Coastal Harvestable Rights Review

Appendices

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Cover image: Andrew Goulstone; Department of Planning, Industry and Environment

Preface

These appendices form part of the ‘*Coastal Harvestable Rights Review—Discussion paper*’ (the discussion paper), and you should read them in conjunction with that paper.

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Appendix 1 Background information

Introduction

Water is a precious, shared resource that is vital for sustaining life and ecosystems, growing crops, creating socio-economic opportunities and maintaining culture. The NSW Government is committed to the sustainable and integrated management of the state's water sources for the benefit of present and future generations.

'Harvestable rights' represent one of three basic landholder water rights established under the *Water Management Act 2000* (WM Act). Harvestable rights allow landholders in most rural areas of NSW to collect a proportion of the rainfall run-off on their property and store it in one or more farm dams up to a certain size.

NSW north coast water users have requested that the NSW Government explore options that would allow them to take more water under their harvestable rights. Coastal areas typically receive higher rainfall than inland areas, and many water users believe that agricultural production is being constrained by increasing competition for water, limitations on accessing water through trade and limits on harvestable rights. In response, the NSW Department of Planning, Industry and Environment is reviewing the harvestable rights limits for coastal draining catchments. The limits are set out in the Harvestable Rights Order—Eastern and Central Division (the Order).

Scope of the Coastal Harvestable Rights Review

The Coastal Harvestable Rights Review (the review) is part of an ongoing discussion with coastal water users about equitable access to water. The purpose of the review is to investigate whether the government could change harvestable rights in coastal NSW and still ensure sufficient water is available for downstream water users and the environment.

The changes the department is looking into are:

- increasing the proportion of average annual regional rainfall run-off that water users may capture from individual properties from 10% to 20%, 30% or 50%
- allowing harvestable rights dams to be built on third-order streams[1], as well as on non-permanent, mapped first- and second-order streams and unmapped streams.

Hydrological modelling of 10 case study catchments has been done to quantify the potential changes to downstream flows. The review also considers potential socio-economic benefits and effects on water trade, water pricing and charges, and the availability of water for the environment.

The following items were outside the scope of the review:

- changes to harvestable rights limits for inland NSW
- changes to other parts of the Order, including the maximum harvestable rights dam capacity (MHRDC) multiplier values and contour maps
- evaluation of water sharing plan rules
- limits on the amount of water that users can take under other basic landholder rights
- quantifying the economic benefits of allowing the building of more and larger dams on first-, second- and third-order streams (the review has taken a qualitative approach)
- identifying specific ecological impacts in case study areas
- measurement of actual take of harvestable rights.

[1] As defined using the Strahler stream ordering system (see Figure 1).

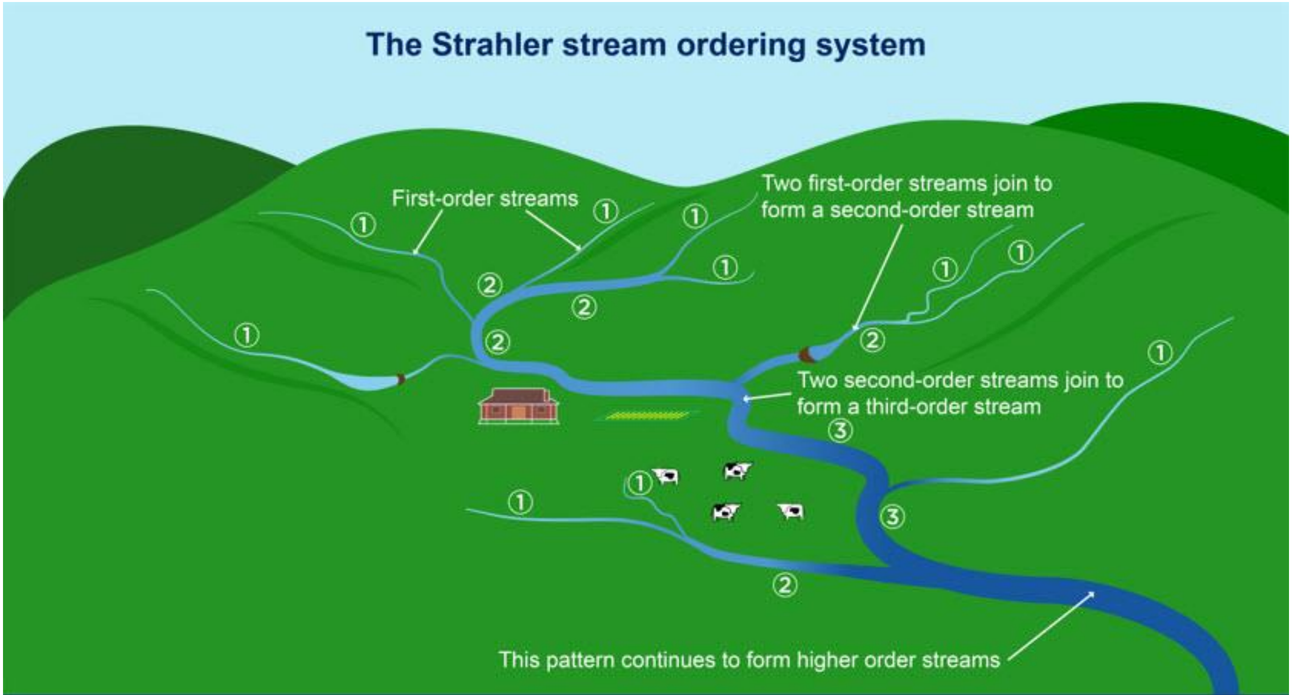
Legislative and policy framework

Harvestable rights

Harvestable rights allow landholders in coastal draining catchments to collect 10% of the average annual regional rainfall run-off from their property and store it in one or more farm dams up to a certain size. To do this, they don't need a water access licence, water supply work approval or water use approval.

Harvestable right dams can be constructed only on 'minor streams'[2], being non-permanent, mapped first- or second-order streams, or unmapped streams. The Strahler stream ordering system, shown in Figure 1, defines first- and second-order streams.

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.



The Strahler system considers the following in determining the stream order of a watercourse:

- Any watercourse that has no other watercourses flowing into it is a first-order stream.
- If two first-order streams join, the stream becomes a second-order stream.
- If a first-order stream joins a second-order stream, it remains a second-order stream.
- If two second-order streams join, they form a third-order stream.
- If a first- or second-order stream joins a third-order stream, it remains a third-order stream.
- If two third-order streams join, they form a fourth-order stream. This pattern continues to form higher order streams.

Figure 1. Strahler stream ordering system

NSW Farm Dams Policy

The ability to construct a dam to capture harvestable rights was introduced in 1999 when the NSW Farm Dams Policy (the Policy) came into effect. Before the Policy, landholders could build an unlimited number of farm dams without a licence, provided the capacity of each dam was less than

[2] As declared in the harvestable rights orders published in *NSW Government Gazette*, No. 40, 31 March 2006, page 1628.

7 ML and the water was used only for stock and domestic purposes. Under the Policy, the permitted size of an unlicensed (harvestable right) dam was based on the size of the property and the regional average annual rainfall run-off. The water from a harvestable rights dam could be used for any purpose.

The Policy aimed to address concerns that new farm dam development in upper catchments was reducing downstream access to river flows. It tried to balance the needs of landholders who rely on rainfall run-off with those of downstream water users, town water supply and the environment. The Policy focused on run-off because most rainfall soaks into the ground, is taken by plants or evaporates, and only run-off can be captured in a dam.

Allowing landholders to harvest all run-off from their properties would lead to greatly reduced water flow into rivers and reduced flows into major storages on which town water supplies rely. Harvestable rights aimed to satisfy essential farm needs, including stock watering, domestic use and general farming purposes. A comparison of these water requirements to dam capacity showed that harvesting 10% of average regional rainfall run-off for individual properties would satisfy these needs. Although not enough to support commercial irrigation, this volume gives farmers the flexibility to trial new crops or projects without needing to purchase water entitlements.

The Policy was established following statewide consultation with representatives of irrigated agriculture, dryland farmers, industry, local councils, environmental representatives and other water users.

Harvestable rights, which were legally established when the WM Act came into effect, replaced the NSW Farm Dams Policy.

Water Management Act 2000

The WM Act provides the framework for sharing and managing water in NSW. It establishes water-management principles and basic landholder rights to water. It also provides key tools to manage and share water, such as water sharing plans, regulations and orders.

Section 53 of the WM Act provides for harvestable rights, which are one of the forms of basic landholder rights.

Harvestable rights orders

Section 54 of the WM Act allows the minister to establish or amend statutory instruments called harvestable rights orders to specify conditions for the capture and storage of harvestable rights water. For example, conditions can apply to the types of water that can be harvested, the maximum harvestable right volume and where harvestable rights dams can be built.

Two harvestable rights orders currently fall under Section 54 of the WM Act:

- The Order for Eastern and Central Division provides landholders with a harvestable right to capture and use 10% of the average annual regional rainfall run-off for any purpose from: (i) non-permanent, mapped, first- and second-order streams, or (ii) unmapped streams.
- The Order for Western Division allows landholders to harvest all[3] rainfall run-off from their property from: (i) non-permanent, mapped, first- and second-order streams, or (ii) unmapped streams.

Figure 2 shows NSW land division boundaries (which are also the boundaries of the current harvestable rights orders) and the area subject to the review. The orders do not apply to land in some specific areas, such as land within three kilometres of a Ramsar-listed wetland of international importance.

[3] Although the Order for Western Division permits landholders to capture all run-off, the volume landholders can capture in harvestable rights dams is limited by the lower rainfall and flatter topography in that area.

This review concerns itself only with catchments that drain to the coast, which are subject to the Order. All additional references to changing the limits in the Order would, if implemented, apply only in coastal draining catchments.

Figure 2. NSW land divisions and area subject to the review

Maximum harvestable right dam capacity

The 10% harvestable right limit is implemented by limiting the total volume of harvestable rights dams on a property. Known as MHRDC, you calculate this volume by multiplying the property size by a location-specific 'volume per area' multiplier value. The multiplier values were originally available to landholders on MHRDC multiplier contour maps (see Figure 3) but are now contained within the MHRDC calculator on the WaterNSW website[4].

[4] www.waternsw.com.au/customer-service/water-licensing/blr/harvestable-rights-dams/maximum-harvestable-right-calculator

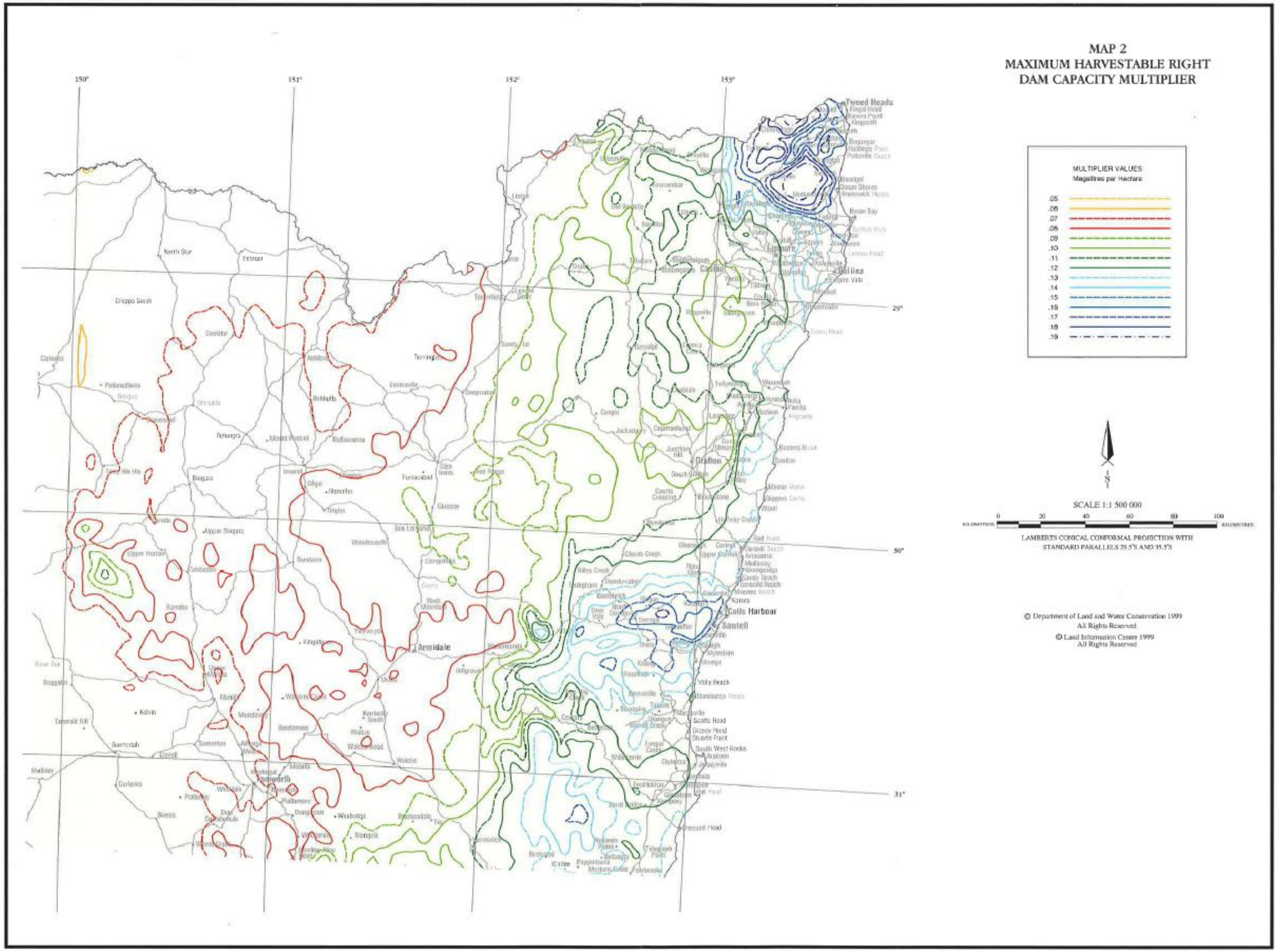


Figure 3. Example MHRDC multiplier contour map (north coast)

The MHRDC multiplier values were calculated using long-term average rainfall data from the Bureau of Meteorology. A nationally accepted method developed by the Australian National University was used to interpolate between rainfall data sites, taking topography into account. This resulted in a statewide average annual rainfall map. The rainfall data was then multiplied by regional run-off percentages based on the figures used for many years in the design of farm water supply dams. The resulting total run-off figure was divided by 10 to give a regional estimate of 10% of run-off. The 10% of run-off was adjusted to account for evaporation and periods between replenishments for a given locality to arrive at the MHRDC multiplier contours.

The method of MHRDC calculation means that larger dams are permitted for properties in high-rainfall areas, such as on the coast, than for those in low rainfall areas (see example in Table 1).

Table 1. Examples of MHRDC calculation

High-rainfall area		**Low-rainfall area**	
Location	= Mullumbimby	Location	= Moree
Property size	= 100 hectares	Property size	= 100 hectares
Multiplier value	= 0.19	Multiplier value	= 0.06
MHRDC	= 100 x 0.19 = **19 ML**	MHRDC	= 100 x 0.06 = **6 ML**

Dams in higher rainfall areas can also fill more frequently than those in lower rainfall areas, allowing users to take a higher volume of water from the dam over a year than the volume of the dam itself. A relative comparison of the harvestable right volume and MHRDC in high- and low-rainfall areas is provided in Figure 1 of the discussion paper.

MHRDCs vary across the coast. See Table 2, which compares the MHRDC for a 100-ha property in each of the case study catchments.

Table 2. Comparison of MHRDC in case study catchments

Case study catchment	**MHRDC (ML) for a 100-ha property**
Duck	10.5
Woolgoolga	13
Bucca Bucca	13.5
Nambucca	13
Allyn	9.5
Wollombi	7
Wyong	11
Wollondilly	7
Double	9
Bega–Bemboka	8.5

Exemptions

Some dams are exempt when determining whether a property has reached its MHRDC (see Schedule 2 of the Order[5]). These include dams:

- to control or prevent soil erosion
- for flood detention and mitigation
- to capture, contain and recirculate drainage and/or effluent to prevent contamination of a water source
- that are 'turkey nest' dams and ring tanks—storages without a natural catchment
- approved by the department (in writing) for specific environmental purposes.

Some of these dams are also regulated by other legislation, such as the *Protection of the Environment Operations Act 1997* and/or state or local environmental planning instruments. Approvals and additional assessments (for example, threatened species assessments) under the *Fisheries Management Act 1994* may also be required.

Dams built before 1999

Dams built before 1 January 1999 that are consistent with the previous approval process do not require licences. Dams built before 1 January 1999 do not need an approval or licence if they satisfy all the following:

- hold 7 ML or less
- are located on either
  - a permanently flowing first- or second-order stream or
  - a third-order or higher stream
- that are used solely for domestic and stock purposes.

The volume of these older unlicensed dams must be included when assessing the right to build additional harvestable rights dams on a property.

Dams built before 1 January 1999 that do not meet these criteria must be licensed.

Permitted uses of water from basic landholder right dams

The water from harvestable rights dams can be used for any purpose. Dams for domestic and stock rights or native title rights can be used only for those purposes.

Harvestable rights and floodplain harvesting

Harvestable rights are different from floodplain harvesting. Although both involve capturing water flowing over the ground, the NSW Floodplain Harvesting Policy (NSW Department of Industry 2018) defines floodplain harvesting as:

the collection, extraction or impoundment of water flowing across floodplains, including rainfall run-off and overbank flow, but excluding the taking of:

- water under a water access licence that is not a floodplain harvesting access licence
- water under a basic landholder right, including water taken under a harvestable right
- water under an applicable water access licence exemption under the WM Act
- used irrigation water.

[5] Pages 1628–1630, gazette.legislation.nsw.gov.au/so/download.w3p?id=Gaz_Gazette%20Split%202006_2006-40.pdf

National Water Initiative

The NSW Government is a partner in the National Water Initiative (NWI). The NWI recognises that governments have a responsibility to ensure water is allocated and used to achieve socially and economically beneficial outcomes in an environmentally sustainable manner.

Farm dams are recognised as a land-use activity with potential to intercept significant volumes of water (see paragraphs 55–57 of the NWI agreement[6]). The NWI agreement states that farm dams need to be managed based on their risk to the integrity of water access entitlements and the achievement of environmental objectives.

Proposed changes to how farms dams are managed must therefore consider whether the benefits of a change (for example, increased production in upstream areas) outweigh the costs (for example, impacts on access for downstream users and the environment).

Interstate farm dam management

Queensland

Farm dams are included in the management of overland flows in Queensland. Water users need a water licence to take or interfere with overland flow water in some areas. However, there is provision for unlicensed dams where they meet certain requirements.

Construction of new works to capture overland flows is regulated under planning legislation as ‘assessable’ or ‘acceptable’ development. Water plans and legislation help to determine which of those pathways apply.

Acceptable development requires self-assessment for certain uses. Under the self-assessment process for stock and domestic dams, dams are permitted on a property up to a maximum dam capacity but can be used only for stock and domestic purposes. Landholders must notify the relevant authority when such dams are built.

Victoria

In Victoria, individuals can take water for domestic and stock purposes from a range of surface water and groundwater sources without a licence. However, a licence is required for domestic and stock dams built on a waterway. Dams for other uses, such as commercial and irrigation use, require a licence regardless of where they are built.

Section 8 of the Victorian *Water Act 1989* enables people to access water without a formal entitlement and free of charge under specific arrangements. This includes farm dams for domestic and stock purposes.

South Australia

Farm dam rules in South Australia vary from region to region. The *Landscape South Australia Act 2019* provides for rights to take water subject to certain conditions. However, a Water Affecting Activity Permit or Development Approval is required for the construction or enlargement of farm dams for most of South Australia[7].

Additional size and location limits are set in region-specific Natural Resource Management Plans (currently being transitioned to Landscape Plans), and in Water Allocation Plans for prescribed water resource areas. Dam capacity limits can vary from 5% to 50% of a property’s mean annual adjusted run-off, depending on the region and mitigation measures for reducing impacts on water

[6] https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/water/Intergovernmental-Agreement-on-a-national-water-initiative.pdf

[7] Minor exemptions apply in the Alinytjara Wilurara, SA Arid Lands and parts of Eyre Peninsula landscape regions.

access by downstream users (e.g. flow bypasses). In some regions, new dams are not allowed to be built on streams unless there is no other suitable location available.

Snapshot of coastal catchments

The people and environments of coastal NSW rely on coastal streams and rivers to provide good-quality water in sufficient quantities for a range of uses. These include:

- drinking water for town water supplies, domestic and stock purposes
- water for:
    - agricultural production
    - industrial use
    - fisheries production
    - ecological processes and services that support healthy and functioning riverine, estuarine and marine environments
    - Aboriginal cultural practices
    - tourism
    - recreation.

Average annual rainfall in coastal draining catchments is typically much higher than in inland areas. A large part of the coast has an average annual rainfall of more than 1,000 mm, with some areas around Wollongong, Port Macquarie, Coffs Harbour and the area north of Yamba and east of Lismore in the 1,500- to 2,000-mm range (see Figure 4). Rainfall patterns, frequency and intensity differ from inland areas, and coastal climates tend to be shifting towards decreased winter rainfall and more intense extreme rainfall events (CSIRO and Bureau of Meteorology 2020).

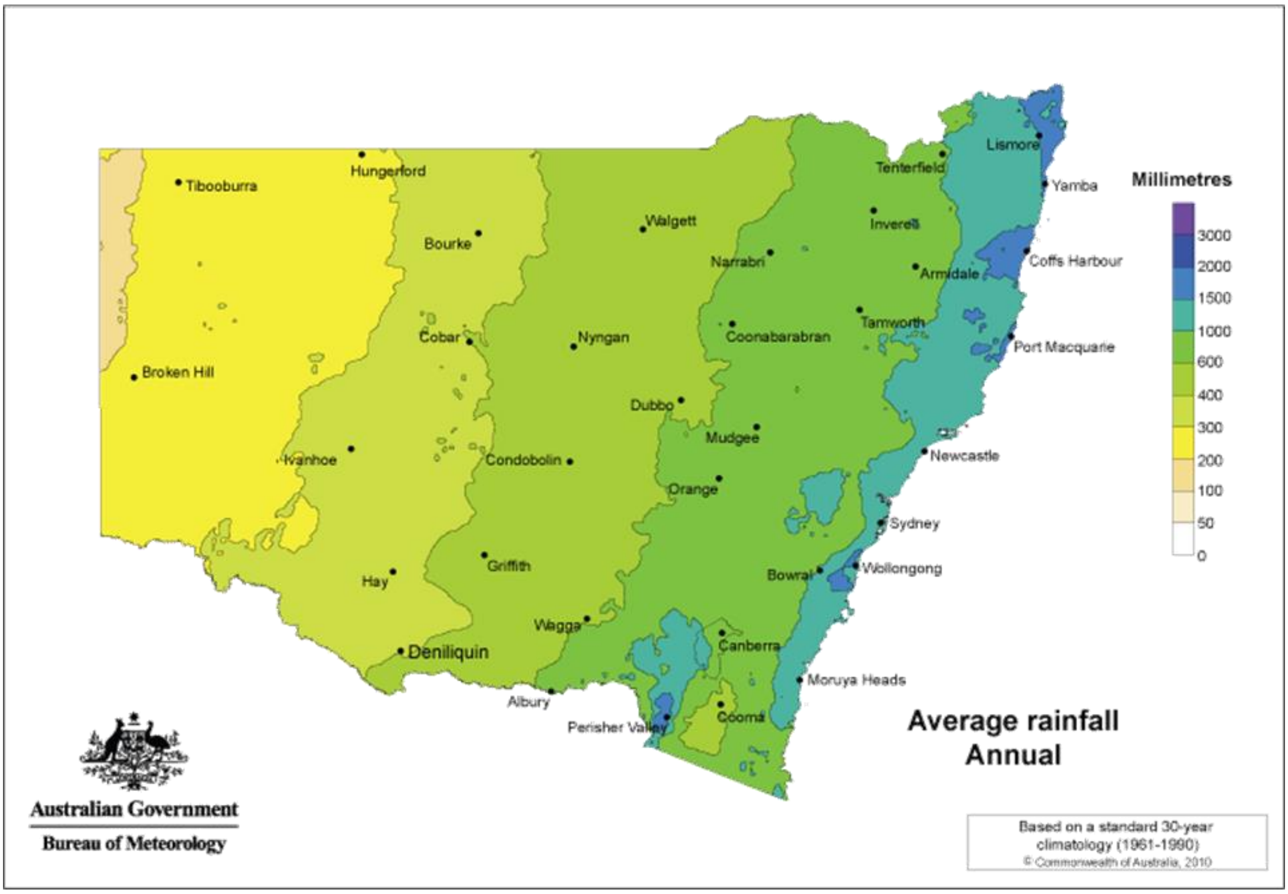


Figure 4. Mean annual rainfall for NSW

Streams and rivers on the coast are usually steeper and shorter, resulting in “flashier” flows than those inland. Most coastal streams and rivers are unregulated—they do not have major storages or dams to control the release of downstream flows. Licensed water users are typically ‘run-of-river’ water users and may pump only when flows are above the cease-to-pump flow level set in the relevant water sharing plan.

The three regulated coastal river systems (Richmond, Upper Hunter and Bega–Brogo) rely on inflows from streams and rivers to supply drinking water for major cities and towns, and water for irrigated agriculture, industry and other uses.

Most coastal unregulated water sharing plans do not include harvestable rights in their long-term average annual extraction limits (LTAAELs). Their LTAAELs were originally set at the existing level of licensed entitlement plus requirements for the other forms of basic landholder rights only. The department would need to consider implications for LTAAEL rules if harvestable rights limits were increased.

There are many licensed water users in coastal draining catchments, most with relatively small entitlements compared with those inland. Some licensed dams (that is, those larger than the MHRDC) in coastal catchments may be located on higher-order streams (third-order or above) and sometimes provide more reliable access to water than run-of-river pumping.

Coastal catchments most recently experiencing water-access issues are generally those:

- where industry is changing, leading to greater demands for water
- where industry relies on run-of-river water access (with no off-river storage), and dry conditions lead to low flows and cease-to-pump conditions being imposed
- that have low levels of water entitlement and restrictions on trade, often due to the presence of high conservation values.

High conservation values that influence how trading rules are set in coastal water sharing plans are often located in the lower catchment. Such values can include estuaries and intermittently closed and open lakes and lagoons (ICOLLs)—for example, Woolgoolga Lake—that rely on flow events to open connections to the sea. High conservation values in upper catchment areas include national parks that are part of the Gondwana Rainforests of Australia UNESCO World Heritage listing, found in the hinterland of most NSW midcoast and north coast river catchments.

About the review

What prompted the review?

The settings for harvestable rights have been a matter of active discussion for many years. This formal review process began in response to requests from north coast water users to increase the limits on their harvestable rights, noting the higher rainfall that coastal areas receive. Some water users in other coastal regions have added to the call for the review. Some users have expressed concern that agricultural production is being constrained by the existing harvestable rights limits, which they believe could be increased while maintaining a sustainable level of access for downstream users. Stakeholders have also raised other water access concerns, such as:

- a lack of available entitlement on the water market and high prices to purchase water
- an inability to trade upstream (for example, in the Bucca Bucca Creek Water Source, within the *Water Sharing Plan for the Clarence River Unregulated and Alluvial Water Sources 2016*) or between catchments.

This review considers the effect of these broader water access concerns.

Stakeholder consultation

The department conducted broad stakeholder consultation on the method to review harvestable rights in July and August 2016. It met with water users, industry representatives and environmental groups in key locations along the NSW coast (Coffs Harbour, Sydney, Maitland, Gosford and Bega) to:

- identify key issues of concern
- identify the reasons behind the desire to change the limits
- obtain feedback on potential changes to the harvestable rights limits.

During initial consultation, stakeholders helped select case study areas and the harvestable rights scenarios for hydrological modelling. The discussion paper describes the case study areas and modelled scenarios.

Appendix 2 below provides feedback from the initial stakeholder consultation phase.

Review constraints and considerations

This review needs to consider the objects and water management principles set out in the WM Act. Additionally, section 9(1)(b) of the WM Act prioritises the protection of the water source and its dependent ecosystems ahead of the protection of basic landholder rights when sharing water.

The review also needs to consider relevant principles and obligations under intergovernmental agreements, such as the NWI, the international Ramsar Convention on Wetlands of International Importance and the UNESCO World Heritage Convention. A key consideration when assessing potential changes to current harvestable rights limits is to ensure enough water is available for other water users and the environment.

Coastal NSW contains a range of water-dependent environmental values, assets and iconic sites, some of which are formally recognised in instruments such as water sharing plans; the Ramsar Convention; and plans of management for land, riverine, estuarine or marine estates. This review does not assess specific impacts on individual environmental assets. However, it does consider the potential for adverse environmental impacts as a result of changes to water available for the environment in different parts of the flow regime.

The outcomes of the hydrological modelling relate to end-of-system flows only. The review also needs to consider flow impacts within the catchment, as Appendix 3 further discusses below.

The review is restricted to coastal draining catchments because inland areas of the Eastern and Central Land Division are subject to sustainable diversion limits set by the Murray–Darling Basin Plan. Under the plan, sustainable diversion limits restrict the amount of water that users can take from each water source for towns, industries and irrigation. So, any increase in water interception by harvestable rights dams would need to be offset by a reduction in other forms of water take, such as take by licensed water users, in years where the sustainable diversion limit is exceeded. Water sharing plan rules may also need to be changed to comply with the Basin Plan's 'no net reduction in the protection of planned environmental water' test[8].

The harvestable rights order is a broad policy tool that applies across a large area. Changing harvestable rights along the coast is likely to affect individual coastal catchments in different ways and to different degrees. A uniform change to harvestable rights across coastal draining catchments needs careful consideration to determine whether this is the best way to address the broader water access and security issues driving the review.

[8] Section 10.28 of the Commonwealth Basin Plan 2012

Appendix 2 Stakeholder feedback from initial consultation

Key feedback from stakeholder consultation on Coastal harvestable rights review, July–August 2016:

- A 50% limit would be unjustifiable in any low-rainfall period and bring water users into conflict.
- Assessment of potential impacts on seafood production from a reduction in water quantity, naturalness of flow and increased barrier to fish passage and environmental connectivity needs to be included in the review scope.
- Concern if water pricing charges increase as a result of increased harvestable rights.
- Concern over cumulative impact of a number of small dams harvesting flows that would otherwise go to licensed entitlement.
- Farm dams host wildlife; however, this positive will never outweigh the environmental benefits that would have been received if water flowed into the coastal wetlands and remained in the stream.
- Forecast increased dry periods will bring water users into direct competition with one another even at the current harvestable rights limit.
- Harvest high flows rather than low flows to decrease stress to rivers in dry times.
- If the flushes in the creeks only come from extreme rainfall events because small events get harvested on-farm, it wouldn't be equitable to other water users.
- Increased harvestable right critical to secure water supply during dry times.
- Increased salinity issues for end-of-system water users if harvestable right is increased.
- Increases to the harvestable rights limit undermines recent changes to the WM Act for mining to hold licences for all take.
- Increasing the harvestable rights limit may undermine water markets, as it will reduce the percentage of water allocated via entitlements—this is inconsistent with the NWI.
- Missed opportunity with water being lost to the sea.
- Natural flow regimes and flow pulses are processes that underpin the economic productivity of the seafood industry—changes to the harvestable rights order may directly impact productivity for the seafood industry.
- Needs to be greater development of the trading market rather than increasing the availability of off-market (or free) water.
- Negative impacts on town water supply from increasing harvestable right take.
- No changes to harvestable rights where town water supply is likely to be affected.
- Opposed to increasing the harvestable rights limit and extending this right to third-order streams.

- Poor compliance of harvestable rights is problematic.
- Scope of review does not account for impacts on non-extractive industries—that is, the seafood industry.
- Should be able to on-sell harvestable right to urban water supply at commercial rates.
- Significant business risk over increasing the harvestable rights limit and extending to third-order streams due to the potential impacts on downstream flows.
- Standard 10% harvestable rights limit doesn't consider regional rainfall differences.
- Supportive of increased harvestable rights limit and extending the harvestable right to third-order streams.
- The current harvestable right arrangement works well—don't want to change something to realise that it doesn't work due to increasing water demand.
- There should be different categories of dams with different rights.
- There will be greater productivity by increasing the harvestable rights limit—through decreased inputs (that is, less water charges) and increased outputs (bigger dams).
- There will be reduced river flows by increasing the harvestable rights limit.
- Trading market is ineffective due to assessment time frame.
- Trading market is ineffective due to limited demand and highly restrictive trading rules.
- Water charges are too high.
- Water users can be more efficient with water use and increase productivity by adopting better practices and more advanced technology to decrease cost margins.

Appendix 3 Hydrological modelling

Objective for modelling

The aim of the modelling was to assess the risk to downstream water users that might result from changes to the harvestable rights limits.

The development of additional farm dams that intercept and store rainfall run-off within a catchment would almost certainly affect flow in the stream network downstream of those dams. The run-off that would otherwise enter the stream network is instead stored in the dam, reducing stream flow. Reduced flows can affect downstream water users and the riverine environments that depend on them.

Whether these **potential** impacts on water users and the environment become **actual** impacts depends on the timing and magnitude of flow reduction, including for reasons such as seasonal demand pattern, dry periods and if high- or low-flow events are affected. The magnitude of flow reduction depends on the magnitude of farm dam development. It also depends on other factors, such as regional climate, the location of new or enlarged dams in the catchment and how actively the water in those dams is used.

The modelling provides a transparent way of estimating the flow reduction based on assumptions of levels of development and water-use patterns. Analysis of the modelling results provides insights into the potential risks to downstream water users and the environment.

Approach

The department prepared and put to tender a scope of works for the modelling study. The successful tenderer was Hydrology and Risk Consulting (HARC). Modelling staff at HARC have extensive experience in similar investigations in other regions in Australia. The approach HARC used was based on that adopted in their other investigations, customised to the specific needs of this work.

The approach relies on calculating the changes in flow at the outlets of the case study catchments that would result from changes in the size, number and location of harvestable rights dams. HARC made calculations using the Spatial Tool for Estimating Dam Impacts (STEDI) modelling framework, a computer program that assesses farm dam impacts. A reference condition (baseline) is initially calculated to estimate the streamflow if there were no farm dams in the catchment. Different configurations of farm dams are then added to create different model runs. In each case study area, 40 harvestable rights scenarios were run, including different combinations of:

- percentage of captured average annual regional rainfall run-off—10%, 20%, 30% and 50%
- where harvestable rights dams can be built—first- and second-order streams versus third-order streams
- level harvestable rights uptake—current level, 25%, 50%, 75% and 100%.

The changes in streamflow from each of the 40 scenarios were then compared with the reference condition. As each set of calculations exceeds 15,000 daily flow values (42 years of daily data), the comparisons are summarised as metrics that can help to interpret the significance of effects on various downstream uses—both consumptive and in-stream—of the water.

These metrics include:

- average annual flow volume
- percentage of time flow falls below regional pumping thresholds
- the frequency and duration of environmentally significant flow events (such as low- and zero-flows, floods and freshes) and recognising seasonal variations of such events.

Method

Data used

The principal inputs to the STEDI model for each case study catchment were observed daily regional rainfall, potential evapotranspiration and observed streamflow. Evapotranspiration is the part of the water cycle that removes liquid water from an area with vegetation and transfers it into the atmosphere by the process of both transpiration and evaporation. The modelling used a sufficiently long record of all these to ensure that flows could be estimated in wet and dry periods.

The department provided the data to enable HARC to set up STEDI models in each case study catchment. As well as observed flows at or near the catchment outlet, this included the following spatial layers:

- catchment boundary
- stream network, including Strahler stream orders
- gridded digital elevation model
- property boundaries
- land use
- mapped location of existing farm dams as points or polygons
- MHRDC multiplier contours.

HARC consulted with the department on appropriate crop water demand patterns from additional harvestable rights farm dams assumed to be developed under the model combinations.

Model implementation

The STEDI models for each case study catchment were set up following these steps:

1. Infill streamflow to ensure consistent 1975–2016 hydrometric record available for comparable reporting
2. Calculate volumes of existing dams based on mapped surface areas
3. Develop spatial layers of hypothetical additional farm dams using property areas and harvestable rights contours according to scenario criteria, as constrained by other practical considerations (for example, not in national parks, existing farm dams, minimum volume)
4. Calculate maximum catchment area and stream connectivity for each existing or additional farm dam using digital elevation model
5. Establish demand patterns for each farm dam, based on size and assumed crop type
6. Proportion flow time series to individual catchment areas and set up time series inflow and climate for each subcatchment.

HARC (2020) provides a detailed description of each step.

The STEDI models were first run for existing levels of harvestable rights dam development, including assumed demand patterns from existing dams. The water captured by each dam was aggregated and added to the observed time series to provide an estimate of the flow for the 'no farm dams' reference condition. This ‘naturalised’ flow time series was then used as the inflow for all 40 scenarios. The models were run using flow data for all years in the 1975–2016 time series. They were statistically analysed over the whole period and then for the driest 10% of the time to identify indicative changes during periods of low rainfall and run-off when competition for water is greatest.

Model suitability

The department considers that the modelling completed for this review is transparent and based on a framework with sound principles and reasonable assumptions. It is an informative tool that provides insights into the potential hydrological impacts of the different harvestable rights scenarios modelled. It highlights important catchment characteristics, such as whether a catchment yields high or low levels of run-off and how this corresponds to the magnitude of impact.

However, as with all modelling, there are some limitations. Although it provides a reasonable mix of wet and dry periods, the 42-year time series is unlikely to include the worst droughts that have occurred (including the most recent drought) or could occur, so the modelling may underestimate the reduction in flows during dry years. And although using a longer time series could include worse droughts than those covered in the 1975–2016 period, it is unlikely to change the general insights that the modelling provides.

Another limitation is that the modelling outcomes represent changes to end-of-system flows only. The review needs to consider potential hydrological impacts within each catchment. For example, an increase in water extracted might have minimal impact on end-of-system flows but have substantial hydrological impacts immediately downstream of the extraction point.

Results

Current level of development

The foundational step in HARC's analysis identified the current number of harvestable rights dams on farms and estimated their volumes using a volume-versus-surface-area relationship derived from previous studies. Table 3 presents the results. The total amount of harvestable rights dam capacity allowed in the catchment was calculated based on the product of area and the MHRDC multiplier contour. This enabled the estimated current total storage to be compared as a proportion of the total allowable harvestable rights storage for the catchment (see % of current harvestable rights in Table 3).

Table 3. Number of current harvestable rights dams, estimated capacity and percentage of current harvestable rights for catchment

Case study area	Number of harvestable rights dams	Estimated volume (ML)	% of current harvestable rights
Duck	933	1,563	31
Woolgoolga	11	31	53
Bucca Bucca	7	10	1
Nambucca	633	1,586	37
Allyn	1,337	1,470	13
Wollombi	4,054	13,379	13
Wyong	864	1,665	51
Wollondilly	7,762	11,450	70
Double	262	667	66
Bega–Bemboka	1,788	4,327	65

Case study area	Number of harvestable rights dams	Estimated volume (ML)	% of current harvestable rights
TOTAL	**17,651**	**38,780**	**25***

*This 'total' percentage is recalculated from the total allowable and total volume.

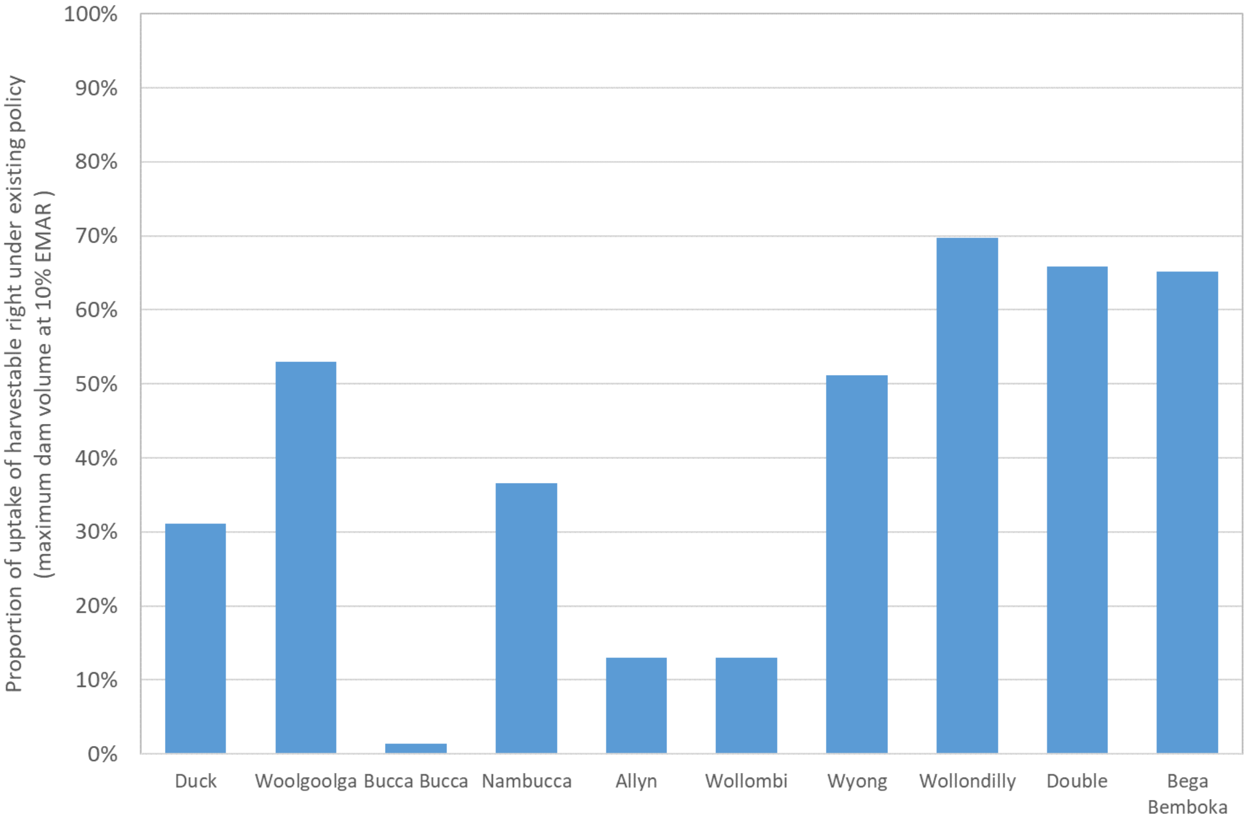


Figure 5. Level of uptake of current harvestable rights by case study catchment

The results in Table 3 and Figure 5 indicate a wide variation in the uptake of harvestable rights across the case study catchments (as at 2016), ranging from 1%–70%. Five of the ten catchments took up 50% or more of their allowable harvestable rights, and a further two more than 30%. The remaining three catchments had negligible to low uptake.

Catchment hydrology

An analysis of the rainfall and flow records for the 10 case study catchments indicates large variations between catchments in:

- rainfall (varying from 638 mm/year to 1,588 mm/year)
- run-off depth (35 mm/year to 645 mm/year)
- run-off as a percentage of rainfall (5% to 41%).

These large variations are a function of the catchments, their topography (slope, aspect, stream network shape) and their land surface (soils, land use, vegetation cover), as well as their climate (rainfall patterns and evaporation patterns).

The average volume of water that would flow out of the case study catchments each year if there were no harvestable rights dams present was modelled (see the 'Mean annual flow' column of Table 4). The HARC report refers to it as the 'unimpacted mean annual flow'.

Table 4. Catchment area and modelled mean annual flow and run-off depth (1975–2016)

Case study area	Catchment area (km²)	Mean annual rain (mm/year)	Mean annual flow (gigalitre/year)	Mean annual run-off (mm/year)	Mean annual run-off (% rain)
Duck	529	958	78	147	15
Woolgoolga	30	1,548	6	198	13
Bucca Bucca	118	1,588	76	645	41
Nambucca	434	1,401	180	415	30
Allyn	1,185	929	371	313	34
Wollombi	1,863	829	125	67	8
Wyong	437	1,173	98	224	19
Wollondilly	1,581	638	56	35	5
Double	153	866	33	218	25
Bega–Bemboka	827	768	159	193	25

Effects on mean annual flow

The current level of development of harvestable rights dams already reduces catchment outflow compared with the reference flows developed for the study (estimated outflows if there were no dams). HARC calculated the percentage reduction in catchment outflow for all 40 scenarios modelled in each case study catchment. Table 5 and Table 6 present a subset of results and report estimated reductions of mean annual flow under current development, and for full uptake of current and alternative harvestable rights limits. Table 5 presents the results for dams allowed to be built on first- and second-order streams. Table 6 shows the results if dams were also allowed to be built on third-order streams.

The results in Table 5 show that under current levels of development, the percentage impacts on mean annual flow are low, except for Wollondilly. The impact in five of the ten case study catchments is less than 1%. Wollondilly has an estimated flow reduction of 12.3%. This markedly different result is likely because of both the high level of harvestable rights dam development (70%) and the low run-off depths (35 mm), respectively the highest and lowest compared with all other catchments.

Full uptake (100%) of the current harvestable rights limits will further reduce flows in most instances. Seven of the ten case study catchments would have less than a 4% flow reduction in these circumstances, with Duck and Wollombi catchments having 5% and 7.4% reductions, respectively. The reason for these greater reductions in mean annual flow appears to be the comparatively low run-off depths in these catchments. Wollondilly already has the greatest percentage reduction (about 12%) in mean annual flows at current levels of uptake. With full uptake of the current harvestable right limits, mean annual flows in Wollondilly would be reduced by approximately 20% of the reference flows, which is the greatest reduction in the case study catchments.

In general, increasing the capacity of harvestable rights dams will further reduce flows but the relationship is not linear.

In some catchments, doubling the harvestable rights percentage from 10% to 20% would also double the reduction in downstream flows, assuming full uptake of both scenarios. For example, a 0.8% reduction in mean annual flows in Bucca Bucca under the 10% harvestable right scenario would double to a 1.6% reduction under a 20% scenario.

However, in other catchments, doubling the harvestable rights percentage results in a smaller proportional change in flows. For example, the mean annual flow reduction in the Double catchment changes from 2.9% to 4.1%. This is less than half the change expected in a linear relationship.

Possible reasons for catchments showing lower proportional changes are:

- the larger MHRDC exceeds the maximum volume that can be generated in the catchment, and dams would not fill up
- the increased harvestable rights dams would reduce not only flows, but also inflows to other harvestable rights and licensed farm dams that fill by capturing run-off.

In cases where the larger MHRDC is reducing inflows to other dams, the implications for licensed farm dams may be important.

Table 5. Percentage reduction of mean annual flow from current and maximum uptake of harvestable rights for dams allowed on first- and second-order streams

Case study area	10% harvestable right, current uptake level	10% harvestable right, 100% uptake level	20% harvestable right, 100% uptake level	30% harvestable right, 100% uptake level	50% harvestable right, 100% uptake level
Duck	1.4	5.0	8.0	10.4	13.8
Woolgoolga	0.5	0.9	1.7	2.6	4.6
Bucca Bucca	0.01	0.8	1.6	2.4	3.8
Nambucca	0.7	1.9	3.3	4.5	6.7
Allyn	0.4	2.9	5.2	7.2	10.4
Wollombi	0.9	7.4	10.0	12.2	15.7
Wyong	1.1	2.5	4.3	6.1	9.2
Wollondilly	12.3	19.6	27.6	32.5	38.1
Double	1.8	2.9	4.1	5.1	6.8
Bega-Bemboka	2.3	3.9	5.8	7.4	10.0

Comparing mean annual flow reductions for first- and second-order stream, and up to third-order stream scenarios (that is, comparing Table 5 results with Table 6 results) shows there are larger proportional changes from allowing dams to be built on third-order streams. However, this is not uniformly true and is less evident in the 20% and 30% harvestable rights percentage scenarios.

Table 6. Percentage reduction of mean annual flow from maximum uptake of harvestable rights for dams allowed on third-order streams

Case study area	10% harvestable right, current uptake level*	10% harvestable right, 100% uptake level	20% harvestable right, 100% uptake level	30% harvestable right, 100% uptake level	50% harvestable right, 100% uptake level
Duck	N/A	5.4	9.3	12.7	18.0
Woolgoolga	N/A	0.9	1.7	2.6	4.6
Bucca Bucca	N/A	0.8	1.7	2.4	3.9
Nambucca	N/A	2.0	3.4	4.8	7.3
Allyn	N/A	2.9	5.5	7.8	12.1
Wollombi	N/A	7.8	10.8	13.5	18.0
Wyong	N/A	2.6	4.4	6.2	9.6
Wollondilly	N/A	20.8	31.2	38.3	46.7
Double	N/A	2.9	4.3	5.6	7.8
Bega-Bemboka	N/A	4.0	6.2	8.2	11.5

* Not applicable, because harvestable rights dams are not currently permitted on third-order streams.

Effects on low flows

For each of the 10 catchments, 40 scenarios were modelled. Although the implications of different scenarios are not the same in all 10 catchments, the Bemboka River, a tributary of the Bega River, illustrates some of the more critical impacts on low flows.

In drier periods, the flow in rivers comes from baseflow. Baseflow is groundwater that intersects the stream network and seeps into the river, maintaining the lower flows in drier periods. Allowing dam development lower down the stream network, below second-order streams, means that baseflow seeping into dams is more likely to be intercepted, reducing the low flows in the downstream reaches.

This has implications for downstream water users (such as water utilities and irrigators) and the in-stream aquatic ecology downstream. In rivers where downstream water users extract low flows, extraction is often prohibited when flows get very low to reduce the risk of the river drying out. For example, in the Bemboka River, irrigators must stop pumping when flow drops below 2 ML per day (the ‘cease-to-pump’ trigger).

Results from the HARC modelling suggest the likely implications for irrigators taking water from the Bemboka River (see Figure 6). In the four scenarios shown, the two orange lines indicate the cease-to-pump frequency if dams were also allowed on third-order streams. These lines climb steeper than the blue lines (no dams on third-order streams), indicating that allowing dams on third-order streams would increase the number of cease-to-pump days in drier years.

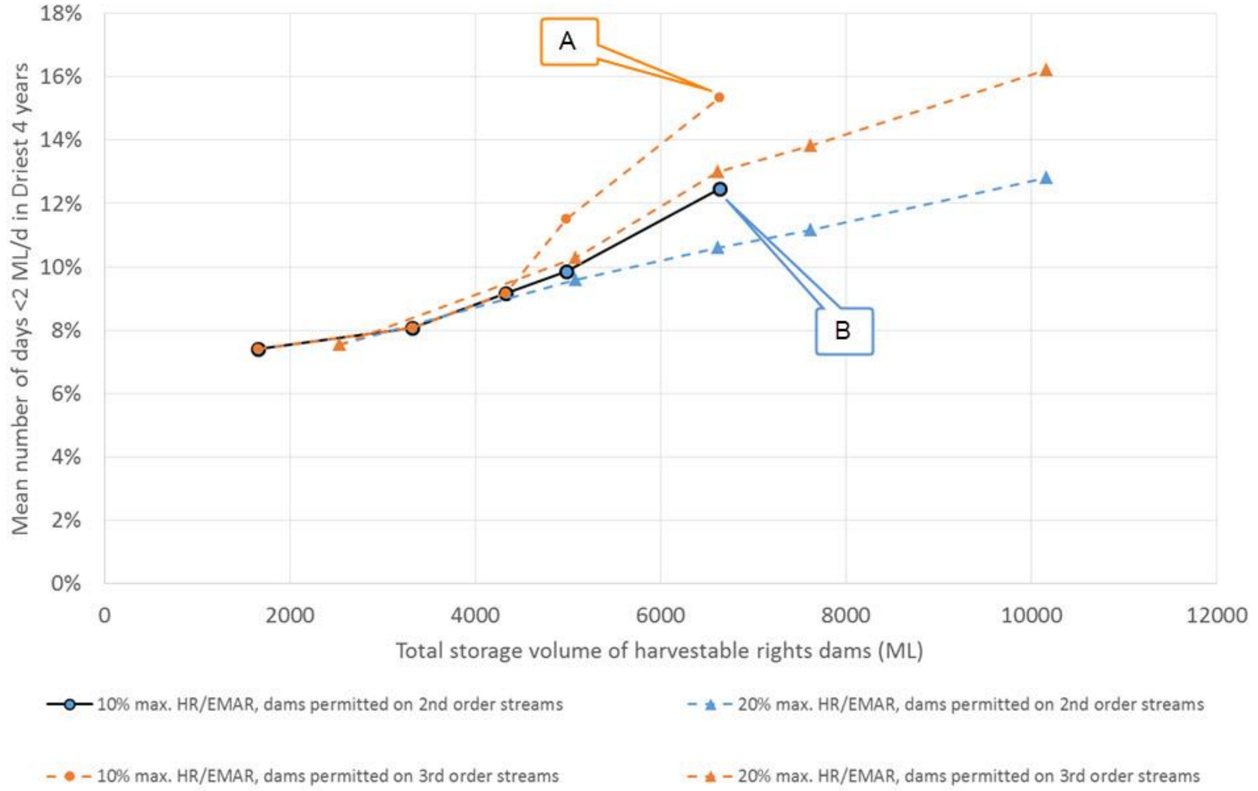


Figure 6. Frequency of cease-to-pump conditions in the Bemboka River under different levels of farm dam development

Point B represents 100% uptake of the 10% harvestable right on first- and second-order streams and shows that on 12.4% of days in drier years, cease-to-pump conditions would be triggered due to the anticipated flow levels. Point A represents a similar scenario but with dams also allowed on third-order streams. This shows cease-to-pump days occurring 15.3% of the year, an increase of 2.9%, which is equivalent to an increase from 45 to 55 cease-to-pump days in dry years on average.

Where new or enlarged harvestable rights dams are restricted to first- and second-order streams, the effect on low flows was less pronounced. Using Nambucca catchment as an example, allowing additional or larger harvestable rights dams on first- and second-order streams only showed negligible change to the number of cease-to-pump days compared to the current harvestable rights limits. In the graph within Figure 7, the dashed line (representing greater dam development than the current limits allow) does not increase to much more than the level of the current harvestable rights limits (the solid line).

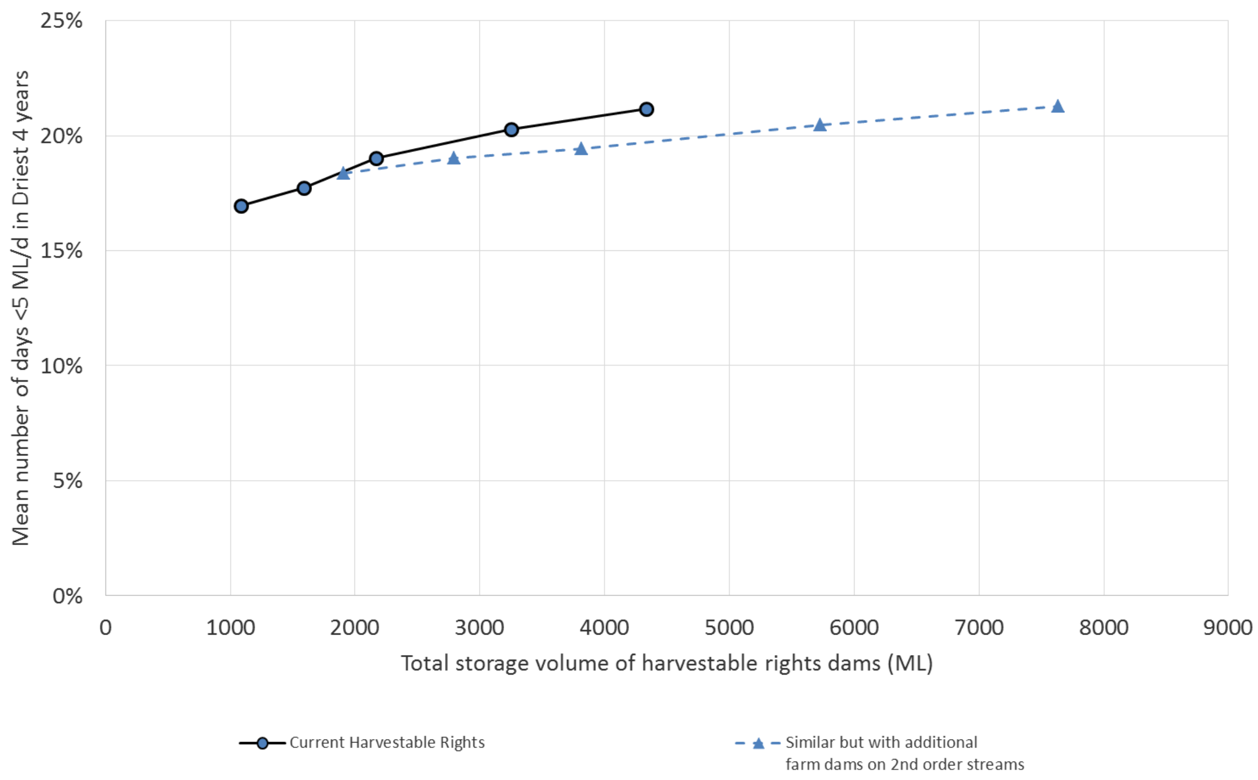


Figure 7. Harvestable right percentage increase effect on low flows in dry years in Nambucca catchment

Effects on freshes

Freshes are higher flows in a river that stay within the banks but rise to wet the banks and the in-stream benches and bars that make up the river channel. Freshes are a result of smaller rainfall events but also depend on earlier weather conditions. If previous weather conditions have been wet, small rainfall events can create a fresh. If it has been dry, a larger rainfall event will be necessary to raise the flow in the river channel.

Allowing increased dam capacity (greater cumulative volume of dams) has implications for the freshes in a river. Increasing the dam capacity within a catchment, through either larger dams or increased numbers of dams, could mean that these higher flows are further intercepted, which would reduce the size of freshes in downstream reaches and potentially remove smaller freshes entirely. This has implications for downstream water users (such as water utilities and irrigators) and the in-stream aquatic ecology downstream.

In rivers where there is a water-dependent asset downstream, such as a wetland, these flows can be important. Results relating to effects on freshes are presented as a case study, similarly to those for low flows, to make changes easier to visualise. The Woolgoolga Creek results show where the implications for freshes could be most critical.

In the case of Woolgoolga Creek, the most downstream point adjacent to the coastline is Woolgoolga Lake, an ICOLL.

Results from the HARC modelling, shown in Figure 8 and Figure 9, suggest there could be implications for the frequency of the opening of Woolgoolga Lake to the ocean. The figures depict eight scenarios, which are based on 100% uptake of the plotted scenarios. As the level of dam storage increases, both plots show a gradual decrease in the number and duration of freshes during the low-flow season.

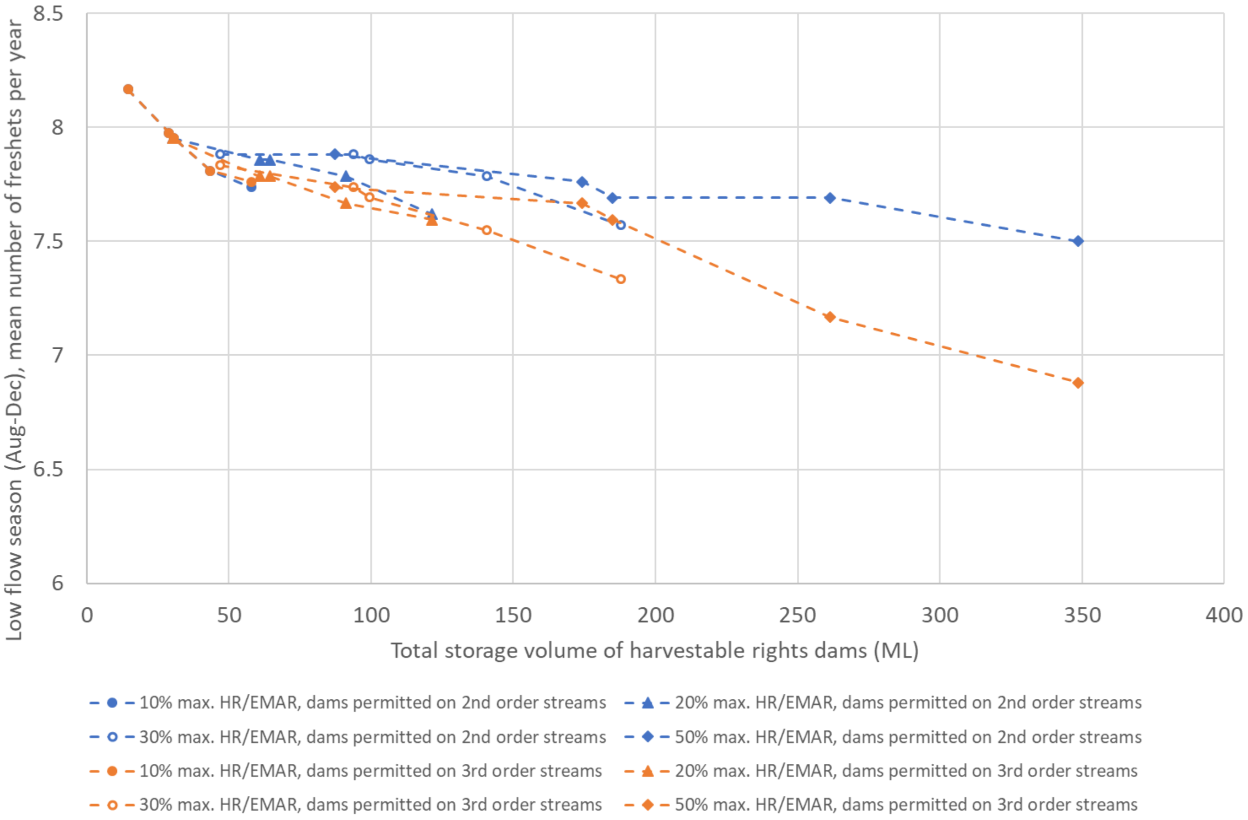


Figure 8. Frequency of freshes in Woolgoolga Creek under different levels of farm dam development

Figure 8 shows that as harvestable rights dam volume increases from 14 ML to 350 ML, the average number of freshes in the months of August to December decreases slightly from more than eight each year to just below eight. With the inclusion of dams on third-order streams (the orange line scenarios), the number of events in the extreme scenario drops to just below seven each year.

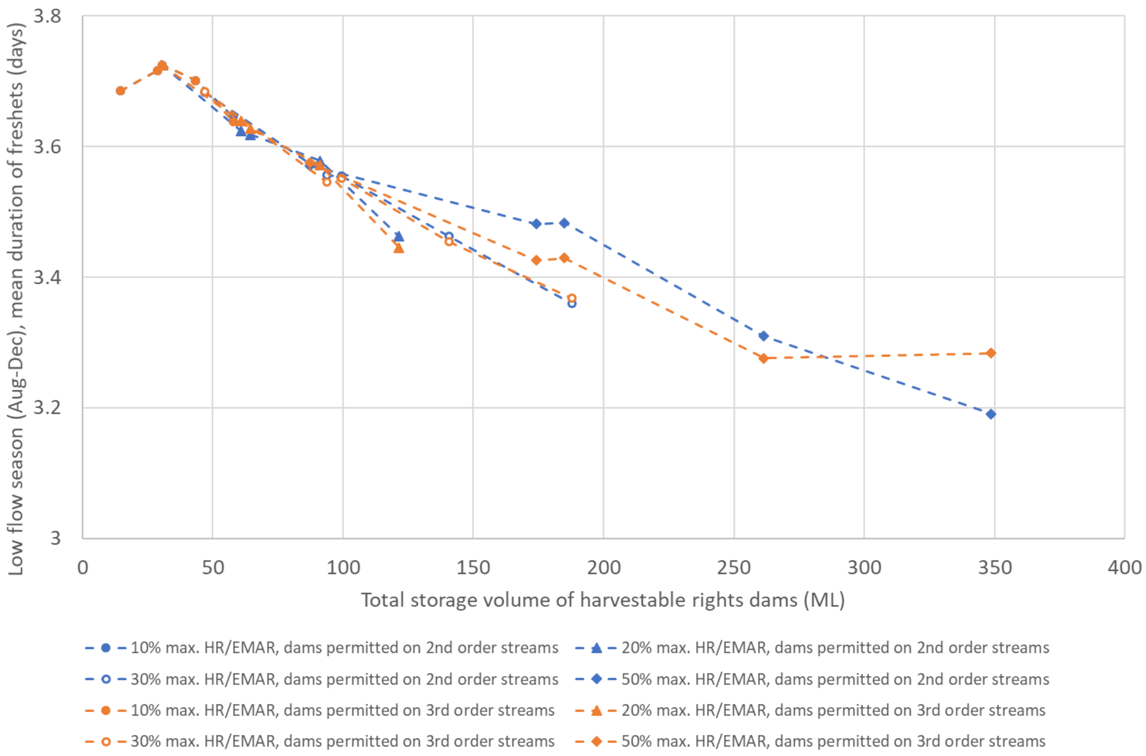


Figure 9. Duration of freshes in Woolgoolga Creek under different levels of farm dam development

The data in Figure 9 shows a small reduction in the duration of freshes from August to December in response to an increase in harvestable rights dam capacity constructed in the Woolgoolga Creek catchment. In general, a decrease in both the frequency (Figure 8) and duration (Figure 9) of freshes would contribute to a reduction in flow volumes.

These figures suggest that the frequency of the opening of Woolgoolga Lake to the ocean could be affected if there was a large amount of dam development in the catchment.

This is important to consider because the ecology of an ICOLL depends on its connection with the ocean and the exchange of fresh water and ocean water. Substantive reductions in the frequency of ICOLL openings could change their plants and animals. The effect of the modelled reductions on the frequency and duration of freshes on Woolgoolga Lake could influence opening frequencies and the health of the lake. The department would need to do further assessment to verify this.

The potential for ICOLLs to be affected is higher in catchments that have large areas of freehold land where more harvestable rights dams could be built than in catchments with large areas of national parks or state forests where dams would not be built.

Effects on annual flows in dry years

For annual flows in dry years, the Wyong River is an example of where the implications of increasing harvestable rights limits could be critical. We cannot assume the same level of change across all catchments, as conditions and uses vary significantly.

During high-flow years, the relative impact of farm dams is small, but in dry years it is more substantial. In wetter years and medium-rainfall years, the dams are kept fuller and will overflow more often. In drier years, the ground surface needs to saturate before water will run off into gullies, creeks and finally into larger streams. When flow is captured in lower order streams (that is, gullies and small watercourses), the relative change to flows in the larger downstream creeks and rivers is higher.

The Wyong River provides the largest flows into Tuggerah Lakes; an estuarine lake system. The tidal limit is created by a weir from which water is diverted for urban water use. Water extracted from this weir is an important and relatively cheap source of water for the Central Coast. The Central Coast water supply scheme is linked to the Lower Hunter urban water supply scheme to help ensure security of supply should one of the schemes be low in stored water.

Under the current harvestable rights arrangements, the annual flows in dry years are estimated to be reduced by 4.69%, as Figure 10 shows. If uptake of harvestable rights rose from the current level of 51% to 75%, the modelling suggests the reduction in annual flow would slightly more than double in dry years but still remain less than 10%.

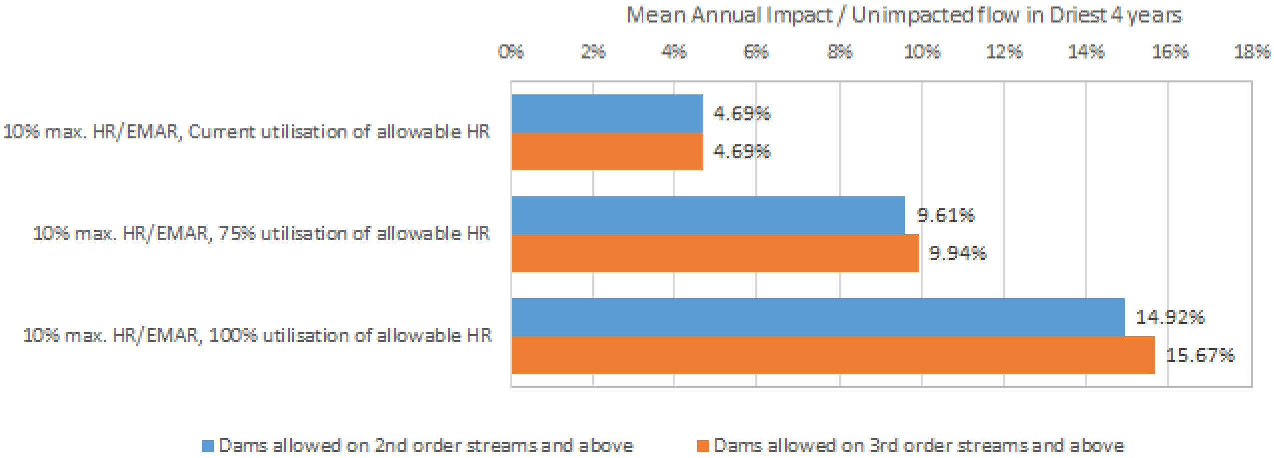


Figure 10. Effect of harvestable rights dams on mean annual flow in dry years under current harvestable rights arrangements – Wyong case study catchment

The Central Coast Council also sources water from rivers other than the Wyong River. However, these rivers are not as likely to be affected as much as Wyong River, as they have different surrounding land uses where dams would not be developed (such as national parks). Urban water extraction from the Wyong River weir is limited by a licence condition that allows extraction of a proportion of the flow. So, if flows are lower, the volume available for extraction is also lower. The weir also needs to provide a small flow for fish passage.

The department has not assessed the impact of the increased uptake of the existing 10% harvestable rights on the supply security of the Central Coast water supply system, as it is outside the scope of this study. However, based on the modelling results in Figure 10, there is likely to be some effect on the water supply security. Councils need to consider water allowed to be taken under harvestable rights when developing their water security strategies.

Increasing harvestable rights would have a greater effect on annual flows in dry years, as Figure 11 shows. Assuming 75% use, the total dry-year flow from the system is reduced by 9.61% under current limits. This would be reduced by 17.45% if the harvestable rights percentage was increased to 20%, and by 30.7% if the harvestable rights percentage was increased to 50%. Figure 11 also illustrates the greater reduction of flow in dry years with harvestable rights dams also allowed on third-order streams.

Further modelling of higher harvestable rights limits would need to be done to understand the full implications for Central Coast Council’s water supply security.

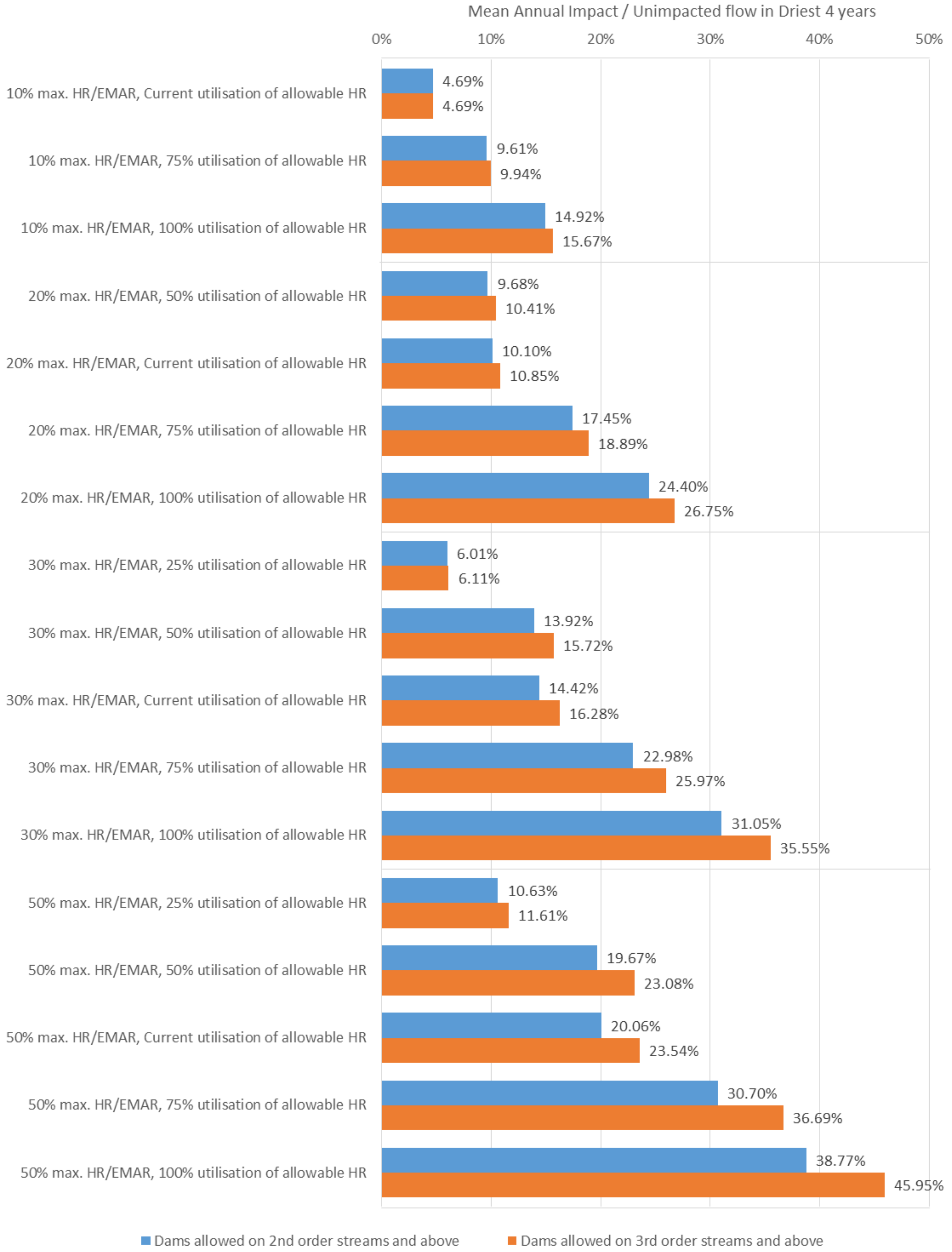


Figure 11. Effect on annual flows in dry years of harvestable rights dams under modelled scenarios in Wyong case study catchment

Discussion of results

Overall, the modelling results show that uniformly increasing harvestable rights could see small changes to flows and various flow-related outcomes (for example, water supply, water access during low-streamflow periods and freshes for environmental benefits) in some catchments and larger changes in other catchments when compared with their reference condition. The range of modelled changes to key flows across all case study catchments is shown in Table 8 and Table 9 in the 'Summary of results' section below.

The extent of changes depend on existing flow patterns, harvestable rights limits, levels of uptake and whether harvestable rights dams are allowed on third-order streams. Differences in catchment characteristics mean that flow related impacts would not be equally distributed across all catchments.

Uptake of harvestable rights

A significant unknown when trying to assess potential hydrological impacts of increasing limits is the level of landholder uptake of harvestable rights. Without knowing how many landholders will adopt harvestable rights, we cannot be sure what the potential effects will be. We tested current uptake levels and four uptake scenarios between 25% and 100%. As expected, the magnitude of flow changes increased when either the harvestable rights limits or the uptake increased.

The likely level of uptake and resulting effects are speculative without further investigations involving community consultation and economic analysis. However, the fact that landholders requested this review and that coastal harvestable rights is a key issue for associations such as NSW Farmers[9] shows demand for additional water. It suggests that further dams would be built to take advantage of any increase to harvestable rights limits.

The current level of harvestable rights has been in place since 1999. It is possible that most landholders who wanted to build dams under the existing rules have done so. It is also possible that slow ongoing growth in harvestable rights dam numbers could be expected as land changes hands or as new commercial opportunities emerge that would be viable with relatively low volumes of water.

Across the 10 case study catchments, there is a large variation in the uptake of existing harvestable rights, from 1%–70% of the total allowance for the whole catchment. This indicates that many landholders have either opted not to use this right or may be unable to use the right at this time (for example, they may have limited means to build a dam now or have no suitable dam location on their property under existing rules). This means that under the current limits, there is already potential for increases in the volume of water intercepted as harvestable rights. This would affect downstream flows to some extent, but the likelihood of this happening is low in some catchments.

The department did not study in depth the drivers for farm dam development for this review. Although in many cases a dam would be constructed to create an independent water supply on a property for stock and domestic purposes, there would also be instances where it would be for another commercial purpose, for example, intensive agricultural enterprises.

Changes to mean annual flow

The modelling results indicate that:

- current development and uptake of harvestable rights varies greatly across the case study catchments. The existing harvestable rights limits have arguably achieved the intended

[9] Source: www.nswfarmers.org.au/NSWFA/NSWFA/Posts/The_Farmer/Environment/NSW_farmers_face_scary_water_crisis_despite_joyous_rain.aspx

purpose of providing essential water requirements for stock, domestic and general farming purposes, without a substantial impact on catchment outflows. With additional harvestable rights uptake under the existing limits, the modelled impacts on end-of-system flows are still not overly high

- of the case study catchments, Wollondilly has both the highest harvestable rights uptake and the lowest run-off. These factors are likely related and show that the effects of increasing harvestable rights (by either increasing the percentage or allowing dams on third-order streams) would be most felt here. That is, although catchments with higher run-off rates are potentially better placed to absorb flow changes from increased harvestable rights, a uniform increase to limits in all coastal draining catchments would likely reduce mean annual flows to a greater degree in already stressed catchments with lower run-off
- in general, increasing the capacity of harvestable rights dams would further reduce mean annual flows, but the relationship is not linear. In some catchments, doubling the harvestable rights percentage from 10% to 20% would also double the reduction in downstream flows, assuming full uptake in both scenarios. However, particularly in drier catchments, there would be a much smaller proportional change inflow reductions, likely indicating stressed catchments
- reduced mean annual flow may have implications for urban water supplies, as it would reduce inflows into downstream weirs that local water utilities use.

Changes to low flows

The modelling results indicate that there would likely be:

- reduced access for downstream water users that use low flows in dry periods. These are often irrigators on unregulated rivers, who do not have on-farm water storage or alternative water sources
- reduced inflows from unregulated tributaries into the regulated rivers during dry periods, which would increase compensating releases for the regulating storages in dry periods
- reduced volume of low flows and increased frequency and duration of low- and no-flow conditions in rivers, which could reduce the refuge value of the habitat available in dry periods.

Changes to freshes

The modelling results indicate that increasing harvestable rights would likely result in:

- reduced frequency of the opening of ICOLLs, which could impact the ecology and amenity of the lake or lagoon
- reduced frequency and duration of the freshes that improve water quality of riverine pools, which could reduce the habitat value and, in turn, the resilience of the riverine or estuarine ecology
- reduced inflows to downstream weirs that local water utilities often use for town and urban water supply during relatively dry periods.

Changes to annual flow in dry years

The modelling results indicate that:

- the relative impact of harvestable rights dams in dry years would be more substantial than in average years
- in dry years, the potential for urban as well as rural communities to be affected by increased harvestable rights would be heightened because of reduced inflows to urban water supplies.

Key hydrological impacts of harvestable rights options

Modelling results showed that the two options under review for increasing harvestable rights would affect end-of-system flows in different ways. The level of landholder uptake of harvestable rights in a catchment would also play an important role in determining how big the flow changes would be. The following sections outline the main ways each option would likely affect downstream flows.

Harvestable rights percentage increase

The modelling shows that:

- as the harvestable rights percentage increases (and as the level of harvestable rights uptake increases), the number and duration of freshes decrease
- the effect of a higher harvestable rights percentage would be greater in dry years (when users need water most), than in average years
- in drier (lower run-off) catchments, there is a strong possibility that increasing the harvestable rights percentage would reduce inflows into other farm dams and downstream flows.

Harvestable rights dams on third-order streams

The modelling shows that:

- allowing dams on third-order streams would affect low flows and increase the frequency and duration of cease-to-pump days, which may affect other water users and the environment
- allowing dams on third-order streams would have a greater effect in dry years (when users need water most) than in average years.

Where farm dam development could be most sustainable

Farm dams could be most sustainable where they are:

- on first- and second-order streams that are not spring-fed (limiting changes to the low flows of larger downstream rivers)
- not upstream of water users that rely on higher flows (for example, town water supply dams and weirs)
- managed to avoid local impacts directly downstream (for example, on a neighbour’s dam)
- in a river system where a small reduction in the frequency and duration of small freshes does not affect the river and estuarine ecology.

Summary of results

The below information illustrates the level of variation between case study catchments in the flow changes modelled by HARC for each harvestable rights limit scenario. Table 7 explains the metrics used while Table 8 and Table 9 include the data on the smallest and largest modelled changes to key metrics across all the case study catchments.

These results represent *average* changes in the hydrology of different parts of the flow regime, which is useful when comparing complex changes across individual catchments. as averages do not show the full variation of changes that could occur within a catchment, more detailed modelling has been done to demonstrate the changes likely to occur for key flow types. These results are available in a series of fact sheets[10]. Taking freshes for example, if the infrequent, very high flows are excluded from the analysis then it provides a picture of the likely effect on smaller freshes events. This is because the infrequent, very high (i.e. flood) flows ‘skew’ the average change in flows and mask the reduction in smaller freshes. We suggest reading the fact sheets in conjunction with the discussion paper, these appendices and the modelling report so that you have a more detailed level of information to consider when providing us with comments on your own context.

Table 7. Description of metrics used

Metric	Description
Percentage reduction in catchment outflow (%)	The percentage reduction in catchment outflow in all modelled years. Change in mean annual flow as a proportion of reference annual flows (estimated outflows if there were no dams).
Percentage reduction in catchment outflow in dry years (%)	The percentage reduction in catchment outflow in the driest 4 years. Change in mean annual flow as a proportion of reference annual flows (estimated outflows if there were no dams) in the driest 4 years.
Average days per year below cease to pump threshold in dry years	The average number of days per year when the river would be below the cease to pump threshold in the driest 4 years. Note: Cease to pump thresholds are included in the respective water sharing plans and they differ for each catchment.
Freshes duration (days) - Low flow season	The number of days that the freshes last for during the low flow season.
Freshes frequency (number of freshes per year) - Low flow season	The number of freshes there are per year during the low flow season.

[10] See www.dpie.nsw.gov.au/coastal-harvestable-rights-dams-review

Table 8. Range of modelled changes in the duration and frequency of freshes across all modelled scenarios and all case study catchments

Harvestable rights percentage (%)	**Level of harvestable rights uptake** (%)	**Duration of freshes Up to 2nd order streams** (min. to max. days)	**Duration of freshes Up to 3rd order streams** (min. to max. days)	**Frequency of freshes Up to 2nd order streams** (min. to max number of freshes per year)	**Frequency of freshes Up to 3rd order streams** (min. to max number of freshes per year)
10	**25**	3.7 - 19.4	3.7 - 19.4	1.5 - 8.2	1.5 - 8.2
10	**50**	3.7 - 19.4	3.7 - 19.4	1.5 - 8.0	1.5 - 8.0
10	**75**	3.7 - 18.0	3.7 - 18.3	1.5 - 7.8	1.5 - 7.8
10	**100**	3.6 - 17.3	3.6 - 16.8	1.5 - 7.7	1.5 - 7.8
20	**25**	3.7 - 19.7	3.7 - 19.7	1.5 - 8.0	1.5 - 8.0
20	**50**	3.6 - 18.5	3.6 - 18.1	1.5 - 7.9	1.5 - 7.8
20	**75**	3.6 - 17.4	3.6 - 17.3	1.5 - 7.8	1.5 - 7.7
20	**100**	3.5 - 17.6	3.4 - 16.5	1.4 - 7.8	1.5 - 7.7
30	**25**	3.7 - 19.4	3.7 - 19.4	1.5 - 7.9	1.5 - 7.8
30	**50**	3.6 - 18.1	3.5 - 17.5	1.5 - 7.9	1.5 - 7.7
30	**75**	3.5 - 17.9	3.5 - 17.0	1.4 - 7.8	1.4 - 7.7
30	**100**	3.4 - 17.3	3.4 - 16.5	1.4 - 7.6	1.4 - 7.6
50	**25**	3.6 - 18.9	3.6 - 18.6	1.5 - 7.9	1.5 - 7.8
50	**50**	3.5 - 17.6	3.4 - 17.7	1.5 - 7.8	1.4 - 7.7
50	**75**	3.3 - 18.1	3.3 - 17.5	1.4 - 7.7	1.3 - 7.5
50	**100**	3.2 - 18.4	3.3 - 16.3	1.3 - 7.5	1.3 - 7.5

Table 9. Range of modelled changes in catchment outflow and the days below cease to pump thresholds across all modelled scenarios and all case study catchments

Harvestable rights percentage (%)	Level of harvestable rights uptake (%)	Percentage reduction in catchment outflow Up to 2nd order streams (min. to max. %)	Percentage reduction in catchment outflow Up to 3rd order streams (min. to max. %)	Percentage reduction in catchment outflow in dry years Up to 2nd order streams (min. to max. %)	Percentage reduction in catchment outflow in dry years Up to 3rd order streams (min. to max. %)	Average days per year below cease to pump threshold in dry years Up to 2nd order streams (min. to max. %)	Average days per year below cease to pump threshold in dry years Up to 3rd order streams (min. to max. %)
10	**25**	0.2 - 5.0	0.2 - 5.0	1.8 - 15.9	1.8 - 15.9	27.0 - 333.5	27.0 - 333.5
10	**50**	0.4 - 8.5	0.4 - 8.5	3.6 - 25.0	3.6 - 25.0	29.5 - 336.8	29.5 - 336.8
10	**75**	0.6 - 13.6	0.6 - 13.7	4.8 - 37.5	4.8 - 38.8	36.0 - 340.3	42.0 - 342.3
10	**100**	0.8 - 19.6	0.8 - 20.8	6.6 - 50.3	6.7 - 58.9	45.5 - 342.5	56.0 - 348.0
20	**25**	0.4 - 6.8	0.4 - 6.7	3.5 - 20.7	3.6 - 20.8	27.5 - 335.0	27.5 - 335.0
20	**50**	0.9 - 13.8	0.9 - 14.3	6.8 - 37.5	7.0 - 39.1	35.0 - 339.8	37.5 - 340.3
20	**75**	1.2 - 20.9	1.2 - 22.9	8.9 - 48.8	9.1 - 55.2	40.7 - 342.0	50.5 - 347.5
20	**100**	1.6 - 27.6	1.7 - 31.2	12.1 - 55.7	12.5 - 65.1	46.7 - 344.8	59.2 - 348.8
30	**25**	0.7 - 9.5	0.7 - 9.5	4.8 - 27.5	5.0 - 28.0	29.5 - 336.8	29.5 - 336.8
30	**50**	1.3 - 17.8	1.3 - 19.9	9.5 - 41.5	9.8 - 46.8	37.0 - 340.5	43.2 - 344.5
30	**75**	1.7 - 26.0	1.8 - 29.7	12.4 - 52.1	12.8 - 59.7	42.0 - 342.0	52.0 - 347.8
30	**100**	2.4 - 32.5	2.4 - 38.3	16.8 - 56.6	17.5 - 66.1	47.0 - 345.0	59.7 - 349.3
50	**25**	1.0 - 13.5	1.1 - 14.1	6.2 - 36.1	6.9 - 37.2	34.2 - 339.3	35.5 - 340.3
50	**50**	2.1 - 23.0	2.1 - 27.3	12.4 - 47.8	14.5 - 54.8	39.0 - 341.3	47.5 - 346.5
50	**75**	2.8 - 31.7	2.8 - 38.4	17.2 - 54.0	18.8 - 62.8	43.5 - 342.5	53.7 - 348.5
50	**100**	3.8 - 38.1	3.9 - 46.7	22.0 - 57.0	25.5 - 66.7	47.5 - 345.3	60.0 - 350.3

Appendix 4 Water trade analysis

Background

Water trade in NSW occurs under the WM Act. Trade in each water source is subject to rules included in the relevant water sharing plan. The principles for water trade, or ‘dealings’, are set out in the minister’s Access Licence Dealing Principles Order 2004. Under the WM Act, water licences are fully separated from land title, which facilitates water trading. Water trade is one of the major quantifiable benefits of implementing water sharing plans. It allows water to move to higher value uses and allows business flexibility in dealing with dry and drought periods.

Three types of dealings can occur in coastal NSW:

- **water allocation assignment trade**—previously known as a ‘temporary trade’, this dealing is the trade or assignment of a volume of water from one water allocation account to another for a given water year
- **share assignment trade**—previously known as a ‘permanent trade’, this dealing is the trade of the whole or part of a share component of a water access licence (that is, the entitlement to water) from one water access licence to another
- **transfer trade**—this dealing is the selling or transfer of a water access licence or a holding in a water access licence from one holder to another.

It appears that harvestable rights changes will more likely affect water allocation and share trades than the transfer trades of licences and holdings in licences. Transfer trades generally occur more often when water licences are bought and sold with land or transfer between family members or land holdings owned by the same entity.

Before water sharing plans were in place, water trade occurred under the *Water Act 1912* (Water Act). There were two types of water trades under the Water Act:

- **permanent transfer**—the outright purchase of part or all of the volumetric entitlement attached to a licence
- **temporary transfer**—the purchase of allocation water from another licence holder on a seasonal basis.

Trade limitations and issues

Following the start of the *Water Sharing Plan for the Hastings Unregulated and Alluvial Water Sources 2019* on 1 July 2019, all coastal catchments are now subject to a water sharing plan. Some water sharing plans prohibit the trade into, out of, or between water sources, particularly in stressed catchments.

When a water sharing plan begins in an area, water licences issued under the Water Act first must go through a conversion process before trade can occur under the WM Act. Although most licences under the Water Act are converted within the first month after a water sharing plan starts, this process can take considerably longer if the licence has a security interest (such as a mortgage or charge) associated with it or if the conditions are complex.

Trades under the Water Act had to go through an advertising and assessment process that could take three to four months, which was reportedly prohibitively long and prevented timely access to and use of the traded water. Trades are generally quicker and easier to process under the WM Act because the water sharing plan process has already assessed environmental and socio-economic risks.

Approach

The department considered two ways to measure the potential impacts on water trade.

Approach 1—potential dollar value opportunity loss

This approach aims to identify the production value of water that could be taken out of the tradeable market if harvestable rights were increased (that is, that value of water that could otherwise have been traded and used for production).

This approach assumes that if harvestable rights were increased, licence holders would hand back their water access licence and shares and use their increased access to and storage of water under harvestable rights instead of taking an equivalent volume of their licensed entitlement from streams, rivers or licensed dams. This would effectively reduce the pool of entitlements available to trade.

The department has reviewed recent trade data from the case study catchments in an attempt to select an appropriate dollar value per megalitre of water traded in each catchment. The department sought to use this data to estimate the potential dollar value that would be taken out of the market for different harvestable rights scenarios.

Data collection

The NSW Water Register contains data for trades under the WM Act. The department searched the register to identify recent water trade activity in the case study catchments. The period searched was the last four full water years: 2015–16, 2016–17, 2017–18 and 2018–19.

This review includes a brief description of previous trading activity under the Water Act rather than specific trade data.

Results

Trades under the WM Act

The following data relates to unregulated river water access licences, shares and allocations only. It does not include aquifer, domestic and stock, high-flow licence and regulated river licence trade data. To maintain privacy, we do not include the pricing data for individual trades, as the limited number of trades with pricing data could make some trades identifiable.

Water allocation assignments

No water allocation assignments (temporary trades) were recorded on the NSW Water Register for any of the water sources within the case study areas during the target period.

Share trades

There were only six unregulated water share trades (permanent trades) on the register within the case study catchments during the target period (see Table 10).

Only the share trade in Sandy Creek water source included a sale price.

Table 10. Unregulated river share trades for the 2015–16 to 2018–19 water years

Water year	Water source	Number of trades	Price available
2015–16	Upper Nepean and Upstream Warragamba Water Source	1	No
2016–17	Wyong River Water Source	1	No
2016–17	Sandy Creek Water Source (in the *Water Sharing Plan for the Bega and Brogo Rivers Area Regulated, Unregulated and Alluvial Water Sources 2011*)	1	Yes
2017–18	N/A	0	N/A
2018–19	Lower Bega/Lower Brogo Rivers Tributaries Water Source	1	No
2018–19	Upper Nepean And Upstream Warragamba Water Source	2	No

Transfer trades

A water access licence or a holding in a water access licence can be sold or transferred from one holder to another under Section 71M of the WM Act. Appendix 5 provides an explanation of how water is priced and a description of the coastal unregulated pricing valleys.

Table 11 summarises unregulated river transfer trades in the case study catchments by pricing valley for 2015–19. A dollar value for the price paid per unit is not listed in the register when transfer trades do not involve the sale or purchase of the water access licence. This may occur if the trade was for the transfer of a holding between licence holders or if a licence was being moved between properties.

Of the 201 transfer trades in the case study catchments over the target period, only 10 had a sale price listed. Of those 10, it is likely that at least three large trades related to mining in the Hunter region.

Table 11. Summary of unregulated river transfer trades in case study catchments by pricing valley for 2015–17

Unregulated pricing valley	Total shares (units or ML)—unregulated river	Number of trades	Number with a price paid '$ per unit'
North Coast	227	21	5
Hunter	5,129	93	5
South Coast	4,379	87	0
Total	**9,735**	**201**	**10**

Trades under the Water Act

In the period from 2013 to 2018, there had been considerable water trading under the Water Act in some areas of NSW. However, limited trading was available in most coastal areas because of high conservation estuary areas, ICOLLs and small management zones with limited entitlement to trade.

Determining potential dollar value opportunity loss

Given the extremely low level of recent trading activity with a sale price in the case study catchments, there is insufficient data to determine a meaningful potential dollar value opportunity loss if water was taken out of the tradeable market. That is, the volume of water associated with licences or entitlement handed back in favour of using increased access to water under harvestable rights.

Approach 2—potential for changed trading behaviour

This approach considers whether increasing harvestable rights, either by increasing the percentage or by permitting dams on third-order streams, would influence licensees' decisions about trade.

Increasing harvestable rights may change how licensees see the need for and the value of their water licence. This could influence their water trading behaviour and change the value of these entitlements.

Increased access to water through increased harvestable rights may prompt two main responses from licensees:

- **sale of entitlement—**if licensees think their water needs would be met by greater access to harvestable rights water, they may decide to either permanently or temporarily sell their licence, entitlement or both. This could be to avoid the costs of maintaining their licence and entitlement or simply to capitalise on an asset now surplus to their needs
- **purchase of additional entitlement**—if licensees think their increased harvestable rights would make it viable to transition to a higher value enterprise, they may seek to purchase additional entitlement to supplement their existing entitlement and harvestable rights water to support the new enterprise. Similarly, landholders without a current water access licence may apply for one and purchase water in these circumstances.

The discussion of hydrological modelling in Appendix 3 indicates that increasing harvestable rights, either by increasing the percentage or by permitting dams on third-order streams, would result in more frequent and/or longer duration cease-to-pump occurrences in some catchments. This would affect water access security of licensed water users and potentially lower the value of licensed entitlements.

Increasing harvestable rights may have the following effects on trade:

- more water in the market and possibly lower market prices through increased supply
- no change
- less water in the market, for example, if licensees elect to move to a higher value enterprise and use both their increased harvestable rights and their licensed entitlement.

The responses of licensees to increased harvestable rights are likely to differ depending on individual circumstances and water needs.

Other trade-related issues

Anecdotal evidence and stakeholder feedback for this review suggests that factors other than the limits on harvestable rights are responsible for the limited trading activity in coastal water sharing plan areas to date. These include:

- a difference in the supply of licensed entitlement people are willing to trade and the demand for licensed entitlement
- water sharing plan dealing (trade) rules
- processing times
- market price of water (based on Bureau of Meteorology data, the average coastal entitlement price is from $2,000 to $3,000 per megalitre and the allocation price is $17 per megalitre)
- lack of ability to access and/or store traded water under current extraction conditions[11]
- high prices to apply to trade relative to the price of water
- metering requirements for water trades
- lack of awareness about options to trade.

Increasing harvestable rights may not have much impact on improving water access through trade if the above factors remain unchanged. However, if the increased harvestable rights prompt licensees to sell their entitlement either temporarily or permanently, the market price of water could decrease as the listing for sale of their entitlement increases supply.

Water trade, particularly on a temporary basis, is likely to improve over time as the WM Act now governs water sharing in all coastal catchments. This may alleviate water access pressure in water sources where trade is permitted, as licensees become familiar with a more streamlined trading process.

[11] Most unregulated licensees are 'run-of-river' water users who cannot access water below certain flow thresholds and who pump directly onto crops/pasture or to where they use the water. This could result in low demand for water currently on the market.

Appendix 5 Water pricing and charges analysis

Background

Water pricing and charges in NSW are based on cost recovery. The Independent Pricing and Regulatory Tribunal of NSW (IPART) is responsible for setting the maximum charges the government can levy for its water management services. The charges recover a share of the costs the government incurs in providing these services.

Charges for water management services apply to water access licences issued under the WM Act and water licences under the Water Act. The charges are paid by:

- irrigators, mines and other industry
- bulk water suppliers
- local councils and water utilities that supply drinking water to cities and towns
- environmental water holders.

There are three unregulated pricing valleys along coastal NSW: North Coast, Hunter and South Coast (see Figure 12).

Unregulated water charges are billed on a one- or two-part tariff basis, depending on whether the supply is metered or not. All unregulated licensed water users are charged a fee for the volume of entitlement they hold. A usage charge is billed for the entire entitlement if the supply is unmetered (one-part tariff) or for only the portion of entitlement taken if the supply is metered (two-part tariff). Most coastal unregulated water users are unmetered and so are billed using a one-part tariff. A minimum charge applies if the combined entitlement and water take charge is below an amount specified by the IPART determination.

Water prices and charges change and are sensitive to the number of water licences and the volume of entitlement in a pricing valley.

The department’s water management charges for unregulated coastal entitlements generate approximately $8.4 million per year (2015–16). Of this revenue, 46% comes from the major water utilities Sydney Water and Hunter Water.

Table 12 shows that 66% of the entitlement on the North Coast attracts a minimum bill or a one-part tariff. The major utilities in the Hunter and South Coast regions hold 60% of the total coastal unregulated entitlement.

Figure 12. Map of North Coast, Hunter and South Coast unregulated water pricing valleys

Table 12. Coastal unregulated entitlement by charging category (in ML)

Pricing region	Minimum bill entitlement	One-part entitlement	Two-part entitlement	Two-part major entitlement	Total coastal unregulated entitlement
North Coast	5,613	173,920	92,544	N/A	**272,077**
Hunter	10,425	168,651	152,027	339,075	**670,178**
South Coast	20,885	83,527	163,219	987,000	**1,254,631**
Total	**36,923**	**426,098**	**407,790**	**1,326,075**	**2,196,886**

Source: Department of Planning, Industry and Environment–Water billing database.

Approach

Because water pricing and charges are based on cost recovery, the department looked into the potential for pricing impacts. We considered whether an increase in harvestable rights would likely affect the number of licensees that share water management costs, the volume of entitlement to which usage charges could be applied, or both.

One way that increasing harvestable rights could affect those factors is if this provided an incentive for some landholders to reduce or give up their licence or entitlement and associated costs in favour of increased on-farm storage of harvestable rights water. This incentive would be a function of the cost of expanding on-farm storage and the costs of holding their existing entitlement. This review discusses this in general terms below.

Cost of augmenting supply

The average harvestable rights farm dam in the case study areas is estimated to be 2–4 ML. Building a small, 2 ML on-farm storage is likely to cost approximately $10,000, and $20,000 for a 4 ML storage. Depending on site conditions, soil testing and engineering design may mean additional costs.

Cost of holding small unregulated entitlements

Most unregulated licensees on the coast hold small entitlements and are subject to minimum billing. In 2017–18, the minimum charge for unregulated licensees was $172.72.

The proportion of coastal unregulated licensees on minimum billing was estimated using IPART's water take charges for each coastal pricing valley and data extracted from the NSW water licensing system. The minimum bill threshold in Table 13 shows the volume (or number of shares) a licensee can hold before their charges would exceed the minimum bill amount. The last two columns show the number and proportion of licences with an entitlement volume at or below the minimum bill threshold.

Table 13. Data for estimating proportion of unregulated coastal licensees on minimum billing

Pricing valley	Water take charge ($/ML)	One-part tariff minimum bill threshold (ML or shares)	Total unregulated licences	Number on minimum bill	% on minimum bill
North Coast	9.21[12]	19	3,389	1,898	56
Hunter	3.32	52	3,079	2,052	67
South Coast	3.13	55	3,313	2,448	74
Total	N/A	N/A	**9,781**	**6,398**	**65**

Sources: IPART pricing information and the NSW water licensing system.

Time required to recover dam building costs

For approximately 65% of unregulated licensees along the coast (those on minimum billing), it would take an estimated 50 years or more to recover the cost of building a $10,000 dam from reduced water charges.

[12] Water take charges on the North Coast are higher than those in the Hunter and South Coast pricing valleys. This likely reflects that there is less entitlement in the North Coast and that the North Coast climate means water users there rely less on extraction than users farther south. As there is less entitlement in the North Coast over which to spread charges, the price per megalitre is higher.

Would coastal licensees keep or hand back their entitlement?

It is unlikely that most coastal licensees would hand back entitlement to the government based on the cost of maintaining their licensed entitlement being too expensive, given most are on minimum billing. Additionally, although the way individuals view the value and costs of their water entitlements varies, in general:

- most licensees see water entitlements as an appreciating asset that they can sell or trade in the future
- licensees perceive that it may be difficult to get the entitlement back should they need it
- the cost of holding the entitlement is low relative to other costs.

If significant entitlement was handed back to the government – that is, withdrawn from the market – price impacts would need to be modelled and costs recovered from remaining users. It is possible that some coastal licensees who take up increased harvestable rights may find their licensed entitlement surplus to their needs and decide to trade their licence or entitlement. This could result in a reduced number of licence holders from which to recover water management service costs, although water use charges would still apply to the traded shares or allocations.

Appendix 6 Environmental water availability considerations

Background

The flow regime of a river plays an important role in shaping the community of plants and animals that live in it. Although all types of flow are important, extreme events, including zero and low flows in drought periods and bankfull flows and floods in wet periods, are significant drivers of a river's ecology. The diagram in Figure 13 illustrates the importance of these different flow components, and Table 14 provides more information.

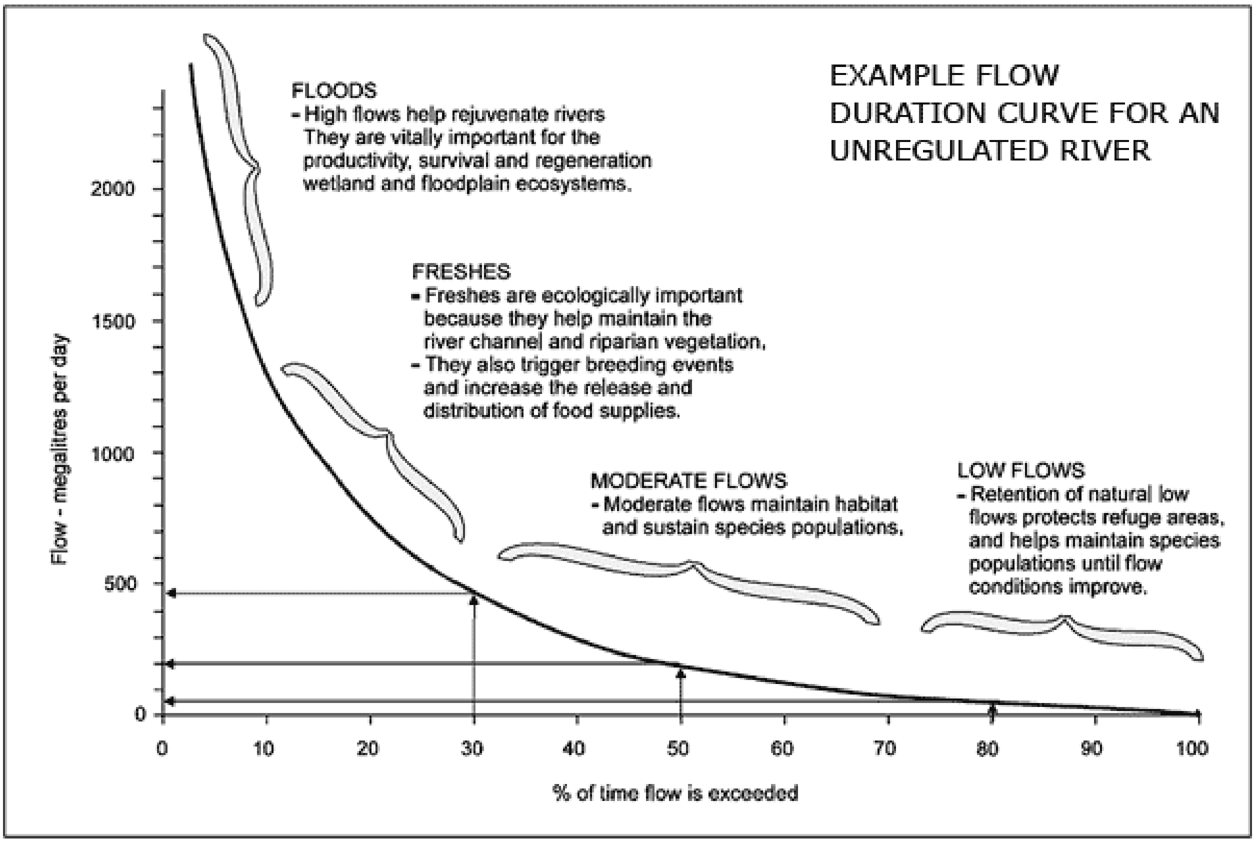


Figure 13. Example flow duration curve for an unregulated river (NSW Government 2002a)

Table 14. Key features of flow components and ecosystem functions

Flow regime component	Key feature
Low flows	Low flows (or base flows) are those flows that are confined to the low flow part of the channel. They persist after rain has stopped as a result of connection to groundwater aquifers. Protection of low flows also protects longitudinal connectivity, as well as important flowing water habitat types (riffles and pools) that support specialist feeding groups including macroinvertebrate communities and fish. Low flows are important to fish communities because they: • provide a diversity of habitats for sheltering, feeding and spawning • establish connectivity and enable longitudinal movement of fish between pools. Large-bodied fish may not move during base flows due to inadequate water depth within riffles, but small-bodied fish may move if conditions suit • constantly exchange and refresh water in pools and therefore maintain reasonable water quality.
Freshes	Freshes are larger flows that inundate the sides of the banks and any in-channel bars and benches that may be present. These are often caused by a rain event leading to increased inflows to the river that travel as a pulsed flow down the system. Freshes are necessary to support in-stream processes and biota in the same way as bankfull and overbank flows, in terms of flow magnitude, duration, timing and frequency. Freshes are distinct events.
Large and infrequent flows or floods	Large flow events occur on an average recurrence interval of greater than a year. These flow events are distinct from low flows and freshes because they can generate bankfull and overbank flows. Bankfull flows are important for maintaining river geomorphology and are often known as 'channel forming' flows, as they help define and maintain channel dimensions, such as width, depth and slope, and in-channel habitats, such as benches and bars. High flows and freshes also act as a natural disturbance in river systems, helping remove vegetation, aquatic plants and organic matter and resetting successional processes. Overbank flows deliver water, sediment and dissolved material, including plant nutrients, to the floodplain and provide temporary access to floodplain aquatic habitats. Water returning from the floodplain to the channel may carry carbon in the form of dissolved carbon and organic detritus, microorganisms and small plankton animals. All are generated by the productive floodplain ecosystem and supported by inputs of water from the channel. Large coastal floods can also damage estuarine ecosystems by returning high volumes of deoxygenated water, high-acidity water or both to the river in a short time, causing major fish kills (for example, an event in the Richmond River during 2008).

Sources: Alluvium 2010; Chessman et al. 2006; Murray–Darling Basin Authority 2010, 2012.

NSW water quality and river flow objectives

The NSW Government has agreed to water quality and river flow objectives that help guide plans and actions to achieve healthy rivers in NSW. The water quality objectives are the agreed environmental values and long-term goals for NSW's surface waters. The river flow objectives identify the key elements of the flow regime that protect river health and water quality for ecosystems and human uses. The river flow objectives are to:

- protect natural water levels in pools of creeks, rivers and wetlands during periods of no flow
- protect natural low flows
- protect or restore a proportion of moderate flows, freshes and high flows
- maintain or restore the natural inundation patterns and distribution of floodwaters supporting natural wetland and floodplain ecosystems
- mimic the natural frequency, duration and seasonal nature of drying periods in naturally temporary waterways
- maintain or mimic natural flow variability in all rivers
- maintain rates of rise and fall of river heights within natural bounds
- maintain groundwaters within natural levels and variability, which are critical to surface flows or ecosystems
- minimise the impact of in-stream structures
- minimise downstream water quality impacts of storage releases
- ensure river flow management provides for contingencies
- maintain or rehabilitate estuarine processes and habitats.

Role of freshwater flows on estuarine, coastal and marine environments

Freshwater flows play an important role in maintaining healthy estuarine and coastal environments. This is reflected in the recent *NSW Marine Estate Threat and Risk Assessment Report*, which ranked ‘modified freshwater flows’ as the fifth highest priority threat to estuaries statewide, given their dependence on freshwater flows. The report ranked them the sixth highest priority threat overall to estuarine and coastal and marine environments (BMT WBM 2017).

Approach

The changes to water available for the environment have been assessed through the hydrological modelling component of the review. This component modelled the likely hydrological impact of different harvestable rights scenarios on flow regimes in the case study catchments. Appendix 3 provides an overview of the hydrological modelling.

Discussion

The modelling indicates that impacts of dams on first- and second-order streams are most likely to affect freshes but can also impact other parts of the hydrograph. In very high-flow events, these dams will have little impact in larger river systems but are likely to impact smaller systems such as ICOLLs. Effects on lower flows will occur where the dams intercept baseflow (groundwater seepage into the river system). The modelling assumes that they do intercept baseflow, but the degree to which they do varies based on the geology.

The modelling assessed likely impacts on river flows at the end of the river systems studied. However, the review needs to consider within-catchment flow impacts. For example, an increase in the amount of water extracted under harvestable rights might have a small effect on end-of-system flows but have a larger hydrological impact immediately downstream of the extraction point.

How potential impacts on flows translate into impacts on specific ecosystem processes and environmental assets also requires more consideration. In the case of ICOLLs, such as Woolgoolga Lake, the impact of the modelled reductions on the frequency and duration of freshes could influence how frequently the lake opens to the ocean and alter the overall health of the lake.

The potential for impacts on ICOLLs would be higher in catchments that have large areas of freehold land, where more harvestable rights dams could be built, than in catchments with large areas of national parks or state forests, where such dams would not be built.

The department needs to consider protection of specific high ecological values and processes both within catchments and at the end of river systems and may require further impact assessment. This is consistent with the principles of the NWI and the WM Act.

Appendix 7 Summary of potential impacts of additional farm dam development in case study catchments

Table 15 summarises potential impacts of additional farm dam development in case study catchments and is adapted from HARC 2020 (Table 5.2). It outlines the types of impacts that an increase in farm dam development could have on key uses of water in each catchment. These impacts have been broadly classified as:

- **nil**—no or negligible impact
- **unlikely**—an impact is unlikely, but if there is an impact, it is likely to be insignificant
- **limited**—there is some certainty of an impact; however, it is likely to be minor
- **some**—there will be some impact of moderate or uncertain magnitude
- **likely**—there is likely to be an impact
- **significant**—there is a likelihood of a significant impact.

The following impact summary is a qualitative assessment only. It relies on expert opinion for the likelihood and scale of impacts across the four categories of systems that may be affected. For example, for town water supply systems, there has been no quantitative assessment of the impact of reduced river flows from an expansion of harvestable rights dams on the secure yield of those systems.

Feedback we gain during public consultation will inform and help refine this summary of potential impacts.

Table 15. Potential impacts of additional farm dam development in study catchments

Catchment	Town water supply	Other water users	Riverine ecosystems	Coastal ecosystems
Duck	**Nil**. There are no town water supplies that are extracting downstream of this catchment.	**Some**. There is considerable water extracted both within and downstream of this catchment for stock and domestic purposes and irrigation.	**Some**. Although located in the larger Clarence River catchment, which is classified as in good condition, any alteration of flow regimes can cause impacts.	**Unlikely**. This catchment is located in the upstream reaches of a large coastal estuary.
Woolgoolga	**Nil**. There are no town water supplies that are extracting from this catchment. Woolgoolga Lake no longer serves as a town water supply source.	**Unlikely**. There is little extractive water use in this catchment and downstream.	**Some**. This is a small coastal catchment; any change in flow regimes will have some effect.	**Likely**. This catchment flows into Woolgoolga Lake, an ICOLL serviced by a small catchment with urban development pressures. Any reduction in flows will have an effect.

Catchment	Town water supply	Other water users	Riverine ecosystems	Coastal ecosystems
Bucca Bucca	**Unlikely**. The regional water supply scheme supplies all villages downstream on the Orara River, except for Nana Glen, which draws town water directly from the river. Construction of a pipeline is currently underway from Karangi water treatment plant to Nana Glen, which should be operational in 2021.	**Some**. There is considerable water extracted both within and downstream of this catchment for stock and domestic purposes and irrigation.	**Some**. Although located in the larger Clarence River catchment, which is classified as in good condition, any alteration of flow regimes can cause adverse impacts.	**Unlikely**. This catchment is located in the upstream reaches of a large coastal estuary.
Nambucca	**Significant**. Nambucca Valley Council water supply relies on access to flows from the river (accessed through bores from a highly connected alluvial aquifer next to the river) to fill a 5-gigalitre off-river storage. Increases in the duration of low-flow periods may affect the ability to replenish storage volumes in dry years.	**Some**. There is considerable water extracted both within and downstream of this catchment for stock and domestic purposes and irrigation.	**Some**. Any changes in flow regimes will have some effect.	**Some**. This catchment is located in the upstream reaches of a medium-sized coastal estuary.
Allyn	**Nil**. Urban communities in the catchment are in the Hunter Water service area.	**Some**. There is considerable water extracted both within and downstream of this catchment for stock and domestic purposes and irrigation. Lostock Dam regulates some of the flow in the catchment, which could impact regulated water users.	**Some**. Any changes in flow regimes will have some effect.	**Unlikely**. This catchment is located in the upstream reaches of the Hunter River, a large coastal estuary.

Catchment	Town water supply	Other water users	Riverine ecosystems	Coastal ecosystems
Wollombi	**Nil**. Hunter Water provides town water supply throughout the region and town water is not sourced from the Wollombi River.	**Some**. There are likely to be extractions for irrigation, stock and domestic purposes, and mining.	**Some**. Any changes in flow regimes will have some effect.	**Unlikely**. This catchment is located in the upstream reaches of the Hunter River, a large coastal estuary.
Wyong	**Some**. Although the Wyong River is used for the Central Coast water supply, the terrain limits the potential for additional farm dam development in upstream areas. Most of the potential for additional development is in the Jilliby Jilliby Creek arm and in the lower reaches of the catchment, well downstream of the water supply offtake.	**Some**. There is some extraction of surface water for irrigation in the Jilliby Jilliby Creek arm of the catchment, with stock and domestic use throughout.	**Some**. Any changes in flow regimes will have some effect.	**Likely**. This catchment is located upstream of Tuggerah Lake, which already has ecosystem stresses from power station cooling uses and urban development.

Catchment	Town water supply	Other water users	Riverine ecosystems	Coastal ecosystems
Wollondilly	**Significant**. This catchment provides water for the Goulburn urban community through a pipeline from the Wingecarribee Dam (maximum of around 2 gigalitres per year) and local on-stream storages to satisfy Goulburn's 6- to 8-gigalitre-per-year water supply requirement. Marulan is not connected to the pipeline and therefore relies on local water sources. Any reduction in flows will reduce supply security and have a minor effect on inflows to Sydney's water supply, Lake Burragorang.	**Limited**. There is some limited extractive water use in this catchment.	**Significant**. This catchment is classified as being in moderate condition. With much of this catchment comprising perennial streams, increases in the frequency and duration of low-flow periods will have an impact.	**Unlikely**. This catchment is located upstream of the large Hawkesbury–Nepean river system, where the impacts of the Sydney metropolitan area are far more significant than increases in rural farm dam development.

Catchment	Town water supply	Other water users	Riverine ecosystems	Coastal ecosystems
Double	**Likely**. Water for the Brogo–Bermagui water supply comes from the regulated WaterNSW storage. The recent drought exposed some vulnerabilities of the existing water supply system, particularly for the Bermagui township. Additional water security options are being reviewed through the regional water strategy process (for example, augmentation of Brogo Dam). In the meantime, any additional impacts on river flows are likely to affect supply security in dry times.	**Likely**. Extractive water use in the regulated catchment depends on the reliability of Brogo dam. Considerable water extraction occurs in the unregulated parts of the catchment, which would have adverse effects.	**Some**. Any changes in flow regimes will have some level of impact, particularly given the regulated nature of the water supply system already in use in the catchment.	**Some**. This catchment is located in the upstream reaches of a medium-sized coastal estuary and already has considerable levels of water extraction.

Catchment	Town water supply	Other water users	Riverine ecosystems	Coastal ecosystems
Upper Bega–Bemboka	**Some.** Bemboka River directly supplies the township of Bemboka and helps recharge an alluvial aquifer that supplies the Bega–Tathra and the Tantawangalo–Kiah water supply systems (the Tantawangalo–Kiah water supply system through the Bega–Yellow Pinch Dam pipeline). The river and aquifer are highly connected. The department would need to investigate further to identify the extent of likely impacts on town water supplies.	**Likely**. There are considerable extractions for irrigation, stock and domestic water uses.	**Significant**. There are high levels of historical water extraction. Further reductions in flows would have an additional effect.	**Some**. This catchment is located in the upstream reaches of a medium-sized coastal estuary and already has considerable levels of water extraction.

Appendix 8 Socio-economic considerations

Background

An understanding of the nature and significance of potential socio-economic impacts is important for making good water management decisions.

Water is critical to the success of many industries that support communities across coastal NSW. It is appropriate to look at socio-economic factors when considering changes to the harvestable rights limits for coastal NSW.

Socio-economic assessment

The Independent Advisory Committee on Socio-economic Analysis (1998) describes socio-economic assessment as:

"a tool used to predict the future effects of policy decisions upon people and can be used to assist people in dealing with change. It provides a better understanding of the scale and distribution of costs and benefits of change and seeks to maximise positive effects and minimise negative effects resulting from this change."

Socio-economic impacts include changes that occur in:

- people's way of life (how they live, work and interact with each other);
- their cultural traditions (shared beliefs, customs and values);
- their community (its cohesion, stability, character, services and facilities); and/or
- their standard and quality of life (level of income, ranges of choice in consumption and the quality and quantity of community infrastructure).

Socio-economic assessments measure the broad range of effects which may arise from changes in policy or practice. These effects may be broken into three key categories—economic, social and environmental.

Incorporating socio-economic considerations into the review

A comprehensive cost-benefit analysis to quantify the likely socio-economic impacts of increasing harvestable rights in coastal NSW was outside the scope and resources of this stage of the review. However, the department has done some high-level, preliminary economic analysis to obtain basic insights into what industries may be affected by a change to harvestable rights along the coast.

Although this analysis does not specifically investigate social aspects, economic impacts can directly and indirectly influence social outcomes. For example, financial benefits and impacts for direct water users and industries can positively or negatively change their ability to employ staff. Changes to employment in an area can modify its socio-demographic structures (such as local and regional populations and age structures). This, in turn, can affect community and institutional structures (such as levels of community and government services or leisure opportunities) and aspects of community vitality and wellbeing.

Changes to harvestable rights could also affect indirect water users and industries, such as the fishing and tourism industries that often rely on healthy functioning ecosystems.

Limitations

This analysis does not identify all external factors or information necessary to fully understand all socio-economic impacts of increasing harvestable rights along the coast. For example, it does not quantify the economic benefits or costs for individual industries that are direct users of water, such as the blueberry or dairy industries, or for other downstream industries, such as commercial and recreational fishing. Rather, it aims to provide some information on how, where and for what purpose water finds use along the coast as a basis for further discussion and analysis.

The information in this section is mostly based on natural resource management (NRM) regions, as it largely comes from other studies and reports that structure the information this way. This means it is unlikely to directly align with the regions used in other sections of this discussion paper (for example, IPART pricing valleys).

We have rounded the figures, so they may not add up to totals within or between related tables.

Approach

Given the original terms of reference and available resources, the department has focused on a high-level, preliminary economic analysis at this stage. The aim of this work is to identify and gather information to provide some insight into:

- which industries might benefit from a change to harvestable rights
- which industries might be adversely impacted
- how behaviours might change
- if possible, to what extent they are affected.

To build a basic water use profile along the NSW coast, the department has considered the following factors:

- the level of urban and agricultural water use
- sources of agricultural water use
- the main agricultural industries using water and their levels of use
- the likely value of water to selected industries.

This review also provides some general information on industries that could be directly or indirectly affected.

Data collection

The department got estimates of agricultural water use in NSW coastal areas from *Water Use on Australian Farms 2015–16* from the Australian Bureau of Statistics (ABS). Although a more recent *Water Use on Australian Farms 2017–18* report is available, data in the earlier report is based on previous NRM regions that better align with the boundaries of the review. The NRM region references below relate to the former NSW Catchment Management Authority boundaries. The department got the estimated value of irrigated agricultural production from *Gross value of irrigated agricultural production 2015–16* from the ABS. This value is also based on those NRM regions.

The department got estimates of coastal urban water use from the NSW performance monitoring reports and the Sydney Water and Hunter Water annual reports. Estimates for typical dam construction costs came from the NSW Soil Conservation Service. The department sourced gross margin data from the NSW Department of Primary Industries—Agriculture website.

Results and discussion

Urban and agricultural water use volumes

Table 16 shows urban and agricultural water use from all sources in the NSW coastal valleys.

Table 16. Urban and agricultural water use in NSW coastal valleys (2015–2016)

Industry	Number	Water used (ML)
Urban water utilities	25	720,150
Agricultural businesses	7,412	172,174
Total	**7,437**	**892,324**

Source: ABS *Water Use on Australian Farms 2015–16.*

Sydney Water dominates the water use data overall, representing 74% of total coastal utility extraction.

Table 17 breaks down water utility and farm data by NRM region. Hawkesbury–Nepean includes Sydney Water extraction, as well as Goulburn Mulwaree and Wingecarribee. Sydney Water can, however, extract water from the Shoalhaven system in the Southern Region.

Table 17. Water use in coastal NSW by NRM region

Water use	Agricultural (ML)	Urban (ML)
Hawkesbury–Nepean	41,884	536,980
Hunter–Central Rivers	62,397	103,110
Northern Rivers	48,309	58,340
Southern Rivers	19,585	21,720
Total	**172,175**	**720,150**

Source: NSW performance monitoring and ABS *Water Use on Australian Farms 2015–16.*

Sources of agricultural water

In coastal NSW, the most common sources of agricultural water are rivers and streams followed by farm dams and then groundwater. The farm dam category includes harvestable rights storages as well as water storages that require a licence and works approval to construct.

Overall, farm dams account for approximately 20% of coastal agricultural water use (see Table 18).

Table 18. Agricultural water sources

Water source	Water use (ML)	Percentage
Rivers and streams	91,385	53
Farm dams and tanks	32,248	19
Groundwater	26,677	15
Other[13]	21,864	13
Total	**172,174**	**100**

Source: ABS *Water Use on Australian Farms 2015–16.*

Use of farm dams varies along the coast, with the North Coast recording the highest use (see Table 19). On the North Coast, farm dams and tanks represent 33% of farm water use.

[13] 'Other' includes water taken from irrigation channels and pipelines, town or reticulated mains supply and recycled water.

Table 19. Agricultural water use in NSW coastal NRM regions by source

Water source	Hawkesbury (ML)	Hunter and Central Coast (ML)	Northern Rivers (ML)	Southern Rivers (ML)
River and streams	23,228	40,003	19,694	8,460
Groundwater	4,033	15,047	4,920	2,678
Farm dams & tanks	8,055	4,027	15,763	4,403
Other	6,568	3,320	7,932	4,044
Total	**41,884**	**62,397**	**48,309**	**19,585**

Source: ABS *Water Use on Australian Farms 2015–16.*

HARC (2020) indicates that dams with a capacity of less than 5 ML tend to be used for stock watering, and larger storages tend to be used for other farming purposes, such as pasture or crop irrigation.

Agricultural water use and value

Across the coastal NRM regions, pasture, cereal and broadacre crop irrigation accounts for 49% of agricultural water use. This is followed by 'other agricultural water', which includes livestock drinking water and activities such as dairy or piggery cleaning. These uses accounts for 27% of agricultural water use. Nurseries as well as cut flower and turf businesses account for 9%, with vegetables, fruit and nut trees, and berry enterprises accounting for 6% each (see Table 20).

Table 20. Agricultural water uses in coastal NRM regions

Agricultural water use	Megalitres per year
Pastures, cereal and broadacre crops	83,822
Livestock drinking, dairy and piggery cleaning, and other	47,293
Nurseries, cut flowers and cultivated turf	15,484
Vegetables for human consumption	9,779
Fruit and nut trees, plantations or berry fruits	9,679
Total	**166,056**

Source: ABS *Water Use on Australian Farms 2015–16.*

Table 21 lists the sizes of the area of different crops watered across coastal NRM regions. This shows that pastures, cereal and broadacre crops collectively cover by far the largest area of irrigated production.

Table 21. Crop area watered 2015–16

Crop area watered	Area (hectares)
Pastures, cereal and broadacre crops	40,522
Nurseries, cut flowers and cultivated turf	2,988
Vegetables for human consumption	3,553
Fruit and nut trees, plantations or berry fruits	5,322
Grapevines	1,178
Total	**53,563**

Source: ABS *Water Use on Australian Farms 2015–16.*

For agricultural production, the most valuable irrigated products on the NSW coast were nursery products, cut flowers and cultivated turf, followed by dairy production.

The gross value of irrigated agriculture in coastal NSW was $793.19 million, with the top five irrigated commodities representing 95% of the total value (see Table 22 and Table 23).

Table 22. Gross value of irrigated agricultural production (GVIAP) in coastal NSW

Irrigated product	$ million
Nurseries, cut flowers and cultivated turf	222.68
Dairy production	181.45
Vegetables	152.38
Fruit and nuts (excluding grapes)	146.97
Production from meat cattle	53.35
Total	**756.85**

Source: ABS *Gross value of irrigated agricultural production 2015–16.*

Table 23. GVIAP per megalitre

Agricultural use	GVIAP/ML
Nurseries, cut flowers and cultivated turf	$14,381
Vegetables	$15,582
Fruit and nuts (excluding grapes)	$15,184

Source: ABS *Gross value of irrigated agricultural production 2015–16.*

Gross margins

A 'gross margin' is the gross income from an enterprise minus the variable costs incurred in achieving it. It does not include fixed or overhead costs, such as depreciation, interest payments, rates or permanent labour.

Gross margins are one indicator to use when comparing the different enterprises that could benefit or see impact from policy changes. Relatively recent gross margin data was available only for a few of the industries in coastal NSW that could benefit or see impact from increased harvestable rights. This data follows. Previous gross margin budget data covering more than 10 years for other industries in coastal catchments, such as nuts, other horticultural crops and broadacre crops, is available on DPI's website (www.dpi.nsw.gov.au/agriculture).

Blueberries

NSW North Coast blueberry production is capital-intensive and requires 3–5 ML/ha (NSW DPI 2015). Estimates for establishment costs are $104,171/ha. These costs do not include costs for augmentation of water supplies, such as construction of new farm dams or installation of pumping equipment.

The gross margin for blueberries is estimated at $83,913/ha.

Livestock

As Table 21 identifies, pasture irrigation forms part of the most widespread category of irrigated water use in the coastal NRM regions. Pastures are irrigated to support different types of enterprises—notably, livestock and dairy production. Although gross margin data is not readily available for the dairy industry along the coast, Table 24 and Table 25 provide gross margins for beef and sheep production, and these are likely to apply similarly in coastal regions.

Table 24. Estimated livestock gross margin data—Beef

Beef enterprise	Gross margin including pasture costs ($/ha)
Coastal weaners—unimproved pasture	135
Coastal weaners—improved pasture	316
Butcher vealers	231
MSA at 20 months	206
Feeder steers	207
Grow out early weaned calves 160–340 kg	348
Growing out steers 240–460 kg	279
Jap Ox	197

Source: NSW Department of Primary Industries' livestock gross margin budgets (DPI 2017a).

Table 25. Estimated livestock gross margin data—Sheep

Sheep enterprise	Gross margin excluding fodder ($/ha)	Gross margin including fodder ($/ha)
1st cross ewes—Terminal meat rams	396	355
Dorper ewes—Dorper rams	405	362
Merino ewes (18 micron)—Merino rams	585	554
Merino ewes (20 micron)—Terminal rams	461	409
Merino ewes (20 micron)—Merino rams	481	451
Merino ewes (20 micron)—75% merino rams, 25% to terminal	482	441
Merino ewes (20 micron)—Maternal meat rams	491	456
Merino ewes (20 micron)—Merino rams, wether lambs finished	506	465
Merino wethers (18 micron)	538	517
Merino wethers (20 micron)	379	360

Source: NSW Department of Primary Industries' livestock gross margin budgets (DPI 2017a).

Data in Table 24 and Table 25 is from 2017. The figures serve as a guide only and are based on beef and sheep enterprises with 100 and 1,000 head of stock, respectively. Gross margins can change with changes in prices or weight of livestock. Refer to the specific gross margin budgets on DPI's website for more details on assumptions and limitations.

Vegetables

Table 26 provides estimated gross margin data for vegetable production in coastal areas of NSW. Where text is in italics, gross margin data is based on production in inland NSW, but the crop also grows on the coast.

Gross margins in dollar value per megalitre of water are available for vegetable production.

Table 26. Estimated vegetable gross margins

Enterprise	Gross margin ($/ha)	Gross margin ($/ML)	Notes
Cabbages	2,315	579	2009. Murrumbidgee Irrigation Area/Sydney Basin.
Potato—fresh summer	*155*	*31*	*2013. Outlines production for inland NSW. Main growing area is Riverina (70%), with tablelands 20% and coast 10%.*
Potato—fresh winter	*895*	*224*	*2013. Outlines production for inland NSW. Main growing area is Riverina (70%), with tablelands 20% and coast 10%.*
Potato—processing	*2,110*	*422*	*2013. Outlines production for inland NSW. Main growing area is Riverina (70%), with tablelands 20% and coast 10%.*
Sweet corn (fresh)—overhead irrigation	10,805	1,351	2009. Sydney Basin.
Tomatoes (fresh)—drip irrigation	19,353	3,226	2009. Sydney Basin. North Coast, Central Coast and the Sydney Basin are the main production areas.
Zucchini	*2,888*	*722*	*2013. Outlines production for inland NSW. Sydney Basin, North Coast and Sunraysia are the main growing areas.*

Source: NSW Department of Primary Industries' vegetable gross margin budgets (DPI 2017b).

Other industries in coastal NSW

Recent gross margin data was not readily available for many of the other key industries in coastal NSW.

The department would welcome any industry-specific data for gross margins or GVIAP per megalitre submitted during the public consultation process so that we can consider this as part of the analysis.

Distribution of irrigated products in coastal NRM regions

The dominance of irrigated products differs across NSW coastal regions. Hawkesbury–Nepean generates 76% of the gross value ($) of coastal production of vegetables and 64% of the gross value of nursery, cut flowers and turf products.

Hunter and Central Coast dominates coastal production of grapes and hay. Northern Rivers dominates with the production of fruit and nuts. The largest coastal dairy production region is Southern Rivers.

General economic information

Pasture

The major use of water in the coastal region is for pasture irrigation. Pasture irrigation supports production in a range of agricultural industries, including various livestock and dairy enterprises.

If additional water were available for pasture irrigation, the major benefit would be a reduction in purchased feed costs. Noting that replacement feed prices will vary seasonally, an average price for replacement feed is likely to be around $350/tonne.

Fishing

Commercial and recreational fishing industries have potential to be affected by increased harvestable rights through changes to stream and river flow regimes. Flow changes can affect freshwater, estuarine and ocean fisheries from a habitat (nursery area) health perspective and influence triggers for migration and spawning events. This can subsequently affect fish populations and fishing opportunities in freshwater, estuarine and ocean environments.

Although quantifying the potential economic impacts on fishing industries was outside the scope of this review, we provide the value of commercial and recreational fishing and aquaculture in NSW below for context.

Commercial fisheries and aquaculture

The NSW fisheries industry was valued at $158 million in 2015–16, with wild fisheries contributing $91 million and aquaculture $64.9 million. Significant contributors to wild fisheries in 2015–16 were prawns, lobster, sea mullet and crab. Sydney rock oysters made up 57% of the total value of aquaculture production.[14]

Recreational fishing

Recreational fishing generates about $3.4 billion of economic activity annually and creates the equivalent of approximately 14,000 full-time jobs. It offers important health and social benefits, and 850,000 anglers enjoy it every year.[15]

Cost to construct additional harvestable rights storages

The Soil Conservation Service has provided the following estimated costs to construct farm dams with capacities typical of those in the case study areas:

- 2-ML dam—$10,000
- 4-ML dam—$20,000.

Observations

Socio-economic analysis provides economic context around some of the industries that may benefit or be affected by changes to water availability as a result of increasing harvestable rights in coastal NSW.

This preliminary analysis suggests that expected benefits to individuals from additional harvestable rights could ultimately be benefits that transfer from other water users reliant on water entitlements.

At an industry level, this may result in some industries benefiting from a broad-scale policy change, and others would be adversely affected depending on their location within the catchment. It may also result in some enterprises within the same industry and catchment benefiting (most likely those in the upper catchment), while others would be negatively affected (those lower down the catchment, more reliant on licensed water or both).

The department would need to conduct a detailed cost-benefit analysis to identify all industries, water users and uses (including cultural, social and environmental) that may be directly or indirectly affected and to obtain a full distribution of benefits and costs across those users and uses.

[14] Marine Estate Management Authority 2017a.
[15] Marine Estate Management Authority 2017b

Glossary

Term	Definition or acronym meaning
Cease-to-pump / CTP	Cease-to-pump rules require users to stop taking water when flow declines below a set level
Coastal NSW/coastal catchments	Catchments in NSW that drain to the coast
Freshes	Higher flows in a river that stay within the banks but rise to wet the banks and the in-stream benches and bars that make up the river channel
GL	Gigalitre (1 GL = 1,000 ML)
Gross margin	The gross income from an enterprise less the variable costs incurred in achieving it. It does not include fixed or overhead costs such as depreciation, interest payments, rates or permanent labour
GVIAP	Gross value of irrigated agricultural product. GVIAP refers to the gross value of agricultural commodities that are produced with the help of irrigation. The gross value of commodities produced is the value placed on recorded production at the wholesale prices realised in the marketplace
HARC	Hydrology and Risk Consulting Pty Ltd
Harvestable rights limits	A term referring to both the harvestable rights percentage and the location (specifically, stream order) where harvestable rights dams may be built as set out in the Order
Harvestable rights percentage	The percentage of average annual regional rainwater run-off landholders have the right to capture under the Order
ICOLLs	Intermittently closed and open lakes and lagoons
Inland NSW	Areas of NSW that do not drain to the coast
IPART	Independent Pricing and Regulatory Tribunal of NSW
LTAAEL	Long-term average annual extraction limit
ML	Megalitre (1 ML = 1,000,000 litres)
NRM	Natural resource management
NSW DPI	NSW Department of Primary Industries
Order/the Order	Harvestable Rights Order—Eastern and Central Division
STEDI	Spatial tool for estimating dam impacts

Term	Definition or acronym meaning
The department	NSW Department of Planning, Industry and Environment—Water (formerly, NSW Department of Primary Industries—Water and NSW Department of Industry—Lands and Water)
The Policy	The Farm Dams Policy
Water Act	*Water Act 1912*
WM Act	*Water Management Act 2000*

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