpose of the review is to investigate whether harvestable rights in coastal NSW could be changed while protecting key environmental needs, as well as ensuring sufficient water is available for existing downstream water users.

The review explores the potential benefits and impacts of increasing the percentage of surface water runoff that a landholder can capture and store in farm dams, as well as allowing harvestable rights dams on third order streams and non-permanent first and second order streams and gullies.

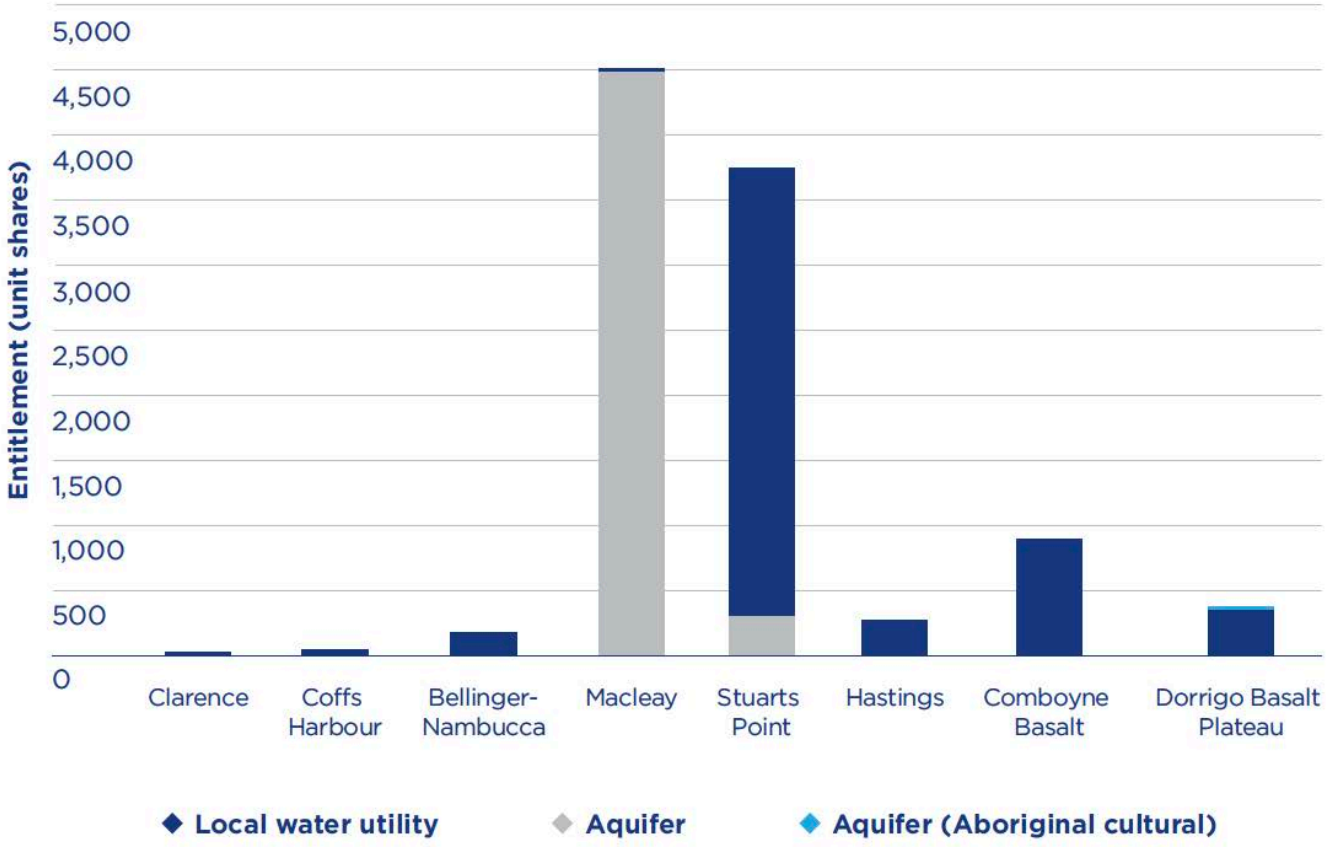
The review is part of an ongoing discussion with coastal water users on opportunities to improve access to water.

Entitlement for access from coastal sands, porous and fractured rock groundwater sources is significantly less than unregulated surface water and alluvial entitlements in the region. There is approximately 8,700 ML of licensed entitlement from coastal sands water sources (Figure 17). Individual entitlements from these sources are typically small and used primarily for stock and domestic purposes. Kempsey Shire Council holds the largest total entitlement of nearly 4,780 ML/yr[128] for town water supply, while licensed extraction from Stuarts Point mainly supports avocado farming. Future demand for groundwater is likely to increase. The largest increases have been estimated for town water (Macleay Coastal Sands) and agriculture, in particular tea tree plantations in the Hastings Coastal Sands. This estimate equates to around 20% of the current total entitlement for the region.[129]

Licensed extraction from porous and fractured rock groundwater sources across the region is also small. Some of these sources extend beyond the North Coast region. The largest entitlement is licensed from the Comboyne Basalt groundwater source to support local agricultural businesses, in particular avocados.

127. For further information on the Strahler system, see NSW Government 2018, *Determining stream order—Fact sheet*, www.industry.nsw.gov.au/
128. This does not include the local water utility (groundwater) licence from the Macleay River unregulated and alluvial water sources.
129. Department of Primary Industries—Water 2016, *Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources: Background document*

Figure 17. Licensed extraction from coastal sands and porous and fractured rock groundwater sources in the North Coast region



Note: Only licensed entitlement for groundwater water sources completely within the North Coast Regional Water Strategy boundary are included as we are awaiting information on the other sources.

Water sharing plans also allow the trade of water access licences, licence shares and water allocations to provide flexibility amongst users. Water markets are based on the concept of establishing the limit for extraction of water and then allowing trading within that limit. It allows water users, rather than the government, to make seasonal and longer-term decisions about how and where water is used. Water trading allows water to be used most productively by allowing users to redistribute their share of the resource from lower value to higher value uses. The water market in the North Coast has been almost completely inactive since the dealing rules were established in water sharing plans. Information about the water market is limited, and some water users have expressed frustration about administrative barriers to trade.

Since the preparation of the existing water sharing plans, we have developed a better understanding about the ecological value of specific reaches of streams. This knowledge provides an opportunity to review and introduce more sophisticated trade zones and rules and allow greater flexibility to water access across the region.

Drainage water

In the first half of the 20th century, the government played an active role in developing the country's natural resources and its economy. In the case of drainage (including drains and floodgates), this role extended to supporting groups of people who wanted to drain their lands including financing works under the *Drainage Act 1939*. This drainage has allowed agriculture to occur on the land and, in some cases, helps with flood management. There are currently 17 active Drainage Unions on the North Coast, with 13 of these in the Clarence River catchment and one in the Macleay River catchment.

While the use of fresh water in drainage channels held up by floodgates does not appear to be widespread, there is some use of this water. The Water Management (General) Regulation 2018 allows sugar cane growers in the Clarence valley to use water from drains for irrigation without a licence during crop establishment, provided certain conditions are met.

Setting priorities for water sharing

The *Water Management Act 2000* sets out how we prioritise water sharing, with the highest priority being for the environment, followed by basic landholder rights[130] (Table 4).

As part of meeting NSW's commitments to the Murray-Darling Basin Plan, the government has established a policy framework for managing water resources in NSW inland regions (only) during extreme events that supports a structured and proactive response. This includes changing the priorities for water sharing during extreme events. Critical human water needs and basic landholder rights (domestic) and essential town water services (authorised by an access licence) become the highest priority, followed by the environment and other water users. This change in priorities is triggered when a water sharing plan (or part of a plan) is suspended. The aim is to operate within the plan rules for as long as possible, as they provide clarity for all users of these water sources.

This policy currently only applies to inland regions, and there is no equivalent instrument that modifies the priorities for water sharing in coastal catchments to safeguard critical water needs during extreme events. Preparation of the North Coast Regional Water Strategy provides an opportunity to consider if a similar framework could also be applied to coastal catchments to ensure basic rights and town water are protected and there is a clear and transparent framework for making decisions during extreme events.

Table 4. Priorities for water sharing under normal circumstances and an example of extreme events rules applied elsewhere in the state[131]

Priority	Extreme events	Normal circumstances
Highest	• Critical human water needs	• Needs of the environment
High	• Needs of the environment	• Basic landholder rights
	• Stock • High security licences • Commercial and industrial activities authorised by local water utility • Water for electricity generation on a major utility licence • Conveyance in supplying water for any priority 3 take	• Local water utility access licences • Major utility access licences • Stock and domestic access licences
	• General security licences	• Regulated river (high security) access licences
Low	• Supplementary licences	• All other forms of access licences • Supplementary access licences

130. Landholders can take water under basic landholder rights without a water licence or approval in certain circumstances. There are three types of basic landholder rights in NSW under the *Water Management Act 2000*: domestic and stock rights, harvestable rights and Native Title rights. More information on basic landholder rights is provided at www.industry.nsw.gov.au/water/licensing-trade/landholder-rights

131. This table describes priorities for water sharing under normal circumstances across the state. It also describes extreme events rules applied elsewhere in the state. There are currently no extreme event rules in place in the North Coast.

Managing floods

The *NSW Flood Prone Land Policy*[132] outlines the government partnership for flood risk management in NSW. It identifies that local councils are primarily responsible for managing flood risk in their communities. The Floodplain Development Manual[133] outlines the roles and responsibilities of local councils, which include:

- developing and implementing floodplain risk management plans to better understand and manage flood risk to the community
- providing information to, and improving the awareness of flooding in, the community
- operating and maintaining their floodplain risk management assets (for example, drainage and levees)
- consider flooding in development and infrastructure decisions
- supporting NSW State Emergency Service (NSW SES) in emergency management and associated planning.

The NSW Government plays an important role in managing flood risk before, during and after floods. This is done primarily through the Department of Planning, Industry and Environment—Environment, Energy and Science who leads the implementation of the *NSW Flood Prone Land Policy* and provides support to councils through the Floodplain Development Manual and associated policies, guidelines and tools. The department is currently reviewing the manual and its associated guidance.

Councils also receive specialist technical support from the department's flood risk management experts and financial assistance through the NSW Floodplain Management Program. This program supports the development and implementation of floodplain risk management plans consistent with the manual. Funding provided through the program to local government authorities to manage flood risk is generally at a rate of $2 for every $1 provided by the council.[134]

The NSW State Emergency Service (SES) leads flood emergency management planning and response. The Floodplain Management Program supports the NSW SES to fulfil its role as the state's flood combat agency.

NSW Government flood risk management investment in the North Coast

The NSW Government, sometimes in partnership with the Australian Government, has been active in supporting flood risk management by local councils in NSW since the 1950s. This led to the establishment of the NSW Floodplain Management Program, which—along with the Floodplain Development Manual—supports the implementation of the *NSW Flood Prone Land Policy* (first issued in 1984).

The NSW Government has provided substantial ongoing investment to North Coast regional councils to manage flooding risk. This has included financial support for the construction of a range of flood detention basins in Coffs Harbour and the upgrading of the levee system that reduces the frequency of flooding in towns, including Grafton. From 2012/13 to 2019/20, the NSW Government awarded more than $12 million of grants under the Floodplain Management Program to local councils in the region to help them better understand and manage the flood risk in their communities.

132. The *NSW Flood Prone Land Policy* is published in the *Floodplain Development Manual.*
133. Department of Infrastructure, Planning and Natural Resources 2005, *Floodplain Development Manual: the management of flood liable land*, NSW Government
134. Department of Planning, Industry and Environment 2018, *Floodplain Management Program*, accessed 26 August 2020, www.environment.nsw.gov.au/topics/water/floodplains/floodplain-management-program

Managing the coast and estuaries

The NSW coastal management framework aims to promote thriving and resilient coastal communities living and working on a healthy coast. The framework provides technical, statutory and financial support to councils to prepare, review and implement coastal management plans to manage coastal hazards, water quality and estuary health including the impacts of climate change.
The framework includes:

- *Coastal Management Act 2016*
- *State Environmental Planning Policy (Coastal Management) 2018*
- NSW Coastal Management Manual
- NSW Coastal Council
- Coastal and estuary grant program
- *Marine Estate Management Strategy*.

The framework provides the means by which councils can manage coastal hazards including coastal erosion and shoreline recession, coastal watercourse entrance instability, coastal inundation, coastal cliff stability, tidal inundation and erosion caused by tidal waters. It also supports catchment management actions that impact water quality and ultimately the health of the region's coastal environment (such as those discussed earlier in the section *Water quality and health*).

Councils in the North Coast region have been working for many years in close consultation with local communities and relevant agencies on coastal planning and are at varying stages of completing their coastal management plans for the open coast and key estuaries. Information such as tidal inundation maps developed by councils through coastal and floodplain risk management planning processes can also be used to support decisions about the management of coastal waterways.

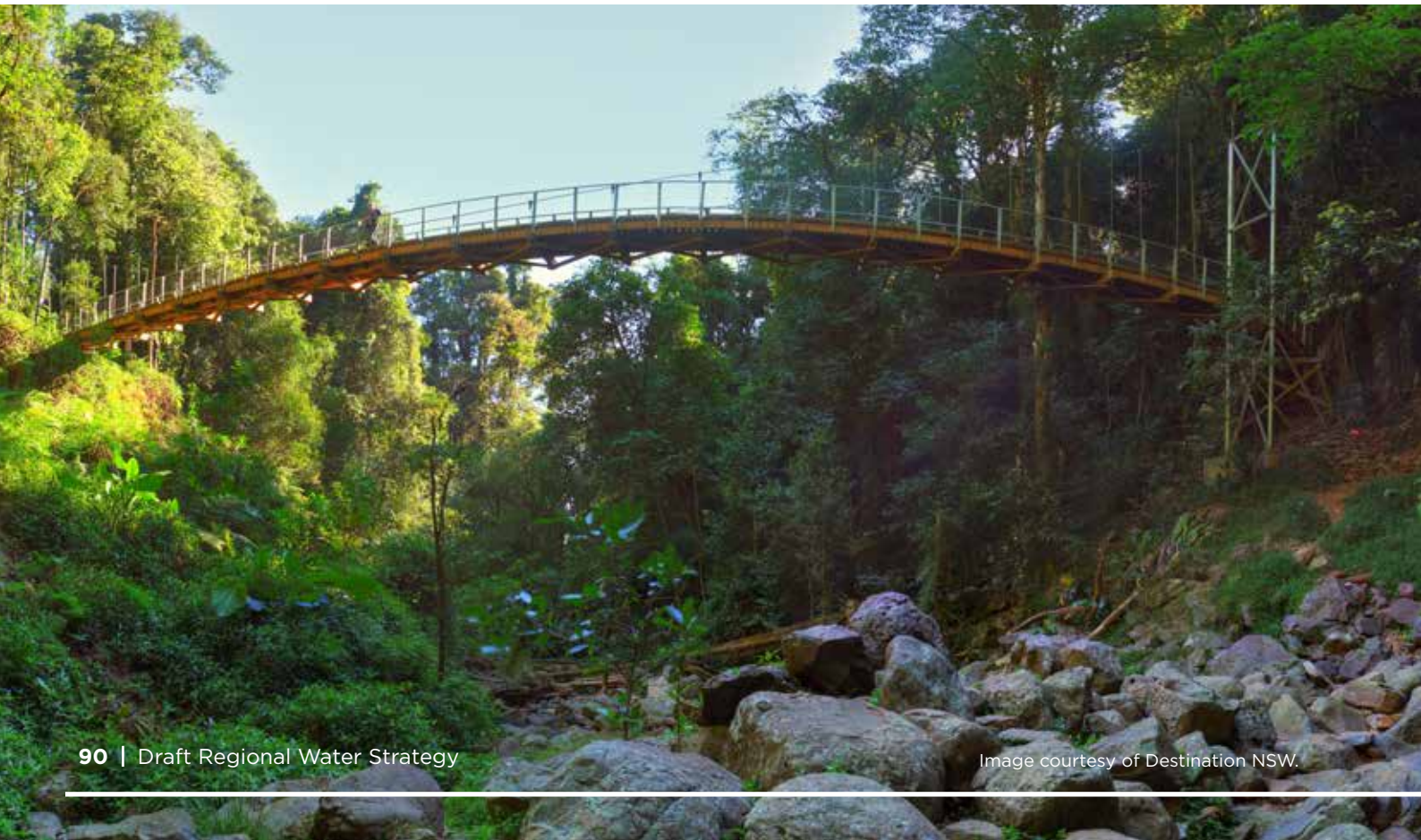


Image courtesy of Destination NSW.

Managing water quality

Water quality is managed through several legislative and regulatory instruments and agencies.

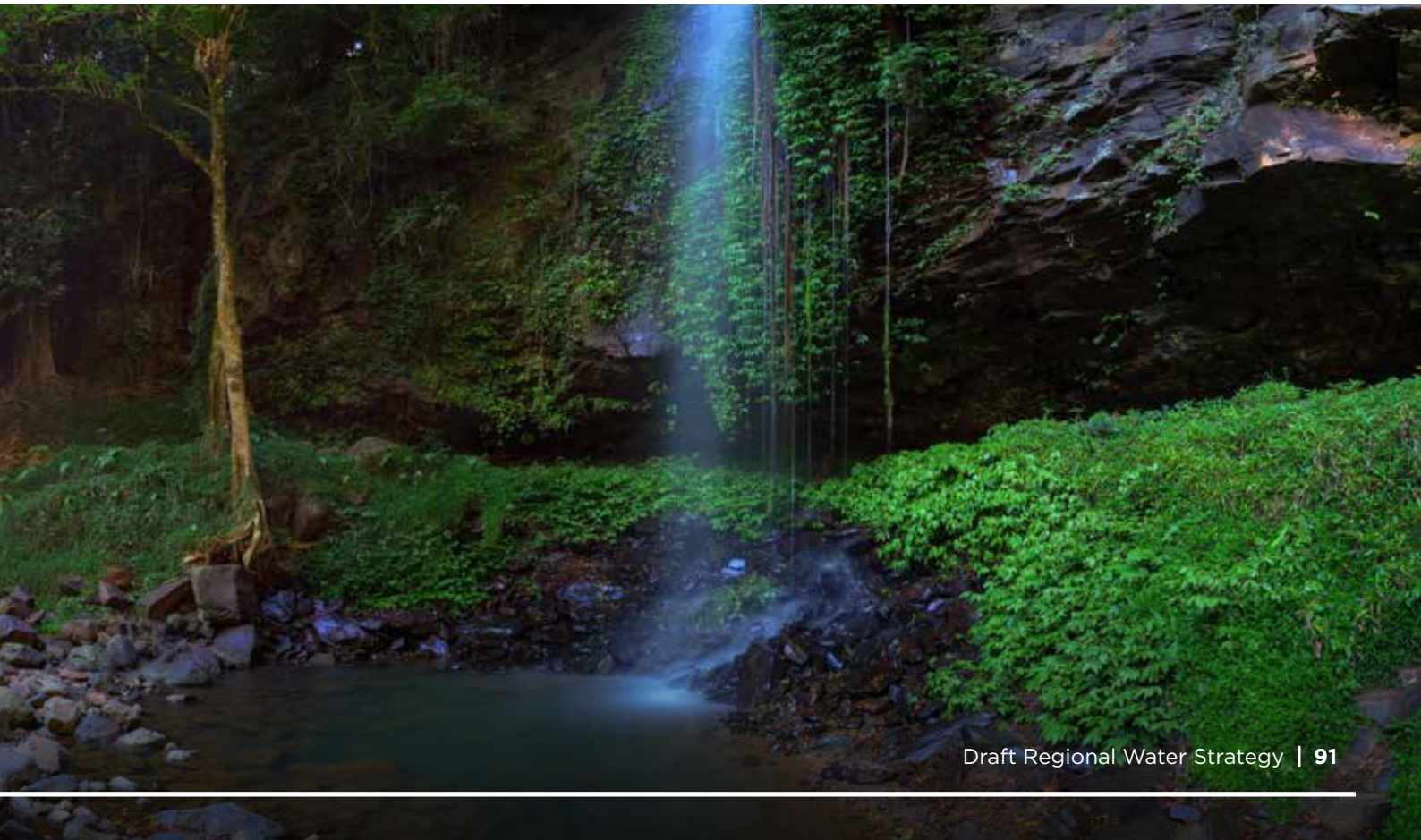
The NSW Government has adopted the *National Water Quality Management Strategy*[135] as its policy to manage the quality of waterways in NSW and protect water resources. The strategy provides guidance for maintaining and improving water quality according to local community environmental values and uses.

In NSW, goals for meeting these values and uses are captured in the NSW Water Quality and River Flow Objectives.[136] Objectives have been developed for all major fresh and estuarine surface water catchments across the state, including the North Coast.

Water sharing plans are a key mechanism to meeting water quality goals. The plans use flow management measures (including extraction limits and cease-to-take rules) to help ensure enough flow is available to meet water quality objectives and targets. Additional mechanisms are available through the approvals and licensing framework. This includes ensuring setback distances and construction standards for new water supply works are enforced to limit groundwater drawdown and minimise the likelihood of increased salinity.

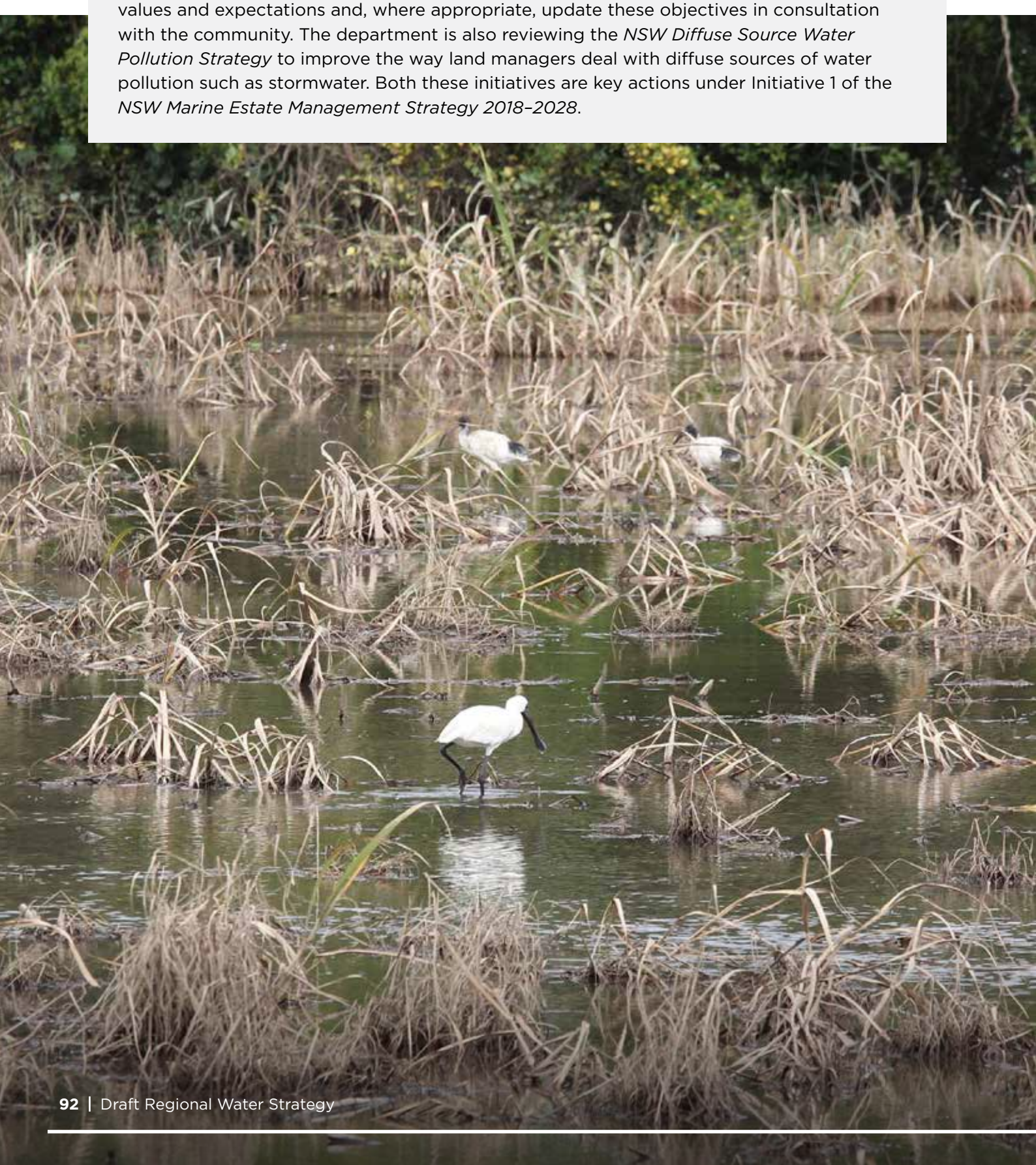
Our new climate data and modelling will help inform our understanding of local water quality risks arising from changed flow regimes and water extraction patterns. Risk assessments, which have already commenced in some parts of the region, are used to inform reviews of water sharing plans.

135. Australian Government 2018, *Charter: National Water Quality Management Strategy*, Department of Agriculture and Water Resources, www.waterquality.gov.au/
136. Department of Environment, Climate Change and Water 2006, *NSW Water Quality and River Flow Objectives*, accessed 24 August 2020, www.environment.nsw.gov.au/ieo/



Water quality objectives review

The Department of Planning, Industry and Environment is reviewing the NSW Water Quality and River Flow Objectives for each catchment in coastal NSW to reflect contemporary values and expectations and, where appropriate, update these objectives in consultation with the community. The department is also reviewing the *NSW Diffuse Source Water Pollution Strategy* to improve the way land managers deal with diffuse sources of water pollution such as stormwater. Both these initiatives are key actions under Initiative 1 of the *NSW Marine Estate Management Strategy 2018–2028*.



As discussed in section 2.2.2, the quality of North Coast water sources is also affected by land use activities, many of which are outside the influence of flow management and therefore cannot be addressed through water planning alone. The process used to assess and manage the impacts of land use activities and water extraction on water quality is outlined in the *Risk-based framework for considering waterway health outcomes in strategic land-use planning decisions*.[137]

This framework helps local councils provide for healthy waterways through regional and local planning instruments, environmental regulation, integrated water cycle management plans, coastal management programs or other catchment management plans for restoring and protecting the health of waterways.

The EcoHealth Report Cards and Monitoring Program provides a substantial database for understanding the current water quality of the region's waterways. This work has previously fed into estuary management plans (the predecessors of the coastal management plans discussed above) and local council *State of the Environment* reporting. Estuary management plans provide a guide for making decisions regarding the long-term management of coastal assets, including impacts borne from upstream catchments. Coastal management plans have the same remit and—along with continued water quality monitoring through programs such as EcoHealth—will be important in guiding actions on or further investigations into catchment-based diffuse runoff that impacts waterways and, ultimately, coastal and marine environments.[138]

Managing catchment water quality also helps local councils meet drinking water quality standards set out in the *Australian Drinking Water Guidelines* (ADWG).[139] The ADWG details a preventative management approach that manages and monitors water quality from the catchment to the consumer. The ADWG is used by NSW Health, the Department of Planning, Industry and Environment and local water utilities (and local councils) to assure safe, good quality drinking water for NSW communities.

Water supplies in regional NSW are monitored for microbiological and chemical quality through the NSW Health Drinking Water Monitoring Program. NSW Health also publicly reports water quality incidents. The Department of Planning, Industry and Environment's Water division monitors the performance of local water utilities in providing drinking water.

The risk of human exposure to potentially toxic blue-green algal blooms is managed through a coordinated regional approach with the Regional Algal Coordination Committees. State-wide and regional contingency plans and guidelines have been developed to manage algal blooms. The guidelines aim to minimise the impact of algal blooms by providing adequate warning to the public, reducing the risk of harm to human and animal health.

The North Coast Regional Water Strategy is an opportunity to consider additional actions to manage water quality in the region.

137. Dela-Cruz et al. 2017, *Risk-based framework for considering waterway health outcomes in strategic land-use planning decisions*, Office of Environment and Heritage and Environment Protection Authority, www.environment.nsw.gov.au/research-and-publications/publications-search/risk-based-framework-for-considering-waterway-health-outcomes-in-strategic-land-use-planning
138. The Ecohealth Report Cards and Monitoring Program were funded as part of delivering estuary management plans. Under the new coastal management framework, councils need to prepare Coastal Management Plans. The plans must be certified by the Minister before any funding for actions in the plan can be sought.
139. NRMMC 2011, *Australian Drinking Water Guidelines*, www.nhmrc.gov.au

Gathering more and better information

Improving the information and range of data we have about water use, water needs and ecological responses will help us to manage the North Coast region's water resources more effectively. It will also ensure we plan to have enough water available at the right time for water users and the environment. Improving the collection of data will give us a better understanding of the water risks in the region for the environment and all water users. More data and knowledge will support future decisions about water sharing, investments in secure water supplies and water quality management, and help to ensure compliance with water access and sharing rules.

Improved information can also help water users, future investors and regions make more informed decisions about the industries that are most suited to each region.

The North Coast region's waterways are not regulated. There are no state-operated dams and catchments are vast, with many small users. With the exception of town water, very few extractions are measured. Sharing arrangements have largely relied on local water users abiding by cease-to-take rules. These arrangements are placed under considerable pressure during dry periods when competition for low flows can be high. Without the ability to measure extractions, it is difficult to ensure water is extracted legally and shared equitably during such periods.

The lack of water extraction data has been a state-wide issue that is being addressed through the implementation of the new non-urban metering framework announced by the NSW Government as part of its 2017 Water Reform Action Plan. Under the framework, all surface and groundwater works covered by the rules will need to be fitted with compliant metering equipment by 1 December 2023.[140] Under the current rules, an estimated 587 water supply works (about 31%) in the North Coast region will be subject to the metering rules: 337 in the unregulated river systems, 39 in the alluvial aquifers, 201 in the North Coast fractured and porous rock groundwater sources and 15 in the North Coast coastal sands groundwater sources.[141] Approximately 2,280 licensed extraction works across these catchments will not be required to install a meter under the new framework.[142]

The Government is committed to continuing to improve the collection and storage of water data for the North Coast region. The Government intends to collaborate at a state and regional level with research and industry partners to harness new technologies to measure, monitor and report water data to drive sector-wide improvements in data collection and sharing. This includes increased capability in satellite imagery observations, comprehensive and reviewed (or enhanced) hydrometric networks, and universal metering and telemetry for non-urban water take. The Natural Resources Access Regulator will also continue to monitor, audit and work with landholders to encourage actions that lead to a notable improvement in levels of compliance with water laws in the region.

140. More information on the non-urban water metering framework is available at www.industry.nsw.gov.au/water/metering/overview-of-the-non-urban-water-metering-framework
141. This information was compiled by the Department of Planning, Industry and Environment based on data collected for the Water Reform Metering Program. It is noted that 53 bores are in the North Coast Volcanics groundwater source and may not be within the boundaries of the North Coast region.
142. Number of groundwater bores 200 mm and above and the number of surface water pumps 100 mm and above across the North Coast region based on the analysis of data collected for the development of the *Non-Urban Water Metering Framework*.

These measures would be supported by other initiatives being taken across government. For example, the Department of Regional NSW - Department of Primary Industry is undertaking a three-year program to identify and map important agricultural lands.[143] Knowing where this land is situated and understanding its location, value and contribution will assist in making decisions to align current and future agricultural land uses and their water needs. The options identified in this draft strategy that support a comprehensive and consistent approach to collecting water statistics and information will greatly help this process.

Technology can help

The NSW Government and WaterNSW are developing a new data platform to increase the availability and accessibility of critical non-urban water information.[144] The platform will provide information on:

- water sharing plan rules
- entitlements and works approvals
- transactions (such as water trades)
- water take from water sources
- flows in rivers and streams.

The initiative is being developed progressively and will be fully operational by 2025.

In addition, under the new metering laws, large surface water users will need to install telemetry and remotely transmit water information to government. This will enable better decisions on the active management of water in-stream and for townships and will give the Natural Resources Access Regulator a reliable source of data about water take to inform its compliance and enforcement functions. It will also support WaterNSW and the Department of Planning, Industry and Environment in their billing activities.

Water users will also be able to access their information via a private online dashboard.

143. Department of Primary Industries 2020, *Important Agricultural Land Mapping in NSW*, accessed June 2020, www.dpi.nsw.gov.au/agriculture/lup/agriculture-industry-mapping/important
144. WaterNSW 2020, *WaterInsights portal*, accessed 10 September 2020, www.waternsw.com.au/waterinsights/water-insights

The availability of groundwater monitoring data is also a state-wide issue. NSW has a strong groundwater management framework that has undergone significant reform. However, opportunities still exist to continue to improve our knowledge and management of groundwater resources. For example, current gaps in our understanding of groundwater resources include information about the resources themselves and how they are being accessed and used by water users. A more comprehensive groundwater monitoring network in the region—one that includes both level and water quality information—is needed to improve our understanding of existing groundwater processes and to make projections of longer-term effects linked to climate change. It will also help us to understand the spatial variability of saltwater intrusion in coastal aquifers.

Continuing to improve our understanding of groundwater will enable better informed decisions to be made about its importance as a local water source, its management and use. Improving our understanding of aquifer recharge zone locations is important to plan for different land uses while protecting our groundwater resources. There are also opportunities to improve our groundwater modelling in areas of high groundwater use on the coast. For example, new numerical models in areas of high use or risk are needed to address town water supply needs and to assess the impacts of sea level rise and saltwater intrusion, new bore licence submissions and groundwater dealings. There are also opportunities to incorporate climate change projections into our long-term planning and development of groundwater resources.

Our most recent drought has highlighted the important role groundwater sources can play in providing supplementary and backup supplies for towns, domestic and stock and other rural uses. Given the expected continuing demands on groundwater, we need to improve our understanding of the interaction between surface water and groundwater resources in the North Coast so we can make decisions that will improve the resilience of our water sources. We need to understand where a change in groundwater use can influence flows to rivers and vice versa. We also need to understand how a changing climate is impacting the replenishment of groundwater resources. More broadly, we need to ensure ongoing investment in groundwater monitoring, metering and modelling so we have the full range of information we need to manage this vital resource into the future.

Good ecological science is based on high quality, long-term data collection programs. Long-term programs can be cost-effective as they are more likely to capture trends that short-term studies will miss. These programs can then inform and supplement short-term reporting, evaluation and assessment initiatives. Improvements to data management, assessment tools and data products will advance our understanding of the region's risk profile.

Collecting better data

Across the North Coast region, there are important opportunities to gather more information about:

- the water requirements (when and how much) of communities, the environment, urban-based commercial businesses and industries
- what the water is being used for, including crop types and yield values
- the interaction between groundwater and surface water in the region
- quantity of water use and patterns of water use in the unregulated system and some groundwater systems
- water quality.

Gathering and analysing this data will improve our understanding of the water risks in the region for the environment and all water users, and support future decisions about water sharing.

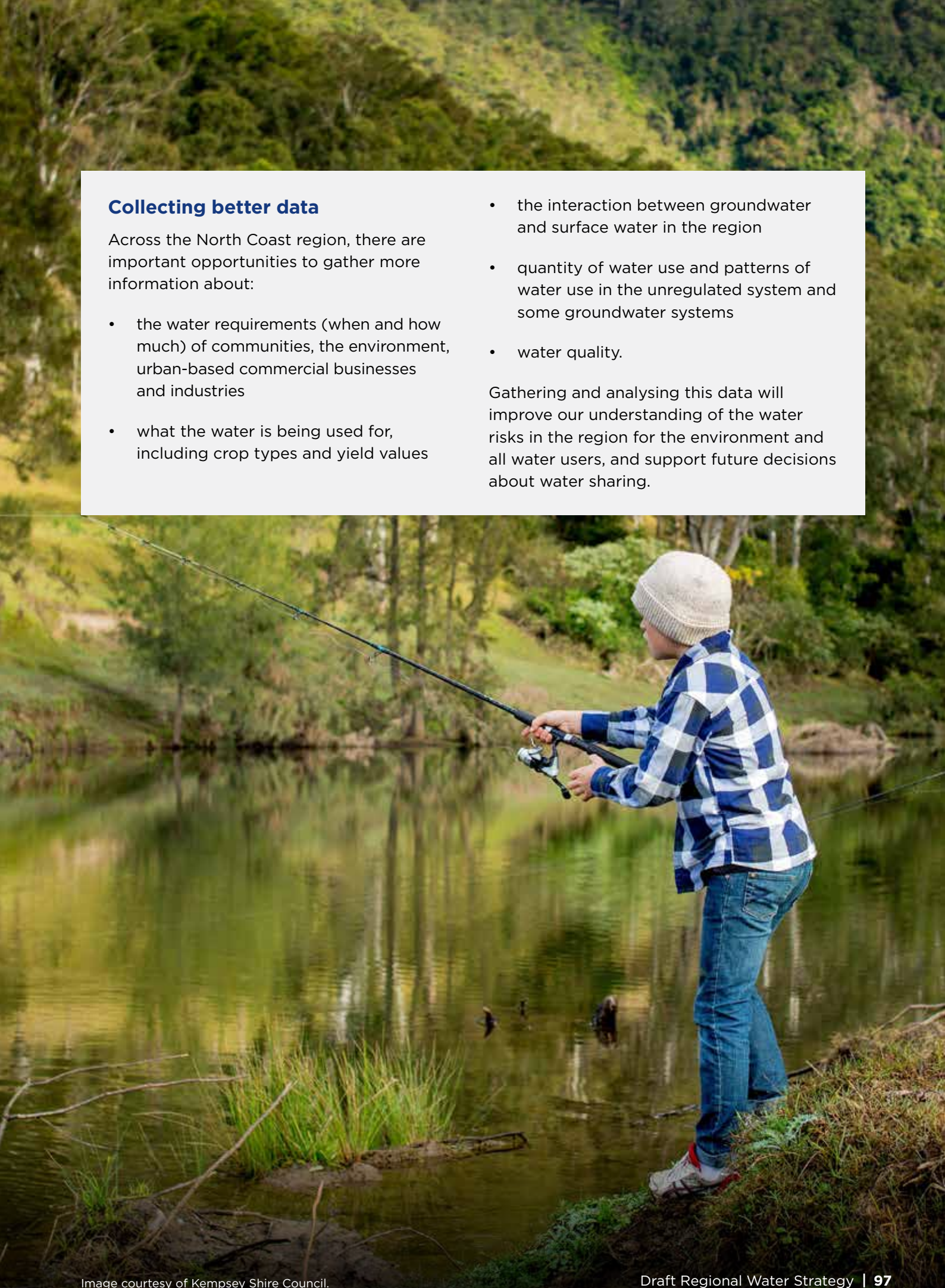


Image courtesy of Kempsey Shire Council.

Image courtesy of My Clarence Valley.

2.3 People, industries and water use

2.3.1 Aboriginal people

The Bundjalung, Githabul, Yaegl, Anaiwan, Gumbaynggirr, Dunghutti and Biripi people are the original inhabitants of the North Coast region.

The land and waters of the North Coast region contain places of deep significance to Aboriginal people that are central to their spiritual and religious belief system, and are often celebrated in ritual, ceremony, story, dance and artwork. The waters support kinship, connection, stories, songlines and healing through medicine and food. Healthy waterways and groundwater systems are critical to sustaining these aspects of Aboriginal life.

The Clarence River marks the boundary of the Bundjalung and Gumbaynggirr people. The Bundjalung Nation is a large mix of around 15 groups or clans whose lands extend across the North Coast and Far North Coast regions and into southern Queensland. The Yaegl people and Githabul people are the traditional custodians of the lower and upper reaches of the Clarence River, respectively. The sovereign ties of the Githabul people were acknowledged in 2007 when the Federal Court recognised Githabul Native Title rights for 1,120 km^2 of public land.[145]

The Gumbaynggirr Nation, one of the largest coastal nations in New South Wales,[146] stretches south from the Clarence River to the Nambucca River and inland to the Great Dividing Range. They were known as the 'sharing people' due to the abundance of food and other resources provided by their land, rivers and coast.[147]

The Macleay Valley is the heartland of the Dunghutti people. The land extends from the coast to the tablelands. The Dunghutti were the first Aboriginal people on mainland Australia to be recognised as having Native Title rights.[148]

The Anaiwan people's ancestral land of the Ngawanya centres around current day Armidale and the surrounding tablelands. It is thought that they occupied the New England tableland from Guyra and Ben Lomond south to Uralla and Moombie Range, north to Tingha at Bendemeer and Armidale. Their lands adjoin the Kamilaroi to the south and west, the Ngarabal to the north and the Gumbaynggirr, Dunghutti and Biripi to the east.

145. McClean, N. 2013, *Being on Country*, Githabul approaches to mapping culture
146. Coffs Harbour City Library 2013, *Aboriginal history of the Coffs Harbour region*
147. www.coffscoast.com.au/play/category/indigenous-heritage/
148. www.nativetitle.org.au/find/pbc/2867

The Biripi people are the people of two rivers —the Hastings and the Manning.[149] They lived in settled villages along the rivers and lakes, which were rich in seafood and bushfoods.

The diversity and abundance of natural resources available in the NSW North Coast resulted in a high density of Aboriginal occupation. Foods ranged from shellfish, fish and eels, kangaroo, small mammals and reptiles to vegetables such as grasses, bracken fern root, yams, berries and seeds, as well as honey. This food was sourced from the coast and rivers, the bush and the grasslands.[150] In the tablelands, food was sourced from the swamps (crayfish and water birds, as well as yams), the forests (for example, echidnas, which are the totem of the Anaiwan people, and nuts from the *Lepidozamia* and *Macrozamia*) and through the burning of the grasslands to attract larger animals.[151] Food was less plentiful on the tablelands and, combined with harsher climate conditions, this encouraged seasonal migration of people (like the Anaiwan and tribes of the Gumbaynggirr and the Dunghutti people) to the coast.

Many sites are of cultural significance to the Aboriginal people of the North Coast. For example, the Clybucca Historic Site, located within the lands of the Dunghutti and Gumbaynggirr nations north of Kempsey, contains part of one of the largest estuarine Aboriginal midden complexes recorded in temperate Australia.[152] The site is estimated to be between 6,000 and 9,000 years old and is evidence of continuous Aboriginal coastal occupation in the area. The midden extends to around 14 km with shell mounds up to two metres high. Significant Dunghutti sites also remain along the coast of the Macleay Valley and include middens and a fish trap in the Limeburners Creek Nature Reserve and a Bora Ring north of Crescent Head.[153] The Nambucca Aboriginal area is another site of significant Aboriginal cultural heritage and protected within a national park.

Native Title claims

Native Title recognises the rights of Aboriginal people to hunt, fish, camp, protect cultural sites and gather natural resources in accordance with their traditional laws and customs. It also grants certain rights over water use and collection in these areas.[154]

Native Title claims have been determined to exist in the North Coast region. There are two Native Title claims accepted for registration and 11 determined Native Title claims[155] (Table 5). The most recent Native Title determination in the region was in 2019.

The NSW Government is committed to improving employment opportunities for Aboriginal people in the North Coast region. Fast-tracking the resolution of land claims will support economic development opportunities for the Aboriginal community. The Aboriginal Participation in Construction Policy supports a minimum of 1.5% Aboriginal participation in construction projects undertaken by government agencies. Additionally, Destination NSW has designed an *Aboriginal Tourism Action Plan* to support the development of Aboriginal tourism across the state.

149. Elaine van Kempen 2003, *An Excerpt from Some Timbers Stories of the Hastings, Indigenous Australians using timber and trees*
150. Australian Museum Consulting 2014, *Clarence Valley Aboriginal Heritage Study. Report to Clarence Valley Council*
151. Elaine van Kempen 2003, *An Excerpt from Some Timbers Stories of the Hastings, Indigenous Australians using timber and trees*
152. As quoted in Appendix 9 of the Northern Rivers Biodiveristy Plan found at www.environment.gov.au/resource/northern-rivers-regional-biodiversity-management-plan. The site was registered on the Register of the National Estate, which has now been replaced with the National Heritage List and the Commonwealth Heritage List.
153. www.macleayvalleycoast.com.au/about/history/
154. Native Title holders are entitled to take and use water pursuant to their Native Title rights under section 55 of the Act in the Bellinger-Nambucca Coastal Sands Groundwater Source, the Clarence Coastal Sands Groundwater Source, Coastal Nambucca River Water Source, as well as multiple water sources within the Clarence River Unregulated and Alluvial Water Sources.
155. The Gumbaynggirr People have four Native Title claims, one of which is to the land within the Gaagal Wanggaan (South Beach) National Park.

Figure 18. Native Title claims on the North Coast

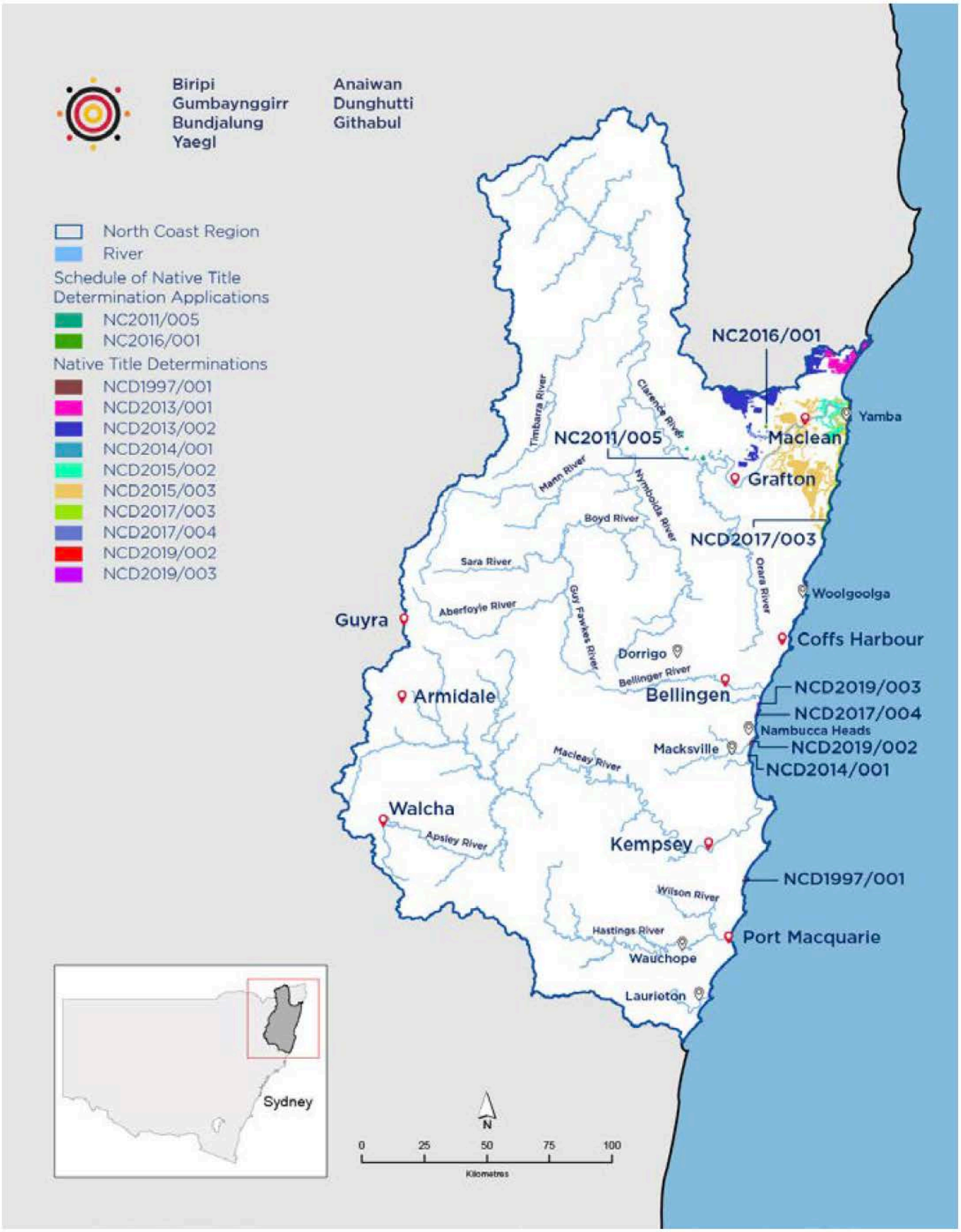


Table 5. Native Title claims on the North Coast[156]

Application name	Tribunal file number	Status	Native Title claim overview
Western Bundjalung People	NC2011/005	Accepted for registration	Native Title exists in parts of the determination area in North East NSW near Tenterfield and Casino. This claim spreads over the Clarence, Glen Innes, Kyogle, Richmond Valley, and Tenterfield local government areas (LGAs).
Bandjalang People #3	NC2016/001	Accepted for registration	Claim on select lots based on application in North Eastern NSW, in the vicinity of Evans Head. These lots spread across the Clarence, Lismore, and Richmond LGAs.
Dunghutti People	NCD1997/001	Determined (registered)	Native Title exists in entire determination area at Crescent Head, within the Kempsey LGA.
Bandjalang People #1	NCD2013/001	Determined	Native Title exists in parts of the determination area which spreads over sections of the Clarence and Richmond LGAs.
Bandjalang People #2	NCD2013/002	Determined	Native Title exists in parts of the determination area which spreads over sections of the Clarence, Lismore and Richmond LGAs.
Gumbaynggirr People	NCD2014/001	Determined	Native Title exists in the entire determination area to the land within Warrell Creek, Nambucca Heads in the Nambucca Valley LGA.
Yaegl People #1	NCD2015/002	Determined	Native Title exists in parts of the determination area in waters of the Clarence River near Yamba, Iluka and Harwood in the Clarence Valley LGA.
Yaegl People #2	NCD2015/003	Determined	Native Title exists in parts of the determination area to the land within the coastal land of the Clarence Valley LGA.
Yaegl People #2 (Part B)	NCD2017/003	Determined	Native Title exists in the entire determination area which extends along the coastal fringe from north of Woody Head south to Wooli within the Clarence LGA.
Gumbaynggirr People	NCD2017/004	Determined	Native Title exists in the entire determination area in the Bellingen Shire LGA.
Gumbaynggirr People #3	NCD2019/002	Determined	Native Title exists in parts of the determination area near Nambucca Heads in the Nambucca Valley LGA.
Gumbaynggirr People #5	NCD2019/003	Determined	Native Title exists in parts of the determination area in the Mid-North Coast NSW in the Bellingen Shire LGA.
Dunghutti People	NC2001/006	Determined (no determination)	Claimant application regarding whether Native Title existing in the application area to the land at Crescent Head in the Kempsey Shire LGA. No determinations of Native Title have been made for this application.

156. Commonwealth of Australia 2017, *Search Register of Native Title Claims*, Commonwealth of Australia, accessed 19 December 2019, www.nntt.gov.au/searchRegApps/NativeTitleRegisters/Pages/Search-Register-of-Native-Title-Claims.aspx

Water used by Aboriginal people

Due to the impacts of COVID-19, the Department of Planning, Industry and Environment had to delay engagement with Aboriginal people in the North Coast region. Although we recommenced our consultation in July 2020, there was not sufficient time to incorporate the full breadth of views and voices in this draft strategy.

However, several important themes have emerged from our engagement with Aboriginal communities in the North Coast to date. In particular, we heard from Aboriginal people that—as recognised traditional custodians of the lands and water sources in the region—they would like more direct input to water management decision making. This would provide the opportunity to incorporate traditional knowledge into water management in the region. We have heard from some Aboriginal communities that the Clarence River should be treated as an upper and lower section, which we will consider in the assessment of the long list of options. We also heard that the water rights afforded to Aboriginal communities through Native Title and cultural water access licences are not clear and that Aboriginal people would like more support to understand and access their water rights.

In addition, we heard during our state-wide community consultations that Aboriginal communities do not have adequate access to water or access to Country to fulfil their cultural rights and to protect cultural sites. While there are some ways of accessing water for cultural purposes, we heard from Aboriginal people that the current provisions in the *Water Management Act 2000* are not meeting their spiritual, cultural, social and economic needs. We also heard that healthy waterways are critical to Aboriginal communities for culture and health and wellbeing.

Aboriginal people's legal rights as they apply to water management have been recognised in international human rights treaties and conventions, in Australian and NSW Native Title and land rights laws, and in national and state-based water plans. These instruments recognise the right to self-determination and the right to access traditionally owned lands and water. They also recognise the importance of maintaining the environmental knowledge and practices of Aboriginal people, promoting their full participation in decisions about water resources and acknowledging Aboriginal cultural values and uses in water planning.

In addition, the *2007 Echuca Declaration* defines cultural flows as 'water entitlements that are legally and beneficially owned by the Nations of a sufficient and adequate quantity and quality to improve the spiritual, cultural, environmental, social and economic conditions of those Nations'.[157]

Australia's Native Title laws recognise the traditional rights and interests to land and water of Aboriginal people. Anyone who holds Native Title with respect to water can take and use water for personal, domestic and non-commercial communal purposes. Native Title holders often have water related aspirations: from protecting water to giving advice on water management practices within a determination area and seeking water allocations.

Aboriginal people can apply for Aboriginal cultural water access licences. If granted, this licence can provide up to 10 ML/year for drinking, food preparation, washing and watering domestic gardens, as well as for Aboriginal cultural uses.[158]

157. Murray Lower Darling Rivers Indigenous Nations (MLDRN) 2007, *Echuca Declaration*
158. Water Sharing Plan for the Clarence River Unregulated and Alluvial Water Sources 2016, NSW Government, www.legislation.nsw.gov.au/view/html/inforce/current/sl-2016-0381

The local Aboriginal communities of the North Coast also have access to Aboriginal Community Development Licences[159] in most of the region's catchments. An Aboriginal Community Development Licence allows water to be pumped from a river during high flows, stored in a farm dam or tank and then used as needed.[160] The water sharing plans for the Clarence, Bellinger, Macleay and Hastings rivers identify water sources where Aboriginal Community Development Licences are permitted within some limits. For example, high flows in the Coffs Harbour water sources are not considered capable of supporting these licences.

We are committed to having an ongoing dialogue with Aboriginal people on the development of the North Coast Regional Water Strategy to ensure that Aboriginal rights, interests and concerns related to water are heard and included in the final strategy.

The final North Coast Regional Water Strategy will reflect the results of engagement with Aboriginal people in the region and consider options to advance the needs and aspirations of Aboriginal people with respect to water.[161] It will also consider how options will help to deliver NSW's commitments under the *National Agreement on Closing the Gap*,[162] including in the four reform areas of:

- formal partnerships and shared decision making
- building the community controlled sector
- transforming government organisations
- shared access to data and information at a regional level.

159. For example, see Part 7 of the *Water Sharing Plan for the Clarence River Unregulated and Alluvial Water Sources 2016*, NSW Government
160. For the purpose of issuing these licences, high flows are defined as those that are exceeded 50% of the time (the top half of the flow regime).
161. More information about our Aboriginal engagement approach is in the *Regional Water Strategies Guide*.
162. National Agreement on Closing the Gap 2020, www.closingthegap.gov.au

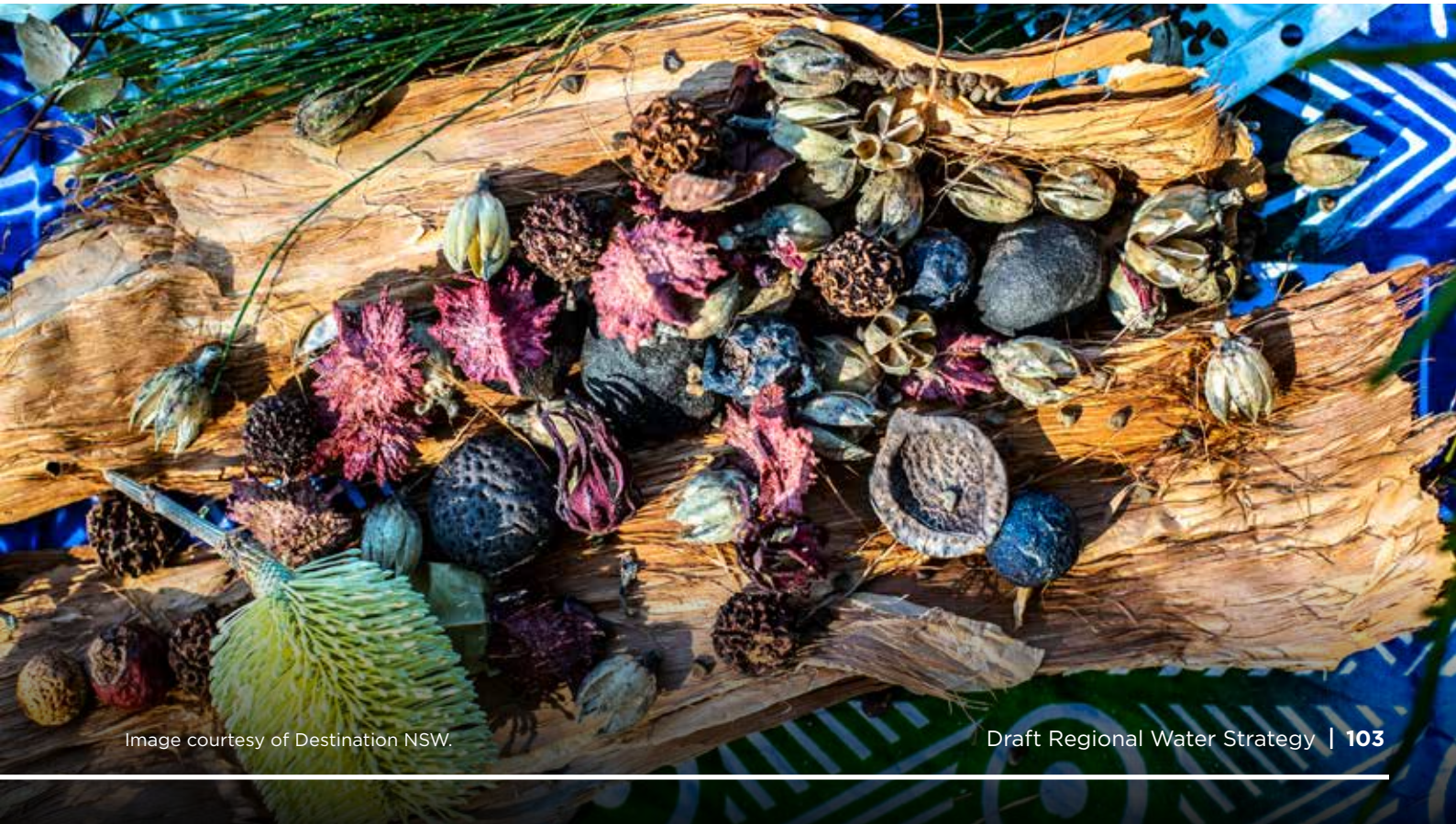


Image courtesy of Destination NSW.

2.3.2 People and towns

The catchments of the North Coast are the third biggest region in the state in terms of population, employment and economic output. The region is home to over 300,000 people and includes the regional centres of Grafton (population 19,046), Armidale (24,584), Port Macquarie (48,723), Coffs Harbour (72,541) and Kempsey (15,378). These centres are important employment, service and cultural hubs for the broader North Coast region. The region also has many smaller towns such as Bellingen, Nambucca Heads, Macksville, Wauchope and Yamba, with populations ranging from around 3,000 to 7,000.[163]

The focus of future investment in the region is to capitalise on the region's natural endowments to make the region the 'best place to live, work and play' in Australia.[164] Over the next 20 years, the population of the region is expected to grow by about 13%, particularly in the local government areas of Port Macquarie-Hastings, Coffs Harbour and Armidale.[165] The Department of Planning, Industry and Environment and councils are developing regional city action plans to support continued growth in these cities (under Action 7.1 of the *North Coast Regional Plan*). These plans will align with the broader goals, directions and actions of the *North Coast Regional Plan*.

As the region grows, so will the need for services such as healthcare, construction and retail. The NSW Government is investing heavily in transport and community infrastructure to cater for the future population:

- over $1 billion for completed upgrades to the Pacific Highway,[166] $23 million for the planning and reconstruction of the Coffs Harbour bypass and a $5 million upgrade of Coffs Harbour regional airport (completed in 2017)
- $284 million for upgrades to hospitals and health facilities, including
  - $194 million for the Coffs Harbour Hospital expansion
  - $73 million for the Macksville Hospital redevelopment
  - $60 million for the Armidale Hospital upgrade
  - $17 million for the Port Macquarie Mental Health expansion
- $107 million from the NSW Regional Growth Fund for infrastructure to support
  - growth in tourism and jobs (nearly $30 million)
  - regional culture ($17.5 million)
  - improvements and upgrades to local facilities ($45.7 million).

163. www.abs.gov.au/census
164. Department of Planning and Environment 2017, *North Coast Regional Plan 2036*
165. Based on 2016 data compiled by the Department of Planning, Industry and Environment. The projections do not include targeted efforts by individual councils to attract population growth.
166. This includes upgrades between Nambucca Heads and Urunga ($390 million, completed in 2016), Kundabung to Kempsey ($115 million, completed in 2017), Warrell Creek to Nambucca Heads ($415 million, completed in 2018) and Frederickton to Eungai ($282.5 million completed in 2016).

Image courtesy of Jaime Plaza Van Roon, Department of Planning, Industry and Environment.

The NSW Government recently declared the Oven Mountain Pumped Hydro Energy Storage project as Critical State Significant Infrastructure. The project, located between Armidale and Kempsey, is aligned with the Government's vision to transition the energy grid towards renewable energy and ensure the grid can manage future demand. The project is forecast to generate around 600 new jobs during construction and to inject over $1 billion of investment into the region.

Future population growth and urban development in the region, coupled with the uncertainties associated with climate change, suggest additional benefits could be achieved if land use planning and strategic investments are more closely integrated with long-term planning around water resources. Efforts have already been made by government to manage the impact of population growth and urban development on the region's water resources. Actions in the *North Coast Regional Plan* aim to focus development to areas of least biodiversity sensitivity in the region (Action 2.1) and ensure local plans include measures to avoid potential development impacts (Action 2.2). The *Marine Estate Management Strategy* also recognises the impact of urban development on the health of the coastal environment and aims to address diffuse urban pollution through new planning tools.

The regional water strategies provide an opportunity to consider how these investments will drive future land use and water demands and identify options to meet these needs and ensure the region has secure and resilient water supplies. The Department of Planning, Industry and Environment is also refreshing the regional plan and further opportunities exist as part of that review to improve the integration of planning around water with strategic planning.

Water for people and towns

Providing secure and resilient water services to regional centres, towns and outlying areas is vital for the long-term sustainability of the region, particularly in the context of a changing climate. It is also vital for supporting regional land use planning goals of a thriving, interconnected economy, vibrant and engaged communities and great housing choices and lifestyle options.[167]

Secure water services support growing populations and contribute to the amenity, liveability and wellbeing of residents and visitors. Water in regional towns and communities also provides broader social benefits. Town swimming pools, healthy rivers, wetlands, lakes and other water bodies offer social and recreational opportunities. They are important spaces for family and community cohesion and provide respite from the heat and humidity of the region's summer months. High quality open spaces and parks connected to water are also important to communities across the North Coast region.

Around 92% of the region's population is connected to a reticulated water supply and around 85% to the sewerage networks managed by each council.[168] Many coastal towns—including South West Rocks (Kempsey Shire Council), Minnie Water (Clarence Valley Council) and Stuarts Point (Kempsey Shire Council)—are not connected to the main reticulated system and rely on smaller local reticulated systems. Other small towns, such as Nymboida and Grassy Head, rely on private water supplies such as rainwater tanks and groundwater.

The region's local councils hold approximately 69,000 ML of surface water and 21,600 ML of alluvial or groundwater (coastal sands) entitlement in the region (Figure 19). This equates to roughly 50% of all licensed water entitlement in the region; although, in some water sources, the proportion can be much higher. For example, 97% of the total groundwater entitlement in the Nambucca Unregulated and Alluvial Water Sources is licensed to Nambucca Valley Council.[169]

The major towns of Kempsey, Bellingen and Macksville, as well as many smaller coastal towns (including Hat Head, South West Rocks and Stuarts Point), rely exclusively on groundwater from alluvials or coastal sands for town water supply. As described in section 2.2.1, upriver alluvials and coastal sands groundwater sources have a high degree of connectivity with surface waters and rainfall. In many cases, cease-to-take conditions on water extraction for these towns is linked to surface water flows.

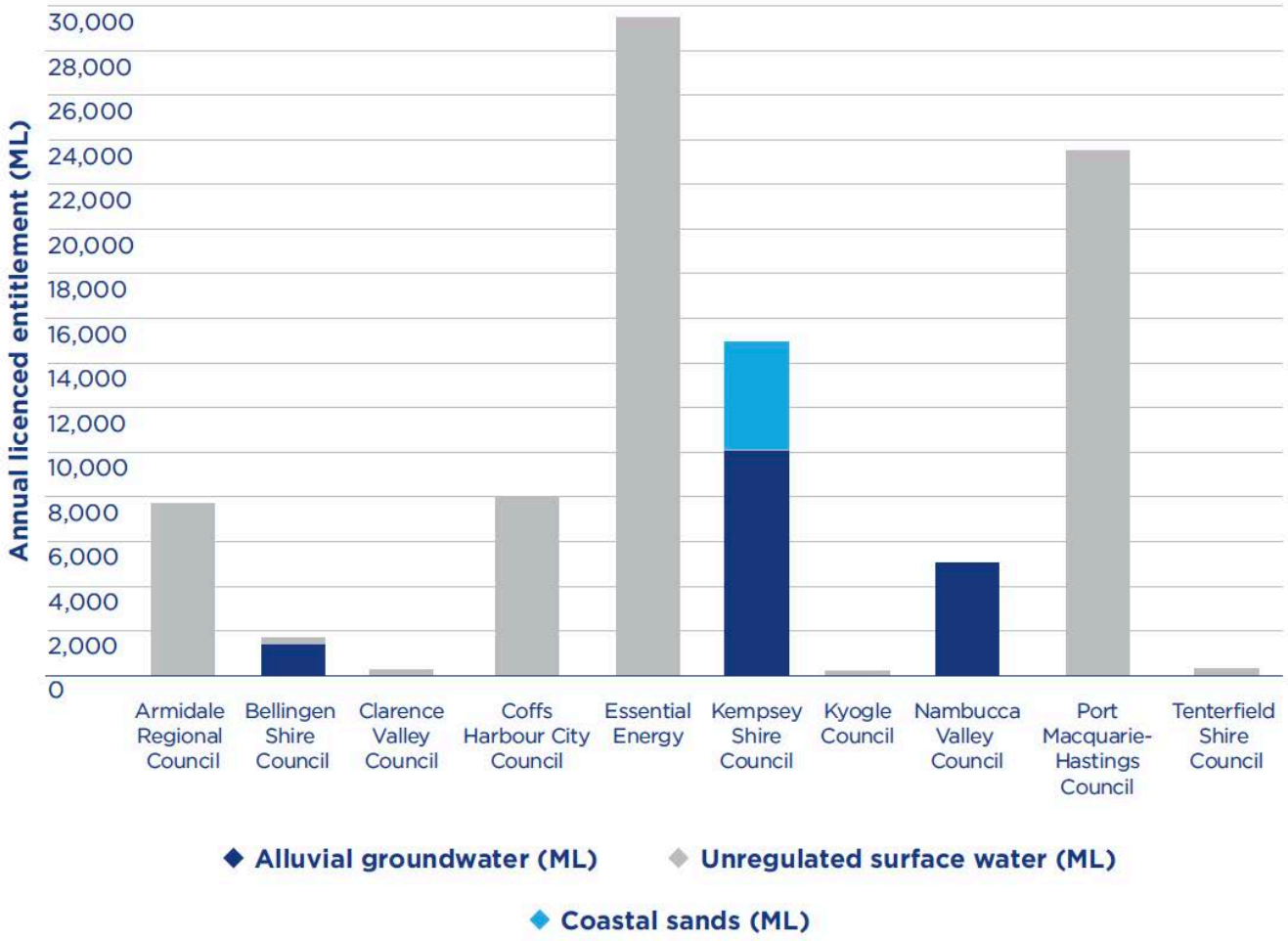
The largest entitlement for town water is held by Essential Energy, a legacy of the water licensing for the Nymboida Hydro-electric Power Station and the associated Nymboida River weir. The licence can only be used for the purpose of town water supply and cannot be used for power generation. The vast majority of Clarence Valley Council's town water supply relies on this licence. Coffs Harbour City Council also relies on the licence through the Clarence-Coffs Harbour *Regional Water Supply Scheme* when it cannot extract the town's water directly from the river.

167. www.planning.nsw.gov.au/Plans-for-your-area/Regional-Plans/North-Coast/Plan
168. Department of Planning, Industry and Environment, www.industry.nsw.gov.au/water/water-utilities/lwu-performance-monitoring-data
169. Department of Primary Industries 2016, *Water Sharing Plan for the Nambucca Unregulated and Alluvial Water Sources—Background document*

Water use by councils is typically far less than their entitlements and, in many cases, has declined significantly since metering and usage charges were introduced in the 1990s.[170]

Storages, as described in section 2.2.1, are generally small and designed to be used during emergencies when flows in the river are too low for extraction to occur.[171]

Figure 19. Water sources of town water supplies in the North Coast region



Source: Department of Planning, Industry and Environment—Water 2019, water licensing

170. www.nambucca.nsw.gov.au/
171. This is also the case for councils that extract from alluvial groundwater sources due to the high connectivity between surface and groundwater flows.

Potential impacts of more variable climate and future climate change on town water supplies in each catchment

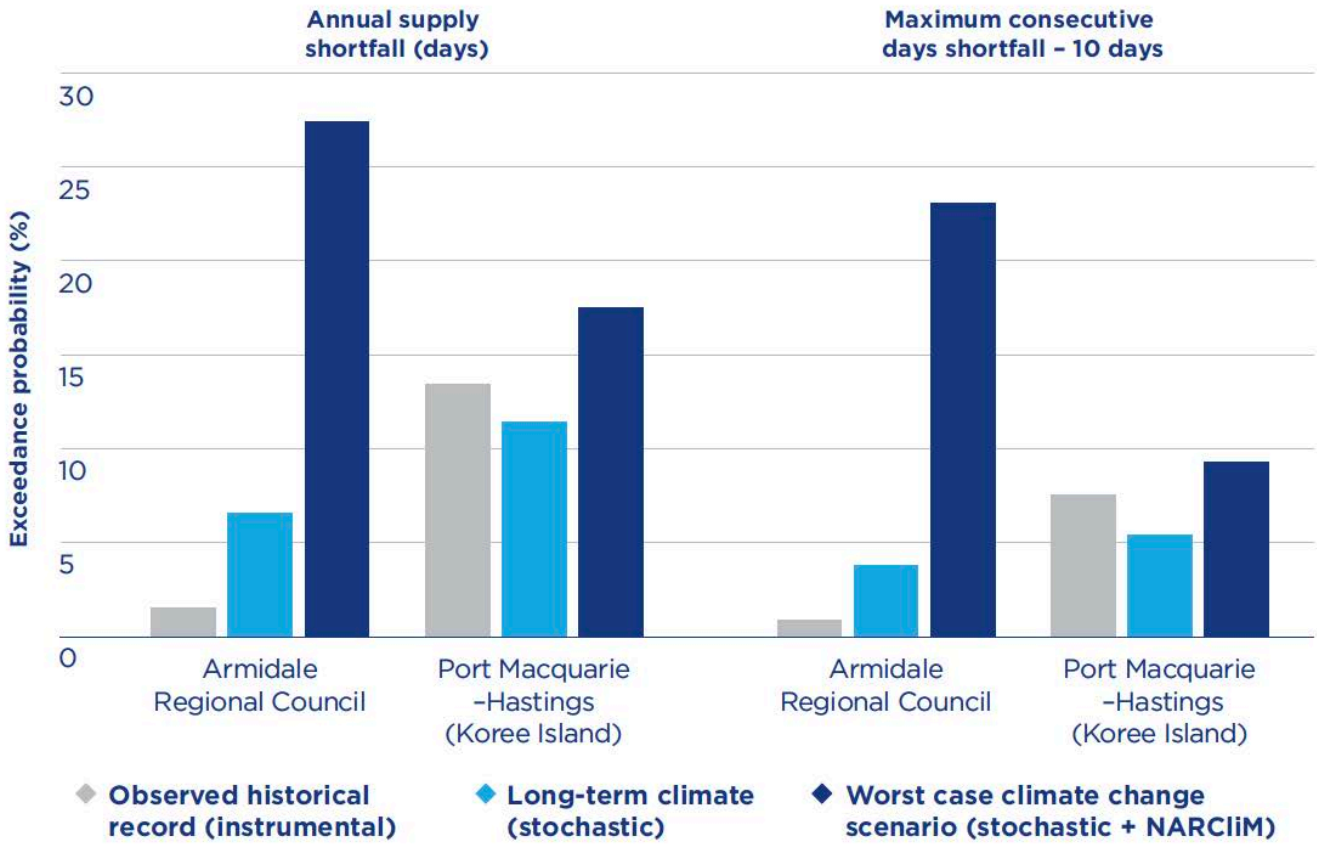
During 2019, the combined effect of extreme dry conditions and bushfires meant towns were at considerable risk of running out of water or having access to contaminated water supplies. For much of the region, this was the driest 12-month period in the observed historical records, with many rivers experiencing the lowest recorded daily flows.

Our new climate data and modelling provides information on the availability and reliability of a large number of the surface water entitlements held by local councils for a range of future plausible climate scenarios.

Future climate change projections could impact all towns and communities in the region but are likely to have the biggest impact on town water security for Armidale Regional Council. Based on current population, the number of days with a shortfall in extraction is projected to increase from less than 2% (based on instrumental data) to around 27% (worst-case climate change projections). The probability of a shortfall period of 10 consecutive days increases from 1% to 23%.

By comparison, the impact of projected climate change on extraction for Port Macquarie-Hastings Council is less severe (Figure 20). Outputs from the new model show a small increase in the probability of any shortfall in extraction – between 14% and 18% (based on instrumental and worst-case climate change projections). For the same consecutive 10-day period discussed above, the probability of occurrence is also a lot lower—around 7% to 9% (based on the worst-case climate change scenario).

Figure 20. Shortfalls in extraction for Armidale Regional Council (Malpas Dam) and Port Macquarie-Hastings Council*



* Based on data collected for the town water extraction at Koree Island

Our new data and modelling shows that the impact of climate variability is stronger for low flows than for median or higher flows. For example, in the Nymboida River (the main source of water for the Clarence-Coffs Harbour *Regional Water Supply Scheme*), cumulative 12-month low flows could be 36% lower.[172] However, the impact on cease-to-take triggers for the main town water extraction points varies, and in some cases is small.

Based on the worst-case climate change projections, the greatest increase in the average number of days when cease-to-take conditions could be triggered is for towns dependent on the Macleay River and the Clarence River (including the Nymboida River) (see Table 6). Conversely, impacts to cease-to-take conditions for towns on the Bellinger River and Hastings River are likely to be small.

Table 6. Average number of days below cease-to-take flow trigger at key sites for town water extraction

Cease-to-take Reference Point	Main town	Average no. of days below cease-to-take flow per year		
		Observed historical records	Long-term climate record	Worst-case climate projection scenario
Hastings River at Ellenborough (207004)	Port Macquarie–Hastings	3	2	3
Bellinger River at Thora (205002)	Bellingen	0.9	0.7	1
Macleay River at Turners Flat (206011)	Kempsey	9	8	16
Nymboida River at Nymboida (204001)	Grafton	28	28.5	44
Orara River at Orange Grove (204068)	Coffs Harbour	8	7	9

172. Based on worst case climate change projection compared to long term climate data for entire 10,000 years of simulated data

Kempsey Shire Council, Nambucca Valley Council and Bellingen Shire Council access water from the region's alluvial groundwater sources. These systems are highly connected to river flows and extraction will be impacted by low surface water flows. For the Macleay River (upstream of Kempsey), daily low flows[173] could be 5% higher under the long-term climate record scenario and up to 48% lower under the worst-case climate change projection scenario.

This has implications for Kempsey's town water supply from the Sherwood borefield due to the high connectivity between the Macleay Valley alluvial groundwater source and the river, as well as for smaller systems (such as Bellbrook) that pump directly from the river. This trend is less significant for the more coastal catchments of the Bellinger, Orara and Hastings rivers (Table 7).

Table 7. Low flows at key reference points for town water extraction

Reference point	95th percentile flow (ML/d)		
	Observed historical records	Long-term climate record	Worst-case climate projection scenario
Hastings River at Ellenborough (207004)	76	85 (+12%)	68 (-10%)
Bellinger River at Thora (205002)	25	29 (+17%)	23 (-7%)
Macleay River at Turners Flat (206011)	67	70 (+5%)	34 (-48%)
Nymboida River at Nymboida (204001)	175	177 (+1.5%)	135 (-23%)
Orara River at Orange Grove (204068)	9	10 (+11%)	8.5 (-8%)

173. Low flows are defined as daily flow with an exceedance probability of 95%

Modelling limitations

- Model calibration is constrained by the limited amount of gauging data and water use data within the region.
- All river systems modelled have downstream tidal limits, which are not taken into account in the model. Caution should be taken in interpreting results in the tidal reaches.
- Off-stream storages and interconnected town or regional water supply schemes have not been included in the model. Reporting of extraction and supply shortfalls has been based on river extraction at licensed extraction points and water sharing plan rules.
- The model only includes surface water sources and users. Surface water–groundwater connectivity has not been taken into account in the models. However, model outputs related to streamflow levels have been used to indicate potential impacts on town water supplies in connected alluvial groundwater sources.
- Base case modelling assesses the impacts of three climate scenarios on current conditions across four of the region's catchments, including land use, water use patterns and management rules. As such, the impact of forecast growth in the region on water reliability or security is not taken into account in the base case. Future conditions will be assessed as part of the options assessment stage.
- The models do not simulate water quality parameters. Modelling results reflect hydrological impacts of long-term climate variability and climate change only. The frequency of poor water quality events and the impact to extraction for town water supplies is considered separately.

Image courtesy of Destination NSW.

In regional NSW, town water supply systems are designed on a consistent basis using the NSW Government's *Guidelines on Assuring Future Water Security*. Systems are planned and sized in consultation with the community, giving consideration to historical and future consumptive needs and climate projections. Local councils are responsible for providing water and sewerage services to their respective communities in a way that balances costs and community expectations about levels of service. This responsibility extends to planning for, and delivering, secure water supplies.

All town water supplies have some level of inherent water security risk and are designed to accommodate moderate levels of restricted service. Local councils undertake water security access risk analyses as part of their integrated water cycle management planning. These analyses take into account:

- headworks (water storage and treatment) arrangement and capacities
- physical water delivery system and operational rules under water sharing plans
- operating protocols and past experiences in delivering water in drought conditions.

The current water security access risks for the region's main drinking water supply systems are shown in Table 8. This information shows that the future water security risks for all major urban centres are high to very high. These systems supply over 80% of the serviced population in the North Coast region. In addition, many of councils' smaller reticulated systems (serving populations less than 1,000) have a medium to high future water security risk. For most of these systems, the risk ratings are influenced by the combined impact of population growth and climate change.

Image courtesy of Destination NSW.

Table 8. Water security risk for major centres and towns in the North Coast region

Water utility	Drinking water supply system	Population served in 2014	Water security risk (2014)	Water security risk (2040)
Armidale Regional Council	Armidale	19,818	Very low	Very high
	Guyra	1,947	High	Very high
Bellingen Shire Council	Bellingen Area	8,343	Very high	Very high
	Dorrigo	1,072	Very low	Very low
Clarence Valley Council	Clarence Valley, Coutts Crossing, Glenreagh	50,959	Very low	High
Coffs Harbour City Council	Coffs Harbour	59,700	Very low	High
Kempsey Shire Council	Kempsey District	12,506	Very high	Very high
	South West Rocks	4,816	High	High
Kyogle Council	Woodenbong	310	Very low	Very low
Nambucca Valley Council	Nambucca District	14,526	Very low	Very low
Port Macquarie-Hastings Council	Hastings District	69,837	Very high	Very high
Tenterfield Shire Council	Tenterfield	2,997	Very low	Very high
Walcha Council	Walcha	1,482	Very high	Very high

Note: These risks represent the preliminary water security risks as assessed by the Safe and Secure Water Program as of April 2020 and are subject to change over time based on further investigation, new information from councils and/or delivery of projects/solutions addressing these risks. Options to address the future water security risks for the drinking water supplies of Kyogle Council, Tenterfield Council and Walcha Council are addressed in the Far North Coast, Namoi or Border Rivers regional water strategy based on the primary town water supply source. The draft Namoi Regional Water Strategy includes an option to source water from the Macleay catchment to secure town water for Walcha.

Source: *NSW Government's Safe and Secure Water Program*

The town water supply systems in the North Coast region are designed to expect surface and alluvial water sources to be fed by regular and predictable rainfall. Consequently, they are vulnerable to the types of extreme dry periods we now know have occurred in the past and that our modelling suggests can occur in the future. This vulnerability was demonstrated over the summer of 2019/20 when water restrictions had to be imposed in all local government areas across the region. Armidale Regional Council was impacted the greatest. Level 5 restrictions were imposed in June 2019 in Armidale, due to the dam reaching its lowest levels since construction. Level 3 restrictions were imposed on residents of Port Macquarie-Hastings Council, Kempsey Shire Council and Bellingen Shire Council. Clarence Valley Council, Coffs Harbour City Council and Nambucca Valley Council imposed only Stage 1 restrictions despite river flows being very low. Council town water storages were key to keeping restrictions to this low level. During the drought conditions of 2002/03, Nambucca Valley Council's water supply system came very close to failure, which prompted a review of the system and subsequently led to the construction of Bowra Dam.[174] Similar impacts to Kempsey's water supply security during 1994 also led to the construction of emergency off-river storage (Steuart McIntyre Dam).[175]

Local councils also provide water to local businesses, including food manufacturing, as well as rural businesses. This non-urban demand for water is significant for some councils. For example, between 40% and 50% of Guyra's treated water supply[176] is used to grow tomatoes at one of Australia's largest glasshouse facilities. Approximately 18% of demand from Kempsey Shire Council's water supply network is for agricultural businesses. Around 3% of the annual town water demand from both Port Macquarie-Hastings Council and Bellingen Shire Council supply is from large food manufacturers. These businesses, like the residents of these areas, were impacted by the dry conditions of last summer. However, councils did not have the ability to enforce restrictions on these non-urban users. Rather, reductions in use were negotiated with individual businesses. There were also multiple cases of water carters accessing water from the town water supply to sell to rural users.

The Department of Planning, Industry and Environment is conducting a state-wide review to clarify the purposes for which water taken under a local water utility licence can legally be used under the *Water Management Act 2000*. The Draft North Coast Regional Water Strategy provides an opportunity to seek feedback from the community on their concerns regarding current access arrangements. It also provides an opportunity to build upon this review and provide a framework to guide a consistent approach to restrictions in use for non-urban water users connected to town water supplies across the region.

Poor water quality in some of the region's water sources has also impacted town water supplies. Runoff after heavy rainfall can dramatically increase turbidity, as well as the concentration of organic matter in the rivers. Rapid fluctuations in flow and turbidity can place significant strain on water treatment facilities, potentially impacting drinking water quality.[177] For example, town water extraction by Clarence Valley Council from the Nymboida River was recently constrained by high turbidity. The severe bushfires of 2019, followed by heavy rainfall, created muddy water in the Nymboida River. Despite sufficient flow, Clarence Valley Council was not able to extract from the river for multiple months and relied on water transferred from Karangi Dam through the Clarence-Coffs Harbour *Regional Water Supply Scheme*.[178]

174. www.nambucca.nsw.gov.au/
175. Kempsey Shire Council 2019, *Kempsey Shire Drought Management Plan*
176. Guyra's water supply is managed by Armidale Regional Council.
177. www.nhmrc.gov.au/sites/default/files/documents/reports/aust-drinking-water-guidelines.pdf
178. www.coffsharbour.nsw.gov.au/

Due to the high connectivity between the Macleay and Bellinger rivers and the upriver alluvial water sources, poor river water quality can impact groundwater extraction for town water supplies in Kempsey and Bellingen, particularly during heavy rainfall when natural bank filtration systems are less effective.[179] Town water supplies reliant on the Bellingen borefield, Bowraville borefield, Macleay River alluvium and Macleay coastal sands groundwater sources are also at risk of saline intrusion into the aquifers due to over-extraction and rising sea levels under future climate change projections.

Malpas and Guyra dams and several small emergency storages, including Steuart McIntyre Dam, also experience frequent algal blooms—requiring expensive water treatment plant upgrades to minimise taste and odour problems.[180] Overall, the region received significantly more customer complaints in the last four years about water quality than the NSW regional median, highlighting that water quality remains a key issue.

These challenges highlight the importance of acting now to ensure adequate water security in the future. This draft strategy considers a suite of options to diversify town water supply systems, including augmenting existing storages, direct potable reuse of recycled water and decentralised desalination, as well as providing training and resources to support the implementation of integrated water cycle management. The strategy recognises the efforts already taken by local councils, including the upgrade of the Puddledock Dam pipeline (Armidale Regional Council) and groundwater investigations being conducted by Kempsey Shire Council and Bellingen Shire Council.

Using water more wisely will help to mitigate the impacts of lower water availability and increasing demand. It will also contribute to meeting water security objectives and may delay the need for system augmentations. For example, Clarence Valley Council has developed a 50-year Water Efficiency Strategic Plan to implement more sustainable water management[181] and Armidale Regional Council is targeting a reduction in daily water consumption to 160 L per person.[182] The regional water strategies provide an opportunity to review and improve existing demand management initiatives. These initiatives can contribute to reducing residential water consumption,[183] which is generally close to the NSW regional median of 159.6 kL per person per year across most of the North Coast but higher in parts of the Northern Tablelands.[184] There is also an opportunity to complement these demand management initiatives with investment in water supply system efficiencies. Non-revenue water[185] in the region is generally lower than the NSW regional median; however, there are opportunities to improve monitoring and asset operation and maintenance to reduce non-revenue water and contribute to improving water supply reliability.

179. Tasleem Hasan 2013, Drinking Water Management System—Bellingen Shire Council, prepared for NSW Health by Viridis Consultants Pty Ltd
180. Chris Keogh 2009, Dealing with taste and odour problems arising from algal blooms in a raw water reservoir, Paper presented at 3rd Annual WIOA NSW Water Industry Engineers & Operators Conference
181. www.clarence.nsw.gov.au/cp_themes/metro/page.asp?p=DOC-EGU-68-82-03
182. www.armidaleregional.nsw.gov.au/environment/water-usage-and-supply/water-restrictions/160-litre-target
183. This refers to total residential water consumption per connection (kL) for 2018/19.
184. www.industry.nsw.gov.au/water/water-utilities/lwu-performance-monitoring-data
185. Non-revenue water is water that has been produced and is 'lost' before it reaches the customer. Losses can be real losses (through leaks, sometimes also referred to as physical losses) or apparent losses (for example through theft or metering inaccuracies).

Increasing the use of recycled water and improving stormwater management could help to reduce the environmental impact of the region's wastewater and stormwater systems. There are also opportunities to reduce the frequency of sewer overflows in several of the region's sewerage systems, although the number of overflows across the region is generally low compared to the NSW median. Providing sewerage schemes for unsewered villages would also reduce the environmental and health impacts of on-site sewage systems, (although, again the number of overflows across the region is generally low compared to the NSW median). Providing sewerage schemes for unsewered villages would also reduce the environmental and health impacts of on-site sewage systems in high risk areas (villages in coastal zones, along the river, areas with high groundwater table and/or sensitive ecosystems). For example, Kempsey Shire Council is currently implementing a sewerage scheme for Stuarts Point in the Macleay catchment.

Sea level rise, coastal inundation and flooding also threaten the performance of local water utility assets. Much of the region's water infrastructure, on-site sewerage systems and stormwater drainage networks are located in estuaries and low-lying floodplains. Improving our understanding of the risks of sea level rise across the region will help local water utilities adapt to these challenges.

Ageing water and sewerage infrastructure requires additional and ongoing capital investment to maintain service levels. This presents a challenge to local councils in the region as the costs of refurbishing or replacing ageing assets add to the costs of augmenting and operating the water and sewerage systems. Local water utility operating costs and typical residential bills across the region generally exceed the NSW regional median, reflecting the high costs of providing these services in the North Coast.

Smaller councils and local water utilities often find it difficult to attract and retain skilled staff and keep pace with advances in regulation and technology that could save money and improve services. Collaboration between councils will be important to meeting these challenges and could include finding economies of scale, unlocking efficiencies through knowledge sharing and working together to drive continued performance improvements across the region.

Image courtesy of Destination NSW.

2.3.3 Jobs and industries

The North Coast region has one of the strongest economies of the state. The region's thriving economy is supported by a highly productive and diverse riverine, coastal and rural landscape, developing inter-regional links (the Pacific Highway as well as east-west links such as the Oxley Highway), high quality infrastructure, distinct, large urban centres, and historically high and relatively reliable annual rainfall.

In 2016, over 111,800 people were employed across the North Coast region.[186] Economic output for the region was $16,824 million in 2017/18 and accounted for 3% of the NSW's output as measured by Gross Value Added. Rental, hiring and real estate contribute the largest proportion of Gross Value Added, while the industries with the highest number of employees are health care and social assistance, retail trade and education and training (Figure 21). Most employment is concentrated in the regional centres of Coffs Harbour and Port Macquarie.

The NSW Government is focused on continued growth in the region. Leveraging the region's location and natural assets will increase job opportunities and consequently support population growth through the specialisation of industry and businesses. Regional economic development strategies, recently developed in consultation with local councils, identify key specialisations of the region as health care, agriculture (particularly horticulture in the coastal local government areas and livestock farming and vegetables in the tablelands), fishing, aquaculture, tourism and in some parts of the region, education and construction.[187] The NSW Government has and will continue to support the growth of these specialisations by improving inter-regional connectivity and stronger urban centres through upgrades and improvements to land and air transport routes, the roll-out of the national broadband network and new and modernised health, education and local community sporting and cultural facilities. The regional water strategies will complement these efforts by looking for opportunities to strengthen the resilience of water resources in the region.

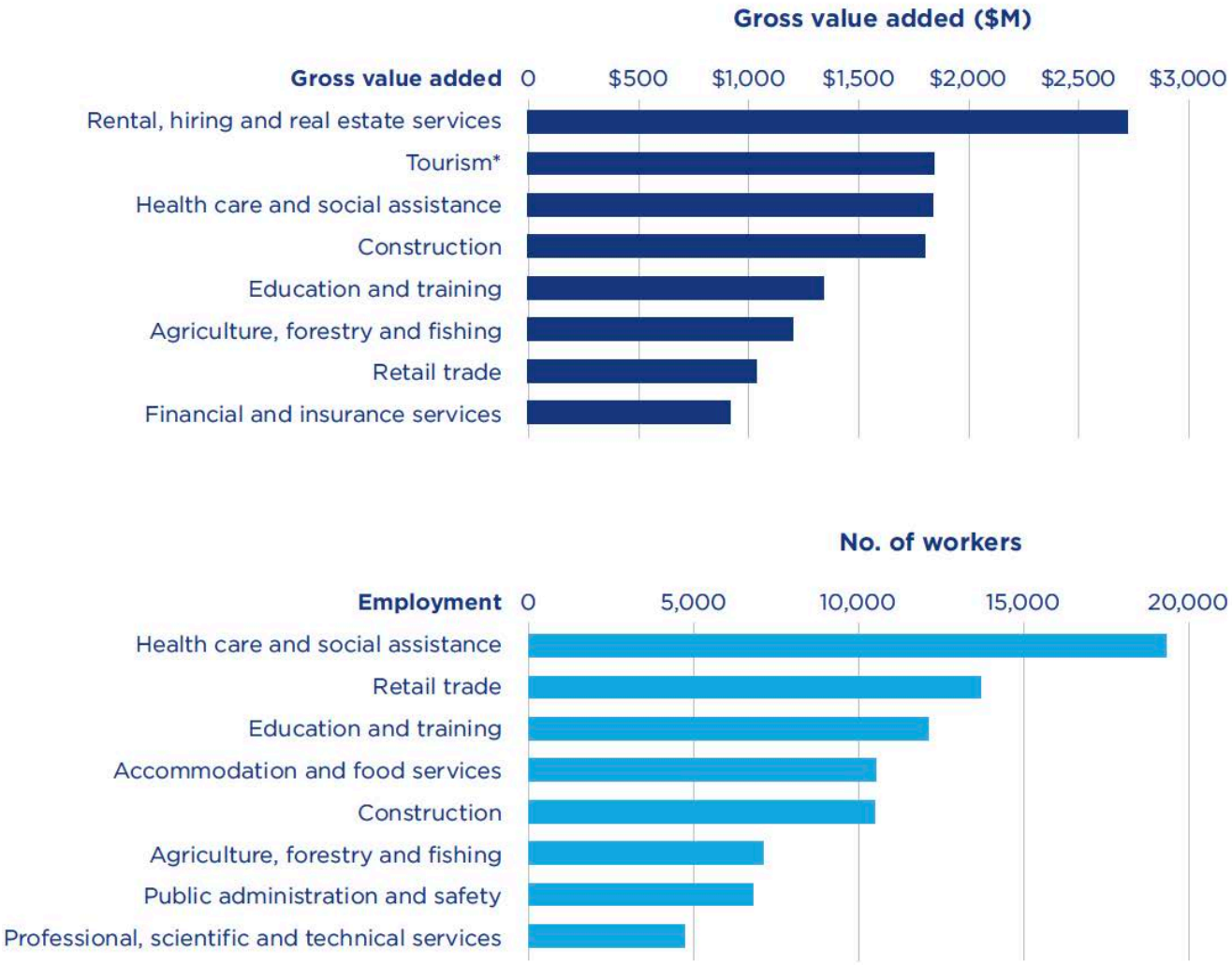
Water is a critical enabler of many businesses in the region. The region's water supplies not only support the local population but also important service industries (including food manufacturing) and retail trade, as well as small and large rural agricultural needs. Farmers, traditionally, have grown crops that are predominately rain-fed, although (as discussed previously) this is changing, with intensive horticulture becoming prominent.

Water also indirectly supports fishing, both commercial and recreational, the expanding aquaculture industry and tourism. It is also important to Aboriginal people, with some communities accessing water to support commercial businesses.

A note about the COVID-19 pandemic: While the COVID-19 pandemic will have an impact on regional communities and economies in the short term, we expect that population will continue to grow in the longer term, although changes to the projected growth rates are uncertain. We expect that demand for water will continue to rise in line with population increases, associated service industries and tourist demands.

186. REMPLAN 2019, *REMPLAN Economy: Custom data*, www.remplan.com.au/economy/
187. There are five Regional Economic Development Strategies relevant to the North Coast region: the Hastings Macleay, the Southern New England High Country, Nambucca, Coffs Coast and Clarence Valley.

Figure 21. Employment and economic outputs of key industries in the North Coast region (2017/18)



Notes: Figures for North Coast region including Armidale regional, Bellingen, Clarence Valley, Coffs Harbour, Kempsey, Nambucca, Port Macquarie Hastings, Walcha local government areas. Top eight industries shown only.

*'Tourism' is not a defined industry category, and indirect employment and contribution to gross value added cannot be calculated. Listed value is total spend on Tourism services as defined by REMPLAN.

Source: REMPLAN 2019, *REMPLAN Economy: Custom data*, www.remplan.com.au/economy/

Image courtesy of Destination NSW.

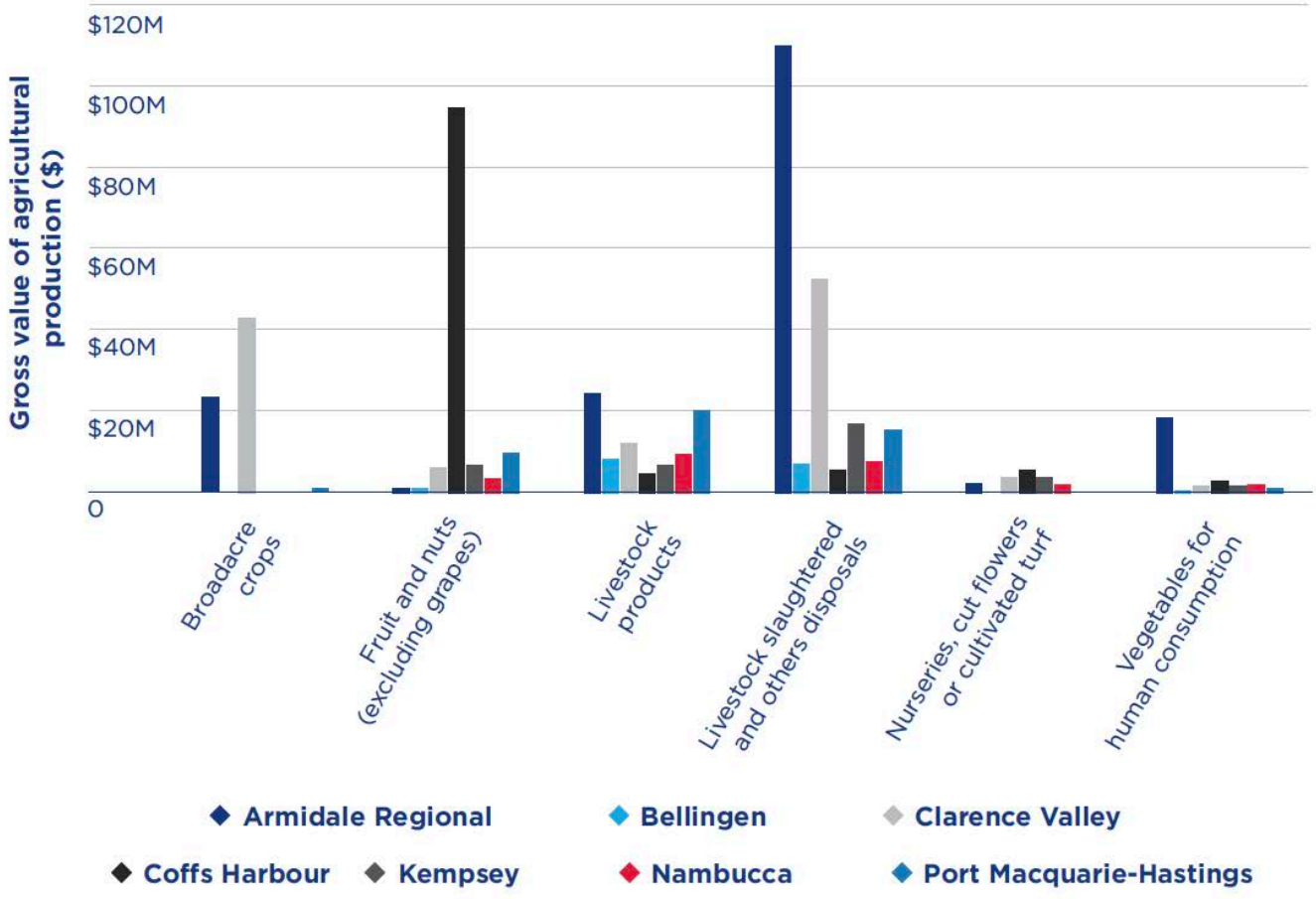
Agriculture

The region supports a diversity of agricultural enterprises that are vital to its economy. In 2017/18, the sector contributed around $1,208 million (7.2%) of regional output and employed around 2% of the regional workforce directly.[188] Agriculture in the tablelands and dry slopes is dominated by livestock grazing for meat and wool production; these activities combined are worth around $130 million each year[189] (Figure 22). Horticulture is also present, with the most significant activities being tomatoes in and around Guyra and avocados on the Comboyne Plateau. In the lowland and floodplain areas, agriculture includes beef and dairy farming, horticulture, nurseries and fodder crops. The value of horticulture is greatest in the Coffs Harbour area, while more traditional industries stemming from cattle and sheep farming are highest in the areas of Kempsey, Port Macquarie-Hastings, Nambucca and Bellingen. Sugarcane is grown in the floodplains of the Clarence River catchment. This industry is in decline, decreasing from over $40 million in 2015/16 to $26 million in 2018/19 due to factors such as decreasing international demand, competition from other markets (for example, the Burdekin region in Queensland) and shifts out of agriculture or to other industries such as beef.[190]

Over the last 20 years, agriculture in the region has undergone significant change, particularly within the region's iconic dairy and banana industries. In the early 1920s, the Comboyne Plateau had over 130 dairy farms but factors, including the deregulation of the milk industry and the movement of processing operations to Sydney and Melbourne, led to a significant decline in farms (as well as production). In 2019, there were only around ten dairy farms still operating in the area. Similar trends have been seen in other catchments, with most farms converting to grazing for beef production or horticulture (avocados). Banana crops, particularly in the Coffs Harbour area, have largely been replaced by intensive horticulture. This shift is due primarily to competition from a strong Queensland market and the allure of high value crops like blueberries. Around 90% of all Australian blueberries are now grown in NSW, with production centred on Coffs Harbour.[191] The farm gate sales from the local blueberry industry are estimated at $300 to $350 million annually[192] and in 2018/19 there were over 100 producing farms.

188. Based on 2016 data compiled by the Department of Planning, Industry and Environment
189. This is based on 2015/16 figures as local government area level data is not provided after this date.
190. The 2019 yield of sugarcane was also affected by frost and the ongoing drought of 2018/19.
191. www.madec.edu.au/blueberries-from-the-americas-to-australia-talk/ and www.australianblueberries.com.au/is-good/growing-regions/
192. www.freshplaza.com/article/9187563/australia-coffs-harbour-blueberries-have-critical-access-to-recycled-town-water/

Figure 22. Value of agricultural production by North Coast local government area



Source: 7503.0 - Value of Agricultural Commodities Produced, Australia, 2015/16[193]

193. 2015/16 was the last year data related to gross value was collected at the local government area level.

Agricultural water use

Irrigation is conducted on a small scale in the North Coast region, due to a combination of generally high, reliable rainfall and the type of crops. Approximately 1,500,000 ha (or 38%) of the North Coast region is used for agriculture—of this, less than 1% is irrigated.[194] Most crops are rain-fed, with irrigation from farm dams, unregulated creeks and shallow aquifers generally only occurring during dry months or extended dry periods. However, this reliance on in-crop rainfall and unregulated water supplies has made the region particularly susceptible to drought as there are very few storages to manage water shortages.

The crops with the greatest demand for irrigation water in the region are pasture and cereal crops (mainly for grazing) and fruit trees (including blueberries and avocados).[195] Irrigation generally occurs in the spring and summer months when crops flower and water is needed to ensure growth and yield formation.

Water for irrigation comes from numerous sources across the region: unregulated rivers, groundwater bores (alluvial and coastal sands, fractured and porous rock sources), licensed farm dams, harvestable rights dams[196] and reticulated town water supplies.

Surface water is predominately used for pasture (such as improved pasture for dairy) and cereal crops, and horticulture and permanent plantings such as tomatoes, cucumbers and berries. The amount of land irrigated on individual broadacre and dairy farms is small compared with the rest of the state (an average of 43 ha) and land irrigated for horticulture averages between five and 10 ha.

The use of coastal sands groundwater for agricultural purposes is minimal for most of the region. This is primarily due to the limited availability of agricultural land, large areas of national parks and nature reserves, the presence of groundwater dependent ecosystems and the presence of potential acid sulfate soils. The largest agricultural users of groundwater across the region are avocados and tea tree plantations. In the past, the Dorrigo Basalt groundwater source, which has excellent quality groundwater, has supported a water bottling industry. However, the location is considered too far away from major markets to make it profitable.

Surface water licences from unregulated rivers far exceed groundwater access (Figure 16 and Figure 17). Most surface water licence entitlements are small compared to those in inland regions and are typically less than 200 unit shares. In terms of groundwater, individual licence entitlements are even smaller (less than 100 unit shares).

The impact of the irrigation industry on the environment relates not so much to the total amount of water it extracts but to the timing of extraction.[197]

Limited data exists on water use patterns in the region. Water extraction from surface and groundwater sources is largely unmetered. Australian Bureau of Statistics and Australian Bureau of Agricultural and Resource Economics and Sciences collect water use information; however, these agencies rely on users supplying information, and will not cover all water users in the region. The Natural Resource Management regions used by the Australian Bureau of Statistics to collate data also do not

194. Adapted to the North Coast region using Australian Land Use Profile data, www.agriculture.gov.au/abares/aclump/land-use/catchment-scale-land-use-reports
195. Based on 2018/19 water use on Australian Farms for the Coffs Harbour-Grafton sub-area
196. Harvestable rights water may be used for any purpose, including irrigation; however, harvestable rights aim to satisfy basic farm needs only so are unlikely to support commercial irrigation.
197. Hope, M. 2003, *NSW North Coast Region Irrigation Profile*

align with the North Coast Regional Water Strategy boundary, making it difficult to make firm conclusions on water use by agriculture in the region.

In addition to water extraction from surface water and groundwater sources, landowners are also entitled to capture up to 10% of the rainfall runoff from their land under harvestable rights provisions. This water can be captured and stored in hillside gullies and small streams.[198] Coastal water users have requested that the NSW Government explore options that would allow them to take more water under their harvestable rights to support agricultural production (More details on the harvestable rights is provided in section 2.2.3).

Many producers in the region access water from the local council town water supply system. Most are small producers such as those in the lower Macleay, but there are also some large, regionally significant operations. Costa tomatoes in Guyra, one of Australia's largest glasshouses, use between 40% and 50% of Guyra's treated water supply annually.[199] Coffs Harbour City Council's recycled water system supplies around 4,500 ML of treated wastewater to blueberry, cucumber and tomato farms to the north of Coffs Harbour.[200] Key businesses, like Norco and Nestle, access town water for production of dairy products.

198. First or second order streams
199. www.armidaleexpress.com.au/story/6090449/council-to-sign-water-agreement-with-elm-street-tomato-farm/#:~:text=peak%20day%20requirements.-,As%20the%20tomato%20farm%20uses%2040%2D50%20per%20cent%20of,treated%20water%20from%20Guyra's%20system
200. This value assumes consumption of 13 ML/day all year round.

Future risks to water use by agriculture

The current climate of the North Coast region provides enough water for agricultural industries most of the time. Water users historically have relied on access to their licences during low rainfall periods, when competition for water can become a significant issue to the region's water sources. Producers in the region are highly dependent on rainfall and, with relatively small on-farm storages available, difficulties in accessing water can put agricultural production at risk. Horticultural industries and dairy farms where the investment is fixed are particularly susceptible to drought.

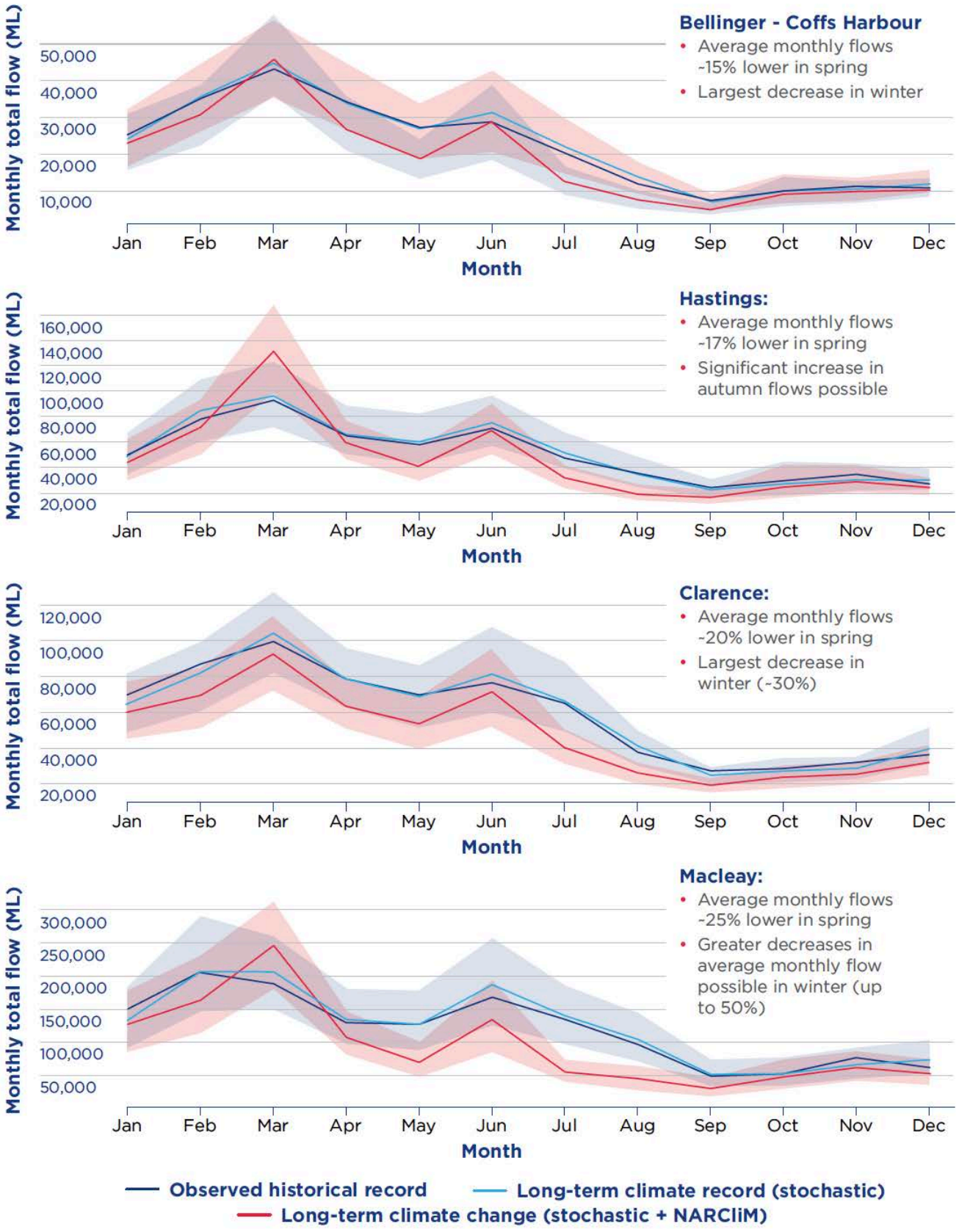
Future pressures on agriculture in the North Coast will be from a combination of factors. The continued shift in the type of agriculture conducted within the region is likely to see a surge in a more constant demand for water. Intensive horticulture as well as dairy businesses have fixed assets, unlike grazing where farmers can agist animals when conditions are dry.

Our new climate data suggests rainfall will be less for most months in the future, particularly over winter and autumn months. Combined with increases in potential evapotranspiration, this will mean users are more dependent on licensed extraction. Concurrently, lower rainfall will mean stream flows are also lower, with significant decreases likely in winter months for most catchments.

Competition between users during spring is likely to continue and potentially increase. Outputs from our new modelling show spring stream flow could be between 15% and 25% lower across the region (Figure 23). This will also place additional pressure on the environmental needs of these waterways.

Image courtesy of Regional NSW - Department of Primary Industry.

Figure 23. Monthly average flows for the Bellinger - Coffs Harbour, Hastings, Clarence and Macleay river catchments



An additional factor to consider for agriculture is sea level rise. As rising sea levels increase salinity levels across the region, irrigators ability to use parts of the river may be affected. Only a small proportion of users are within the current tidal pool, with the tidal limit extending at least 20 km upstream in all catchments. Even a small rise in sea level may jeopardise access to users immediately upstream.

Our understanding of the potential future risks to agriculture are constrained by an overall lack of data. As stated above, the collection of data in the region is ad hoc and there is a lack of consistency in the data that is collected. Recent advances in data analytics provide an opportunity to significantly grow the evidence base for decision making and to deploy more sophisticated compliance strategies to ensure water take is equitable and meets the long-term needs of the region. Such action will be critical in managing potential impacts from a changing climate.

We also need better information on the capacity and environmental needs of the region's rivers, creeks and groundwater sources. For example, we need to be confident that extraction limits protect the region's resources.

As a start, the Department of Regional NSW - Department of Primary Industry is undertaking a vulnerability assessment of the impact of climate change on the state's primary industries and the potential opportunities for these industries to adapt. These findings will be available in mid-2022 and will inform future water policy and actions.[201] The North Coast Regional Water Strategy provides an opportunity to build on this work and look at options that would support the region's industries to build resilience and mitigate the impact of these climate risks.

201. The study includes the five primary industries of extensive livestock, broadacre and irrigated crops, horticulture and viticulture, forestry and fisheries.

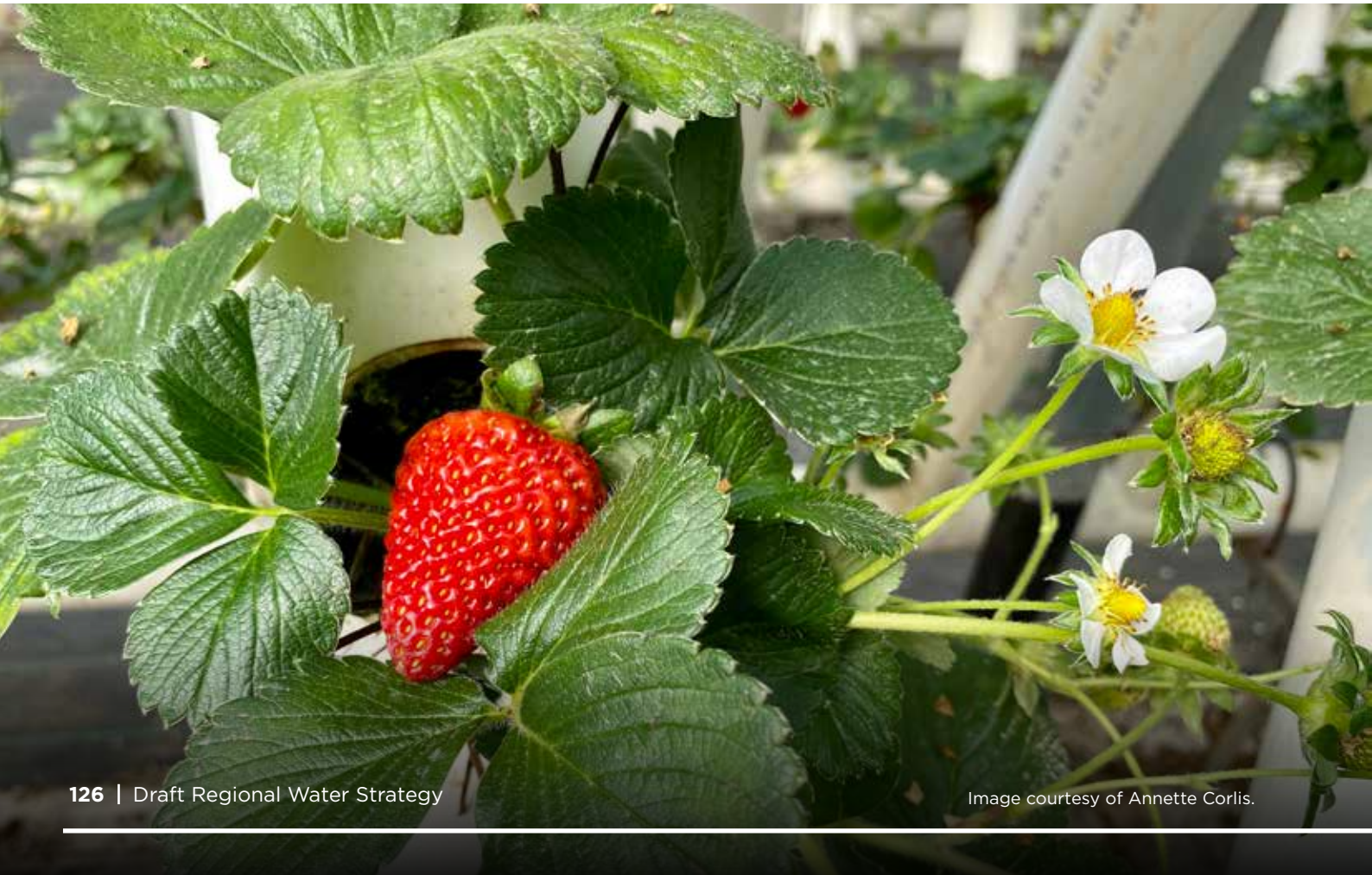


Image courtesy of Annette Corlis.

Image courtesy of Destination NSW.

Fishing and aquaculture

In 2018/2019, the Gross Value Added of the commercial estuarine wild harvest for the North Coast was $9.6 million, generated predominately from businesses in the Clarence, Kempsey and Port Macquarie local government areas. The total landed catch[202] was 1,127 tons and included sea mullet, school prawns and male and female mud crabs. For that same period, Sydney Rock Oyster production from the Nambucca River, Macleay River, Hastings River and Camden Haven had a gross value of production of nearly $7 million.[203] Both industries have flow on economic benefits—for the commercial fishing industry in 2010, these benefits were an estimated $216 million.[204]

Water management and land use practices in the catchment will affect these industries. For example, rainfall and freshwater inflows to the estuary are important cues in the lifecycle for freshwater prawns, facilitating downstream migration, gonad maturation and spawning.

Aquaculture is particularly vulnerable to poor water quality. All harvest areas must meet strict water quality standards, otherwise the area is closed and the oysters cannot be harvested. The disturbance of acid sulfate soils, as well as diffuse sources of pollution (including increased nutrient loads, turbidity and bacterial contamination) from urban and rural runoff are high risks to Sydney Rock Oyster businesses across the region.[205]

Many of the actions being implemented under the *NSW Marine Estate Management Strategy* and coastal management program will help to reduce water quality impacts from land use practices on these industries. The North Coast Regional Water Strategy also has a role to play in supporting long-term planning to support healthy waterways and investigating methods to increase the depository of water data available to decision makers.

202. Landed catch is the total catch brought to shore. It does not include discards that are thrown away at sea.
203. Department of Primary Industries 2020, *Aquaculture Production Report 2018-2019*
204. UTS 2000, *Valuing coastal fisheries—social and economic evaluation of NSW Coastal Professional Wild Catch Fisheries—Recreational and professional fishing: friend or foe?*, www.frdc.com.au/project?id=3016
The estimate includes Clarence, Coffs Harbour and Ballina (in the Far North Coast region)
205. Lawrence, A. 2012, *Hastings River Oyster Farmers Environmental Management System*, Nambucca River Oyster Farmers 2014, *Environmental Management System: A voluntary, industry-driven, environmental initiative*, Macleay River Oyster Farmers 2014, *Environmental Management System: A voluntary, industry-driven environmental initiative*

Tourism and recreation

The North Coast, along with the Far North Coast, is one of the most popular destinations in Australia. The region's natural beauty and vibrant regional centres attract on average five million visitors annually. Most of this visitation is from domestic travel. In 2019, tourist expenditure in the region amounted to about $1,800 million and employed nearly 10,000 people. Coffs Harbour and Port Macquarie local government areas were the most popular destinations based on both expenditure and contribution to employment.

Tourist attractions and events that rely on a healthy environment and water availability include:

- nationally significant wetlands and freshwater lakes
- national parks, including the Gondwana Rainforest World Heritage Area and Oxley Wild Rivers National Park
- nature-based attractions including the Koala Hospital and Billabong Zoo
- monthly community and produce markets that showcase the region's local produce and artisan products
- local festivals including the Slim Dusty Country Music Festival (Kempsey), the Bello Winter Music Festival (Bellingen), Blues and Berries (Woolgoolga), Hello Koalas Festival Treasure Hunt (Port Macquarie) and the Grafton Jacaranda Festival.

Developing nature-based experiences is a key focus of the NSW Government's current planning to support growth in tourism.[206] Nature has close links to the other experiences considered unique and attractive to the region's tourism market—camping and caravan holidays, food and local produce, arts, heritage and Aboriginal culture, events, health and wellbeing, and business events. Ensuring water is managed to support a healthy riverine and coastal environment is critical to supporting this key engine of growth for the region.

However, the region's tourist popularity can create challenges, including increasing pressure on local infrastructure—roads, water supply and wastewater services. Demands on water and wastewater services during tourist periods can be higher, but are largely unknown.

Tourism in the region, like the rest of Australia, has been impacted by the COVID-19 pandemic. However, with travel to and from Australia suspended (or severely limited) for the foreseeable future, and travel within Australia slowly opening up, there is the potential for a domestic-led recovery. This is positive for tourism across the North Coast region, which already relies mainly on domestic travel. In 2020, the NSW Government provided funding to seven of the region's annual events, acknowledging the importance of these events in attracting tourists to the North Coast and recognising the pandemic's economic impact on these events.[207]

206. dncnsw.com/resources/
207. This funding was awarded through the NSW Government's $1 million 2020 Regional Event Fund, www.destinationnsw.com.au/news-and-media/media-releases/59-regional-events-receive-government-funding-to-boost-local-tourism-economies

Image courtesy of Simon Hughes, Destination NSW.

Image courtesy of Jaime Plaza Van Roon, Department of Planning, Industry and Environment.

Forestry

Many parts of the North Coast were founded on the back of logging and forestry. Forestry plantations account for around 1.2% of the total land area and are estimated to intercept between 0.2 and 0.8% of total runoff in the region.[208] When large enough, forestry plantations can intercept significant quantities of surface runoff and can impact downstream water availability. The volume of water intercepted by forestry plantations in the North Coast is not large enough to be included within the long-term annual extraction limits of the relevant water sharing plans.

Plantations across the North Coast were badly affected by the 2019 bushfires, with over a third of the pine plantations near Grafton and Walcha destroyed. The NSW Government has invested $46 million to help replanting efforts.[209] This includes the $1 million expansion of the Forestry Corporation's Grafton Production Nursery, which will enable the nursery to double production—producing four million pine and eucalyptus seedlings to replant state forests across the North Coast.

The plantation forestry sector in the North Coast region is not expected to expand in the near future. Water use by the new planting is likely to be less initially (during plant establishment), but increase as the trees go through their rapid growth phase. Plantations are continually monitored and assessed under the *Plantations and Reafforestation Act 1999* to determine if water management changes are needed to account for any increase in water interception.

Forestry activities (timber harvesting as well as road construction) can increase soil erosion and contribute to poor in-stream water quality and macrophyte cover.[210] Sub-catchments of the Macleay River with large extents of forestry are recorded to have fair to poor water quality and fair to very poor macrophyte populations and diversity.[211] However, these results have not been clearly linked to a particular activity in the catchment.

Improving water quality in coastal catchments is a key management action of the *Marine Estate Management Strategy*. The regional water strategy can support these actions through options that improve the collection and storage of water data available for the North Coast and that help identify linkages between poor land use practices and water quality.

208. Data is available for the Clarence (0.8%), Macleay (0.2%), Bellinger (0.3%) and Hastings (0.3%) Rivers from Sinclair Knight Merz, CSIRO and Bureau of Rural Sciences 2010, Surface and/or groundwater interception activities: initial estimates, National Water Commission, Canberra.
209. NSW Government to regrow forestry industry following catastrophic bushfires www.dpi.nsw.gov.au/about-us/media-centre/releases
210. Webb and Haywood 2005 as quoted in Webb et al. 2007, *Effects of plantation forest harvesting on water quality and quantity: Canobolas State Forest*, NSW, Proceedings of the 5th Australian Stream Management Conference. Australian rivers: making a difference, Charles Sturt University, Thurgoona, New South Wales
211. Ryder, D., Mika, S., Vincent, B., Burns, A. and Schmidt, J. 2016, *Macleay Ecohealth Project 2015-2016: Assessment of River and Estuarine Condition, Final Technical Report*, University of New England, Armidale

Emerging industries in the North Coast

The region's natural assets are also likely to support a resurgence of past industry operations, particularly pumped hydro-electric power generation (pumped hydro) and mining. Both of these industries will need access to the region's water resources.

Renewable energy

The NSW Government considers pumped hydro as critical to supporting an integrated approach to meeting future energy needs[212] and has identified the New England area (particularly east of Armidale in the unregulated surface water sources of the Macleay River catchment) as one of NSW's Renewable Energy Zones.

The NSW Government and the Australian Government have put measures in place to support private sector investment in pumped hydro. In 2018, the NSW Government produced the Pumped Hydro Roadmap, which included a NSW Pumped Hydro Opportunity Map that identified multiple opportunities for pumped hydro around Armidale.

In October 2020, the NSW Government declared the Oven Mountain Pumped Hydro Energy Storage project as Critical State Significant Infrastructure. The proposed project is a 600 MW development located between Armidale and Kempsey. It is an off-river system, with two reserves and a total capacity of 6 GL. Being 'off-river' means that once filled, the project will have only a small annual water demand to manage system losses (primarily evapotranspiration). The project proposal also suggests the storages could be used to provide water for fire-fighting and town water security to Kempsey.

In addition, UPC Renewables are in the planning and development phase for another scheme, located 30 km south of Armidale. The system will have an installed capacity of 400 MW with eight hours of storage (or 3,200 MWh). The bottom reservoir has a capacity of 3,200 ML, requiring an initial fill of approximately 50 ML/day.

In November 2020, the NSW Government released the NSW Electricity Infrastructure Roadmap which sets out a plan to build a modern electricity grid at lowest cost and in places that work for regional and rural communities. The roadmap will drive an estimated $32 billion in private investment to 2030 and support an estimated 6,300 construction jobs and 2,800 ongoing jobs, mostly in regional NSW in 2030.

Under the roadmap, the NSW Government has established the $50 million Pumped Hydro Recoverable Grants Program to accelerate the development of pumped hydro energy storage projects in the state. The program will hold an open tender of recoverable grants to establish a three gigawatt pipeline of 'shovel ready' pumped hydro projects. The grants will help prospective projects meet the significant upfront costs of undertaking early-stage planning and development activities, with the funds ultimately recoverable by the NSW Government once a project has reached financial close or the development rights have been sold.[213]

Although the development of these projects will occur independently of the North Coast Regional Water Strategy, each could have implications for the future water security of regional towns, communities and industries in the region and the health of the environment—implications that need to be considered when developing the strategy.

212. www.energy.nsw.gov.au/media/1546/download
213. Another key action in the Roadmap is the establishment of an Electricity Infrastructure Investment Safeguard Scheme to drive investment in new generation, long duration storage and firming capacity (such as pumped hydro). More information is available at www.energy.nsw.gov.au/government-and-regulation/electricity-infrastructure-roadmap

Mining and resources

The North Coast region has a long history of mining. The Macleay River catchment is endowed with elevated concentrations of metals such as gold, arsenic and antimony. These deposits are concentrated in the Hillgrove region and were first mined 140 years ago. Mining in the Clarence River valley dates back to a similar time, with towns such as Cangai (copper), Nymboida (coal), and Lionsville (gold) founded on mining exploration.

Presently, there is only one mining operation active in the region. In December 2020, the Hillgrove Gold Mine restarted production after closing in 2015. There are at least four companies currently considering future exploration (gold, antimony, cobalt and copper).

Mining requires access to water through the entire life-cycle. Volume requirements are often small; however, they need to be reliable. Mining processes also do not need high quality water. Should these industries develop further, the regional water strategies provide an opportunity to explore options such as supplying fit-for-purpose water and supporting innovation in water reuse for the mining industry.

Historic mining practices, particularly from the Hillgrove area, resulted in mineral waste entering the streambed sediments of the Macleay River and some of its tributaries. These in-stream sediments contain arsenic and antimony and were identified as a dominant source of contamination in one of the Macleay catchment's main tributaries, Bakers Creek.[214] The upper Macleay catchment is highly mineralised, and inputs of both arsenic and antimony also occur from natural processes.

There are ongoing concerns about water quality in the region, from the upper reaches of the Macleay River catchment to the coastal floodplains, and the associated impacts on town water quality and industries such as aquaculture. Remediation planning of some point sources has commenced, however it is unlikely that in-stream material will be remediated due to feasibility (terrain), potential collateral environmental impacts and extremely high cost.

These water quality impacts are exceptional and stem from a period when standards and regulations did not exist. The potential environmental impacts from all phases of mining operations are now better controlled through legislation, regulation, standards and statutory approvals processes.

214. Department of Industry 2016, *Derelict Mines—Macleay Catchment: Arsenic and Antinomy Assessment Stages 2 and 2a, October 2016*

Image courtesy of Destination NSW.

Chapter 3

Options for the North Coast Regional Water Strategy

Image courtesy of Destination NSW.

Snapshot

We have developed a long list of options that could be included in the final North Coast Regional Water Strategy.

- To identify these options, we have drawn ideas from previous studies, experiences of past droughts, consultation with local councils, and government reforms and programs.
- Each option is expected to address at least one of the objectives set for the regional water strategies.
- The options aim to contribute to achieving our vision of having healthy and resilient water resources for a liveable and prosperous North Coast region.
- The options are not listed in a particular order, nor prioritised.

The options we are considering aim to tackle the challenges facing the North Coast region and maximise opportunities arising from regional growth and investment.

Options in the current long list focus on:

- **maintaining and diversifying water supplies**, including augmentation of the Clarence-Coffs Harbour *Regional Water Supply Scheme*, increasing on-farm storage and introducing climate-independent water sources such as desalination, and wastewater reuse
- **protecting and enhancing natural systems**, including ensuring limits on extraction are sustainable and based on the protection of key environmental assets, long-term planning to guide waterway management and on-ground works to improve fish passage
- **supporting water use efficiency and conservation**, including capacity building programs, water market reviews and improved data collection.

In addition to the three key focus areas identified above, the final long list of options will also include a focus on **improving the recognition of Aboriginal people's water rights, interests and access to water**. These options will be developed following further face-to-face engagement with Aboriginal communities in the North Coast region (which has been delayed due to the COVID-19 pandemic).

In each of these areas, we are open to exploring fresh ideas and innovative solutions that will add value to regional industries, leverage new investments and support new economic, employment and environmental opportunities.

Not all options will be progressed.

- Inevitably, these options will involve trade-offs and choices. To fully understand the impacts, trade-offs and synergies, we will seek feedback on these options before undertaking a formal assessment process.
- The assessment process will look at the positive and negative effects of the option, its cost efficiency, how widely its benefits are likely to be distributed and its feasibility. Not all the regional water strategies objectives can be quantified. When the outcome is difficult to assess in a financial context, options will be assessed on how effective they are in terms of achieving objectives, rather than on a cost basis.
- Preferred options, and packages of options delivered together, will be informed by a range of evidence including modelling, expert judgement and community input. These will form the final, comprehensive North Coast Regional Water Strategy.

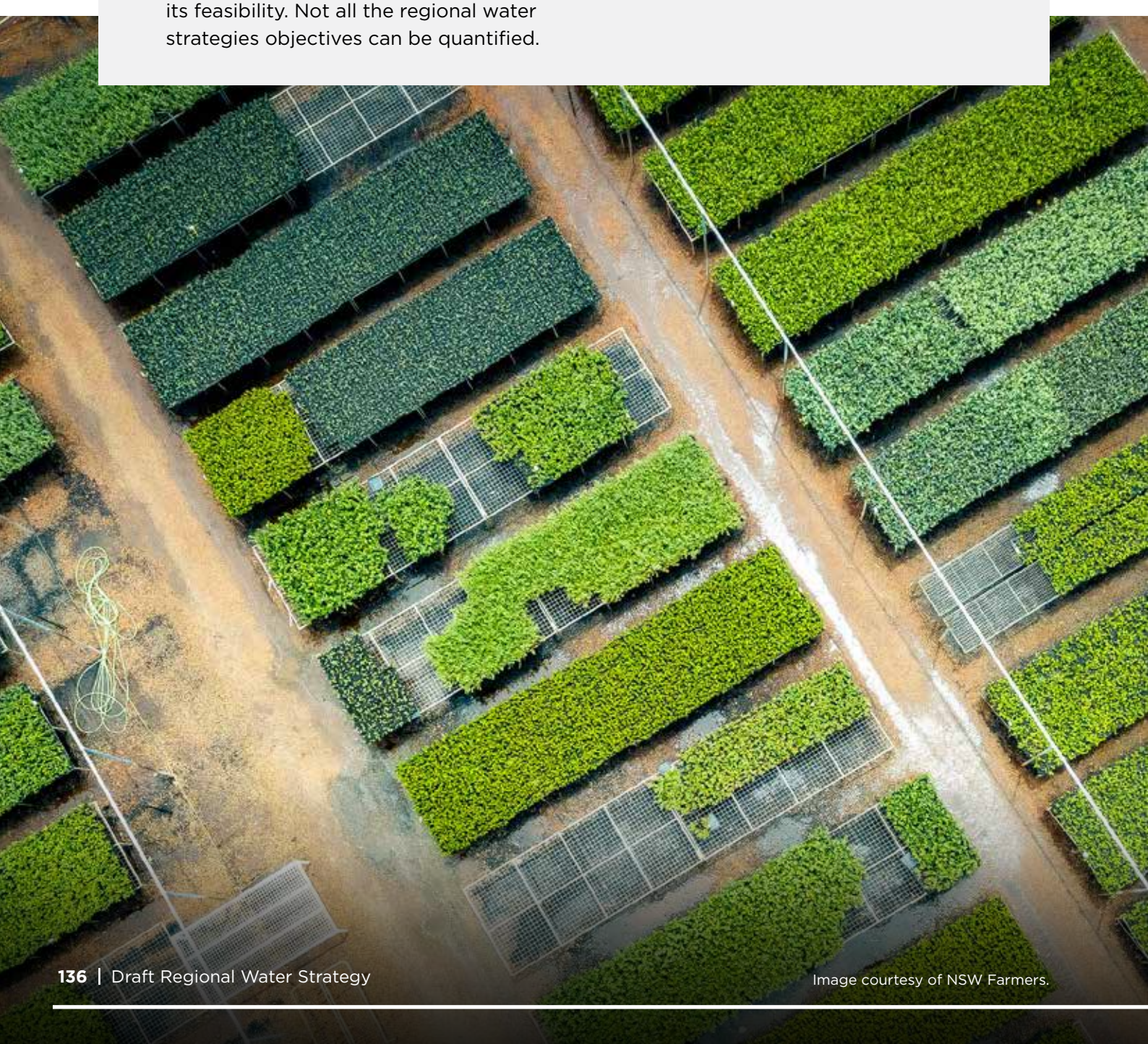


Image courtesy of NSW Farmers.

3.1 Our vision for the North Coast Regional Water Strategy

The current challenges in the North Coast region stem from competition for water during drier, low-flow periods, a shift in industry demand for water from predominately rain-fed crops, limited options for inter-connections across catchments and a paucity of data to properly understand the impact of current practices on the region's environment. Future climate conditions—changing rainfall patterns, higher evapotranspiration, potentially longer dry periods and more intense storms—are likely to further exacerbate these challenges. Although we can't change the region's climate or the basic hydrology of our river and groundwater systems, we can deliver better outcomes for the region by changing:

- infrastructure in the region, such as local council storages, licensed and harvestable rights farm dams, weirs, pumps, pipes and channels
- how we manage the water system, such as water sharing arrangements, allocations, cease-to-take conditions and flood mitigation
- how we support best practice water use and water user behaviour
- how we manage our catchments and waterways
- any combination of the above four options.

We have identified policy, planning, regulatory, educational, technology and infrastructure options that address the challenges the region may face and maximise opportunities arising from growing regional centres, emerging and expanding industries and new investments in transport and community infrastructure.

Our vision for the strategy

Our vision for the strategy is to support the delivery of healthy, reliable and resilient water resources for a liveable and prosperous North Coast region. To achieve this, we need to position the region so there is the right amount of water of the right quality delivered in the right way for people, Aboriginal communities, towns, industries and the environment.

3.2 Identifying and developing the options

We have developed a long list of options that could be included in the final North Coast Regional Water Strategy. In preparing this list, we recognise previous work that has been done over the last few years to identify initiatives that could improve water management and water security in the region. We have collated these initiatives and supplemented them with further actions based on feedback from local councils, joint organisations, Aboriginal communities and government agencies. The public consultation process and further engagement with Aboriginal people will provide another opportunity to identify options and seek feedback on the long list of options. Bringing all of these options together will help us to align and better sequence the various water reform processes as we develop the strategy.

In developing the list of options for the North Coast region, we have specifically considered the following:

- Each option is expected to address at least one of the regional water strategy objectives (see Figure 4 in Chapter 1). Some options will support multiple objectives. Other options may have positive benefits for one objective while having negative impacts for another objective. We do not have all of the information at the moment to understand these impacts. We will do further work to understand these impacts and seek your views on how each option may impact you and your values.

- While considering a range of options to maintain and improve the resilience of the region's water resources in the face of a variable and changing climate, we have also included options that take the next step in identifying innovative water solutions that will add value to existing industries, create opportunities for new industries and generate greater benefits that extend across the community.

- As discussed in section 1.3.1, the NSW Government has invested in new climate datasets and improved modelling to gain a more accurate understanding of future climatic conditions in the North Coast region. A number of options in the long list propose reviews of existing policy settings, operational rules and management plans considering this new data.

- As discussed in section 1.3.2, we have drawn on a range of sources to develop the options, including existing studies, past experience (such as water management during the summer of 2019/20), engagement with local councils and current NSW Government initiatives and programs. This process acknowledges the significant amount of thought and work already directed towards addressing the region's water-related challenges. More information about these sources is in the *Regional Water Strategies Guide*.

- We have had conversations with local councils to understand their views on what options could be considered in the North Coast Regional Water Strategy to improve water security and quality for towns and communities (see section 1.3.3).

- We have sought expert advice from government agencies.
- As discussed in section 1.3.3, face-to-face engagement with Aboriginal communities on the North Coast region was delayed due to the COVID-19 pandemic. Rather than including potential options in the current long list before this consultation has taken place, we are committed to ensuring that options with a primary focus on Aboriginal people's water rights, interests and access to water are developed through further face-to-face engagement with Aboriginal communities. This will enable us to address some of the specific requests of the communities, including engaging with Aboriginal communities in the upper and lower sections of the Clarence separately. This will also ensure that we include the extensive knowledge of our Traditional Owners in water management decisions. Example options developed as a result of our state-wide consultations include reviewing cultural water access licences and ensuring greater involvement of Aboriginal people in water management.

We have not ordered or prioritised the options identified for the North Coast long list of options and many options on the list have not been costed.

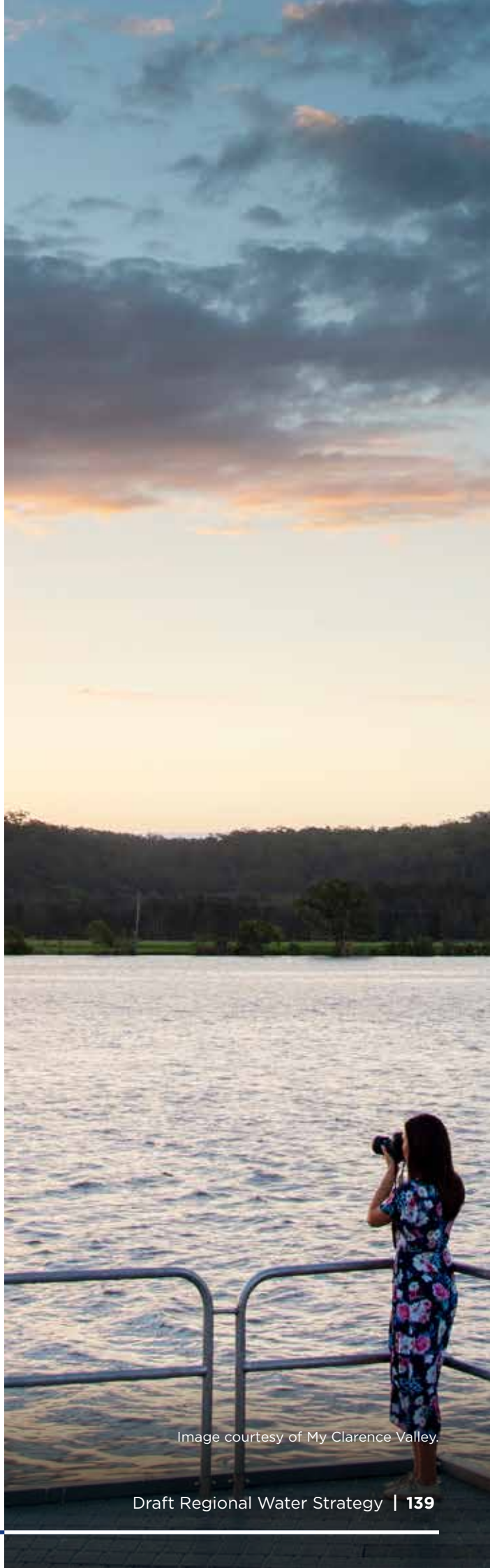


Image courtesy of My Clarence Valley.

3.3 Which options will be progressed?

Not all options in the long list will be progressed. Only feasible options will be progressed following an assessment process.

Inevitably, these options—and their priority in the North Coast Regional Water Strategy—will involve trade-offs and choices. To understand the impacts and trade-offs we will first seek your feedback on these options and then use a formal options assessment process which will look at:

- **Effect**
  To what extent are the options expected to contribute to, or otherwise impact on, the objectives over the planning horizon and/or during extreme events?

- **Impacts and magnitudes of impacts**
  A risk assessment of the positive or negative impact of the option on the objectives, and the magnitude and frequency of these impacts.

- **Cost efficiency**
  To what extent are the options likely to deliver cost effective outcomes?

- **Distribution of benefit**
  Is there likely to be a broader public or regional benefit from the option, or is the benefit concentrated to a small number of users?

- **Feasibility**
  To what extent is the option likely to be feasible, including regulatory/policy change, stakeholder acceptance, time to implement, cost, alignment with government policy (national and international) and technical feasibility?

Further information on this process is in the *Regional Water Strategies Guide.*

It is unlikely that a single option will be capable of addressing all of the identified risks across the objectives we have set for the strategy. The greatest benefits are likely to be realised by combining options (or packaging them) so that they complement each other to improve the efficiency of the system, offset impacts or unlock greater benefits by using the different levers that are available—such as policy and infrastructure levers.

For example, infrastructure options may improve water reliability for industries and water security for towns but could have negative environmental impacts. To mitigate these impacts, and increase the benefit of the projects, infrastructure projects could be combined with:

- environmental options that could mitigate the impacts of the infrastructure on native fish species and environmental assets, such as wetlands and estuaries

- demand management measures to make sure industries are operating as efficiently as possible

- policy and regulatory options that review whether the water sharing arrangements under altered conditions are appropriate.

However, combining some of the options might mean that other options cannot be pursued. At present, we do not have enough information to understand the trade-offs between options or combinations of options that are described in Table 9.

As development of the strategy progresses, preferred options and combinations of options—and their trade-offs—will be informed by multiple lines of evidence including modelling, expert judgement and community input. In particular, as discussed in section 1.3.1, the NSW Government has invested in new modelling to gain a more accurate understanding of future climatic conditions in the North Coast region. This new data, along with economic analysis, will be used to understand the pros and cons of each option and the impact of various combinations of options in addressing the key challenges facing the region.

It is important to remember that the way we progress options will need to take account of the *Water Management Act 2000*.

Image courtesy of Annette Corlis.

3.4 North Coast: Long list of options

Table 9 summarises the long list of options we have identified for the draft North Coast Regional Water Strategy. Detailed information about each option, the challenges it will address, its potential combination with other options and further work required to progress the option is set out in the *North Coast: Long list of options.*

The current long list of options focuses on:

1. **maintaining and diversifying water supplies**
2. **protecting and enhancing natural systems**
3. **supporting water use and delivery efficiency and conservation.**

Concentrating on the five regional water strategy objectives will enable us to address the challenges facing the North Coast region, while maximising opportunities for regional communities and industries, and supporting their aspirations.

We have heard from communities that the regional water strategies should not just focus on the risks and challenges of today. This is why our current long list of options not only focuses on the issues identified in Chapter 2, but also includes a number of options that may become important in future decades.

These options need to be supported by comprehensive and robust data and information and the right tools and infrastructure to implement change in the future.

However, this means that some of our draft long list options are still in a conceptual state. We need to continuously work with communities, environmental managers, Aboriginal peak bodies, Aboriginal people and industries to develop and refine these ideas further.

As noted previously, the options included in Table 9 are not ordered or prioritised and many have not been costed.

Regional water strategy: objectives

Deliver and manage water for local communities
Improve water security, water quality and flood management for regional towns and communities.

Enable economic prosperity
Improve water access reliability for regional industries.

Recognise and protect Aboriginal water rights, interests and access to water
Including Aboriginal heritage assets.

Protect and enhance the environment
Improve the health and integrity of environmental systems and assets, including by improving water quality.

Affordability
Identify least cost policy and infrastructure options.

Table 9. Long list of options: summary

Option	Description	Objective
Maintaining and diversifying water supplies—*Opportunities to improve town water security, maintain suitable water quality and support growth and jobs in the region*		
1. Expand the Clarence-Coffs Harbour *Regional Water Supply Scheme*	Investigate the potential benefits of connecting Bellingen Shire Council and Nambucca Valley Council to the Clarence-Coffs Harbour *Regional Water Supply Scheme*.	
2. Portable desalination	Investigate the deployment of temporary desalination plants as an emergency drought response for extreme conditions. By planning in advance, the units can be built quickly if and when needed, and they would be removed when no longer required. This option would also consider permanent decentralised units.	
3. Emergency water supply provided by new pumped hydro storage projects	Investigate the opportunity to use water stored by future pumped hydro-electric projects in the region for firefighting and emergency town water supply. **The Oven Mountain Pumped Hydro Energy Storage project has recently been declared Critical State Significant Infrastructure. The project proposal notes the opportunity to provide town water security to Kempsey and water for firefighting.**	
4. Augment Shannon Creek Dam	Augment Shannon Creek Dam up to its designed maximum capacity of 72 GL to provide additional town water security for the Clarence and Coffs Harbour LGA through the Clarence-Coffs Harbour *Regional Water Supply Scheme*.	
5. Upgrade major town water treatment facilities	Upgrade major town water treatment plants across the region to reduce water quality and water security risks and to provide operational flexibility for local councils in the North Coast.	
6. Repurpose existing assets to provide emergency storage for local industries	Investigate the opportunity to repurpose decommissioned local storages and groundwater bores to provide improved water security to towns and/or industries.	
7. Vulnerability of surface water supplies to sea level rise and saline intrusion	Identify and quantify the risks to the region's surface water supplies due to sea level rise. This option would build on hydrodynamic modelling completed under the *Marine Estate Management Strategy* to assess the risks of sea level rise on tidal pool and estuarine water users as well as local council water and sewerage infrastructure.	
8. New industry and rural licence category within major council storages	Introduce a new industry and rural licence for non-urban water extraction from town water supply systems. This option would assist in providing clarity and transparency on water take by existing rural customers, and potentially allow councils to be bulk water sellers to new entrants such as intensive horticulture.	

Option	Description	Objective
9. Protecting coastal groundwater resources for town water supplies and rural water users	Coastal sands can be a ready source of groundwater during droughts for both town water supply and rural water users. This option would take a proactive approach to protecting these resources and ensuring adequate groundwater access and sustainable use during times of low surface water availability. Activities could include collecting more information and creating up-to-date maps, installing monitoring bores near towns at high risk, addressing policy gaps and considering the viability of a groundwater supply network that feeds into local water utility infrastructure during drought.	
10. Remove impediments to water reuse projects	Recycled wastewater is already being used for a broad range of applications across the region, with many councils considering new opportunities for use. However, there are barriers to the implementation of reuse projects and the greater adoption of recycled wastewater. This option would review impediments to water reuse projects in the region, including cost, community acceptance and regulatory and administrative requirements.	
11. Increase use of recycled wastewater for intensive horticulture	Investigate opportunities for the region's wastewater treatment plants to meet current and future demands from intensive horticulture. Potential locations for new or expanded reuse schemes include the local government areas of Coffs Harbour, Clarence Valley, Kempsey and Armidale.	
12. Indirect potable reuse of purified recycled water	Investigate the opportunity to discharge highly purified recycled water into existing council storages to reduce council demand on river and groundwater extraction.	
13. Direct potable reuse of purified recycled water	Investigate the injection of highly purified recycled water directly into the potable water supply network. This option is likely to include a pilot project that will help provide a better understanding of the technical, economic and social factors important to adoption.	
14. Increased harvestable rights	Increase the proportion of rainfall that can be captured as a harvestable right. A review of harvestable rights is currently underway and is considering the effects of increased harvestable rights and of allowing dams to be built on larger tributaries within NSW catchments that drain to the coast. It aims to determine if greater access to water for agricultural production could be allowed, while ensuring enough water is available for downstream water users and the environment. **A review of harvestable rights for all coastal draining catchments is an existing NSW Government commitment. In December 2020, the Department of Planning, Industry and Environment published a discussion paper and detailed supporting information of the potential benefits and impacts of increasing the harvestable rights percentage, as well as allowing harvestable rights dams on third order streams. Public consultation, including a submission period, on the paper is scheduled for early 2021.**	

Option	Description	Objective
15. Increased on-farm water storage	Assess the hurdles to constructing on-farm storages, the value of on-farm storages to industry and the regional water security benefits of greater on-farm storage uptake compared with other water storage options. The options would also consider the risks to downstream water users and the environment from an increase in on-farm dams.	
Protecting and enhancing natural systems—*Opportunities to protect and enhance environmental outcomes and realise broader community benefits through a healthy environment*		
16. Establish sustainable extraction limits for North Coast surface water and groundwater sources	Review the existing long-term average annual extraction limits for surface water and groundwater sources to ensure they are sustainable, are based on best available science and protect ecological, economic, social and cultural water needs. The review would also investigate methods for defining end of system flows to protect the ecological needs of coastal lagoons, estuaries and wetlands. This option is likely to include the review of existing rules governing extraction, such as cease-to-take and cease-to-flow conditions.	
17. Convert low-flow water access licences to high-flow water access licences	Review the barriers to, and opportunities for, the conversion of low-flow to high-flow class access licences in North Coast surface water sources to reduce competition for water during low-flow periods.	
18. Long-term water plans to support healthy coastal waterways	Develop a long-term water plan to sustain and improve the health of priority environmental assets, ecosystem functions and key species across the North Coast. The plan will build on the experience gained from inland regional NSW long-term water plans.	
19. Characterising coastal groundwater resources	Good groundwater management is underpinned by area-specific knowledge of groundwater resources. This option would invest in the characterisation of coastal groundwater resources in the North Coast region (including the coastal sands, floodplain and upriver alluvials, and porous and fractured rock groundwater sources). The groundwater resources for these areas would be characterised through extensive field investigations, expansion of the existing monitoring network, metering of all forms of groundwater take, development of conceptual and numerical groundwater flow and transport models, and publishing of annual resource updates.	
20. Protecting ecosystems that depend on coastal groundwater resources	A critical but often overlooked element of the water cycle is groundwater and groundwater dependent ecosystems (GDEs). GDEs support a range of species and provide important ecosystem services such as habitats. They also have inherent environmental value. Under this option, a range of projects would be initiated to advance our knowledge and management of GDEs.	

Option	Description	Objective
21. Improve stormwater management	Identify and investigate potential locations for precinct-scale stormwater harvesting and reuse projects in new urban developments to improve urban stormwater quality and reduce impacts on waterways within towns and regional centres. The option would adopt the principles of water sensitive urban design and also consider the potential social benefits of stormwater harvesting, such as improved amenity, reduced urban heat island impacts and higher property values.	
22. Bringing back riverine and estuarine habitats and threatened species	A new *Bringing Back Threatened Species* program to restore riparian and wetland habitats by protecting and enhancing priority areas using best practice management. This program would improve the condition, connectivity and resilience of habitat and landscape that has suffered a serious decline in quality and quantity due to land use activities since European settlement. The program would also build skills and share the knowledge of local landholders, community groups and Aboriginal people.	
23. Fish-friendly water extraction	Native fish can be inadvertently extracted by pumps and are then unable to return to the river system. This option would require the installation of screens on pumps to reduce the amount of fish being extracted at pump sites. The *Screens for Streams* program will partner extractive water users with scientists and engineers to reduce native fish mortality. This collaborative program will target high priority reaches or installations in the North Coast region.	
24. Improve fish passage in the North Coast region	Barriers to fish passage are a major contributor to the decline of native fish species. This option would replace or remediate four high priority barriers in the North Coast region in accordance with the *NSW Fish Passage Strategy*. This will improve recruitment, distribution, growth and survivorship for native and threatened fish species. The outcomes of fish passage remediation will be enhanced by work to secure adequate environmental flows.	
25. Addressing cold water pollution	Evaluate the degree of cold water pollution from existing storages in the North Coast and work with asset owners to implement appropriate capital and operational responses to mitigate these impacts. This five-year partnership would commence with a scoping study to assess the issues and identify suitable works and project partners.	
26. Coastal, regional focused water reference groups	Stakeholder advisory panels already operate in inland regional NSW. This option would support the operation of a similar group in the North Coast to provide a mechanism to seek stakeholder comments and feedback on water policy and reform specific to the region and the coast. The remit of this coastal water reference group could also extend to land use planning to improve the integration of regional urban development and water management.	

Option	Description	Objective
27. Planning for climate change impacts on coastal groundwater resources	The shallow nature of coastal groundwater resources provides advantages for water access. However, it also means they are vulnerable to impacts from climate change and sea level rise. Possible impacts include reduced water availability for consumptive use and the environment due to reduced groundwater recharge, salination of aquifers by seawater intrusion and inundation, waterlogging, contamination and flooding. In this option, the Department of Planning, Industry and Environment—Water would collaborate with Local Land Services, councils and universities to co-design and implement local-scale projects to better understand and manage these impacts.	
28. River Recovery Program for the North Coast: a region-wide program of instream works, riparian vegetation and sediment control	This option will consider the costs and benefits of a region-wide program to better manage catchment hydrology and erosion by providing landholders with financial assistance and technical expertise to implement river rehabilitation works. The program could include in-stream works (such as log jams, rock chutes, log weirs and rock revetment), establishing/rehabilitating riparian vegetation, reducing erosion and decreasing sediment loads in streams.	
Supporting water use and delivery efficiency and water conservation—*Opportunities to improve the efficiency of existing water delivery systems, increase productivity and address water security challenges through demand management options*		
29. Improved data collection on water use and patterns	Investigate opportunities to improve data collection on water take across the region. These opportunities are likely to acknowledge new technologies for measuring, monitoring and reporting water data to drive sector-wide improvements in data collection and sharing. Examples include increased capability in satellite imagery observations, comprehensive and reviewed (or enhanced) hydrometric networks, and universal metering and telemetry for non-urban water take. A review of the non-urban metering framework for the coastal regions may also be required to support improved data collection in the region.	
30. Active and effective water markets	Review water markets (unregulated and groundwater) in the North Coast region to improve their efficiency and effectiveness, including giving transparency and confidence to water users, encouraging water entitlement holders to trade to more efficient areas of the catchments and broadening the market to create opportunities to move water more effectively.	
31. Apply the *NSW Extreme Events Policy* to the North Coast region	Extend the *NSW Extreme Events Policy* from the Murray-Darling Basin to coastal regions to give local water utilities and other water users clarity and direction regarding reduced water take during periods of drought. The option would also establish a Critical Water Advisory Panel and develop an Incident Response Guide for the North Coast region.	

Option	Description	Objective
32. Regional demand management program	Investigate the coordination of a region-wide water conservation and demand management program that would include all local councils in the North Coast. The program could also include rural water users. This could bring consistency in approach and efficiencies in monitoring and implementation across the region and may delay and downsize future water sources required for the region.	
33. Regional network efficiency audit	Region-wide audit of water supply network infrastructure leakage. The audit will identify opportunities to reduce water losses through network leaks and unaccounted take, as well as minimise annual volumes of non-revenue water.	
34. Regional capacity building program and skills hub	This option would establish a regional capacity building program to provide the necessary skills, information and technical assistance to better support best practice management of water in the North Coast. The program would support the capacity needs of urban, rural and commercial water managers and aim to build capacity to support water stewardship and local decision making.	
35. Support for local councils to lift performance standards	This option will consider how the North Coast Regional Water Strategy can support high quality water service delivery for communities by local councils. This is a recommendation of the Auditor-General report *Support for regional town water infrastructure*.	
36. Regional framework to manage restrictions for non-urban water users of town water	Develop a framework for managing water use during drought by commercial and rural water users connected to town water supply. This option recognises that town water supply networks supply numerous commercial and rural businesses, which can be a strain on town water security during extended dry periods.	

Image courtesy of Annette Corlis.

Chapter 4

Where to from here?

We have developed this draft strategy based on the new evidence base we have, the latest policies and programs for the region and feedback from government agencies, local councils and peak Aboriginal groups.

The outcomes, challenges, opportunities and options we have identified in this strategy will be tested, evaluated and refined based on your input.

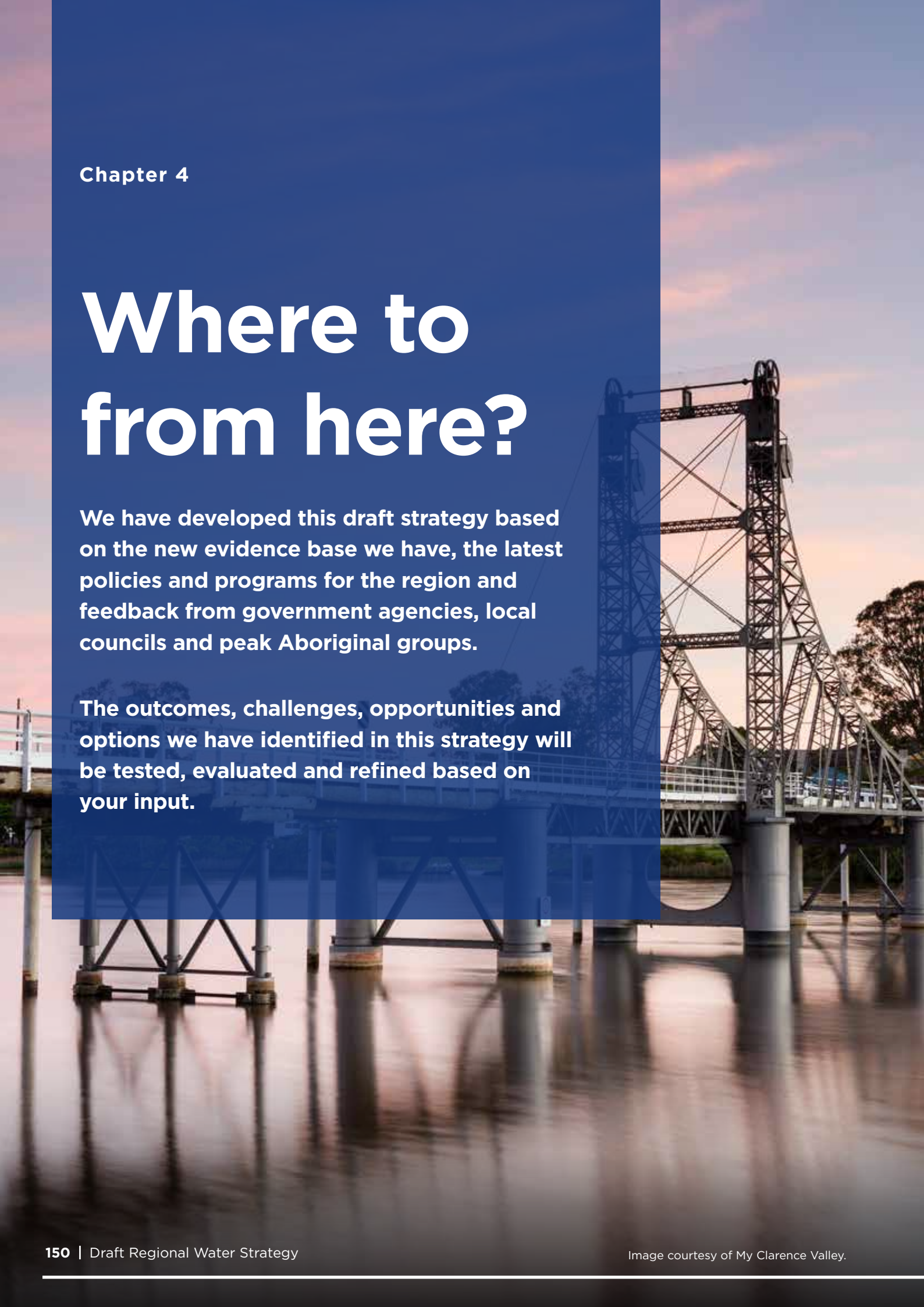


Image courtesy of My Clarence Valley.

4.1 Finalising the strategy

Our next steps are to use the feedback you provide to analyse, screen and assess the long list of options, put together a portfolio of options to be progressed and develop a final strategy for release by the end of 2021. We will also be prioritising further engagement with Aboriginal communities to develop additional options for the final strategy.

We recognise that in getting to the final strategy there may be hard trade-offs, but the only way we can make the best decisions possible is to deal with issues proactively and realistically. This will give us the most likely chance of long-term success.

The final North Coast Regional Water Strategy will include review processes to ensure the region has an effective strategy in place that remains relevant for future water management.

Following completion, each regional water strategy will be reviewed when the equivalent water sharing plans are reviewed.

4.2 Implementing the strategy

Community engagement does not end with consultation but is a vital part of implementation. The final North Coast Regional Water Strategy will map out our approach to implementation and include an implementation plan. This plan will set out how NSW Government agencies and other organisations with a role in NSW water management will deliver key actions and strategies for maximising water security and availability for all users and the environment. This implementation plan will be clear about timeframes and responsibilities for delivery.

We want to be clear about how we work with communities and regions to ensure:

- we are accountable for what we promise our regions
- we have the right partnerships in place to drive forward action
- we are transparent in how we go about those actions
- we can check with those with on the ground and lived experience that the directions and actions we pursue continue to be the right ones for each region.

Image courtesy of Destination NSW.

Your voice is important

We have prepared this draft strategy to continue our discussions with you about the future management of water in your community. It has been prepared in consultation with local councils and Aboriginal communities.

We would like to hear your views on the draft strategy and whether you have any further information that could help us to assess the benefits or disadvantages of any of the options. This may include:

- how your household, business, industry or community currently manages the impacts of a highly variable climate
- the current and future challenges you see in the North Coast region and how you think these should be addressed
- how the management of water resources can be improved or leveraged to create and take up new opportunities in the region
- the options presented in this draft strategy
- how we can achieve our aims for accountability and transparency
- the best ways of partnering with communities and regions to implement the strategy.

Your views on the strategy's vision and objectives are also important.

This Draft North Coast Regional Water Strategy is on public exhibition from 3 March 2021 for a six-week period.

A range of supporting information is available at www.dpie.nsw.gov.au/north-coast-regional-water-strategy.

You can also have your say on the draft strategy by providing written feedback to the Department of Planning, Industry and Environment by midnight 14 April 2021 via:

Web: www.dpie.nsw.gov.au/north-coast-regional-water-strategy

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

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

We will be holding sessions on the draft strategy during the public exhibition period to help shape the final strategy. These sessions will give participants an understanding of the context for the strategy, what the latest modelling is telling us and what the options for better managing water in the North Coast region could mean. Times and locations for these sessions can be found at www.dpie.nsw.gov.au/north-coast-regional-water-strategy

We will also continue to meet with local councils, Aboriginal communities and other stakeholders. Talking with these groups is critical for designing a strategy that builds on their knowledge and capacity, is feasible in terms of implementation and links to their relevant initiatives, plans and strategies.

Attachments

Image courtesy of My Clarence Valley.

Attachment 1

Targeted stakeholder engagement

Overview

A thorough engagement program supports the development of the regional water strategies. The purpose of engagement is to inform, gain information and feedback, collaborate with key stakeholders on strategy development and build support for the regional water strategy.

Development of the North Coast Regional Water Strategy is supported by four engagement phases:

1. Targeted engagement with councils, joint organisations, Aboriginal people and peak bodies
2. Public exhibition of the draft regional water strategy and targeted engagement with State and regional peak bodies
3. Further targeted engagement with councils and joint organisations in each region, as well as Aboriginal people and peak bodies
4. Public release of final regional water strategy.

An interagency panel was formed to assist in the development of the draft North Coast Regional Water Strategy. This panel, chaired by the Department of Planning, Industry and Environment—Water, included representatives from across the Department of Planning, Industry and Environment cluster including Environment, Energy and Science, Energy, Climate Change and Sustainability and Strategy and Reform.

Members of the panel also included representatives from the Natural Resources Access Regulator and the Department of Regional NSW, including Local Land Services, Mining, Exploration and Geoscience, and the Fisheries and Agriculture sections of the Department of Primary Industries.

This report documents targeted stakeholder feedback during engagement phase one of the development of the North Coast Regional Water Strategy.

Engagement

Discussions were held with local councils, joint organisations and Aboriginal communities between March 2020 and October 2020. The following organisations or communities participated in discussions.

Local council/local water utilities/ joint organisation/other organisations	Aboriginal community
Armidale Regional Council	Dunghutti Elders Council
Bellingen Shire Council	Kempsey Local Aboriginal Land Council
Coffs Harbour City Council	NSW Aboriginal Land Council
Clarence Valley Council	Gumbaynggirr Nation
Kempsey Shire Council	Anaiwan Nation
Mid North Coast Joint Organisation	Coffs Harbour Local Aboriginal Land Council
Port Macquarie–Hastings Council	Biripi Nation
Nambucca Valley Council	Port Macquarie Local Aboriginal Land Council
	Miimi
	Traditional Owners
	Community members

The purpose of discussions was to establish a collaborative relationship with local councils, joint organisations and Aboriginal communities, as well as to gain an understanding of key water challenges and risks in the North Coast region. Discussions focused on gaining feedback on a long list of options for the draft North Coast Regional Water Strategy.

Discussions with Aboriginal communities focused on cultural challenges and the development of cultural options.

Summary

Quick stats and hot topics

A total of 18 meetings were held, with 74 people external to the Department of Planning, Industry and Environment attending and participating in discussions during the targeted engagement phase. Information about participants and a summary of recurring themes and hot topics are outlined below.

Targeted local council/joint organisation/ other organisation engagement	Targeted Aboriginal engagement
Quick Stats	**Quick Stats**
12 targeted meetings	6 targeted meetings
40 people participated in discussions	34 people participated in discussions
Meetings held regionally face-to-face and by video conference	3 local land councils and 5 Aboriginal groups
Over 340 ideas, opportunities, challenges and suggestions identified	Over 213 ideas, opportunities, challenges and suggestions identified

Recurring themes	Recurring themes
Councils don't just want another strategy—they want to see a meaningful action plan that will improve water security in the region	Aboriginal people have a strong connection with water. It is the lifeblood of Country and the blood of the people
Most councils consider their town water supply to be secure (the main exceptions being Bellingen and Armidale)	Need for improved access to rivers/waterways and Country for Aboriginal people
Complexity of town water licences makes it difficult to maximise extraction and secure demand for some towns	Need to protect water quality for users and the environment—upstream and downstream
Council water supplies are used by industry, including some key growers—Costa tomatoes (Armidale), Norco Milk (Bellingen)	Need for improved water literacy for Aboriginal people
Support use of treated wastewater as a potential alternative water source for intensive horticulture as well as non-potable demands (through a purple pipe network)	Local training and employment opportunities along rivers/waterways—such as river rangers, cultural officers, eco-tourism, education activities
Need to shift the approach to managing extreme events, such as drought, from reactive to proactive	Protection and conservation of Aboriginal cultural heritage.
	Engagement needs to be culturally appropriate

Targeted local council/joint organisation/ other organisation engagement	Targeted Aboriginal engagement
Hot topics	**Hot topics**
Regional water strategies implementation plan, options, funding and governance framework	Lack of access to Country and rivers has changed cultural use of freshwater. Want to get legal access for cultural use, health and well-being
Impacts of extreme events like drought, flooding and fires on water supply and quality	Local involvement in water management
New hydrological modelling outputs and how councils might be able to use them	River health is a concern. Needs to be greater accountability around looking after rivers
Changing industries and the growing demand for water	Water scarcity and compliance: who is taking the water and how much?
	Cultural water licensing

Image courtesy of NSW Farmers.

Detailed feedback

The following two tables summarise the feedback from round one and round two of the targeted engagement phases.

Council engagement

Topic	Comment
Collaboration and engagement	Attendees value inclusive consultation processes and ongoing consultation. • Expressed desire to be part of ongoing consultation. • Suggested regular feedback about the strategy development was needed. Mentioned there was insufficient consultation on previous government documents—particularly the recent review of the Bellingen Water Sharing Plan. • Advised the need to consider the Aboriginal perspective on water—such as the Aboriginal perspective on the use of groundwater.
Regional Water Strategy development	Attendees support the development of the North Coast Regional Water Strategy. • Attendees don't just want another strategy. They want to see a meaningful action plan that will improve water security in the region. • Queried the relevance of a regional water strategy to local councils and town water when each council manages and sources its water from independent water sources. • Suggested the strategy needs to be holistic: - it needs to address and be cognisant of the high level of interconnection between surface water and groundwater - it needs to consider the cumulative impacts of industries on the region's water resources—for example, blueberries and forestry - it needs to consider the Aboriginal perspective on water. • Suggested that the timing around the development of the regional water strategy was ideal—particularly in the context of the recent events (droughts, fire). • Noted that many parts of the North Coast community place a high value on the region's environment and will want to see it effectively managed through this strategy. The exception was for lower socio-economic groups in relation to reuse schemes where the environmental benefits would not be considered enough to outweigh the costs.

Topic	Comment
Regional growth and water security	• Expressed concern regarding non-compliance amongst new horticultural users and the cumulative impacts of these industries on water security and waterway health. • Advised that there is concern regarding groundwater sources that supply town water (Bellingen and Kempsey). The concerns included capacity of the groundwater system, particularly during drought, and the risk of saline intrusion from over-extraction. • Noted that changes and growth in industries are leading to changes in demands for water. Commented that blueberry growers are building big storages across the region and are considered a large water user. • Expressed general support for reuse of treated wastewater. Coffs Harbour City Council noted that they have invested in a scheme to provide recycled wastewater to local horticultural businesses, while other councils provide treated wastewater for non-potable uses such as irrigation and vehicle washdown. • Advised that the use of recycled wastewater is supported by most councils and communities; however, there are significant barriers affecting adoption. Examples discussed included costs, audits of end-user management plans, storage requirements and sporadic demands. • Noted that for some local government areas, particularly in low socio economic areas, the perceived environmental benefits are unlikely to outweigh the cost to implement. • Advised that many councils supply town water for agricultural and other industrial needs under their local town water licence. Key growers include Costa tomatoes (Armidale) and Norco Milk (Bellingen). • Noted that the use of town water by agriculture varies across the region. In some local government areas, town water is used mainly during drought. However, there are some big businesses that have a regular demand on town water. • Advised there is a lack of strategic direction for water resource management to inform local decision making: - risk of 'changing goalposts' in terms of environmental approval conditions—for example, Shannon Creek Dam is designed to be raised in the future but changes to legislation may make raising unfeasible. Strategic direction can be undermined by these changes.
Town water licences	Attendees commented about the complexity of town water licences, which makes it difficult to maximise extraction and secure demand for some local towns. • Suggested that it may not lead to the most optimal planning and investment path in the future. Attendees from Clarence Valley Council and Coffs Harbour City Council noted the current and future uncertainty regarding access to town water from the Nymboida River at the Nymboida weir.
Water quality	Attendees advised that some parts of the region experience water quality issues that affect access to town water. • Noted that high turbidity water is an issue in some areas. Runoff following heavy rainfall can dramatically increase turbidity as well as the concentration of organic matter. • As a consequence, some councils have identified the need to upgrade their water treatment facilities to provide greater operational flexibility. • Rapid fluctuations in flow and/or water quality can cause significant strain on the facilities and is a common cause of water-borne disease outbreaks. • Elevated levels of iron were noted as a water quality concern for some councils.

Topic	Comment
Managing extreme events	Attendees stressed that the dry conditions and extensive bushfires that occurred across the region in 2019 were difficult. • Noted a range of impacts: - several towns in the region were at risk of running out of water - local storages were impacted by poor water quality (algal growth and elevated levels of iron), which raised concern as to the use of the water for potable supply - water was carted from town water supplies to many smaller communities and rural users - rural users were contacting councils for emergency water supply - significant loss of crops—the main example provided was for blueberry production within the Coffs Harbour area - some councils noted that town water supplies were also impacted by fighting bushfires. • Recognised that the conditions of 2019 highlighted the vulnerability of the water management system to extreme dry conditions. • Some attendees noted that the heavy rainfall in March 2020 exacerbated water quality issues, with many water treatment plants unable to manage the resulting high turbidity water. One council was not able to extract for numerous months despite high flows because turbidity remained high. • Stressed the need to improve rules and procedures supporting and guiding water access arrangements during droughts: - managing restrictions for non-urban water users connected to reticulated supplies to ensure a consistent approach that does not impact water security for potable, urban water needs - section 60 requirements of the *NSW Local Government Act 1993* to ensure approvals for emergency works (new or modified) is not hampered by 'red tape'. • Stressed need for consistent messaging from councils/government on drought responses and restrictions to water supplies: - for example, consistent messaging regarding restrictions to water supplies would enable residents moving between towns to understand what a Level 4 restriction meant across the region.
Groundwater	Attendees advised there is a lack of state-wide information on groundwater sources. • Noted that there is generally a much better understanding of surface water compared to groundwater. • Advised that some councils have already procured studies to better understand the capacity of the local groundwater resource and the potential impact to town water security from projected climate change. • Noted concern that rural users may be using more water than they were entitled to, but without meters, this could not be verified: - suggested an audit of water use data, but acknowledged it would be difficult without meters.

Topic	Comment
Integrated Water Cycle Management Plans and hydrological outputs	Attendees advised work to develop Integrated Water Cycle Management Plans for each council is in various stages of development. • Advised the Integrated Water Cycle Management Plans is a critical process in understanding security. • Mentioned that the Integrated Water Cycle Management Plans provided councils with: - a good or better understanding of the risk to future town water security - answers to questions about the best town water security option, which could help drive investment - a clearer idea of local or regional water security solutions - possible new options for using wastewater. • Noted concern that the region has a limited ability to implement Integrated Water Cycle Management Plans. Some examples of implementation barriers included small pool of specialist consultants and lack of appropriately trained staff and technicians. It was also noted that some communities may not be willing to pay for initiatives such as treated, recycled wastewater and that the environmental benefits were not enough to justify the additional cost. • Very interested in how the new hydrological modelling outputs might help councils understand climate change and potential risks to future town water security.
Treated wastewater	• Attendees generally expressed support for the use of treated wastewater as a potential alternative water source for non-potable uses as well as for agriculture. • Advised some councils supply recycled water to their communities for non-potable uses, such as sportsground irrigation. • Advised there is the potential for future use by horticulture but this would require planning and infrastructure upgrades. • Noted the following limitations to further uptake of recycled wastewater schemes: - EPA approvals process is currently very difficult and lengthy. The application process takes six months or longer. - councils have identified offsets but are not allowed to use reclaimed water - councils do not have the capacity to oversee the end user management plans, particularly if there are multiple, different users - schemes are most effective if the demand is constant—however, experience has shown that industry demand for treated wastewater is only when conditions are dry - constituents from some LGAs are unlikely to support the use of treated wastewater for non-potable use, mainly because of the high cost to construct, operate and maintain.

Topic	Comment
Challenges	Attendees identified a range of challenges in the North Coast region, including: • completely unregulated system, with limited options for inter-connections across catchments • rural demands for water are likely to increase, as intensive horticulture expands • limited measurement data on water use • regulatory and administrative barriers to innovative and efficient water use • limited strategic planning to inform local decision making • skill and training limitations to foster best practice water management and encourage efficient water use • region is vulnerable to extended dry periods • town water supplies can be affected by high turbidity and other water quality issues • saline intrusion due to sea level rise and increases in storm surges may affect future water security.
Opportunities	Attendees identified a range of opportunities in the North Coast region, including: • support for local councils in upgrading existing storages to ensure water is available when needed • augmentation of the existing Clarence-Coffs Harbour *Regional Water Supply Scheme* • clarify existing rules to ensure water take is equitable, transparent and sustainable • provide more flexible water access arrangements • build capacity to support water stewardship and local decision making • ensure consistency and transparency in water management and response to drought • improve the collection of water use and monitoring data to better understand current patterns and opportunities for conservation • improve monitoring of coastal groundwater sources.

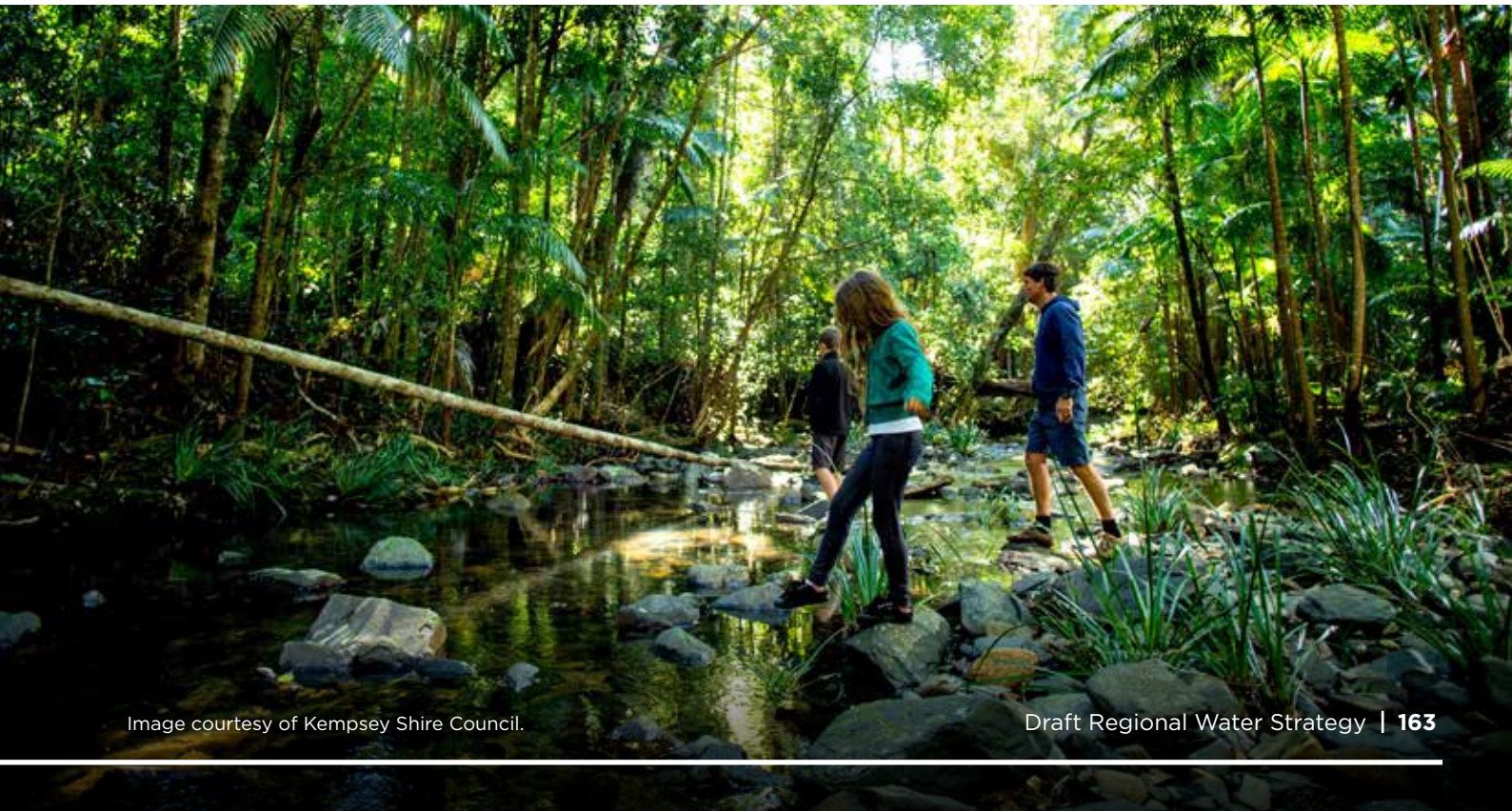


Image courtesy of Kempsey Shire Council.

Aboriginal engagement

Topic	Comment
Cultural heritage	Attendees expressed the importance of being able to access and protect cultural and sacred sites that underpin Aboriginal cultural heritage. • Water is the lifeblood of Country. • The stories of the various rivers across the region are critical to understanding cultural access to water. • Flowing rivers are important for connection to Country. • The river is important for the communities' overall well-being. Attendees noted the following concerns that are affecting their access to the region's rivers and waterways and ultimately their cultural heritage. • Runoff from farms as well as waste generated from historic mining operations are degrading the water quality of the rivers, particularly in the Macleay River. • Travelling stock reserves are important accesses for community; however, these are often locked up. • It's hard to foster a connection to Country with the kids when the rivers aren't flowing. Attendees also expressed that they consider looking after the rivers a part of their cultural heritage.
Engagement and partnership	Attendees expressed they value having culturally appropriate conversations about water, but were concerned their voice had been ignored in the past. Attendees welcomed continued engagement on the regional water strategy and other water policy, noting the following: • Elders need to be given the opportunity to listen and speak first. • Prefer to discuss the regional water strategies in person. • Need to consider ways to engage the younger Aboriginal community. • Roles and responsibilities of the various NSW Government departments need to be clarified to ensure the local Aboriginal community understand who they need to talk to about particular issues. • Use of plain English terminology when explaining water concepts. • Knowledge provided during engagement should go back to the communities who provided the information; not just have it destroyed with the knowledge then lost. Attendees suggested developing a group similar to Northern Basin Aboriginal Nations to coordinate the voice of the region.
Regional water strategy development	Attendees expressed interest in the development of the North Coast Regional Water Strategy, and advised the strategy should consider: • Opportunities to repair, and not just sustain, current conditions—particularly if they are poor. • Supporting opportunities to involve and provide employment for local Aboriginal people. • Collaboration between all stakeholders both to inform strategy development, and integrate scientific and aboriginal cultural knowledge. • Integrating the United Nations development goals into the North Coast Regional Water Strategy (rights to water and sanitation). • Distinctions between catchments in terms of issues and access. • Options should consider enabling access to water to enable economic autonomy and supporting the collection and integration of cultural knowledge into water management practices.

Topic	Comment
Water management	Attendees stressed there is confusion about how water is managed across NSW and a general perception across the community that water management is too complicated. Attendees also noted the community would like more information on both state and federal reform packages. Attendees are concerned about water management and its impact on the environment, particularly cultural flow, environmental flow and cultural water licence processes. Concerns raised regarding the cultural water access licence process included: • Native Title rights. • The application process is complicated and not culturally appropriate. • There is confusion regarding the scope and tenure of the licence, as well as Native Title rights considerations. • The application process needs to be fair and equitable. There is a social cost when the river doesn't flow—including antisocial behaviour and mental health issues. • Water management language is too complex and difficult to understand. • There is confusion over what role each government agency plays in water management, what costs are involved with cultural water access licences and who is responsible for paying the fees. • The fees need to be reviewed and should be less than consumptive users (particularly as the licence cannot be used for commercial purposes). The following concerns were raised in relation to cultural and environmental flows (noting the above comments related to cultural heritage): • Impacts from mining—both legacy and new operations—on water quality (and in the case of future operations—river flows). • General feeling that the health of the rivers is in decline.

Draft options and suggestions for other options	Attendees provided a number of comments and suggestions on draft options.
	• Review of aboriginal cultural access licences.
	• Regional Aboriginal Water Advisory Committee.
	  - Formal groups of local Aboriginal stakeholders to support local decision making.
	• Regional Cultural Water Officer employment program.
	  - This could include education and knowledge building activities.
	• Co-management investigation of Travelling Stock Reserves.
	• Water dependent cultural practices and site identification.
	  - Need to integrate options that would improve access for Aboriginal people to rivers, waterways and culturally significant sites.
	• Linkages with the Cultural Fishing Strategy being developed.
	• Options to provide water for isolated communities.
	
	Attendees also raised concerns on the proposed inland diversion schemes, stating clearly they 'don't want the Clarence dammed'.
	
	A single infrastructure option was noted—to pipe water south from Queensland to the North Coast region during cyclone season.

All feedback has been considered in developing the draft North Coast Regional Water Strategy and stakeholders will continue to be engaged throughout the public exhibition process and the finalisation and implementation of the strategy.

Next steps

In response to the COVID-19 pandemic, the Department of Planning, Industry and Environment has redesigned its engagement program for the regional water strategies. The pandemic has changed the way we will engage with our stakeholders and communities, replacing some face-to-face consultation with virtual, online and contactless methods.

In a meeting on 25 March 2020 with Aboriginal peak organisations, the department was advised that face-to-face meetings are the only appropriate way of engaging with Aboriginal people. This meant that, due to the pandemic, face-to-face engagement with Aboriginal communities on the North Coast was delayed. Engagement recommenced in July 2020 and discussions with local Aboriginal communities will continue throughout the strategy development.

The department is committed to engaging with the Aboriginal communities on the North Coast as appropriately as possible during the COVID-19 pandemic to ensure that Aboriginal rights, interests and concerns related to water are heard and included in the final strategy.

The Draft North Coast Regional Water Strategy will go on public exhibition from 3 March 2021 for a six-week period. During this period, additional targeted and general public engagement will take place and written submissions will be accepted regarding the strategy.

Following the review of the public exhibition period, further targeted engagement will be undertaken before the final regional water strategy documents are published.

Image courtesy of Destination NSW.

Attachment 2

Glossary

Term	Definition
Access licence	An access licence entitles its holder to take water from a water source in accordance with the licence conditions. Key elements of an access licence are defined in section 56(1) of the NSW *Water Management Act 2000* as: *(a) specified shares in the available water within a specified water management area or from a specified water source (the share component), and* *(b) authorisation to take water:* *(i) at specified times, at specified rates or in specified circumstances, or in any combination of these, and* *(ii) in specified areas or from specified locations (the extraction component).* An access licence may also be referred to as a water access licence or a WAL.
Acid sulfate soils	Soils that are saturated with water and contain microscopic crystals of iron sulfide materials. Acid sulfate soils are harmless when undisturbed, if dug up or drained they come into contact with oxygen and the iron sulfide crystals oxidise. This turns them into sulfuric acid, which can cause damage to the environment and structures.
Allocation	The specific volume of water licence holders can access. The amount of water allocated to licence holders varies from year to year based on the type of licence, size of their individual entitlement, dam storage levels, river flows and catchment conditions.
Aquifer	Geological structure or formation, or landfill, that can hold water.
Basic landholder rights	Where landholders can take water without a water licence or approval under section 52, 53 and 55 of the NSW *Water Management Act 2000*. There are three types of basic landholder rights under the NSW *Water Management Act 2000:* • domestic and stock rights—where water can be taken for domestic consumption or stock watering if the landholder's land has river frontage or is overlying an aquifer • harvestable rights—where landholders can store some water from rainfall runoff in dams • Native Title Rights—anyone with a Native Title right to water, determined under the *Commonwealth's Native Title Act 1993*.
Biota	The total collection of animal and plant life of a geographic region or habitat.
Blackwater event	An event that occurs when flooding washes organic material into waterways where it is decomposed by bacteria, releasing carbon, depleting oxygen levels and giving water a black or tea-coloured appearance. The sudden decrease in oxygen can result in the death of fish and other organisms.
Catchment	A natural drainage area, bounded by sloping ground, hills or mountains from which water flows to a low point. Flows within the catchment contribute to surface water sources as well as to groundwater sources.

Term	Definition
Cease-to-pump rule	A requirement in water sharing plans that licence holders stop pumping when the river flow falls below a certain level.
Climate-independent water source	A source of water that does not depend on rainfall or streamflows for replenishment. Includes seawater desalination and recycled water.
Climate variability	Describes the way key climatic elements, such as temperature, rainfall, evaporation and humidity, depart from the average over time. Variability can be caused by natural or man-made processes.
Cold water pollution	An artificial decrease in the temperature of water in a river. It is usually caused by cold water being released into rivers from large dams during warmer months.
Cultural flows	While the NSW *Water Management Act 2000* does not define cultural flows, the Murray Lower Darling River Indigenous Nations Echuca Declaration, 2007, defines cultural flows as: 'water entitlements that are legally and beneficially owned by the Nations of a sufficient and adequate quantity and quality to improve the spiritual, cultural, natural, environmental, social and economic conditions of those Nations.'
Direct employment	Refers to employment directly arising from the demand for a specific product or service.
Effluent	Flow leaving a place or process. Sewage effluent refers to the flow leaving a sewage treatment plant. An effluent stream is one that leaves the main river and does not return.
Endangered ecological community	Ecological communities as listed in 'Schedule I' of the *Threatened Species Conservation Act 1995* or Schedule 4 of the *Fisheries Management Act 1994*.
End of system	The last defined point in a catchment where water information can be measured and/or reported.
Entitlement	The exclusive share of the available water that a licence holder can take, subject to allocations.
Environmental asset	Natural features that contribute to the ecosystem of a region.
Environmental water	Water allocated to support environmental outcomes and other public benefits. Environmental water provisions recognise the environmental water requirements (planned environmental water) and are based on environmental, social and economic considerations, including existing user rights.
Evapotranspiration	The combined effect of evaporation and transpiration.
Evaporation	The process by which water or another liquid becomes a gas. Water from land areas, bodies of water and all other moist surfaces is absorbed into the atmosphere as a vapour.
Extraction limit	A limit on the long-term average volume of water that can be extracted from a source.
Fertigation	Crop fertigation is the technique of supplying dissolved fertiliser to crops via an irrigation (or drip) system.
Fish passage	The free movement of fish up and down rivers and streams.

Term	Definition
Floodplain	Flat land bordering a river or stream that is naturally subject to flooding and is made up of alluvium (sand, silt and clay) deposited during floods.
Freshes	Freshes are where the surface water flow is of sufficient size and duration to 'reset' river reaches. Resetting includes improving water quality, clearing sediment build-up to enhance instream habitat, redistributing sediment to enable normal geomorphic processes, redistributing nutrients to enable normal levels of instream productivity and encouraging instream biota to disperse and/or breed.
General security licence	A category of water access licence under the NSW *Water Management Act 2000*. This category of licence forms the bulk of the water access licence entitlement volume in NSW regulated rivers and is a low priority entitlement (i.e. receives water once essential and high security entitlements are met).
Gross regional product	A measure of the market value of all goods and services produced in a region within a period of time. Gross Regional Product is a similar measure to Gross State Product and Gross Domestic Product.
Gross value added	A measure of the value of goods and services produced in an area, industry or sector of an economy. Gross value added is a similar measure to Gross Regional Product.
Groundwater	Water located beneath the ground in the spaces between sediments and in the fractures of rock formations.
Groundwater-dependent ecosystem	Ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services.
Harvestable rights	Harvestable rights provisions entitle landowners to build a dam or dams of a certain capacity in certain locations to capture a proportion of the rainfall runoff from their land. Landowners can do this without needing a water access licence, water supply work approval or a water use approval.
High flows	Also called bankfull events, these reshape the channel, creating habitats such as pools, bars and benches.
Hydrologic stress	Refers to the level of extraction in a river system. In NSW, 'high hydrologic stress' is defined as 70–100% average annual river flow extracted; and 'medium hydrologic stress' as 40–60% flow extracted.
Indirect employment	Jobs that are created by other businesses to support the primary employment sector.
Inflows	The amount of water coming into a surface water source or groundwater source.
Intermittently closed and open lakes and lagoons	Intermittently closed and open lakes and lagoons are coastal lakes and lagoons that alternate between being open or closed to the ocean. Intermittently closed and open lakes and lagoons are separated from the ocean by a sand beach barrier or berm that forms or breaks down depending on the movement and distribution of sand and sediment by waves, tides, floods and winds.
Joint organisation	An entity formed under the NSW *Local Government Act 1993* to perform three principal functions in a region: strategic planning and priority setting, intergovernmental collaboration and shared leadership and advocacy. Each joint organisation comprises at least three member councils and aligns with one of the State's strategic growth planning regions.

Term	Definition
Local water utilities	Generally, these are council owned and operated utilities that provide water supply and sewerage services to local communities.
Managed aquifer recharge	Intentional recharge of water to aquifers for subsequent use or environmental benefit.
Non-revenue water	Water that has been produced and is "lost" before it reaches the customer. Losses can be real losses (through leaks, sometimes also referred to as physical losses) or apparent losses (for example through theft or metering inaccuracies).
Operational rules	The procedures for managing releases and extractions of water (surface and groundwater) to meet the rules of relevant legislation and policy (e.g. water sharing plans, long term water plans).
Patches	Patches represent relatively discrete areas of relatively homogeneous environmental conditions where the patch boundaries are distinguished by discontinuities in environmental character from their surroundings that are perceived by, or relevant to, the organism or ecological phenomenon under consideration.
Paleoclimate data	Refers to climate records prior to instrumental records. Various environmental indicators can be used to reconstruct paleoclimate variability extending back hundreds of thousands of years in time. These indicators include marine and terrestrial deposits, tree rings and ice cores.
Permanent plantings	Crops that are not replanted after a growing season. These crops generally require more than one growing season to be productive. Examples include grapes, citrus fruits and almond trees. These are different from annual (or broadacre) crops, which are harvested within 12 months of planting and require replanting to produce a new crop.
Recharge	Groundwater recharge is a hydrologic process where water drains downward from surface water to groundwater. Groundwater is recharged naturally by rain, floods and snow melt and to a smaller extent by drainage directly from surface water (such as rivers and lakes).
Recycled water	Water that has been treated to a 'fit for purpose' standard for a specific application as per the Australian Guidelines for Water Recycling.
Regulated river	A river system where flow is controlled via one or more major man-made structures (e.g. dams and weirs). For the purposes of the NSW *Water Management Act 2000*, a regulated river is one that is declared by the Minister to be a regulated river. Within a regulated river system, licence holders can order water which is released from the dam and then taken from the river under their water access licence.
Resilience	Resilient water resources as those that are able to withstand extreme events, such as drought and flood, and/or adapt and respond to changes caused by extreme events.
Riffle habitats	Riffles are short segments of shallow water in a river or stream created by the deposition of rocks and gravel, characterised by fast, turbulent water. The rocky bottom of riffle habitats provides shelter, food deposition and protection from predators.
Riparian	The part of the landscape adjoining rivers and streams that has a direct influence on the water and aquatic ecosystems within them.
Salinity	The concentration of sodium chloride or other dissolved minerals in water.

Term	Definition
Stochastic climate datasets	Stochastic climate datasets are extended climate sequences that are synthesised using statistical methods applied to observed data of rainfall and evapotranspiration and can include paleoclimatic data. These extended sequences include a more complete sample of climate variability, part of which describes more severe drought sequences.
Storage	A state-owned dam, weir or other structure which is used to regulated and manage river flows in the catchment. There are also a range of storages owned by local water utilities. Also refers to the water bodies impounded by these structures.
Stormwater	Flow generated from rainfall falling on hard (impervious) surfaces.
Supplementary licence	Where a surplus flow from rain events cannot be captured in storages or weirs, and this water is not needed to meet current demands or commitments, then it is considered surplus to requirements and a period of Supplementary Access is announced. Supplementary Water Access Licence holders can only pump water against these licences during these announced periods. Other categories of licence holders may also pump water during these periods.
Surface water	All water that occurs naturally above ground including rivers, lakes, reservoirs, creeks, wetlands and estuaries.
Sustainable diversion limit	Sustainable diversion limits are how much water, on average, can be used in the Murray-Darling Basin by towns, communities, industry and farmers in a particular surface water or groundwater source. The limit is written into law in NSW through water sharing plans.
Synthetic datasets	Data that is artificially created using algorithms and not obtained by direct measurement or generated by actual events.
Transmission losses	Water, from an accounting perspective, that is considered lost. This water has been lost through surface water seeping into the ground or evaporation.
Transpiration	The process where plants absorb water through their roots and then evaporate the water vapor through pores in their leaves.
Tributary	A smaller river or stream that flows into a larger river or stream. Usually a number of smaller tributaries merge to form a river.
Unregulated river	These are rivers or streams that are not fully controlled by releases from a dam or through the use of weirs and gated structures. However, in some catchments there are town water supply dams that control flows downstream. Water users on unregulated rivers are reliant on climatic conditions and rainfall. For the purpose of the NSW *Water Management Act 2000*, an unregulated river is one that has not been declared by the Minister to be a regulated river.
Wastewater	Water that is an output of or discharged from a particular activity; for example, from domestic, commercial, industrial or agricultural activities. The chemical composition of the wastewater (compared to the source) will be contaminated.

Term	Definition
Water accounting	The systematic process of identifying, recognising, quantifying, reporting, assuring and publishing information about water, the rights or other claims to that water, and the obligations against that water.
Water reliability	Refers to how often an outcome is achieved. It is often considered to be the likelihood, in percentage of years, of receiving full water allocations by the end of a water year for a licence category. For example, a 60% reliability means that in 60% of years a licence holder can expect to receive 100% of their licensed entitlement by the end of the water year. Other measures of volumetric reliability could also be used; for example, the percentage allocation a licence holder could expect to receive at a particular time of the year as a long-term average. Reliability may also refer to how often an acceptable water quality is available. A reliable water supply gives some clarity to water users and helps them plan to meet their water needs.
Water resource plan	A plan made under the *Commonwealth Water Act 2007* that outlines how a particular area of the Murray–Darling Basin's water resources will be managed to be consistent with the Murray–Darling Basin Plan. These plans set out the water sharing rules and arrangements relating to issues such as annual limits on water take, environmental water, managing water during extreme events and strategies to achieve water quality standards and manage risks.
Water rights	The legal right of a person to take water from a water source such as a river, stream or groundwater source.
Water security	Water security in the context of regional water strategies refers to the acceptable chance of not having town water supplies fail. This requires community and government to have a shared understanding of what is a 'fail event' (for example, no drinking water or unacceptable water quality) and the level of acceptability they will pay for.
Water sharing plan	A plan made under the NSW *Water Management Act 2000* which sets out the rules for sharing water between the environment and water users, and between different water users, within whole or part of a water management area or water source.
Water source	Defined under the NSW *Water Management Act 2000* as 'The whole or any part of one or more rivers, lakes or estuaries, or one or more places where water occurs naturally on or below the surface of the ground and includes the coastal waters of the State.' Individual water sources are more specifically defined in water sharing plans.
Water trade	The process of buying and selling water entitlements and water allocations.
Water year	The annual cycle associated with the natural progression of hydrological seasons: starting with soil moisture recharge and ending with maximum evaporation/ transpiration. In NSW (as for all of the southern hemisphere), the water year runs from 1 July to 30 June.
Wetland	Wetlands are areas of land where water covers the soil—all year or just at certain times of the year. They include swamps, marshes, billabongs, lakes, and lagoons. Wetlands may be natural or artificial and the water within a wetland may be static or flowing, fresh, brackish or saline.

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