MARSDEN JACOB ASSOCIATES

economics
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strategy

Regional water value functions

Values for inclusion in the cost-benefit analysis to support NSW Regional Water Strategies

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A Marsden Jacob Report

Prepared for NSW Department of Planning, Industry & Environment
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Acronyms used in this report

AAD	Average annual damage
ABS	Australian Bureau of Statistics
ARI	Average return interval
DNRE	Department of Natural Resources and Environment
DPI	Department of Primary Industries
DPIE	NSW Department of Planning, Industry & Environment
DPIPWE	TAS Department of Primary Industries, Parks, Water and Environment
DMPC	Department of the Prime Minister and Cabinet
DSE	Department of Sustainability and Environment
Flood RAM	Flood rapid appraisal method
GL	Gigalitre (one billion litres)
GM	Gross margin
ha	Hectare
kL	Kilolitre (one thousand litres)
L	Litre
MDB	Murray-Darling Basin
MJA	Marsden Jacob Associates
ML	Megalitre (one million litres)
NM	Net margin
NPV	Net present value
OPBR	Office of Best Practice Regulation
oz	Ounce
RWS	NSW Regional Water Strategies
S&D	Stock and domestic
t	Tonne
VWAP	Volume weighted average price
WAL	Water Access Licence
WTP	Willingness to pay

1. Executive summary

Marsden Jacob Associates (Marsden Jacob) was engaged to provide regional water value functions to support the development of Regional Water Strategies across NSW. This report documents these values and provides guidance on how they be applied in the cost-benefit analysis for the Strategies.

The NSW Government's Regional Water Strategies program will assess the future water needs of 12 regions across NSW. The Strategies will identify the challenges and choices involved in meeting each region's needs and set out actions to manage risks to water security and reliability.

The Regional Water Strategies program will assess a range of different policy, planning, behavioural, regulatory, technology, and infrastructure options to meet long term water needs in each region. The NSW Government requires that Regional Water Strategies be assessed within a cost-benefit analysis framework. Options will be informed by hydrological modelling that estimates the change in water availability or reliability for key water users.

1.1 How this report supports the Regional Water Strategies program

Marsden Jacob was engaged to provide economic values for changes in water availability or reliability to key water users in regions across NSW. We have also provided mathematical functions that demonstrate how these values would be applied in the hydro-economic modelling.

In this report, key water users include town water supplies, irrigators, mining companies, and recreational water users. Values for environmental and cultural uses of water will be considered as part of the development of Regional Water Strategies, but are not within the scope of this report.

The values from this report will be used by the Department of Planning, Industry and Environment (DPIE) in 'rapid' cost-benefit analysis across each region in NSW. Following this, full business cases will be prepared including detailed cost-benefit analysis to inform final decision-making for the Strategies. The business case process will provide further opportunity to incorporate region-specific factors into the assessment.

1.2 Our approach for estimating values for key water users

Our approach draws on our experience undertaking hydro-economic modelling and evaluation of regional water strategies across NSW and Australia more broadly. The important features of the values we have estimated are that they:

1. **Focus on key water user groups in each region** – the hydrological modelling will capture changes in water availability and reliability for key water users (as opposed to every water user) in each region. We have consulted with subject matter experts at DPIE to identify the key water users in each region.
2. **Align with NSW Government Guidelines for Cost-Benefit Analysis (TPP17-03)** – the values from this project are consistent with the NSW Government Guidelines for Cost-Benefit Analysis, including that the population with standing is the NSW community. The categories of values include avoided costs,

producer surplus, consumer surplus, government revenue, and benefits to the broader community. The values will be applied to costs and benefits that are measured incrementally to the base case.

3. **Broadly reflect how users make water decisions** – our values are based on an understanding of the way with which water is used in practice. For example, our values reflect that irrigators of annual crops tend to scale their operations each year depending on expected water availability, whereas irrigators of permanent crops tend to increase their operations following a permanent increase in water availability/reliability and are also exposed in periods of supply shortfalls.
4. **Reflect values over the longer term** – while economic values vary over the short term based on many factors including commodity prices and input costs, the values in this report reflect average conditions over the long term. This long-term focus aligns with the Regional Water Strategies program which assesses potential policy and infrastructure solutions over a 40-year period.
5. **Economic, not financial values** – given the values are intended to be used in cost-benefit analysis, they are economic as opposed to financial values. In some cases, economic values may be considerably different to the financial value. For example, the financial costs of carting water are often higher than the economic cost. Financial analysis will be undertaken as part of the subsequent business cases.

1.3 Summary of our findings

1.3.1 Town water supply

Town water is a key water user in all Regional Water Strategy regions. Hydrological modelling will identify town water supply systems across NSW that are likely to experience future supply 'shortfalls', where supply falls short of demand. Water supply shortfalls result in economic costs, and options being considered as part of Regional Water Strategies that improve town water security provide a benefit in the form of avoiding these costs.

In this report we have estimated the economic costs of town water supply shortfalls. To do this for diverse regions across NSW, it was necessary to develop a simplified framework. Based on consultation with the utilities team in DPIE we developed the framework summarised in Figure 1 below.

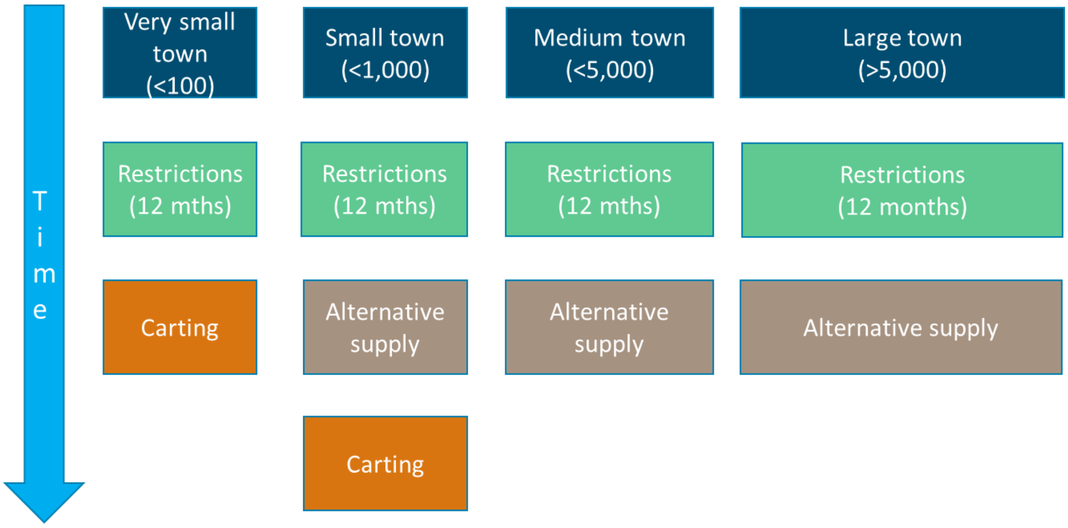
Under the framework, it is assumed that the measures to response to town water shortfalls will be based on the size (population) of the town. We have developed four size categories ranging from very small (less than 100 people) to large towns (more than 5,000 people).

All towns regardless of size are assumed to first use water restrictions to address a supply shortfall for a period up to 12 months. The level or severity of water restrictions, and the associated costs, is assumed to increase over this period.

We have estimated the economic costs of water restrictions at:

- **$1,100 to $1,800/megalitre (ML)** for the first six months of restrictions, and
- **$3,500 to 4,100/ML** for the next six months of restrictions.

Figure 1: Framework for town water supply



Source: Marsden Jacob Associates.

For the first six months of restrictions, the range of values reflects the estimated costs for local water utilities to implement water restrictions, including awareness and education campaigns.

If a water supply shortfall extends beyond six months, the severity of restrictions is assumed to increase and in addition to the water utility's costs, households and businesses also bear economic costs. These costs are broad ranging, and include social and environmental factors that affect a community's general standard of living and wellbeing. The economic and social costs of water restrictions are commonly estimated through 'willingness to pay' (WTP) studies. We have based our values on two WTP studies conducted in the Australian Capital Territory (ACT).[1] We consider these studies to be methodologically robust, and the results are similar to previous NSW Government guidelines for the economic cost of water restrictions under the NSW Safe and Secure Program.[2] In response to stakeholder comments on an earlier draft of this report, we have increased the upper end of this range ($4,100/ML) to account for potentially higher business WTP for avoiding severe restrictions in regional NSW.

We have developed a spreadsheet model that includes the assumptions that underpin these values. If considered appropriate in the rapid cost-benefit analysis, these assumptions could be updated to better reflect the circumstances for a particular region.

In the event that a town's water supply remains in shortfall after 12 months, under our framework it is assumed that alternative supply measures then need to be put in place, informed by investigations that would have been undertaken both prior to and during the water restrictions period. The intent is that alternative supply arrangements would be put in place to ensure that the town does not run out of water.

The cost of alternative supply arrangements are highly site-specific. They may include the development of bores, pumps and water treatment infrastructure to access groundwater. In limited circumstances, water treatment may require reverse osmosis, and in coastal areas alternative water

1 We have based our findings on McNair & Ward (2012) and Hensher et al. (2006). Further details are provided in Appendix 1.
2 We discuss guidance from the NSW Safe and Secure program in Appendix 1.

supply might involve seawater desalination. In light of this substantial variation, we have provided 'benchmark costs' that may assist as a starting point for rapid cost-benefit analysis. However, these benchmark costs should not replace more detailed site-specific cost estimates, particularly where hydrological modelling indicates a town water supply system that is likley to experience frequent or prolonged shortfalls. Infrastructure investments being considered under Regional Water Strategies would be subject to engineering cost estimates as part of the business case development.

As indicated in Figure 1, it is only for very small or small towns where water carting from another catchment would be feasible to meet the town's needs. We have estimated the economic cost of carting water at $203/ML/km based on Transport for NSW guidelines.[3] These costs could also be applied to medium and larger towns where carting is considered necessary to temporarily supplement water supplies.

1.3.2 Irrigators and industrial water users

Other key water users across the regions are irrigators and industrial water users. The economic value of improved water availability or reliability for irrigators and other industrial water users (excluding mining) is based on estimates of producer surplus. Producer surplus is the difference between the price that a producer receives and the cost of production.

Where possible we have based estimates of producer surplus for agricultural irrigators on margin budgets sourced from the NSW Department of Primary Industries. In some instances, we have supplemented these with margin budgets sourced from other jurisdictions (e.g. the Queensland Government's AgMargins tool and Tasmanian DPIPWE's gross margin analysis spreadsheets). In these instances, we have revised the margin budgets to reflect the relevant NSW regional climatic and growing circumstances.

Mining values are estimated differently as they are assumed to be foreign-owned, so the economic benefits are based on payments to government (such as royalty returns). This approach is consistent with the NSW Government Guidelines for the economic assessment of mining and coal seam gas proposals, and is considered conservative because the margin return if the mine is NSW owned would be anticipated to be higher than the royalty returns being received by the NSW Government.[4]

Table 1 summarises these values for key users in each of the regions. Given different climates, soil types, and topographies, the economic value of the same commodity tends to vary across regions. We have also included lower and upper bound estimates to reflect variability in key inputs to these values. Note for brevity we have not included the upper and lower bounds for the permanent crops. These are provided in Table 13.

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3 This value is calculated as the sum of travel time costs, vehicle operating costs (VOCs), and externality (pollution) costs. These costs are sourced from NSW Government | Transport for NSW (2020), *Economic Parameter Values*. https://www.transport.nsw.gov.au/system/files/media/documents/2020/200527%20-%20TfNSW%20Economic%20Parameter%20Values%20v2.0.pdf.

4 To view these guidelines, see: https://www.planning.nsw.gov.au/~/media/Files/DPE/Guidelines/guidelines-for-the-economic-assessment-of-mining-and-coal-seam-gas-proposals-2015-12.ashx.

Table 1: Economic values for user categories, by region ($2020)

Region	Irrigators of annual crops *(lower and upper bounds in parentheses)*	Irrigators of permanent crops	Mining & other industry[5]
Macquarie	• Cotton $325/ML ($275-375/ML)	• Oranges $500/ML ($2,400/ML during shortfall) • Viticulture $525/ML ($950/ML during shortfall) • Horticulture (Vegetables) $1,250/ML	**Coal (Open cut mining):** ***Thermal: $11,500/ML*** ***Semi-soft coking: $14,500/ML*** ***Coking: 19,000/ML*** • Moolarben Mine – Yancoal • Wilpinjong Mine – Peabody **Coal (Underground mining):** ***Thermal: $10,000/ML*** ***Semi-soft coking: $13,000/ML*** ***Coking: 16,500/ML*** • Ulan Coal (Ulan West & Ulan Underground) – Glencore **Copper: $12,500/ML** • CSA Mine – Glencore • Tritton Copper Operations – Aeris Resources **Gold: $12,500/ML** • Peak & Hera Gold Mines – Aurelia Metals • Tomingley Gold Operations – Alkane Resources **Zinc, Lead, Silver: $10,000/ML** • Endeavor Mine – CBH Resources
Lachlan	• Cotton $250/ML ($200-300/ML) • Wheat $175/ML ($100-275/ML)	• Oranges $450/ML ($2,300/ML during shortfall) • Almonds (Nuts) $1,100/ML ($1,300/ML during shortfall) • Olives $1,200/ML ($2,800/ML during shortfall)	**Gold, Copper, Silver: $12,500/ML** • Cadia Mine – Newcrest **Copper: $12,500/ML**

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[5] For coal mining, a range of values is provided. This is because different values apply to coking (metallurgical) and thermal coal.

Region	Irrigators of annual crops *(lower and upper bounds in parentheses)*	Irrigators of permanent crops	Mining & other industry[5]
			• Northparkes Mine – CMOC-Northparkes
Gwydir	• Cotton $375/ML ($300-425/ML)	• Oranges $450/ML ($2,400/ML during shortfall) • Pecans $800/ML ($3,200/ML during shortfall)	None
Far North Coast	• Lucerne (Hay) $175/ML ($75-275/ML) • Sorghum $175/ML ($125-225/ML)	• Blueberries $7,500/ML ($15,000/ML during shortfall) • Avocados $3,000/ML ($4,100/ML during shortfall) • Macadamias $2,700/ML ($4,700/ML during shortfall) • Dairy cattle $200/ML (during shortfall only) – We note that water is typically underutilised in this catchment, so water availability is usually not a limiting factor for herd size	None
North Coast	• Lucerne (Hay) $150/ML ($75-250/ML) • Sorghum $175/ML ($125-225/ML)	• Blueberries $5,500/ML ($14,000/ML during shortfall) • Avocados $2,700/ML ($3,900/ML during shortfall) • Horticulture (Vegetables) $3,600/ML[6] • Dairy cattle $200/ML (during shortfall only) – We note that water is typically underutilised in this catchment, so water availability is usually not a limiting factor for herd size	None
Namoi	• Cotton $350/ML ($300-400/ML) • Wheat $175/ML ($100-275/ML) • Lucerne $150/ML ($100-175/ML) • Sorghum $175/ML ($125-250/ML)	• Oranges $475/ML ($2,400/ML during shortfall)	**Coal (Open cut mining):** ***Thermal: $11,500/ML*** ***Semi-soft coking: $14,500/ML*** ***Coking: 19,000/ML***

6 The shortfall value is not applicable for tomatoes because they are typically grown as an annual crop. However, they have been included in the permanent crop category because production cannot be easily scaled up.

Region	Irrigators of annual crops *(lower and upper bounds in parentheses)*	Irrigators of permanent crops	Mining & other industry[5]
	• Oats $150/ML ($100-250/ML) • Barley $150/ML ($100-200/ML)		• Maules Creek Mine – Whitehaven • All other open cut mines (incl. Tarrawonga Mine, Sunnyside Mine) – Whitehaven • Boggabri Mine – Idemitsu **Coal (Underground mining):** ***Thermal: $10,000/ML*** ***Semi-soft coking: $13,000/ML*** ***Coking: 16,500/ML*** • Narrabri Mine – Whitehaven
Border Rivers	• Cotton $350/ML ($300-400/ML) • Wheat $175/ML ($100-275/ML) • Sorghum $150/ML ($125-200/ML) • Barley $150/ML ($100-175/ML)	• Macadamias $1,300/ML ($2,800/ML during shortfall)	None
Western	• Cotton $250/ML ($225-300/ML) • Wheat $175/ML ($125-225/ML) • Barley $150/ML ($125-175/ML)	• Viticulture $400/ML ($700/ML during shortfall) • Olives (Broken Hill) $750/ML ($2,200/ML during shortfall)	**Zinc, Lead, Silver: $10,000/ML** • Perilya Mine – Zhongjin Lingnan (formerly: Perilya) • Rasp Mine – CBH Resources **Mineral sands: $10,000/ML** • Ginkgo & Snapper Mines – Tronox (formerly: Cristal Mining) • Copi Project (to commence production in Q2 2021) – Relentless Resources
South Coast	• Lucerne (Hay) $150/ML ($75-250/ML)	• Dairy cattle $200/ML (during shortfall only) – We note that water is typically underutilised in this catchment, so water availability is not a limiting factor for herd size	None

Region	Irrigators of annual crops *(lower and upper bounds in parentheses)*	Irrigators of permanent crops	Mining & other industry[5]
Murray	• Cotton $225/ML ($175-250/ML) • Rice $175/ML ($150-200/ML) • Potatoes $150/ML ($0-350/ML) • Wheat $150/ML ($100-200/ML) • Oats $150/ML ($75-250/ML) • Barley $150/ML ($125-175/ML) • Lucerne (Hay) $150/ML ($75-250/ML)	• Almonds (Nuts) $1,100/ML ($1,300/ML during shortfall) • Viticulture $475/ML ($825/ML during shortfall) • Nectarines/Peaches $450/ML ($2,100/ML during shortfall) • Oranges $450/ML ($2,100/ML during shortfall) • Olives $1,000/ML ($2,600 during shortfall)	None
Murrumbidgee	• Cotton $225/ML ($175-250/ML) • Rice $175/ML ($150-200/ML) • Potatoes $150/ML ($0-350/ML) • Wheat $150/ML ($100-200/ML) • Oats $150/ML ($75-250/ML) • Barley $150/ML ($125-175/ML) • Lucerne (Hay) $150/ML ($75-250/ML)	• Almonds (Nuts) $1,000/ML ($1,300/ML during shortfall) • Olives $975/ML ($2,500 during shortfall) • Viticulture $500/ML ($850/ML during shortfall) • Nectarines/Peaches $450/ML ($2,100/ML during shortfall) • Oranges $450/ML ($2,100/ML during shortfall)	None
Greater Hunter	• Lucerne (Hay) $150/ML	• Blueberries $5,300/ML • Strawberries $7,000/ML • Cherries $8,000/ML • Vegetables $1,500/ML • Viticulture $650/ML	**Coal (Open cut mining):** ***Thermal: $11,500/ML*** ***Semi-soft coking: $14,500/ML*** ***Coking: 19,000/ML*** • Mount Thorley Warkworth Mine – Coal & Allied/Rio Tinto • Rix's Creek South Mine – BCL • Liddell Mine – Glencore • Hunter Valley Operations Mines – Yancoal • Wambo Mine – Peabody

Region	Irrigators of annual crops *(lower and upper bounds in parentheses)*	Irrigators of permanent crops	Mining & other industry[5]
			• Mount Arthur Mine – BHP • Mangoola – Glencore • Bengalla Mine – Bengalla Mining **Coal (Underground mining):** ***Thermal: $10,000/ML*** ***Semi-soft coking: $13,000/ML*** ***Coking: 16,500/ML*** • Integra Underground Mine – Glencore • Rix's Creek North Mine – Glencore • Ashton Mine – Yancoal • Muswellbrook Mine – Idemitsu

1.3.3 Recreational water users

While not consumptive users, the community enjoys water resources for recreation activities. The options that are being assessed as part of Regional Water Strategies may also affect these recreational users.

Our estimate of the recreation value of water is **$20 per trip per day**. This estimate combines both consumer surplus and producer surplus, and is based on a literature review of the economic value of water-based recreation and adjusted to 2020 dollars.

There is a degree of caution that should be exercised in applying this value in rapid cost-benefit analysis. It is important to establish a causal relationship between water availability and the magnitude of recreational activity. We recommend that this value is most relevant for Regional Water Strategy options that:

- deliver a significant improvement to a waterway that would otherwise be in very poor condition; or
- avoids a waterway being in very low flow where recreational activities would not be possible.

Care also needs to be taken to apply the value based on 'induced' demand. If (i) water-based recreation takes place in one location instead of another, (ii) the experience is 'about the same', and (iii) the cost of engaging in recreation is the same, then the economic value (consumer and producer surplus) from the activity is also about the same. In this case, there is no incremental change in economic value from recreation because there is a suitable substitute site nearby.

1.3.4 Unregulated and supplementary water, and overland flows

For water users who rely on unregulated water, supplementary water, and overland flows, the value of water is a function of (i) the time of year it becomes available and (ii) the margin returns from the irrigated crop it is used to grow, or livestock it is used to water.

In regions that rely heavily on these sources of water, if the land area is available, it is commonplace (particularly inland rather than in a coastal context) to augment water supply reliability through the use of large on-farm storages. Provided these storages are not already at capacity, water will usually be diverted to them whenever it becomes available.

However, water in storage incurs losses through seepage and evaporation. The magnitude of these losses is a function of the quality of the storage (e.g. soil type, degree of compaction, clay lining, use of cells, use of covers, etc), weather conditions (temperature, humidity), and the duration of storage (longer storage results in greater losses, all else equal). Storage losses result in stored water having a lower economic value than water extracted from a regulated system and immediately applied to a crop or used for another purpose (e.g. mining).

1.3.5 Stock and domestic water

The value of stock and domestic water has been modelled as a function of the difference in returns from two options available to a grazier during times of stock and domestic water shortfall; either (i) purchase or source additional water to alleviate the shortfall and maintain their current herd or (ii) reduce the herd size now – by selling non-core stock initially then selling core stock only if necessary

– and re-stock when conditions improve. It must be noted that these are shortfall value and thus they are significantly higher than the values that beef, sheep and dairy producers are willing to pay in water markets. Rather they are reflective of the values that they would pay to avoid having to reduce their herd size and subsequently re-stock.

Table 2 summarises these values for key users, across a range of regions and feed types. Given different climates, soil types, and topographies, the economic value of the same livestock sector tends to vary across regions. We have also included lower and upper bound estimates to reflect variability in key inputs to these values.

Table 2: Economic values for stock and domestic water used for livestock grazing ($/ML, $2020)

Key water user	Low	Central	High
Beef cattle – Coastal, improved pasture	4,000	7,000	10,000
Beef cattle – Coastal, unimproved pasture	1,500	2,500	3,500
Beef cattle – Inland, native pasture	3,000	5,000	7,000
Dairy cattle – North NSW	3,000	5,000	7,000
Dairy cattle – South NSW	5,000	8,000	11,000
Sheep	4,000	5,000	6,000

1.3.6 Flood impacts

Flooding (or spill) occurs when water supply for a storage or river exceeds its capacity. While not a user of water, the hydrological modelling in Regional Water Strategies may consider incremental changes associated with flood impacts on towns, for instance if a dam raising results in improve flood mitigation.

Flood damage usually impacts most significantly on towns and communities, but can also impact on other user groups (e.g. agriculture and other industry). In accordance with the agreed project scope, the focus of this section is the costs that flooding imposes on towns and communities. The impacts on overland flows are not within scope of this report.

Cost impacts can be grouped into three categories:

- Direct (tangible) damages – physical impacts, such as to houses, other buildings, agriculture, and public infrastructures such as roads, bridges, and utilities
- Indirect (tangible) damages – impacts from disruption to normal activities, such as emergency response, clean-up, and disruption to transport, employment, and commerce due to being ‘cut off’
- Intangibles – non-market impacts, such as loss of biodiversity, stress, or mental health impacts

To incorporate flood related costs and benefit it is proposed that the hydro-economic modelling incorporate the Flood RAM (rapid appraisal method)[7]. Flood RAM is a methodology that enables estimates of flood damages to be made for an area without the need for excessive data, where these values are sufficiently robust for inclusion in a cost-benefit analysis. Refer to Appendix A1.5 for a detailed description of this the Flood RAM approach.

1.4 Report structure

The rest of this report is structured as follows:

- **Chapter 2** introduces the Regional Water Strategies program and regional water value functions,
- **Chapter 3** outlines our high-level approach for developing regional water value functions,
- **Chapter 4** summarises our findings of key water users and values across each region, and
- **Appendix 1** provides more technical details on how we have calculated value functions for each user group and our key assumptions.
- **Appendix 2** includes a list of references.

Accompanying this report are four spreadsheet models that provide further details on our calculation of economic values. These include annual and permanent crops, mining, and the cost of shortfalls to town water supply.

[7] Department of Sustainability and Environment, 2009, Review of Flood RAM Standard Values.

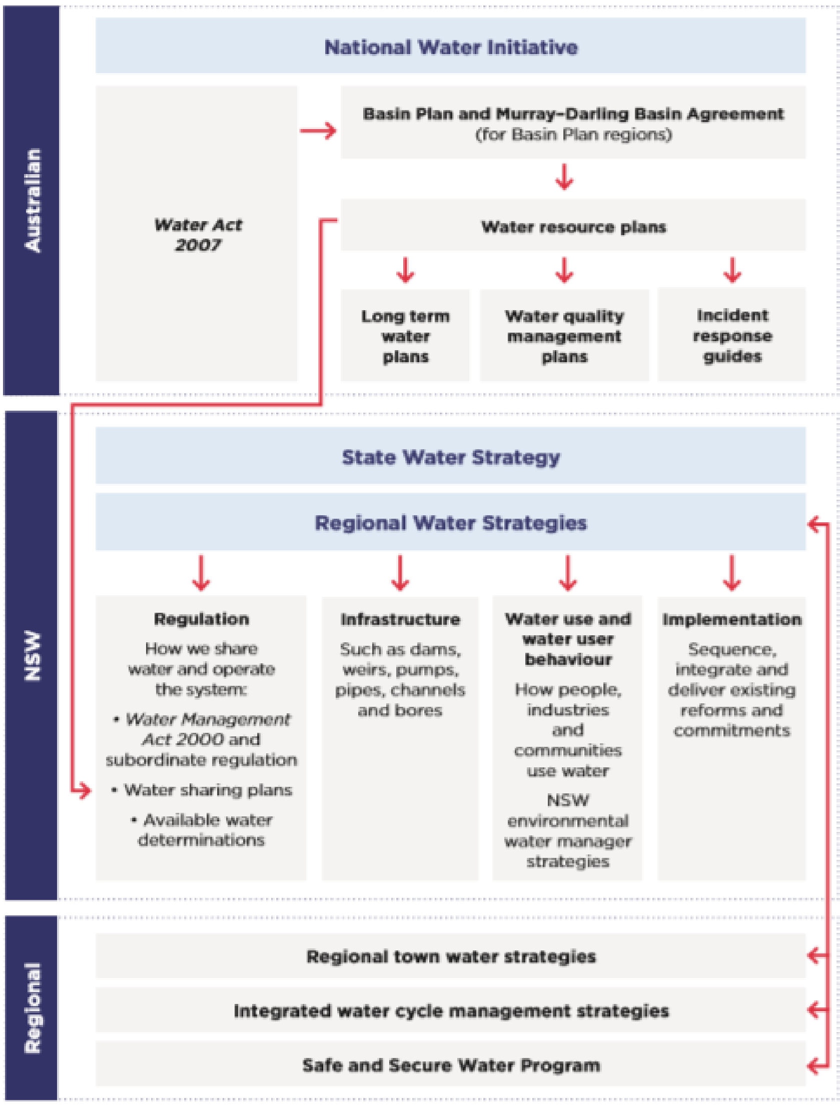
2. Introduction

Regional Water Value functions are a key input to the economic analysis that is to be undertaken to inform Regional Water Strategies across NSW.

2.1 NSW water policy and planning context

The Regional Water Strategies Program sits within a broader policy and planning context that guides the management of water resources in NSW (Figure 2). Regional Water Strategies will integrate and align with other NSW Government programs such as the State Water Strategy, Water Resource Plans, long term watering plans, and the Safe and Secure Water Program which provides options to address local-level issues.

Figure 2: NSW water policy and planning framework



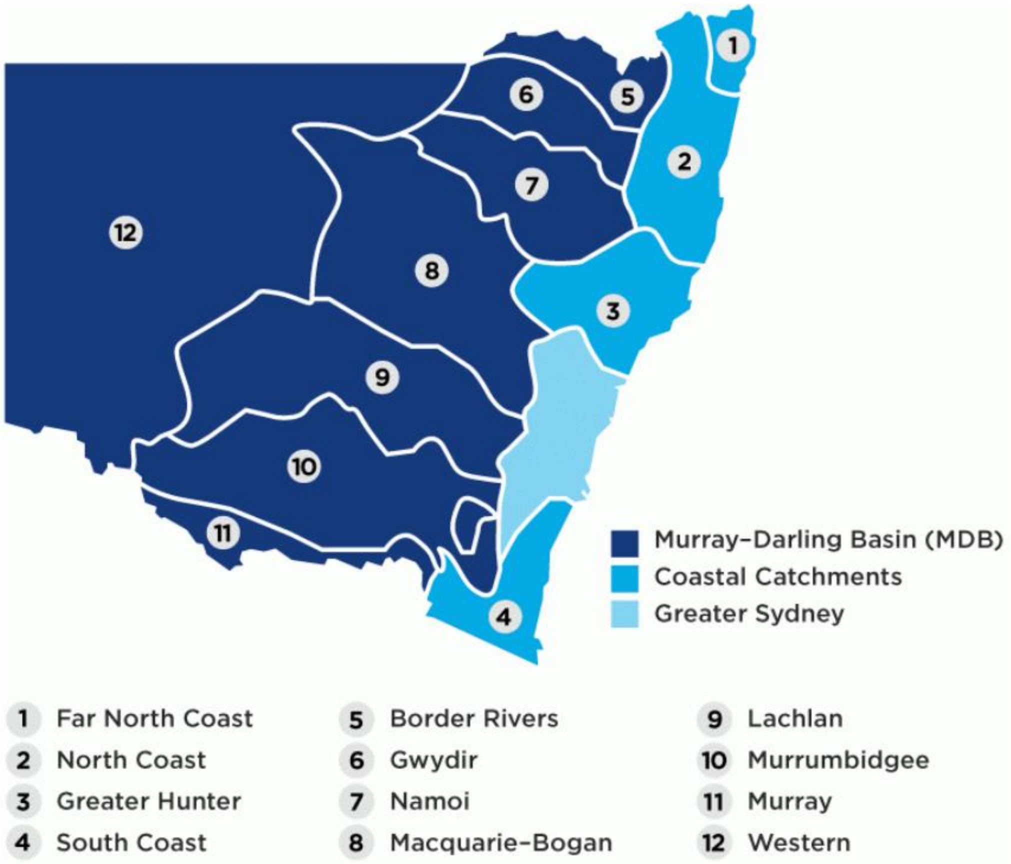
Source: DPIE

2.2 The Regional Water Strategies program

2.2.1 About the program

DPIE is working in partnership with WaterNSW, local councils, and Aboriginal communities to develop Regional Water Strategies for 12 catchments in NSW (Figure 3).

Figure 3: Regional Water Strategy catchment areas in NSW



Source: NSW Government, https://www.nsw.gov.au/snowy-hydro-legacy-fund/water-security.

For Regional Water Strategies a range of options are being investigated – including policy, planning, behavioural, regulatory, technology, and infrastructure solutions – to deliver tailored solutions for managing the water needs of NSW over the long term.

Regional Water Strategies will set out a long-term 'roadmap' of actions to deliver five objectives. Options selected for inclusion in the final strategy for each region will need to address at least one of these objectives, which include the following:

1. Deliver and manage water for local communities
2. Enable economic prosperity
3. Recognise and protect Aboriginal cultural values and rights
4. Protect and enhance the environment
5. Affordability – Identify least cost policy and infrastructure options.

Key rationales of the program are:

- securing basic landholder rights and essential town water supplies during extreme events, such as the current drought, and
- at all other times, providing greater flexibility to deliver across all of the objectives outlined above, including providing water for the environment.

2.2.2 Process

The development of Regional Water Strategies has been prioritised based on need, risk, and alignment to the NSW State Infrastructure Strategy 2018–38. This includes a catchment needs assessment for each region and current drought impacts. Upstream catchments are analysed to inform downstream strategies. The information used to develop and finalise the strategies includes scientific data, local and traditional knowledge, and community feedback.

Key stakeholders during the development phase include Councils, Joint Organisations, peak groups, and the public. DPIE have met with Aboriginal communities to seek input on cultural values and rights. Insights from previous engagement on Water Resource Plans and other programs is used in the development of Regional Water Strategies.

The strategies will provide an opportunity to explore how to better integrate and shape future planning and policies to deliver improved water outcomes. The objectives, challenges, opportunities, and options identified in the draft regional water strategies will be tested, evaluated, and refined based on feedback from the public exhibition process and stakeholder engagement.

DPIE are developing a long list of options that includes potential policy management and infrastructure measures to ensure a broad range of possible solutions are tested. The long lists will be available when a draft strategy is released for public exhibition. DPIE will include stakeholder feedback with other data to analyse these options to create a final short list of actions and the evidence to support these actions.

The final regional water strategies for each region will include:

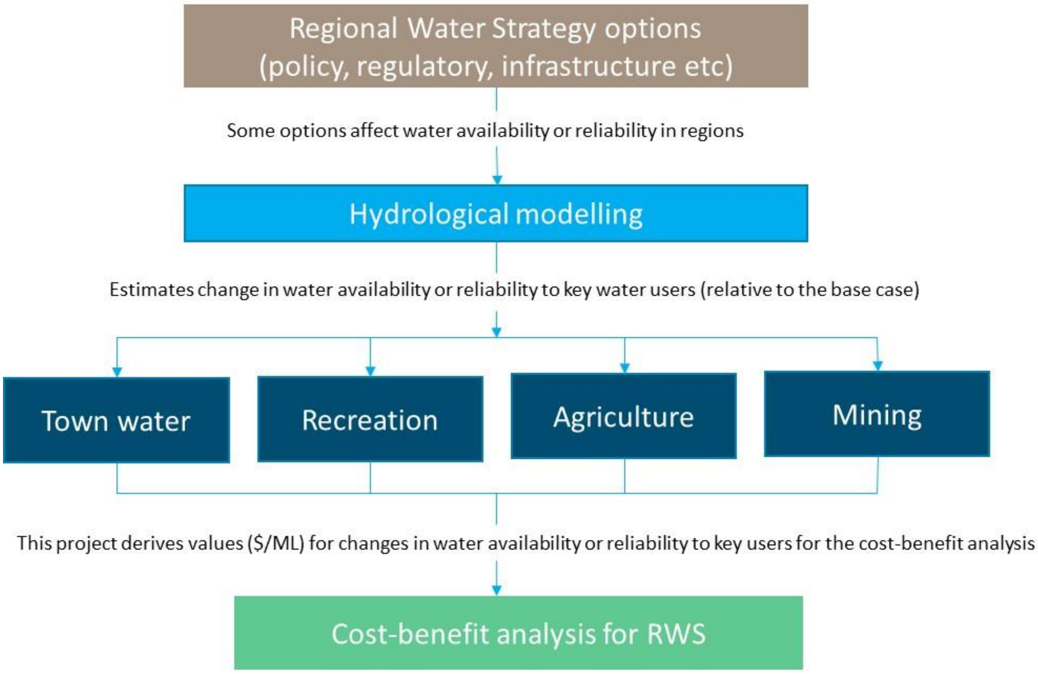
- a final package of actions approved by government;
- an implementation plan including a clear governance structure for delivery; and
- opportunities for local and regional partnerships.

The Greater Hunter Regional Water Strategy has been finalised and will be implemented over the coming years. Work is underway on the strategies throughout 2020, and delivery of the final strategies is expected in 2021.

2.3 How this project supports the Regional Water Strategies program

DPIE will use the regional water values and functions derived from this project as an input to the rapid cost-benefit analysis being undertaken for Regional Water Strategies. This will ensure that the analysis for each region is based on a consistently framed set of values. Figure 4 summarises how the regional water value functions will be used as part of the cost-benefit analysis, with further information following.

Figure 4: Summary of cost-benefit analysis for Regional Water Strategies



Source: Marsden Jacob Associates.

2.3.1 Cost-benefit analysis for Regional Water Strategies

The range of policy and infrastructure options under consideration for Regional Water Strategies will result in changes to water access and water security for key users (towns, irrigated agriculture, mining, and recreational users) in each region.

To evaluate these options, the costs and benefits need to be identified and measured incrementally to the base case. The base case is generally the status quo for water management arrangements in each region. Under each different option, the analysis will consider (based on the hydrology) changes in water availability for key water users – where the change is always measured against the base case. The assessment involves separating out the impacts on distinct user groups. In other words, how the gains and losses are distributed among key user groups, and whether any user groups are disproportionately impacted (either positively or negatively).

2.3.2 Steps involved in cost-benefit analysis (hydro-economic modelling)

To provide context for this report, below is an outline of the steps involved in undertaking cost-benefit analysis for Regional Water Strategies:

1. Generate hydrological modelling outputs for the base case and options in each region. A large number of model runs (i.e. modelled hydrological sequences) will be generated for the base and scenario cases to provide insight into the impacts of the proposed policy and infrastructure options. This modelling is needed to understand where and when costs and benefits will present.

2. Identify the costs (such as capital and operating costs for new infrastructure) and benefits (such as improved reliability of water to users).
3. Draw upon available information to support the quantification of the benefits and costs of the proposed changes, where each is assigned a dollar value.
4. Undertake hydro-economic modelling of the option cases, incrementally to the base case.
5. Compare costs and benefits to determine whether any of the proposed options results in an improvement, or otherwise, compared to the base case.

The focus of this report is to inform steps 2 and 3 of the cost-benefit analysis. The following chapter provides more information about these values and how to interpret them.

The values from this project are not intended for a financial analysis. Box 1 below outlines some key differences between economic and financial analysis and the implications of this for the regional water value functions in this report.

Box 1: Economic vs financial analysis

A cost-benefit analysis (economic analysis) has some similarities with financial analysis. Both quantify costs and benefits into the future and discount these to obtain a net present value.

The key differences are how costs and benefits are valued and the discount rate that is used.

Costs and benefits included and valuation basis

A financial analysis is done from the perspective of each agency involved in delivering the project. It includes interest expenses, taxes, and depreciation. A cost-benefit analysis excludes the impact of financing costs, taxes (in most cases), depreciation, and amortisation as these are considered transfers for the purpose of measuring social welfare. A cost-benefit analysis will include spill over impacts on the rest of the economy, natural capital, and other impacts that affect social welfare. A cost-benefit analysis shows real resource flows while a financial analysis shows cash flows.

An example of the difference between an economic and financial value is the cost of carting water. Assuming that a Council needs to buy water from a different Council/utility in NSW and truck it into town:

1. The **financial cost** of carting to the Council includes the cost to purchase the water, and the cost to purchase or hire trucks to transport the water
2. The **economic cost** of carting includes vehicle operating costs, travel time, and externality costs (e.g. pollution). The cost of the water itself is a transfer between two NSW parties (unless the water is sourced outside NSW) and so is not included in the economic cost.

Discount rate

A cost-benefit analysis uses real discount rates, while a financial analysis usually uses nominal discount rates. In cost-benefit analysis, the real discount rate reflects the long-term social opportunity cost of capital (i.e. for society collectively, including public and private sectors). In financial analysis, the nominal discount rate typically reflects the cost of capital to the entity undertaking the proposal.

More information is provided in the NSW Government Guidelines to Cost-Benefit Analysis (TPP17-03).

2.4 Limitations and assumptions

The economic values in this report have been prepared to support rapid cost-benefit analysis for Regional Water Strategies across NSW. The rapid cost-benefit analysis will assist the NSW Government to determine which options should be assessed further in a full business case. The business case will include more detailed cost-benefit analysis as well as financial analysis.

We have aimed to account for region-specific factors affecting values where possible within the scope of this report. However, it was outside the scope of this study to conduct primary research (e.g. stakeholder surveys) to develop values for each region. In some cases, notably the costs of town water supply shortfalls, it was necessary to develop a simplified framework to derive values. The framework allows DPIE to change assumptions if this is considered necessary for a particular region in the rapid cost-benefit analysis. We have provided benchmark costs for alternative town water supply options. As these costs are highly site-specific, the intent is that these benchmarks be used as a starting point for rapid cost-benefit analysis. The extent of further analysis and consideration during the rapid cost-benefit analysis should be proportionate to the extent that town water supply shortfalls are likely to be an issue in a particular location. The hydrological modelling will help to inform this. The subsequent business case phase of Regional Water Strategies will provide the opportunity to incorporate further site-specific considerations into the assessment.

It was also outside the scope of this study to forecast how key water users in each region, and the values for these users, change over time (for example, from year to year). Our approach is focussed on the existing key water users and values that are representative of the longer term.

Where possible, we have used publicly available sources of information to derive economic values. We have referenced these information sources throughout this report an in accompanying spreadsheets. Where we considered there was a lack of suitable publicly available information, we have relied on our own estimates. These generally derive from our internal databases based on past consulting projects. To derive economic values, it was necessary to make several assumptions. These assumptions are documented and discussed throughout this report, and in the accompanying spreadsheet models.

3. Our approach

Our approach to developing regional water value functions is proven and practical. It draws on our recent experience in hydro-economic modelling and evaluating Regional Water Strategies.

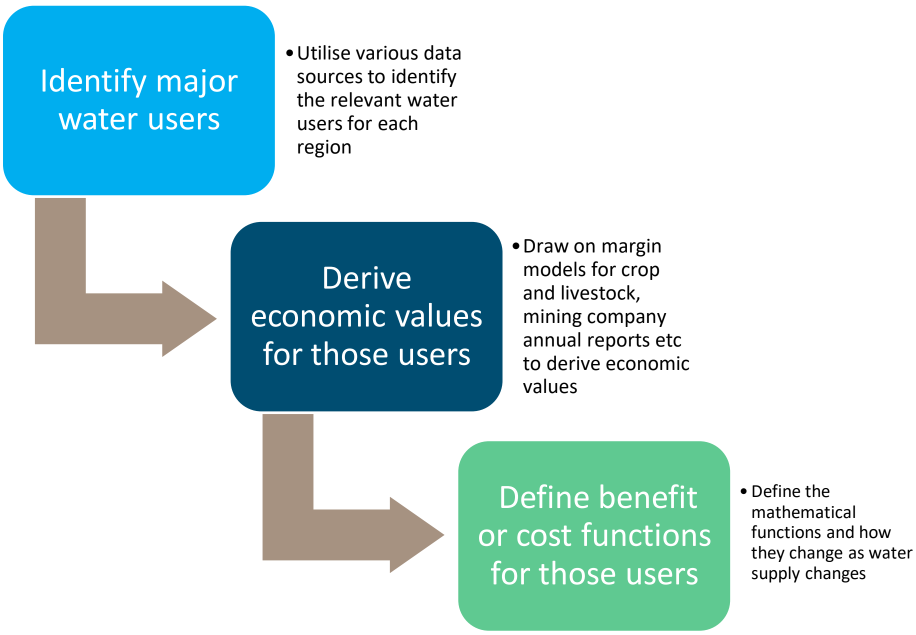
This chapter outlines our approach to developing regional water value functions. Our approach is broadly consistent across regions; however, the following chapters explain how we have dealt with issues specific for each region.

Our approach reflects that the NSW Government requires that Regional Water Strategies be assessed within a cost-benefit analysis framework. We have engaged with NSW Treasury to ensure that the values from our approach are consistent with NSW Government Guidelines for Cost-Benefit Analysis (TPP17-03).[8]

3.1 Overview of our approach

There are three main steps in our approach to develop regional water value functions, summarised in Figure 5 below. The following sections discuss these steps in more detail.

Figure 5: Overview of our approach



Source: Marsden Jacob Associates.

8 NSW Government (2017), *Guide to Cost-Benefit Analysis*, Policy and Guidelines Paper TPP17-03.

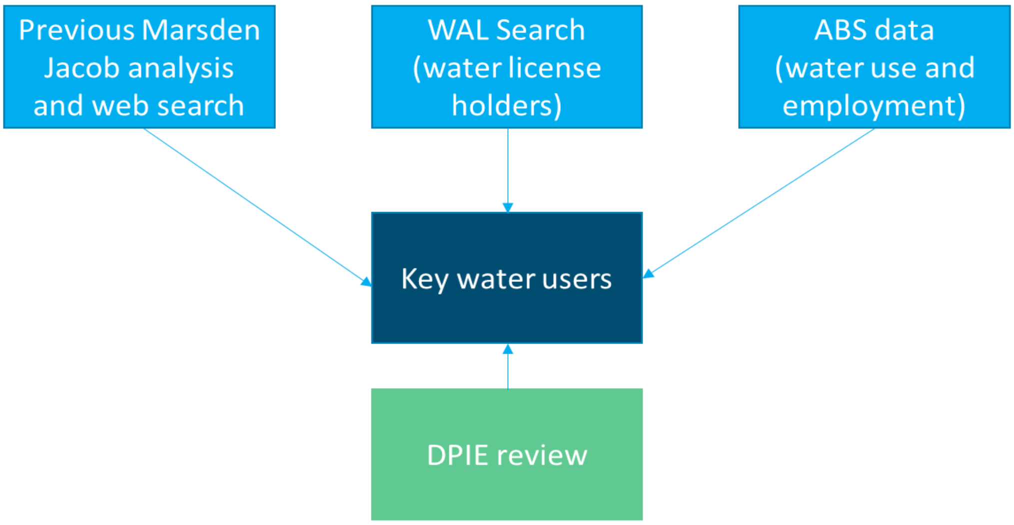
3.2 Step 1: Identifying major water users in a region

The first step in our approach is to identify the main water users in a region. Water users can be either:

- **Primary/direct** – these are consumptive users of water including irrigators, mining companies, utilities, and town water supply
- **Secondary/indirect** – these are non-consumptive users of water, for example, recreational users and tourism operators.

To identify the primary and secondary users of water in each region, we drew on our previous analysis and experience, identified the current water license holders (based on searches on the NSW Water Register and web searches to confirm their line of business), and checked the findings against Australian Bureau of Statistics (ABS) data on employment by industry and water use. We also discussed our findings with the relevant regional experts at DPIE to ensure it aligned with their on-the-ground experience.

Figure 6: Approach to identifying water users



Source: Marsden Jacob Associates.

We have focussed on identifying the main water users in each region. We have not sought to establish a value function for every individual water user. This is because it would make the hydro-economic modelling unduly complex, with little material gain to the overall accuracy of the results.

As discussed further throughout this report, the main user groups include:

- Town water supply;
- Irrigators of annual crops;
- Irrigators of permanent crops;
- Mining companies; and
- Recreational water users.

It is outside the scope of this report to estimate the value of changes in environmental uses of water, including planned environmental releases based on Water Sharing Plans and held environmental water by the Commonwealth Environmental Water Office.

The impact of changes in water available for environmental purposes will be considered separately as part of the development of Regional Water Strategies.

Box 2: Values for industrial water users on town water supply

In some regions, there are industrial water users that are connected to town water supply. In the hydrological modelling for Regional Water Strategies, water use for these businesses will likely be included within town water supply. The values we have estimated for changes in water availability to towns incorporates impacts on residents, businesses, local government/water utilities, and the broader community (see section A1.1 for further discussion).

Where a key industrial water user is separately licenced, the hydrological modelling can capture changes in water availability to this user separately. For this reason, we have estimated a value for these industrial users. Our approach to this is discussed in the following section.

3.3 Step 2: Deriving economic values

The second step in our approach involves deriving the economic values that apply to changes in water availability for the user groups identified in Step 1. This section explains the methods used and how to interpret economic values for different users.

3.3.1 Categories of values

The are several different categories of values that we have identified. These align with the benefit categories in the NSW Government Guidelines to Cost-Benefit Analysis (TPP17-03) and include:

- **Avoided costs** – For example, the avoided cost of water restrictions being imposed on a town water supply, or the avoided cost of implementing alternative supply arrangement or carting in water.
- **Producer surplus** – The difference between the price that a producer receives and the cost of production (as discussed below, for irrigators, we included both gross and net margins).
- **Consumer surplus** – The difference between the price consumers are charged and their willingness to pay (in the context of this report there is loss of consumer surplus when water restrictions are imposed on town water supply).
- **Government revenue** – Incremental revenues that accrue to the government as the result of an option. Note that revenue changes that would have occurred regardless of the option should not be included, and government revenues accrued within the State that are an expense for another party within the State should be considered a ‘transfer’ rather than a cost or benefit.
- **Benefits to the broader community** – Benefits that flow to the community as a whole as well as to individual consumers or private businesses. ‘Positive externalities’ refer to activities that may have beneficial third-party effects on groups or industries other than the direct recipient of the service.

In Table 3, we outline the main economic values relevant to each user group, a broad description of how we estimate them and how they should be applied. Further details in provided in the technical appendix. Note that in the table below the values are framed as positive values resulting from improved access to water. The values will be negative if access to water is reduced.

Table 3: Economic values for user categories

User	Category	Description	How we estimate the economic value	How the value should be applied
Town water supply	Avoided cost	A town experiences a water supply shortfall – that is to say the hydrological sequences identify that demand exceeds available supply in the analytical period. In a prolonged drought, this shortfall may continue for several months. When there is a water supply shortfall, restrictions need to be imposed on homes and businesses, and if the drought continues long enough, alternative water sources will be needed. These measures impose economic costs on the community, where the cost rises the longer the drought continues.	In consultation with DPIE, we have developed a framework for valuing the economic costs of water supply shortfalls based on the size of the town. The framework incorporates the costs of two broad policy responses: • The first response is the imposition of water restrictions, which results in costs associated with level of service. In practice, this means residents of the town are restricted in how they use water, and these restrictions increase the longer the drought continues. We estimate the cost of restrictions using estimates of consumer surplus or producer surplus. • If a drought continues for longer than 12 months, it is assumed that alternative supply arrangements could be required. Alternative supply arrangements are highly site specific and may include: – development of bores and water treatment infrastructure (which might involve reverse osmosis for specific treatment) to provide access to groundwater resources, or development of infrastructure to permit access to dead storage volumes). We estimate benchmark costs of this infrastructure as a starting point for these costs. These benchmarks should not replace site-specific estimates where these are available. – carting of water from another catchment. Carting of water from elsewhere in the same catchment is likely to be unviable because a shortfall is likely to be experienced throughout the entire catchment. We estimate the economic cost of carting water from different regions based on NSW Government	The economic cost of any shortfall in town water supply will be calculated for each option considered under Regional Water Strategies per the framework in Appendix 1. An option provides a benefit from improved water reliability for town water supply where it avoids costs of supply shortfalls relative to the base case, for a specific hydrological sequence.

User	Category	Description	How we estimate the economic value	How the value should be applied
			guidelines for economic appraisal of transport.[9] For many towns (greater than 1,000 people), carting is unlikely to be viable due the quantum of water that needs to be transported, so alternatives such as desalination and setting up access to dead water storage will likely be required. • More details on our framework is provided in Appendix 1.	
Irrigators with annual crops	Producer surplus	Irrigators with annual crops (e.g. cotton, wheat, rice) tend to hold general security entitlement which provide a less reliable water supply compared to high security entitlement. For annual cropping, areas planted to crops are a function of both water availability prior to the growing season and seasonal outlook (in the case that irrigators speculatively plant). Irrigators of annual crops are generally able to scale their production to expected water availability. Greater certainty around expected allocations is likely to result in greater areas planted, while increased water security is also likely to result in smaller in-season crop losses.	The value of improved water availability for irrigators with annual crops is based on a producer surplus approach, estimated using **gross margins**. Gross margins are defined as the gross income from an enterprise less the variable costs involved in achieving it. We use gross (as opposed to net margins) because of the short term/annual nature, and ability to easily scale up or scale down production. Gross margins capture only the costs and benefits for a single season. Gross margins vary over time, as commodity prices and input costs change. As it is not feasible to forecast changes in gross margins over long timeframes, we have a single estimate which is typical of long-term average margins for that commodity. Similarly, rather than estimating margin returns for different individual producers the gross margin estimates capture margin returns for a typical or	An option under a Regional Water Strategy that improves water availability for annual cropping will provide additional ML of water and result in additional areas planted relative to the base case (and vice versa). Each additional ML is valued at the gross margin value for that region.

[9] NSW Government | Transport for NSW (2020), *Economic Parameter Values*. https://www.transport.nsw.gov.au/system/files/media/documents/2020/200527%20-%20TfNSW%20Economic%20Parameter%20Values%20v2.0.pdf.

User	Category	Description	How we estimate the economic value	How the value should be applied
			average producer in each catchment. This is deemed appropriate because it aligns with the water demand functions in the hydrological modelling.	
Irrigators with permanent crops	Producer surplus	Irrigators of permanent plantings (e.g. fruit and nuts, and vegetables) tend to hold high security entitlements or put in place more sophisticated water holding arrangements (such as packages of surface water entitlements, leases, forwards, and groundwater) to achieve their desired water security. To these irrigators, reliability is critically important because, unlike annual crops, permanent plantings require water each year. In years of lower announced allocation, temporary water is likely needed to meet any shortfalls, and keep plants alive and long term yields uncompromised.	The incremental benefit (or cost) for irrigators with permanent crops is based on a producer surplus approach, estimated using **net margins**. Unlike gross margins, net margins also include fixed costs. This is because permanent crops are not easily scaled, and thus increasing production will involve incurring fixed costs. As with annual crops, the net margin is based on long-term average returns. This value is applicable to Regional Water Strategy options that facilitate expansion of permanent cropping (such as permitting the conversion from general to high security entitlements). Under conditions of shortfall, the value of water to irrigators of permanent crops will be higher than the longer-term average because water is needed to keep crops alive, to maintain both current and future yields. For permanent crops, if the crop is compromised due to shortfall it takes up to 10 years for a crop to reach maturity in terms of its annual output. Therefore, in times of significant water supply shortfall, the value of water is based on the avoided loss of margin returns that would otherwise result from (i) the permanent crop (or a proportion thereof) dying, (ii)	An option under a Regional Water Strategy that provides a demonstrable and enduring improvement in water availability or reliability is valued at the net margin for each ML of the additional water supplied (relative to the base case). Supply shortfalls for permanent crops are valued at the respective recovery cost per ML. Similar to town water supply, an option provides a benefit from improved water availability where it avoids costs of supply shortfalls relative to the base case.

User	Category	Description	How we estimate the economic value	How the value should be applied
			the crop needing to be replanted, (iii) the new plants taking up to 10 years to reach maturity, and (iv) the new plants achieving lower yields and returns before they reach maturity. If, for example, a permanent crop takes 10 years to reach maturity, the value of (or capacity to pay for) water during times of shortfall reflects the difference between: 1. The levelised present value of returns from a mature crop over 10 years. 2. The levelised present value of returns from a newly planted crop (including establishment costs) over 10 years.	
Mining companies	Government revenue	Mining companies are typically foreign owned meaning producer surplus flows outside NSW. Producer surplus that accrue to foreign companies do not have 'standing' in cost-benefit analysis for NSW. For this reason, our approach focusses on mining royalties paid to the NSW Government. Under this approach, revenue from taxation could potentially also be included, but because mining companies (like many other business) will actively minimise their tax burden,	Royalties are calculated as a percentage of revenue or output, which means production costs are not required in order to estimate revenue or output per ML (and royalties paid per ML). Our estimates are typical of long-term average royalties per ML. Unlike permanent cropping, a permanent improvement in water availability will not increase mining production. This is because factors other than water supply (such as commodity prices and approval conditions) are more important in their influence on productive capacity during times of typical water availability. However, water is likely to be a constraining input during times of shortfall/drought.	A Regional Water Strategy option provides a benefit to mining where it reduces the incidence of supply shortfalls relative to the base case. The incremental water supplied is valued at the royalty value per ML.

User	Category	Description	How we estimate the economic value	How the value should be applied
		it is not possible to reliably estimate the change in taxation payable.		
Stock and domestic water users	Producer surplus	During times of stock and domestic water shortfall, a grazier can either (i) purchase or source additional water to alleviate the shortfall and maintain their current herd or (ii) reduce the herd size now – by selling non-core stock initially then selling core stock only if necessary – and re-stock when conditions improve	The incremental benefit for graziers is based on a producer surplus approach, estimated using **gross margins**. As with crops, the gross margin is based on long-term average returns. Under conditions of shortfall, the value of stock and domestic water to graziers will be higher than the longer-term average because water is needed to, if possible, retain the core herd, which is usually preferrable to completely de-stocking then subsequently re-stocking when conditions improve. If de-stocking is required, it is assumed that it would take four years to rebuild the herd to its previous levels. Therefore, in times of significant stock and domestic water supply shortfall, the value of water is based on the avoided loss of margin returns that would otherwise result from de-stocking then subsequently re-stocking the herd. The value of (or capacity to pay for) water during times of shortfall reflects the difference between: 1. The levelised present value of returns from maintaining the herd size (and incurring additional costs e.g. drought feeding).	

User	Category	Description	How we estimate the economic value	How the value should be applied
			2. The levelised present value of returns from partially de-stocking then subsequently re-stocking when conditions improve.	
Recreational water users	Consumer surplus and producer surplus	These are non-consumptive users of water. As there is no market where we can observe the value of improved water access and security, we need to use economic valuation techniques to estimate the value.	We have focussed on applying a small number of high quality and directly relevant economic evaluations for value transfer. The focus was on previous studies into the gross direct and indirect economic contribution that recreational activities make. The economic value estimates are indicative order of magnitude estimates based on the best available information. We note that the economic values reported are gross recreation values. If some recreational activity moves elsewhere within the study area and/or new recreationists are expected to visit the area as a result of the proposed restrictions, the net impact will be less than the gross impact.	We recommend that this value is most relevant for Regional Water Strategy options that: • deliver a significant improvement to a waterway that would otherwise be in very poor condition (unsuitable for recreational use); or • avoids a waterway being in very low flow where recreational activities would not be possible. Care also needs to be taken to apply the value based on ‘induced’ demand. See further discussion in the next chapter.

3.4 Step 3: Defining benefit/cost functions for water users

In step three of our approach, we describe the mathematical benefit and cost functions for the different water users. In the following sections, the proposed values for the key users by region are defined and the underpinning functions are detailed in the supporting technical appendix.

4. Key water users and values

This section provides our findings on the key water users in each region and the economic value of improved water availability or reliability to these users.

4.1 Introduction

This chapter provides our findings on the economic values for the key water users. To assist hydro-economic modellers using the values from this analysis, in this section we provide:

- Town water supply benefit values, framed so that they can be applied to towns across all regions
- Irrigation and industrial use benefit values, detailed on a region and crop specific basis
- Stock and domestic water values, detailed on a region and livestock specific basis
- Recreational water users benefit values that can be applied across all of the regions

Further information on how we have estimated the values is provided in the technical appendices.

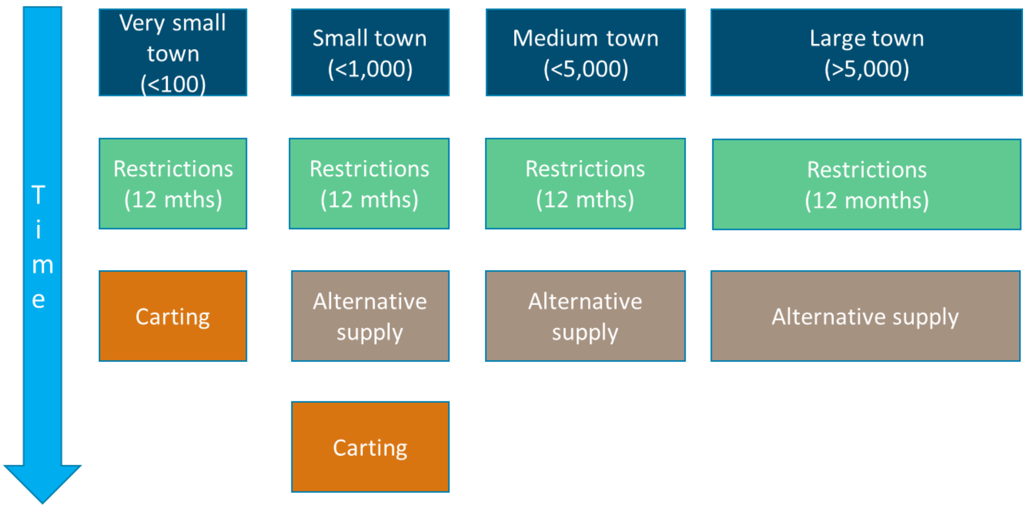
4.2 Town water supply

One potential benefit of options being considered as part of the Regional Water Strategies program is improving water reliability for towns. The economic value of this can be estimated based on the avoided cost of putting in place measures to address town water supply shortfalls.

4.2.1 Framework for town water supply

To guide our analysis, we developed a framework in consultation with the utilities team at DPIE, which is summarised in Figure 7 below.

Figure 7: Framework for town water supply



Source: Marsden Jacob Associates.

Under our framework, the response to town water shortfalls is based on the population of the town (or towns) that the water supply is supporting:

- All towns will first apply water restrictions to address a supply shortfall, for a period up to 12 months. Water restrictions impose an economic cost on the community resulting from a loss of consumer and producer surplus (loss of economic/social welfare).
- If a town's water supply remains in shortfall after 12 months, alternative supply measures need to be put in place:
  - For a very small town with a population less than 100, water is carted into town by truck from the nearest location that water is available (the economic costs of carting water are on a per kilometre basis).
  - For a small town with a population between 100 and 1000, the alternative supply may involve developing a groundwater bore and pumping water into the existing water treatment infrastructure. Carting water may be used as a last resort, or where it is not feasible to access groundwater.
  - For medium and large towns, alternative supply involves the development of bores and water treatment infrastructure[10] to provide access to groundwater resources. For medium and large towns, it would not be feasible to cart water to meet the town's water needs but in some instances it may be used to supplement water supplies.

Note that while we refer to a single town in this framework, there may be multiple towns served by a supply network. The framework should be applied to all towns within a supply network. The costs for these measures is discussed below.

4.2.2 The cost of water restrictions

We have estimated the economic costs of water restrictions at:

- **$1,100 to $1,800/megalitre (ML)** for the first six months of restrictions, and
- **$3,500 to 4,100/ML** for the next six months of restrictions.

For the first six months of restrictions, the range of values reflects the estimated costs for local water utilities to implement water restrictions, including awareness and education campaigns, for example.

If a water supply shortfall extends beyond six months, the severity of restrictions increases and in addition to the water utility's costs, households and businesses also bear economic costs. These economic costs are broad ranging and include social and environmental factors that affect a community's general standard of living and wellbeing. Economic and social costs of water restrictions are commonly estimated through WTP studies.

We have estimated these costs based largely on two key studies from the literature that derive household and business WTP to avoid water restrictions in the Australian Capital Territory (ACT).[11]

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[10] Desalination might be a feasible option for coastal areas where seawater is available.

[11] Key studies that we have based our findings on are McNair & Ward (2012) and Hensher et al. (2006). Further details are provided in Appendix 1.

We consider these studies to be methodologically robust, and as discussed in Appendix 1, the results are similar to previous NSW Government guidelines on the economic cost of water restrictions.

During our consultation on an earlier version of this report, several stakeholders commented that poor town water security acts to reduce business investment in some regions and that this should be reflected in the value. While we agree that concerns over water reliability may act to limit or reduce business investment, this is a location specific issue and cannot be generalised across NSW. Further, it would need to be established that this investment is 'lost' to NSW and does not locate to another area within the State that has better water security. Where a demonstrable case can be made in this regard, we consider that high security water entitlements in the relevant region would represent an upper bound on the value of water.

Our estimate of business WTP to avoid water restrictions is based on a study in the ACT. It is reasonable that some business customers may have a higher WTP to avoid severe restrictions, particularly in those regions in NSW that have recently, or are still experiencing, severe drought. We have addressed this issue in in two ways:

- Firstly, we increased the WTP estimate for business customers by 50% to form the top end of the cost range ($4,100/ML)
- Secondly, we based the economic cost of restrictions in the second six months on the higher cost of 'stage 4' restriction costs, rather than an average of stage 3 and stage 4. This is explained further in Appendix 1.

In Appendix 1 and the accompanying spreadsheet model we provide further details of our calculations and assumptions. Some of our assumptions were necessary to convert WTP per household/business per year into $/ML. The framework and assumptions we applied to determine the range of values above can adapted for a particular region, if considered necessary by DPIE. We have also outlined in Appendix 1 some of the challenges and limitations involved in applying WTP values in this study from existing literature.

4.2.3 The cost of alternative supply measures

If a town's water supply shortfall extends beyond 12 months, it is assumed that alternative supply measures may need to be put in place. The intent is that these measures are implemented in time to ensure the town water supply does not run out.

The cost of developing alternative supply measures is highly site-specific. The costs will be driven by numerous factors including the size of the town, the proximity and characteristics of alternative water supplies, level of water treatment required, etc. In light of this variation, we have provided 'benchmark costs' for developing bores, pumps and water treatment infrastructure to access groundwater. We have also provided benchmark costs for the circumstances where it is considered that water treatment requires reverse osmosis, and in coastal areas seawater desalination.

The benchmark costs in Table 5 provide an initial guide that can be adapted as appropriate to a particular region in the rapid cost-benefit analysis. The benchmark costs should not replace site-specific cost estimates, in particular where hydrological modelling indicates a town water supply system that is likley to experience regular and/or prolonged shortfalls.

Table 4: Benchmark costs of alternative water supply ($2020)

Item	Value	Source(s)	Notes
Bore development capital cost	$175,000 to $410,000	CSIRO (2002), p 13.	Includes drilling (including test hole), bore casing and screens, bore development, diesel pump, motor, motor protection gear and installation costs. Cost varies depending on pumping capacity, bore depth, system design, materials used etc.
Bore useful life	30 years	NSW DPI (2014), p 64.	
Annual pump maintenance	$2,000 to $5,000 p.a	CSIRO (2002), p 12.	Pump maintenance assumed to be 5% of pump value.
Pumping cost	$130 to $270/ML	CSIRO (2002), PP 15-16.	Diesel cost $0.7325/litre (TfNSW Guidelines 2020), Pump efficiency 74%, Derating 75%, Pumping head 140m to 300m, Pumping rate 5 ML/day to 25ML/day. Assumptions can be changed in the accompanying spreadsheet model.
Pump useful life	10 years	Marsden Jacob assumption	Assumption based on previous economic analysis projects undertaken by Marsden Jacob.
Pipeline	$360 to $1,230/metre	NSW DPI (2014), pp 11-13.	These rates rates allow for pipe supply, excavation, lay, backfill, restoration, fittings and thrust blocks. Assumed between 300mm and 600mm. 30% contingency included.
Pipeline useful life	80 years	NSW DPI (2014), p 64.	
Water treatment	$400-$500/ML	Midcoast Council (2018), p 2.	Cost includes operation, chemicals, electricity, monitoring and other costs.
Reverse osmosis (RO) plant	$1m-$3m/ML/day	Based on DPIE estimate	Advice from DPIE that typical RO capital cost of $2m/ML.
Seawater desalination plant	$6m to $15m/ML/day	Marsden Jacob estimate	Cost for a permanent plant based on database analysis from WSAA (2020). Seawater desalination only relevant in coastal areas.
Desal/RO annual operating and maintenance (O&M) cost	6% of capital cost	Marsden Jacob estimate	Includes power, labour, routine maintenance, membrane replacement, chemicals, cleaning, repair. Based on engineering cost estimates from previous Marsden Jacob economic analysis projects of Desal/RO plants.

Item	Value	Source(s)	Notes
Desal/RO annual O&M – on standby	1% of capital cost	Marsden Jacob estimate	Assumed 40% of fixed operating cost. Based on engineering cost estimates from previous Marsden Jacob economic analysis projects of Desal/RO plants.
RO/Desal plant useful life	30 years	Marsden Jacob estimate	Based on engineering reports from previous Marsden Jacob economic analysis projects of Desal/RO plants.
Carting costs	$203/ML/km ($194-219/ML/km)	Transport for NSW (2020), *Economic Parameter Values*.	Calculated as the sum of travel time costs, vehicle operating costs (VOCs), and externality (pollution) costs.

Under our framework, for very small and small towns water may be carted in from another catchment. We have estimated the economic cost of carting water at $203/ML/km.[12] For medium and larger towns, carting may be used to supplement water supplies. As noted above, the financial cost of carting water may be considerably higher than the economic cost. Further details of the derivation of these estimates in provided in Appendix 1 and the accompanying spreadsheet model.

4.3 Irrigation and industrial uses

The economic value of improved water availability or reliability for irrigators and other industrial water users is based on estimates of producer surplus.

Where possible, farm gross margin budgets have been sourced from the NSW Department of Primary Industries as the starting point for generating region-specific margins. However, for some key water users/ enterprise types, these budgets are either not available or are too old to be relied upon to reflect current production conditions. In these cases, the analysis has been supplemented using margin budgets sourced from other jurisdictions (e.g. the Queensland Government's AgMargins tool and Tasmanian DPIPWE's gross margin analysis spreadsheets).

Economic values estimated for mining are based on

(i) revenue data sourced from publicly available annual reports, and

(ii) water use corresponding to the water access licences (WALs) known to be held by each company.

However, this data is not available for every separate mine, which makes it necessary to assume similar economic values across all mines of the same type (e.g. all open cut coal mines or all gold mines). We consider that such an assumption is plausible on the basis that water will be used similarly (e.g. for dust suppression), regardless of the location of the mine. Although there might be some regional differences in conditions such as temperature, humidity and evaporation, the paucity of data means the precise impacts on water use and economic values cannot be robustly estimated. Therefore, the use of consistent values for each mine type is our preferred approach.

Table 5 to Table 7 summarise these values for each of the regions. Given different climates, soil types, and topographies, the economic value of the same agricultural commodity tends to vary across regions.

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12 This value is calculated as the sum of travel time costs, vehicle operating costs (VOCs), and externality (pollution) costs. These costs are sourced from NSW Government | Transport for NSW (2020), *Economic Parameter Values*. https://www.transport.nsw.gov.au/system/files/media/documents/2020/200527%20-%20TfNSW%20Economic%20Parameter%20Values%20v2.0.pdf.

Table 5: Economic values for annual crops, by region

	Economic value ($/ML) *Values in parentheses represent lower and upper bound estimates*							
Region	Cotton	Wheat	Barley	Rice	Lucerne (Hay)[13]	Potatoes	Oats	Sorghum
Macquarie	325 (275-375)							
Lachlan	250 (200-300)	175 (100-275)						
Gwydir	375 (300-425)							
Far North Coast					175 (75-275)			175 (125-225)
North Coast					150 (75-250)			175 (125-225)
Namoi	350 (300-400)	175 (100-275)	150 (100-200)		150 (100-175)		150 (100-250)	175 (125-250)
Border Rivers	350 (300-400)	175 (100-250)	150 (100-175)					150 (125-200)
Western (North)	250 (225-275)	175 (125-225)	125 (100-175)					
Western (South)		150 (100-175)	150 (125-175)					
South Coast					150 (75-250)			
Murray	225 (175-250)	150 (100-200)	150 (125-175)	175 (150-200)	150 (75-250)	150 (0-350)	150 (75-250)	
Murrumbidgee	225 (175-250)	150 (100-200)	150 (125-175)	175 (150-200)	150 (75-250)	150 (0-350)	150 (75-250)	
Greater Hunter					150			

[13] Although lucerne is not an annual crop, the biological lag between planting and achieving full yield is very small. This means it is more appropriately considered as an annual crop for the purpose irrigator responses to changes in water security.

Table 6: Economic values for permanent crops and livestock, by region

Region	Economic value ($/ML): *Expansion values shown in first row, Shortfall values shown in second row, Low-High ranges shown in parentheses*										
	Oranges/ Nectarines/ Peaches	Viticulture	Horticulture (Vegetables)[14]	Strawberries/ Cherries	Pecans	Almonds	Macadamias	Blueberries	Avocados	Olives	Dairy Cattle[15]
Macquarie	500 (200-825)	525 (400-700)	1,250 (775-1,950)								
	2,400 (1,700-3,100)	950 (800-1,200)	N/A								
Lachlan	475 (200-775)					1,100 (875-1,375)				1,175 (825-1,600)	
	2,300 (1,600-3,000)					1,300 (1,100-1,600)				2,800 (2,300-3,300)	
Gwydir	450 (250-675)				800 (650-950)						
	2,400 (1,900-2,900)				3,200 (2,700-3,700)						

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14 Although horticultural crops are not necessarily permanent crops, they are typically capital intensive. This means they are more appropriately considered as permanent crops for the purpose irrigator responses to changes in water security.

15 We note that water is typically underutilised in these catchments, so water availability is typically not a limiting factor for herd size. It is only during times of shortfall/drought where water is likely to be a limiting factor on herd size.

	Economic value ($/ML): *Expansion values shown in first row, Shortfall values shown in second row, Low-High ranges shown in parentheses*										
Region	Oranges/ Nectarines/ Peaches	Viticulture	Horticulture (Vegetables)[14]	Strawberries/ Cherries	Pecans	Almonds	Macadamias	Blueberries	Avocados	Olives	Dairy Cattle[15]
Far North Coast							2,750 (2,100-3,600)	7,500 (5,000-10,500)	2,950 (2,650-3,300)		N/A
							4,700 (3,800-5,800)	15,000 (13,500-17,000)	4,100 (3,800-4,500)		200 (150-250)
North Coast			3,625 (2,075-5,475)					5,500 (4,000-7,500)	2,675 (2,425-2,975)		N/A
			N/A					14,000 (12,500-16,000)	3,900 (3,500-4,200)		200 (150-250)
Namoi	475 (250-700)										
	2,400 (1,900-3,000)										
Border Rivers							1,325 (1,100-1,600)				
							2,800 (2,300-3,300)				
Western		400 (350-475)								750 (575-975)	

Region	Economic value ($/ML): *Expansion values shown in first row, Shortfall values shown in second row, Low-High ranges shown in parentheses*										
	Oranges/ Nectarines/ Peaches	Viticulture	Horticulture (Vegetables)[14]	Strawberries/ Cherries	Pecans	Almonds	Macadamias	Blueberries	Avocados	Olives	Dairy Cattle[15]
		700 (600-800)								2,200 (1,900-2,600)	
South Coast											N/A
											200 (150-250)
Murray	450 (275-650)	475 (425-550)				1,100 (875-1,325)				1,000 (750-1,300)	
	2,100 (1,700-2,600)	800 (700-900)				1,300 (1,100-1,600)				2,600 (2,200-3,000)	
Murrumbidgee	450 (275-625)	500 (425-600)				1,050 (825-1,250)				975 (750-1,225)	
	2,100 (1,700-2,500)					1,300 (1,000-1,500)				2,500 (2,200-2,900)	
Greater Hunter		650	1,500	7,000-8,000				5,300			

Table 7: Economic values for mining and operating mines, by region

	$11,500-19,000/ML	$10,000-15,500/ML	$12,500/ML	$12,500/ML	$10,000/ML	$10,000/ML
Region	Coal (Open cut)	Coal (Underground)	Gold	Copper	Zinc, Lead, or Silver	Mineral sands
Macquarie	• Moolarben Mine – Yancoal • Wilpinjong Mine – Peabody	• Ulan Coal (Ulan West & Ulan Underground) – Glencore	• Peak & Hera Gold Mines – Aurelia Metals • Tomingley Gold Operations – Alkane Resources	• CSA Mine – Glencore • Tritton Copper Operations – Aeris Resources	• Endeavor Mine – CBH Resources	
Lachlan			• Cadia Mine – Newcrest	• Northparkes Mine – CMOC-Northparkes		
Gwydir						
Far North Coast						
North Coast						
Namoi	• Maules Creek Mine – Whitehaven • All other open cut mines (incl. Tarrawonga Mine, Sunnyside Mine) – Whitehaven • Boggabri Mine – Idemitsu	• Narrabri Mine – Whitehaven				
Border Rivers						
Western					• Perilya Mine – Zhongjin Lingnan (formerly: Perilya)	• Ginkgo & Snapper Mines – Tronox (formerly: Cristal Mining)

Region	$11,500-19,000/ML Coal (Open cut)	$10,000-15,500/ML Coal (Underground)	$12,500/ML Gold	$12,500/ML Copper	$10,000/ML Zinc, Lead, or Silver	$10,000/ML Mineral sands
					• Rasp Mine – CBH Resources	• Copi Project (to commence production in Q2 2021) – Relentless Resources
South Coast						
Murray						
Murrumbidgee						
Greater Hunter	• Mount Thorley Warkworth Mine – Coal & Allied/Rio Tinto • Rix's Creek South Mine – BCL • Liddell Mine – Glencore • Hunter Valley Operations Mines – Yancoal • Wambo Mine – Peabody • Mount Arthur Mine – BHP • Mangoola – Glencore • Bengalla Mine – Bengalla Mining	• Integra Underground Mine – Glencore • Rix's Creek North Mine – Glencore • Ashton Mine – Yancoal • Muswellbrook Mine – Idemitsu				

4.4 Stock and domestic water uses

The methodological framework used to value stock and domestic (S&D) water is similar to that used for valuing water availability shortfalls to permanent crops. The following methodology is described in the context of beef cattle operations. However, values for dairy cattle and sheep are also presented.

For permanent crops, the shortfall value captures the importance of the additional water needed to keep crops alive, and maintain both current and future yields. The shortfall value captures the capacity to pay for additional water to meet a shortfall, and prevent a permanent crop from being compromised/dying then replanted. The shortfall value is based on avoided costs and can alternatively be thought of as an avoided recovery cost.

Similarly, a grazier is faced with two options during times of S&D shortfall; either (i) purchase or source additional water to alleviate the shortfall and maintain their current herd or (ii) reduce the herd size now – by selling non-core stock initially then selling core stock only if necessary – and re-stock when conditions improve. Therefore, the grazier can either:

(i) Retain the current herd, but this option would require either:
   a. The purchase or sourcing (carting) of additional water for stock watering purposes (and, potentially, the purchase of additional feed, if this input is also in shortage)
   b. Agistment of at least some of the herd on a different property

(ii) De-stocking of some or all of the herd, followed by re-stocking when there is no longer an S&D shortfall:
   a. There is typically a hierarchy for the sale or retention of different classes of stock
   b. For example, for a cattle operation, de-stocking is likely to occur in the following sequence:
      i. Finished young stock and aged stock – Selling of these animals is likely to have little impact on farm operations because they would have been sold imminently, regardless of an S&D shortfall.
      ii. Castrated stock – These animals have no value for breeding purposes; however, they might be unfinished, which means they would sell at a lower price than a finished animal (i.e. at a price discount). There will also be a cost saving (feed, drenches, etc.) associated with selling these animals early, so the incremental cost of de-stocking these animals earlier than planned will be less than the price discount described above.
      iii. Replacement stock – These animals are not currently used for breeding, but will be rotated into the breeding herd in future, to replace older females that have become less productive and are removed from the herd.
      iv. Young, sound, breeding females – This class of stock is the most valuable and is capable of the best production when the S&D shortfall/drought breaks.

4.4.1 Relationship between duration of S&D shortfall and value of S&D water

Shortfalls of 3 months to 1 year

The de-stocking of finished young stock, aged stock, and castrated stock will likely have no material impact on farm returns because these animals would likely have been sold imminently or could be sold at a minor price discount compared to a finished animal. By de-stocking these classes during the early stages of an S&D shortfall, the core breeding herd can be maintained for a longer time. However, even after de-stocking non-core stock, it is likely that there will remain some degree of S&D shortfall. Anecdotal evidence provided by NSW Department of Primary Industries (DPI) suggests that the cost of S&D shortfalls over the first year are likely to be of a similar magnitude to relatively short-distance carting (e.g. 20-30km). Based on the economic cost of carting water, it is assumed that the shortfall value of S&D water for shortfalls of duration one year or less is $4,000-6,000/ML. It should be noted that this is an economic value (comprising vehicle operating cost, travel time related cost and other externalities) as separate from financial costs which could be significantly different depending on the transport infrastructure and resources available to the farmer.

Shortfalls of 1-2 years

S&D shortfalls of duration between one and two years will be associated with positive shortfall values. Indicative benefits and costs for the two options described above (maintaining herd size vs. partially de-stocking then re-stocking) are provided in Table 22 and Table 23. For Option 2, it is assumed that it takes four years to re-stock the herd – one-quarter of the original herd size in each of the four years after an S&D shortfall.

Shortfalls of 2+ years

At the opposite end of the spectrum, it is assumed that S&D shortfalls of duration two years or longer are associated with a shortfall value of $0/ML. The rationale applied here is that S&D shortfalls of such long duration will also be accompanied by feed (pasture, hay, silage) shortages, such that livestock will invariably require cost-prohibitive levels of supplemental feed.[16] In this scenario, feed is the limiting input, rather than S&D water.

4.4.2 Summary results

The stock and domestic shortfall values for a range of cattle and sheep enterprises are reported in

[16] This is a necessary simplifying assumption. Although not every drought of 2+ years duration will be accompanied by feed shortages in every catchment/region, this assumption is representative of the majority of droughts.

Table 8. We acknowledge that these values are much higher than the market values that are observed in water markets. However, markets would no longer be functioning because for S&D to be in shortfall, all other sources of surface water for extractive purposes (aside from critical human needs) will have already been exhausted.

These shortfall values should only be applied when the hydrological modelling for a policy option indicates an avoided S&D shortfall over a period of **between three months and two years**. For avoided shortfalls over longer than two years (feed, rather than water, is likely to be the most limiting input), the shortfall value is zero, as described in detail in Section 4.4.1.

Table 8: Stock and domestic shortfall values for livestock grazing ($/ML)

Key water user	Low	Central	High
Beef cattle – Coastal, improved pasture	4,000	7,000	10,000
Beef cattle – Coastal, unimproved pasture	1,500	2,500	3,500
Beef cattle – Inland, native pasture	3,000	5,000	7,000
Dairy cattle – North NSW	3,000	5,000	7,000
Dairy cattle – South NSW	5,000	8,000	11,000
Sheep	4,000	5,000	6,000

4.5 Recreational water users

Based on a literature review, we have estimated the value of water-based recreation at **$20 per trip per day**.

Recreation activities generate benefits (consumer surplus) for the individuals engaging in them and these benefits have an economic value. This economic value can derive from water-based recreation activities including water skiing, wake boarding, kayaking, etc.

Increases in water-based recreation also generate benefits to recreation-based businesses (producer surplus). For example, recreationists might buy petrol, food, accommodation, and other services when they travel to engage in recreation. The difference between the revenue received by a business (which is the same as expenditure by recreationists) and the business' production cost is the producer surplus, which represents an economic benefit.

A degree of caution should be exercised in applying the value of $20 per trip per day for Regional Water Strategies. This is because it is important to establish a causal relationship between water availability and the magnitude of recreational activity. We recommend that this value is most relevant to options that:

- deliver a significant improvement to a waterway that would otherwise be in very poor condition (unsuitable for recreational use); or
- avoid a waterway being in very low flow where recreational activities would not be possible.

Care needs to be taken to apply the value based on 'induced' demand. If (i) water-based recreation takes place in one location instead of another, (ii) the experience is 'about the same', and (iii) the cost of engaging in recreation is the same, then the economic value (consumer surplus) from the activity is also about the same. In this case, there is no change in economic value from recreation because there is a suitable substitute site nearby.

We also investigated an economic value for improved water availability for tourism operators. Similar to recreational users, it is difficult to establish a causal relationship between water availability and the magnitude of tourism.

Appendix 1. Further technical details and assumptions

This section outlines the technical methodology and assumptions underpinning the estimated regional water values for key user groups.

A1.1. Town water supply

Water demand for rural towns is typically relatively consistent over time.[17] Unlike for extractive industries, such as agriculture and mining, extraction of water for use by rural towns will increase in dry periods typically due to increased outdoor watering but the change can be relatively minor. Also, during drought periods water used in an urban context will typically fall because restrictions regimes are put in place that limit water use.

Shortfalls to rural towns are usually considered through a progression of actions. For example:

- Restrictions (valued using consumer surplus and producer surplus estimates);
- Alternative supply sources (groundwater);
- Carting (valued at economic cost of transport).

Each of these are discussed below.

Water restrictions

Water restrictions may impose an economic cost on the community when they:

- **reduce the quantity** of potable water that a customer can consume, and that the customer would otherwise have been prepared to purchase
- **remove a choice** over how potable water could have been used prior to water restrictions being introduced (for example, watering lawns)
- **reduce the amenity value, functionality, or both** of parks, gardens, open spaces, and playing fields (particularly highly used public assets, but also private assets).

Water restriction costs to customers also include the direct costs associated with implementing or adjusting to the restrictions, which are passed on to customers by water utilities, local government, and businesses. For example, water utilities must pay for the cost of advertising and enforcing restrictions. Similarly, local governments may need to replace trees that die during or after drought because of insufficient water. Ultimately, these costs will be passed on to customers.

When we consider the costs that arise from urban water restrictions (and, therefore, the benefits that would arise from avoiding restrictions), three main dimensions determine the magnitude of the costs:

[17] This is described below as the 'normal amount of demand'.

- **Severity**: the increasingly stringent controls that are placed on allowable water use as we progress through the different stages of water restrictions.
- **Frequency:** how often water restrictions are imposed over a given period. A low frequency might be 1 in 100 years, while a high frequency could be 10 in 100 years. All else being equal, higher frequency imposes additional costs for customers because investments need to be made in order to adapt to restrictions.
- **Duration:** the period of time that each stage of restriction is in place. A short duration might be a month to address an acute water shortage due to infrastructure failure, while a longer duration would be multiple years over which restrictions are in place.

The economic literature on the costs of water restrictions is typically organised around these three dimensions of water restrictions.

Water security planning in NSW also typically takes into account the severity, frequency, and duration of water restrictions. Under the '5/10/10' design rule, the total time spent in drought restrictions should be no more that 5% of the time, restrictions should not need to be applied in more than 10% of years and when they are applied the water supply system should be able to provide 90% of the unrestricted dry year water demand (i.e. 10% reduction in demand) through a repetition of the worst recorded drought.[18] The hydrological modelling that will be undertaken for Regional Water Strategies will help to inform how well town water supplies across NSW meet such design rules.

Who bears the costs of water restrictions?

The following stakeholder groups may be affected by water restrictions:

- **Households**. Households are residential customers consuming water inside and outside of the home.
- **Businesses**. This is a very broad sector of the customer base. Water uses vary substantially among this group, and therefore the impact of water restrictions on the group will also vary substantially. For example, water restrictions have a bigger impact on nurseries and car washes than on warehouses.
- **Water utilities / local government**. Water restrictions are time consuming and costly to implement. Costs include advertising to raise awareness that restrictions are in operation, to educate water users on restricted uses, and to reinforce those messages for the duration of the restrictions. Water utilities can also suffer short-term costs from a mismatch in capital and operational expenditure to manage water restrictions and the capacity to recover those additional costs through regulated water tariffs.
- **Community**. In the past, restrictions on outdoor water use by local government have resulted in the 'browning off' of previously green open space, including sporting fields. During the Millennium Drought, sporting fields and open green space were affected in this way. The economic loss is thought to arise from a loss in amenity value associated with the appearance and functionality of green spaces and the inability to use some sports fields during periods of severe restrictions.

[18] For example, see discussion of the 5/10/10 rule in NSW DPI Office of Water, *Assuring future urban water security*, December 2013 (Draft), pp 1-2. Available at: http://www.water.nsw.gov.au/__data/assets/pdf_file/0005/665609/assuring-future-urban-water-security-draft.pdf

Urban water restrictions affect different customer groups in different ways. Even within the one customer group (for example, residential customers) the costs can be different for individual customers because of the way they use water.

Estimated cost of restrictions

We have estimated the economic costs of water restrictions at:

- **$1,100 to $1,800/ML** for the first six months of restrictions, and
- **$3,500 to 4,100/ML** for the next six months of restrictions.

These ranges are based on several assumptions discussed below. These assumptions can be changed as appropriate for a particular location.

For the first six months of restrictions, the value per ML is based on the estimated cost of low level 'Stage 1' and 'Stage 2' restrictions as shown in Table 9. The Stage 1 to Stage 4 restrictions in this table are based on the ACT and it is assumed that regions across NSW impose similar stages of restrictions.[19] During Stage 1/2 restrictions only the costs to water utilities are included. This is because consumers and businesses are not materially inconvenienced by low level water restrictions and therefore tend to place no value on avoiding them. The water utility costs are estimated to range between $30 to $50 per household/business per annum. This estimate is based on Marsden Jacob analysis of publicly available water utility financial data.[20]

If a supply shortfall continues past six months, it is assumed that Stage 3 and Stage 4 water restrictions are imposed, which become more onerous on households and businesses. The household willingness to pay (WTP) for avoiding Stage 3 and 4 water restrictions is based on a study in the ACT by McNair and Ward (2012).[21] This survey was completed after a drought, which is important because household WTP to avoid severe and long-duration water restrictions has been found to be higher following a drought. The study showed households were unwilling to pay to avoid Stage 1 and 2 restrictions, but for example are willing to pay $280 ($2020) if that results in Stage 4 restrictions being imposed for one rather than two years in every 20 years.[22]

For costs to business, Hensher et al. (2006) carried out a WTP study that specifically asked business customers in the ACT what they would be willing to pay to avoid each stage of water restrictions, and over what duration. The results have a similar pattern to those for residential customers in that business customers are unwilling to pay to avoid Stage 1 and 2 restrictions. They are also unwilling to pay to avoid restrictions that do not last for more than a year. The estimates indicate that businesses are willing to pay $350 ($2020) to virtually eliminate the chance of Stage 3 and Stage 4 restrictions being imposed over a 20-year period.

The WTP estimates are in $/household and $/business and we needed to convert these into $/ML. Table 9 shows our assumptions for these conversions.

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19 The Stage 1, 2, 3 & 4 restrictions are described in McNair and Ward (2012), p 12.

20 The study was undertaken for the Victorian Department of Environment, Land, Water and Planning. See Marsden Jacob (2018).

21 McNair B, Ward M (2012). *Willingness to pay research project*, Australian National University, Canberra.

22 McNair and Ward (2012) report the costs borne by households under each stage of water restrictions (Stage 3 = $65 per household and Stage 4 = $215 per household) relative to a baseline of permanent water restrictions. For the purposes of this analysis we assume that government policy to reduce the likelihood of Stage 4 restrictions being imposed by 1 year would also reduce the likelihood of Stage 3 restrictions by 1 year. As a result, the WTP for the outcome of that policy action is the sum of Stage 3 and Stage 4 restrictions ($65 + $215 per household).

Table 9: Estimated cost of water restrictions ($2020)

	Stage 1/2 Low	Stage 1/2 High	Stage 3 Low	Stage 3 High	Stage 4 Low	Stage 4 High	Comment
Cost per separate house $/yr	$0	$0	$65	$65	$280	$280	Based on McNair & Ward (2012)
Cost per townhouse $/yr	$0	$0	$32.50	$32.50	$140	$140	Assumed to be 50% of household WTP based on Marsden Jacob (2018)
Cost per apartment $/yr	$0	$0	$5	$5	$5	$5	Assumption based on Marsden Jacob (2018)
Cost per business $/yr	$0	$0	$350	$525	$350	$525	Based on Hensher et al. (2006)
No. of separate homes	10,000	10,000	10,000	10,000	10,000	10,000	Representative of a larger town
No. of townhouses	1,200	1,200	1,200	1,200	1,200	1,200	Split of dwelling type based on ABS analysis[23]
No. of apartments	500	500	500	500	500	500	Split of dwelling type based on ABS analysis
No. of businesses	4,000	4,000	4,000	4,000	4,000	4,000	Marsden Jacob estimate relative to no. of households
Avg. separate house usage/yr	185 kL	185 kL	185 kL	185 kL	185 kL	185 kL	Marsden Jacob estimate
Avg. townhouse usage/yr	120 kL	120 kL	120 kL	120 kL	120 kL	120 kL	Marsden Jacob estimate
Avg. apartment usage/yr	100 kL	100 kL	100 kL	100 kL	100 kL	100 kL	Marsden Jacob estimate
Average business usage/yr	600 kL	600 kL	600 kL	600 kL	600 kL	600 kL	Marsden Jacob estimate
Water utility costs	$235,500	$392,500	$235,500	$392,500	$235,500	$392,500	Estimated between $30 to $50 per household/ business per year based on Marsden Jacob (2018)

23 To estimate the proportion of separate homes, townhouses, and apartments we referred to ABS 2016 census data for the average across Albury, Ballina, Bathurst, Bourke, Griffith, Gunnedah, Moree, Narrabri, Snowy-Monaro, and Wagga Wagga. See http://stat.data.abs.gov.au/Index.aspx?DataSetCode=ABS_C16_T24_LGA

	Stage 1/2 Low	Stage 1/2 High	Stage 3 Low	Stage 3 High	Stage 4 Low	Stage 4 High	Comment
Total cost of restrictions to households	$0	$0	$691,500	$691,500	$2,917,500	$2,917,500	Sum of cost x no. of household type
Total cost of restrictions to business	$0	$0	$1,400,000	$2,100,000	$1,400,000	$2,100,000	Cost x no. of businesses
Total cost of restrictions - all	$235,500	$392,500	$2,327,000	$3,184,000	$4,606,000	$5,463,000	Sum of costs to all customers
Total unrestricted water use / yr	4,444 ML	4,444 ML	4,444 ML	4,444 ML	4,444 ML	4,444 ML	Calculation based on avg. usage
Water retained through restrictions	5%	5%	25%	25%	30%	30%	Assumption based on estimate of response to restrictions.
Water retained through restrictions (ML)	222 ML	222 ML	1,111 ML	1,111 ML	1,333 ML	1,333 ML	Unrestricted water use x water retained through restrictions
Total cost per ML	**$1,100**	**$1,800**	**$2,100**	**$2,900**	**$3,500**	**$4,100**	Rounded to nearest $100

Note: the estimated cost per household includes an allowance for public open space.

To convert WTP into $/ML we needed to estimate the proportion of different types of dwellings, as well as typical annual water consumption for different types of water customers and estimated water retained (%) through restrictions. This analysis was undertaken using Australian Bureau of Statistics (ABS) Census data and water utility reports. These assumptions can be changed in the accompanying spreadsheet model where considered appropriate for a particular location.

Our initial assumption about the percentage of water that is retained through various stages of restrictions is conservative relative to the targeted reductions referred to in McNair and Ward (2012).[24] However, our assumptions are very similar to hydrological modelling assumptions used for projects we have recently been engaged on in NSW. The implication of lower assumed percentages of water retained is that the $/ML costs in Table 9 are higher than would otherwise be the case.

During our consultation on an earlier version of this report, several stakeholders commented that poor town water security acts to reduce business investment in some regions and that this should be reflected in the value. While we agree that concerns over water reliability may act to limit or reduce business investment, this is a location specific issue and cannot be generalised across NSW. Further, it would need to be established that this investment is 'lost' to NSW and does not locate to another area within the State that has better water security. Where a demonstrable case can be made in this regard, we consider that high security water entitlements in the relevant region would represent an upper bound on the value of water.

Our estimate of business WTP to avoid water restrictions is based on a study in the ACT. It is reasonable that some business customers may have a higher WTP to avoid severe restrictions, particularly in those regions in NSW that have recently, or are still experiencing, severe drought. We have addressed this issue in in two ways:

- Firstly, we increased the WTP estimate for business customers by 50% to form the top end of the cost range (see the fourth row in Table 9 under the 'high' estimate)
- Secondly, we decided to base the economic cost of restrictions in the second six months on the higher cost of 'Stage 4' restriction costs, rather than an average of Stage 3 and Stage 4.

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24 McNair and Ward (2012), p 12.

Box 4: How our WTP estimates compare to NSW Government guidelines

The NSW Government has previously endorsed WTP values for avoiding water restrictions as part of the Restart NSW – Safe and Secure Water Program (SSWP). Released in 2018, the guidelines were designed to support preparation of a cost-benefit analysis as part of a Business Case for the SSWP.

The guidelines reference WTP of $218/household/year ($2017) to avoid water restrictions entirely. This figure derives from Cooper, B. Crase, L. Burton, M. (2011) *Urban Water Restrictions: Attitudes and Avoidance* and is equivalent to around $225/household/year in $2020. The $225/household/year estimate compares to our WTP estimates in the top four rows of Table 7 based largely on McNair and Ward (2012) and Hensher et al (2006). $225 per household is lower than our estimate for stage 4 water restrictions for a separate dwelling ($280/household/year) but higher than our other household estimates. Our estimates include business customers, as well as different household dwelling types.

See NSW Department of Industry, *Safe and Secure Water Program – Cost Benefit Analysis Guiding Principles*, March 2018, p 5.

It is important to outline some general limitations and assumptions involved in applying WTP studies to a broad range of geographical areas as required in this report:

- The WTP studies are specific to the ACT and its water restriction stages/rules – we are implicitly assuming that regions across NSW have similar restriction stages and that customers have similar behavioural responses to the imposition of restrictions.
- The WTP estimates are 'bounded' – for Stage 4 restrictions (households), the bounds can be applied to scenarios reducing Stage 4 restrictions from a 2:20 year occurrence to a 1:20 year occurrence (WTP $280) or 0:20 year occurrence (WTP $560). For Stage 3, they can be used to model WTP to reduce Stage 3 for up to an 8:20 year occurrence.

The framework summarised in Table 9 is amenable to changing assumptions (for example, the proportion of dwelling types or percentage water retained through restrictions), if considered appropriate for a particular location. We have provided a spreadsheet model that facilitates these changes.

Alternative supply options

Water restrictions are a temporary response to drought. If a water supply shortfall continues past 12 months, then based on the consultation undertaken for this project we understand that alternative supply arrangements may be required. The options include accessing groundwater or, for smaller towns, carting water. Groundwater is generally of higher quality and requires less or minimal treatment compared to surface waters. On rare occasions, reverse osmosis is required for specific treatment to remove contaminants. Reverse osmosis is very rarely needed to reduce salinity. The cost to develop bores and water treatment infrastructure to access groundwater resources will largely depend on site-specific characteristics.

We have provided these 'benchmark' costs in Table 4 in section 4 of this report. These are intended as a starting point for the rapid cost-benefit analysis. To put the costs into perspective, a 3 ML/day desalination plant operating at 20% capacity (operating two in every ten years), would have a levelised cost of around $16,000/ML. The same plant operating at 100% capacity would have a levelised cost of around $7,900/ML.

Infrastructure options considered as part of Regional Water Strategies would be subject to detailed business cases where more detailed site-specific costs would be considered.

Residual value

NSW Government cost-benefit analysis guidelines propose a default assumption that an asset will have reached the end of its economic life by the end of the analysis period, and therefore the residual value would be zero. Alternatively, the asset may have a 'scrap' value which can be counted as a benefit at the end of the analysis period.

In some cases where an asset has not reached the end of its useful life, a residual value benefit may be included in the cost-benefit analysis if the asset is still of use or there is a market for its resale. In this case, the guidelines propose that the remaining value of the asset should be based on the lesser of:

- the replacement cost; and
- the present value of future benefits.

Value functions for very small and small (<1,000 people) towns

When a smaller (i.e. very small and small) rural town experiences, or is expected to experience, shortfalls in water supply, the decision pathway is assumed to involve the following progression of steps:

1. Impose restrictions on water usage by residents and industry; then
2. Impose *stronger* restrictions on water usage by residents and industry; then
3. Source water via carting from a different catchment.

Given the relative magnitude of water demanded by many rural and regional communities compared to the amount of water being used, in conditions which produce water supply shortfalls, restrictions can be considered a short-term measure. However, it is worth noting that there is a level of water at which the amenity and liveability of the community is diminished. For these reasons, it is assumed that the cost function for not providing enough water to smaller rural communities is:

$$TC_{smaller\ town_{t,i}} = f_{rest}\left(Q_i^{norm}, Q_i^{min}, Q_{t,i}\right) + f_{min}\left(Q_i^{min} - Q_{t,i}\right)$$

Where $TC_{smaller\ town_{t,i}}$ is the total cost, or loss, associated with the current level of supply to the town, $Q_{t,i}$. If the current supply is not meeting the normal amount of water delivered to towns, Q_i^{norm}, then a cost is experienced, such that $TC_{smaller\ town_{t,i}} > 0$. However, if $Q_{t,i} \geq Q_i^{norm}$, then $TC_{smaller\ town_{t,i}} = 0$.

It is assumed that in conditions where the town's water requirements cannot be met (any quantity where $Q_{t,i} < Q_i^{norm}$), social costs are generated. These costs comprise the costs of restrictions as well as the loss of amenity. These costs are assumed to be zero if $Q_{t,i} \geq Q_i^{norm}$. In contrast, Q^{min} is the reduced amount of water that will be supplied to the community to ensure its continued viability. The latter costs are referred to as the Day Zero quantity of water to be supplied to the town.

For example, the following loss function is provided as an illustrative example for a hypothetical very small rural town and community:

$$TC_{smaller\ town_{t,i}} = \begin{cases} \$0 & if\ Q_{t,i} \geq Q_i^{norm} \\ \$1{,}500\left(Q_i^{norm} - Q_{t,i}\right) & if\ Q_{t,i} < Q_i^{norm}\ \&\ max\left(Q_{t-1,i}, \dots, Q_{t-6,i}\right) \geq Q_i^{norm} \\ \$3{,}500\left(Q_i^{norm} - Q_{t,i}\right) & if\ max\left(Q_{t,i}, \dots, Q_{t-6,i}\right) < Q_i^{norm}\ \&\ Q_{t-13,i} \geq Q_i^{norm} \\ \$3{,}500\left(Q_i^{norm} - max\left(Q_i^{min}, Q_{t,i}\right)\right) + \$10{,}000\left(Q_i^{min} - Q_{t,i}\right) & if\ max\left(Q_{t,i}, \dots, Q_{t-13,i}\right) < Q_i^{norm} \end{cases}$$

Where the four conditions of the above function capture the following scenarios:

1. There is not currently a supply shortfall, so no losses are incurred.
2. There is currently a shortfall. However, in at least one of the preceding six months there was not a shortfall. This means that the lower level of restrictions on residential use of water are currently in place.
3. There is currently a shortfall, and this shortfall has persisted for the last seven to 12 months. This means that the higher level of restrictions on residential use of water are currently in place.
4. The town is entering the thirteenth (or later) month of experiencing a shortfall, so carting is in effect.

In the example equation, it is assumed that the costs associated with restrictions, $1,500/ML for the first six months then $3,500/ML for the following six months, are incurred for the first twelve months of any water shortfall event (noting this was based on hydrological advice and might vary for other locations). Subsequent shortfalls incur cartage costs associated with maintaining a minimum supply of water to the town, at $10,000/ML[25], because this is deemed a feasible solution for the relatively small towns being supplied. For larger towns, carting of water might not be as feasible, meaning an alternative version of the loss function is required (see below).

Value functions for larger (medium and large) rural towns (≥1,000 people)

When a larger rural town experiences, or is expected to experience, shortfalls in water supply, the options are likely to be more complicated. These options could be to:

1. Impose restrictions on water usage by residents and industry; then
2. Impose *stronger* restrictions on water usage by residents and industry; then
3. Source water from an alternative supply (e.g. pumping groundwater); then
4. Source water via carting from a different catchment.

Carting (assumed to be $10,000/ML in this illustrative example) represents the option of last resort, because the financial cost can be very high. In contrast, sourcing water using an alternative supply $16,000/ML used in the illustrative example below) represents an intermediate option. Although options 3 and 4 are similar in terms of economic cost, they are likely to differ significantly in terms of financial cost, which is why the use of an alternative supply technology will be preferred to carting water, even in cases where carting is associated with a lower economic cost.

A larger town will also experience a cost, or loss, associated with water supply shortfalls.

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[25] In this illustrative example, it is assumed water is carted 55km.

For example, the following loss function is provided as an illustrative example for a hypothetical larger rural town and community:

$$TC_{larger\ town_{t,i}} = \begin{cases} \$0 & if\ Q_{t,i} \geq Q_i^{norm} \\ \$1{,}500(Q_i^{norm} - Q_{t,i}) & if\ Q_{t,i} < Q_i^{norm}\ \&\ max(Q_{t-1,i}, \dots, Q_{t-6,i}) \geq Q_i^{norm} \\ \$3{,}500(Q_i^{norm} - Q_{t,i}) & if\ max(Q_{t,i}, \dots, Q_{t-6,i}) < Q_i^{norm}\ \&\ Q_{t-12,i} \geq Q_i^{norm} \\ \$3{,}500\left(Q_i^{norm} - max(Q_i^{min}, Q_{t,i})\right) + \$16{,}000(Q_i^{min} - Q_{t,i}) & if\ max(Q_{t,i}, \dots, Q_{t-24,i}) < Q_i^{norm}\ \&\ Q_{t-25,i} \geq Q_i^{norm} \\ \$3{,}500\left(Q_i^{norm} - max(Q_i^{min}, Q_{t,i})\right) + \$10{,}000(Q_i^{min} - Q_{t,i}) & if\ max(Q_{t,i}, \dots Q_{t-25,i}) < Q_i^{norm} \end{cases}$$

Where the four conditions of the above function capture the following scenarios:

1. There is not currently a supply shortfall, so no losses are incurred.
2. There is currently a shortfall. However, in at least one of the preceding six months there was not a shortfall. This means that restrictions on residential use of water are currently in place.
3. There is currently a shortfall, and this shortfall has persisted for the last seven to 12 months. This means that the higher level of restrictions on residential use of water are currently in place.
4. The town is entering the thirteenth to twenty-fourth month of experiencing a shortfall, so an alternative supply technology is being used ($16,000/ML). This option is predicated on the alternative supply technology being available in working order.
5. The town is entering the twenty-fifth (or longer) month of experiencing a shortfall, so carting is in effect ($10,000/ML).

It should be noted that the above example is illustrative only. Any future application of this framework should occur only after consultation with, and based on advice from, the hydrology team and DPIE Water, and industry stakeholders.

Key assumptions for carting

The key assumptions that underpin the economic values associated with carting are outlined in Table 10, and resulting economic cost estimates are provided in Table 11.

Table 10: Assumptions for carting

Variable/Characteristic	Assumed value
Vehicle type	Heavy rigid
Vehicle mass (empty)	2 tonnes
Vehicle mass (loaded)	20 tonnes
Volume of water carried per load	18,000 L
Roughness (IRI)	1-2 (Very good)
Roughness (NRM)	25
Gradient	4%
Curvature	Straight (20 degree/km)

Variable/Characteristic	Assumed value
Vehicle Operating Costs (VOC)	\$0.859/km
Travel time value (incl. 1 occupant + freight)	\$0.43/km
Externality costs (per tonne-kilometre)	\$0.03836/tonne-kilometre
Externality costs when vehicle loaded (per kilometre)	\$0.7672/km
Externality costs when vehicle empty (per kilometre)	\$0.07672/km
Total trips per water delivery	1 trip loaded; 1 trip unloaded (i.e. return trip)
Crash costs	\$0.1147/km
Overall cost per kilometre when vehicle loaded	\$2.1709/km
Overall cost per kilometre when vehicle empty	\$1.4804/km

Table 11: Economic cost of carting for various distances travelled (\$2020)

Distance between two catchments (km) [one way]	Economic cost of carting (\$/ML) [return trip]
50	10,000
100	20,000
200	41,000
300	61,000
400	81,000
500	101,000
600	122,000
700	142,000
800	162,000
900	183,000
1,000	203,000

A1.2. Annual cropping

For most catchments, the majority of general security water is used for irrigating annual crops. This is because, by their nature, annual crops (e.g. cotton, wheat, rice) can easily be scaled up or down in response to water availability. In contrast, permanent plantings require significant volumes of water, year-to-year, to remain viable.

Returns to annual cropping should be valued based on gross margins, where a gross margin is the difference between total revenue and total variable cost for the chosen enterprise (e.g. cotton), expressed on a per-hectare or per-megalitre basis.

$$GM_{t,i} = \frac{R_{t,i}\left(p_y, y\left(\boldsymbol{x}, \boldsymbol{z}_{t,i}, \bar{\boldsymbol{z}}\right)\right) - VC_{t,i}(\boldsymbol{p}_x, \boldsymbol{x})}{W_{t,i}}$$

Where:

$GM_{t,i}$ is the gross margin per ML of irrigation water applied

$R_{t,i}$ is total revenue per hectare

$VC_{t,i}$ is variable cost per hectare

W is megalitres (ML) of irrigation water applied per hectare

y is the output, which is commonly referred to as the crop yield

p_y is the output price

$\boldsymbol{p_x}$ is the vector of input prices

$\boldsymbol{x}$ is the vector of input quantities

$\boldsymbol{z_{t,i}}$ is the vector of all other inputs that vary over time (e.g. rainfall, temperature, pests, diseases)

$\bar{\boldsymbol{z}}$ is the vector of all other inputs that are effectively constant over time (e.g. soil type)

Key assumptions for annual crops

The key assumptions that underpin the economic values associated with annual crops are outlined in Table 12.

Table 12: Assumptions for irrigators of annual crops

Catchment	Key crop/s	Irrigation water requirement (ML/ha)	Yield (bales/ha or t/ha)	Output price ($/unit)	GM range ($/ML)	GM midpoint ($/ML)	VWAP[26] of allocation prices for last 3 WYs [annual range of VWAPs] ($/ML)
Macquarie	Cotton	7.5-8	11.5-12.5	$537/bale (lint & seed)	275-375	325	285 [50-1,235]
Lachlan	Cotton	8-9	10-11	$537/bale (lint & seed)	200-300	250	225 [50-570]
	Wheat	2-2.5	6-7	$250/tonne	100-275	175	
	Oats	2.75-3.25	4-5	$350/tonne	100-250	150	
	Barley	4.5-5	6-7	$300/tonne	125-175	150	

[26] The VWAP is the volume weighted average price. These values are provided alongside the gross margin estimates, for additional real-world context.

Catchment	Key crop/s	Irrigation water requirement (ML/ha)	Yield (bales/ha or t/ha)	Output price ($/unit)	GM range ($/ML)	GM midpoint ($/ML)	VWAP[26] of allocation prices for last 3 WYs [annual range of VWAPs] ($/ML)
Gwydir	Cotton	6.5-7.5	12-13	$537/bale (lint & seed)	300-425	375	378 [200-500]
Far North Coast	Lucerne (Hay)	2.5-3	450-500	$8.60/bale	75-275	175	N/A
	Sorghum	2.75-3.25	7.5-8.5	$225/tonne	125-225	175	
North Coast	Lucerne (Hay)	2.75-3.25	450-500	$8.60/bale	75-250	150	N/A
	Sorghum	3-3.5	7.5-8.5	$225/tonne	125-225	175	
Namoi	Cotton	6.75-7	11.5-12.5	$537/bale (lint & seed)	300-400	350	297 [150-450]
	Wheat	2-2.5	6-7	$250/tonne	100-275	175	
	Oats	2.75-3.25	4-5	$350/tonne	100-250	150	
	Barley	4.5-5	6-7	$300/tonne	100-200	150	
	Lucerne	7-8	450-500	$8.60/bale	100-175	150	
	Sorghum	3.25-3.75	7.5-8.5	$225/tonne	125-225	175	
Border Rivers	Cotton	6.5-7	11.5-12.5	$537/bale (lint & seed)	300-400	350	276 [50-500]
	Wheat	2.25-2.5	6-7	$250/tonne	125-250	175	
	Barley	4.75-5	6-7	$300/tonne	100-175	150	
	Sorghum	3.5-3.75	7.5-8.5	$225/tonne	125-200	175	
Western (North)	Cotton	10-11	11.5-12.5	$537/bale (lint & seed)	225-300	250	111 [10-150] (Lower Darling)
	Wheat	2.75-3.25	6-7	$250/tonne	125-225	175	
	Barley	5-5.5	6-7	$300/tonne	100-175	125	
Western (South)	Wheat	2.25-2.5	7.5-8	$250/tonne	100-175	150	
	Barley	4-4.5	6-6.5	$300/tonne	125-175	150	
South Coast	Lucerne (Hay)	2.75-3.25	450-500	$8.60/bale	75-250	150	N/A
Murray	Cotton	8.5-9.5	8.5-9.5	$537/bale (lint & seed)	175-250	225	

Catchment	Key crop/s	Irrigation water requirement (ML/ha)	Yield (bales/ha or t/ha)	Output price ($/unit)	GM range ($/ML)	GM midpoint ($/ML)	VWAP[26] of allocation prices for last 3 WYs [annual range of VWAPs] ($/ML)
	Rice	11-12	10-11	$415/tonne	150-200	175	346 [80-1,000]
	Potatoes	3.75-4.25	525-575 bags/ha	$28/bag	150-200	175	
	Wheat	2-2.5	7.5-8	$250/tonne	100-200	150	
	Oats	2.25-2.75	4.5-5.5	$350/tonne	75-250	150	
	Barley	4-4.25	6-6.5	$300/tonne	125-175	150	
	Lucerne (Hay)	2.75-3.25	450-500	$8.60/bale	75-250	150	
Murrumbidgee	Cotton	8.5-9.5	8.5-9.5	$537/bale (lint & seed)	175-250	225	328 [70-800]
	Rice	11-12	10-11	$415/tonne	150-200	175	
	Potatoes	3.75-4.25	525-575 bags/ha	$28/bag	150-200	175	
	Wheat	2-2.5	7.5-8	$250/tonne	100-200	150	
	Oats	2.25-2.75	4.5-5.5	$350/tonne	75-250	150	
	Barley	4-4.25	6-6.5	$300/tonne	125-175	150	
	Lucerne (Hay)	2.75-3.25	450-500	$8.60/bale	75-250	150	

A1.3. Permanent cropping

For most catchments, the majority of high security water is used for irrigating permanent crops. This is because, by their nature, permanent crops (e.g. nuts, citrus, viticulture) require a reliable supply of water, year-to-year, to remain viable. If these plants experience a supply shortfall, for as little as one season, their yields are likely to be negatively impacted for several seasons or, as a worst-case, the plants might die or become unproductive.

Returns to permanent cropping should be valued based on net margins, where a net margin is the difference between total revenue and total cost for the chosen enterprise (e.g. nuts), summed over the productive life of the plant and expressed on a per-hectare or per-megalitre basis. Since the returns from permanent crops are typically lower in the early seasons, and increase then stabilise as the plant matures, it is most appropriate to express the net margin as levelised or annualised returns.

Using this approach, levelised net margins capture the entire life cycle of costs and benefits involved in producing a permanent crop.

Expansion values

Expansion values of water are determined under conditions of average water availability, including average allocations and average rainfall. Expansion values are applied where an option under a Regional Water Strategy provides a demonstrable and enduring improvement in water availability or reliability, and increases the area planted (relative to the base case). Here, the net margin per ML applied reflects the average amount of irrigation required to supplement water provided by rainfall.

A net margin for any single year is expressed on a per-hectare or per-megalitre basis.

$$NM_{t,i} = \frac{R_{t,i}\left(p_y, \boldsymbol{x}, y\left(\boldsymbol{z_{t,i}}, \bar{\boldsymbol{z}}\right)\right) - \left(VC_{t,i}(\boldsymbol{p_x}, \boldsymbol{x}) + FC_{t,i}\right)}{W_{t,i}}$$

Where:

$NM_{t,i}$ is the net margin per ML of irrigation water applied, for an individual year

$FC_{t,i}$ is the fixed cost attributed to enterprise i

These net margins (per ML) must then be discounted and summed over the expected productive life of the crop, T, as follows:

$$NPV_i = \sum_{t=1}^{T} NM_{t,i}$$

Which is then converted to an annualised net margin, using the formula:

$$N_i = \frac{NPV_i}{\left[\frac{1-(1+r)^{-T}}{r}\right]}$$

Where:

r is the real discount rate

N_i is the average value of water (i.e. based on conditions of average water availability)

Shortfall values

As previously noted, for permanent crops (e.g. nuts, fruit, viticulture), it takes up to 10 years for the crop to reach maturity and thus reach maximum production. Therefore, in times of water supply shortfall, the value of water is based on the avoided loss of margin returns that would otherwise result from (i) the permanent crop dying, (ii) the crop being replanted, (iii) the new plants taking up to 10 years to reach maturity, and (iv) the new plants achieving lower yields and returns in the meantime.

If, for example, a permanent crop takes 10 years to reach maturity, the value of (or capacity to pay for) water during times of shortfall reflects the difference between:

1. The levelised present value of returns from a mature crop over 10 years.
2. The levelised present value of returns from a newly planted crop (including establishment costs) over 10 years.

The shortfall value of water will also be a function of:

- The amount of water required by the crop, which will be the sum of:
    - The usual level of irrigation required by the crop on an annual basis (under average conditions), which is defined as U. For example, this amount might be 8ML/ha; and
    - The additional water required to supplement the amount that is usually provided by rainfall (under average conditions), but is not being provided due to extremely dry conditions (i.e. drought). For example, this amount might be 5ML/ha, which must instead be supplemented by applying additional irrigation. Define this additional irrigation requirement as S.
- The expected number of years that drought/extremely dry conditions will prevail. The longer a drought is expected to persist, the greater the amount of additional water will be required to sustain the permanent crop, and the lower the associated shortfall value of water. Define the expected number of years that drought/extremely dry conditions will prevail as D.
    - Although the equations below allow for D to be varied, it is recommended that a value of $D = 1$ be used because this is most representative of how irrigators will undertake planning regarding future water availability. in other words, for practical reasons, they will usually plan only one year ahead.

Case 1

The net margins (per ML) corresponding to the returns from a mature crop, over 10 years, are discounted and summed, as follows:

$$NPV_i^1(U_i, S_i, D) = \sum_{t=11}^{20} NM_{t,i}(U_i, S_i, D)$$

Which is then converted to a levelised (or annualised) net margin, using the formula:

$$N_i^1(U_i, S_i, D) = \frac{NPV_i^1(U_i, S_i, D)}{\left[\frac{1-(1+r)^{-10}}{r}\right]}$$

Case 2

The net margins (per ML) corresponding to the returns from a newly established crop, over 10 years, must be discounted and summed, as follows:

$$NPV_i^2(U_i, S_i, D) = \sum_{t=1}^{10} NM_{t,i}\,(U_i, S_i, D)$$

Which is then converted to a levelised (or annualised) net margin, using the formula:

$$N_i^2(U_i, S_i, D) = \frac{NPV_i^2(U_i, S_i, D)}{\left[\frac{1-(1+r)^{-10}}{r}\right]}$$

Additional water requirement

The levelised additional water requirement is determined by, first, calculating the sum of discounted additional water use:

$$NPV_i^W(U_i, S_i, D) = \sum_{t=1}^{10} W_t(U_i, S_i, D) \quad where \quad \begin{matrix} W_t = U_i + S_i \; if \; t \leq D \\ W_t = U_i \; if \; t > D \end{matrix}$$

Which is then converted to a levelised (or annualised) additional water requirement, using the formula:

$$W_i(U_i, S_i, D) = \frac{NPV_i^W(U_i, S_i, D)}{\left[\frac{1-(1+r)^{-10}}{r}\right]}$$

Shortfall value of water

The shortfall value of water is then calculated as:

$$SV_i(U_i, S_i, D) = \frac{N_i^1(U_i, S_i, D) - N_i^2(U_i, S_i, D)}{W_i(U_i, S_i, D)}$$

The expected number of years that drought/extremely dry conditions will prevail, D, is a determinant of the shortfall value of water, where a larger value of D means additional water requirements will persist for more years, and the estimated shortfall value of water will be lower.

However, as also noted above, it is recommended that a value of $D = 1$ be used because this is most representative of how irrigators will undertake planning regarding future water availability. In other words, for practical reasons, they will usually plan their water resource only one year ahead because of the highly uncertain (unpredictable) nature of water availability in future years. A value of $D = 1$ has been used to estimate the shortfall water values included in this report.

Key assumptions for permanent crops

The key assumptions that underpin the economic values associated with permanent crops are outlined in Table 13.

Table 13: Assumptions for irrigators of permanent crops

Catchment	Key crop/s	Irrigation water requirement (ML/ha)	Yield at maturity (t/ha)	Output price ($/t)	NM value ($/ML)	Water requirement usually provided by rainfall/ precipitation (ML/ha)	Shortfall value ($/ML)
Macquarie	Oranges	6.5-7.5	35-50	500	500 [200-825]	5.75	2,400 [1,700-3,100]
	Viticulture	2.5-3.5	11-12	600	525 [400-700]		900 [800-1,200]
	Horticulture (Cucumbers)	2-3	18-22	350	1,250 [775-1,950]		N/A
Lachlan	Oranges	7-8	35-50	500	475 [200-775]	5.25	2,300 [1,600-3,000]
	Almonds (Nuts)	12.25-13.25	3-4	7,000	1,100 [875-1,375]		1,300 [1,100-1,600]
	Olives	3.5-4.5	9.5-10.5	22,000	1,1175 [825-1,600]		2,800 [2,300-3,300]
Gwydir	Oranges	6-7	40-50	450	450 [250-675]	6.25	2,400 [1,900-2,900]
	Pecans	6.5-7.5	7-8	4,750	800 [650-950]		3,200 [2,700-3,700]
Far North Coast	Blueberries	2.5-3.5	9.5-10.5	20,000	7,500 [5,000-10,500]	10	15,000 [13,500-17,000]
	Avocados	9.5-10.5	14.5-15.5	5,000	2,950 [2,650-3,300]		4,100 [3,800-4,500]

Catchment	Key crop/s	Irrigation water requirement (ML/ha)	Yield at maturity (t/ha)	Output price ($/t)	NM value ($/ML)	Water requirement usually provided by rainfall/ precipitation (ML/ha)	Shortfall value ($/ML)
	Macadamias	3-4	4.5-5.5	5,000	2,750 [2,100-3,600]		4,700 [3,800-5,800]
	Dairy cattle				N/A		200
North Coast	Blueberries	3.5-4.5	9.5-10.5	20,000	5,500 [4,000-7,500]	9	14,000 [12,500-16,000]
	Avocados	10.5-11.5	14.5-15.5	5,000	2,675 [2,425-2,975]		3,900 [3,500-4,200]
	Horticulture (Tomatoes)	5.5-6.5	50-60	1,500	3,625 [2,075-5,475]		N/A
	Dairy cattle				N/A		200
Namoi	Oranges	6.5-7.5	40-50	450	475 [250-700]	6.5	2,400 [1,900-3,000]
Border Rivers	Macadamias	7-8	4.5-5.5	5,000	1,325 [1,100-1,600]	6	2,800 [2,300-3,300]
Western	Viticulture	5.75-6.75	13-14	600	400 [350-475]	2.75	700 [600-800]
	Olives	6-7	10-11	22,000	750 [575-975]		2,200 [1,900-2,600]
South Coast	Dairy cattle				N/A		200
Murray	Almonds (Nuts)	13.5-14.5	3.2-4.2	7,000	1,100 [875-1,325]	4	1,300 [1,100-1,600]
	Viticulture	4.75-5.5	13-14	600	475 [425-550]		800

Catchment	Key crop/s	Irrigation water requirement (ML/ha)	Yield at maturity (t/ha)	Output price ($/t)	NM value ($/ML)	Water requirement usually provided by rainfall/ precipitation (ML/ha)	Shortfall value ($/ML)
							[700-900]
	Oranges	8.25-9.25	35-45	550	450 [275-650]		2,100 [1,700-2,600]
	Olives	4.75-5.75	10-11	22,000	1,000 [750-1,300]		2,600 [2,200-3,000]
Murrumbidgee	Almonds (Nuts)	13.75-14.5	3.1-4.1	7,000	1,050 [825-1,250]	3.875	1,300 [1,000-1,500]
	Olives	5-5.75	10-11	22,000	975 [750-1,225]		2,500 [2,200-2,900]
	Viticulture	4.5-5.5	13-14	600	500 [425-600]		800 [700-1,000]
	Oranges	8.5-9.25	35-45	550	450 [275-625]		2,100 [1,700-2,500]

A1.4. Industry (excl. agriculture)

Other industrial users of water, such as mining, abattoirs, and golf courses are likely to vary in the mix of entitlements they hold. For example, industrial users (such as abattoirs) and commercial users (such as golf courses) that use irrigation water typically hold mostly high security or groundwater entitlements, while mining companies generally hold a combination of general security and high security entitlements, as well as groundwater entitlements. Although, it should be noted that these descriptions might not apply to all catchments.

Per-ML profit margins (excl. fixed costs) can be used to value any forgone units of output from these industrial users of water, as a result of water supply shortfalls. In the case of mining companies, these are typically foreign owned, which means only the royalties paid have standing in a cost-benefit analysis. Under this framework, revenue from taxation could potentially also be included, but because mines (like many other business) will actively minimise their tax burden, it was not possible to reliably estimate the change in taxation payable.

More generally, the net benefits from mining are calculated as:

$$Total\ royalites\ \times\ (1 - NSW\ ownership\ \%)$$

This is because the proportion of royalties attributed to NSW owners are considered a transfer in a NSW-focussed cost-benefit analysis, meaning they have a net economic impact of zero. However, we have assumed 100% foreign ownership of NSW-based mining companies, which means all royalty revenue collected has standing in the cost-benefit analysis.

Royalties are calculated as a percentage of revenue or output, which means production costs are not required in order to estimate revenue per ML (and royalties paid per ML). Royalties for most of the mineral types extracted in NSW are imposed at a rate of 4% of ex-mine value (value less allowable deductions). Royalties for coal are higher, at (i) 8.2% of value of open cut coal, (ii) 7.2% of value of underground coal, and (iii) 6.2% of value of deep underground coal; with the decreasing royalty rates correlating with increasing production costs per unit of coal.[27]

The appropriate method of valuing for other industrial users will depend on the nature of the user. For example, first, a golf course must apply sufficient water, year-to-year, for its grass to remain viable, which makes it similar to a permanent cropping enterprise. Second, although an abattoir should be able to easily scale production, it is also highly capital intensive and likely has a high proportion of fixed costs. This means frequent shutdowns would severely impact on business profitability and long-term viability. For both golf courses and abattoirs, valuing water based on the net margin approach described for permanent cropping is likely to be more appropriate than using the gross margin approach described for annual cropping.

Key assumptions for mining

The key assumptions that underpin the economic values associated with mining are outlined in Table 14.

Table 14: Assumptions for mining

Commodity/Mineral	Royalty rate (% of ex-mine value less allowable deductions[28])	Typical water use per saleable unit of commodity extracted	Long term output price (product price)	Economic value of water $/ML
Coking Coal (Open cut mining)	8.2%	500L/tonne	$130/tonne	19,000 [15,000-22,500]
Semi-soft coking Coal (Open cut mining)	8.2%	500L/tonne	$100/tonne	14,500 [11,500-17,500]

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27 https://www.resourcesandgeoscience.nsw.gov.au/miners-and-explorers/enforcement/royalties/royalty-rates, accessed: 10 June 2020.

28 Allowable deductions are assumed to be 10% of ex-mine value.

Commodity/Mineral	Royalty rate (% of ex-mine value less allowable deductions[28])	Typical water use per saleable unit of commodity extracted	Long term output price (product price)	Economic value of water $/ML
Thermal Coal (Open cut mining)	8.2%	500L/tonne	$80/tonne	11,500 [9,500,-14,000]
Coking Coal (Underground mining)	7.2%	500L/tonne	$130/tonne	16,500 [13,500-20,000]
Semi-soft coking Coal (Open cut mining)	8.2%	500L/tonne	$100/tonne	13,000 [10,000-15,500]
Thermal Coal (Underground mining)	7.2%	500L/tonne	$80/tonne	10,000 [8,000-12,500]
Coking Coal (Deep underground mining)	6.2%	500L/tonne	$130/tonne	14,500 [11,500-17,000]
Semi-soft coking Coal (Open cut mining)	8.2%	500L/tonne	$100/tonne	11,000 [9,000-13,000]
Thermal Coal (Deep underground mining)	6.2%	500L/tonne	$80/tonne	9,000 [7,000-10,500]
Gold	4%	5,000L/oz	$1,600/oz	12,500 [10,000-14,500]
Copper	4%	17,500L/tonne	$5,500/tonne	12,500 [10,000-14,500]
Zinc, Lead, or Silver	4%	N/A	N/A	10,000 [8,000-12,000]
Mineral Sands	4%	N/A	N/A	10,000 [5,000-15,000]

A1.5. Flood impacts on towns

Flooding (or spill) occurs when water supply for a storage or river exceeds its capacity. A flood event can both impose costs and generate benefits.

In this analysis, we focus on flood impacts on towns and set out a framework for the assessment of flood impacts in the hydro-economic modelling.

The Bureau of Meteorology currently specifies the conditions under which minor, moderate, and major flood events take place. It has been indicated by DPIE that these specifications can be incorporated into the hydrologic modelling, such that it will identify the frequency, severity, and duration of these events.

Flood related costs impacts are grouped into three categories:

- Direct (tangible) damages – physical impacts, such as to houses, other buildings, agriculture, and public infrastructures such as roads, bridges, and utilities
- Indirect (tangible) damages – impacts from disruption to normal activities, such as emergency response, clean-up, and disruption to transport, employment, and commerce due to being 'cut off'
- Intangibles – non-market impacts, such as loss of biodiversity, stress, or mental health impacts

When this grouping has been completed then we propose that the Flood RAM (rapid appraisal method)[29] is used. Flood RAM is a methodology for the rapid and consistent evaluation of floodplain management measures in a benefit cost analysis framework. Flood RAM enables estimates of flood damages to be made for an area without the need for excessive data, it also facilitates consistency and hence comparability across different evaluations.

Actual versus potential damage cost

It is important to distinguish between potential and actual damage when assessing flood damage. Actual damage cost estimates should be used in analyses where there is evidence that property owners will have time to prepare for the flood event.

- potential damage is the damage that would occur if no remedial action is undertaken and the exposure to the flood event is not reduced.
- actual damage is the damage that occurs after actions have been taken to reduce the exposure to the flood event (e.g. sand bagging, removing valuable items, etc.).

Estimating actual damage, which is usually estimated as a proportion of the potential damage, requires an assessment of the property type, how experienced property owners are in dealing with floods, and the frequency of flood events (e.g. 2, 5, 10, 20, and 100 year average return interval (ARI) events).

Evidence shows that extended warning times and better preparedness (i.e. recent experience with flooding) reduce the actual damage costs from flooding; often significantly (see Table 15). The Flood RAM report (DSE 2009)[30] suggests that the actual damage costs for commercial buildings are typically about 45% of potential damage. The ratio of actual to potential damages varies more widely for residential properties, and will also vary across different areas and communities, depending on warning time and community experience with flooding.

[29] Department of Sustainability and Environment, 2009, Review of Flood RAM Standard Values
[30] Department of Sustainability and Environment, 2009, Review of Flood RAM Standard Values

Table 15: Flood RAM ratios of actual to potential damage costs

Warning time	Experienced community	Inexperienced community
Less than 2 hours	0.8	0.9
2 to 12 hours	Linear reduction from 0.8 at 2 hours to 0.4 at 12 hours	0.8
Greater than 12 hours	0.4	0.7

Source: Flood RAM (DNRE 2000)

Commercial building and content damage

Actual damage cost estimates for commercial buildings depend on the depth of over floor inundation and are shown in Table 16. Clean up costs are accounted for in addition to building and content damage and are estimated as 40% of building and content damage (DSE 2009).

Table 16: Commercial building and content damage (medium value contents) ($2020)

Depth of overfloor inundation (m)	Potential Damage ($/m^2)	Actual Damage ($/m^2)
3	706.5	317.9
2.7	706.5	317.9
2.4	706.5	317.9
2.1	706.5	317.9
1.8	565.7	254.6
1.5	528.9	238.0
1.2	423.7	190.7
1	352.6	158.6
0.9	335.5	151.0
0.6	282.9	127.2
0.5	264.5	119.1
0.3	201.4	90.6
0.2	177.6	79.9
0.1	132.9	59.8
0.05	94.7	42.6
0	52.6	23.7
-0.3	0.0	0.0

Source: Marsden Jacob Associates, based on DSE (2009)

Residential building and content damage

Building damage cost for residential buildings is a function of over floor inundation and building type (see Table 17). Building damage cost are higher for single-storey dwellings.

Table 17: Residential building damages ($2020)

Building type	Damages ($)
Single-Storey Residential Building	y = 19,365 + 7,165x
Two-Storey Residential Building	y = 13,556 + 4,919x

Note: y = estimated damage; x = over floor depth (m) (positive values only)
Source: Marsden Jacob Associates, based on DSE (2009)

Similar to building damages, value of content lost depends on over floor inundation levels. This is shown in Table 18 by building type.

Table 18: Residential content damages ($2020)

Building type	Depth of over floor inundation (m)	Damages ($)
Single-Storey Residential Building	x ≤ 0	y = 0
	0 < x < 2	y = 32,367 + 32,367x
	x ≥ 2	y = 97,101
Two-Storey Residential Building	x ≤ 0	y = 0
	0 < x < 2	y = 22,631 + 22,631x
	x ≥ 2	y = 68,023

Note: y = estimated damage; x = over floor depth (m) (positive values only)
Source: Marsden Jacob Associates, based on DSE (2009)

Clean-up costs[31] and external damages[32] are accounted for in addition to building and content damages. Estimates recommended in the Flood RAM report have been adjusted for inflation. Clean-up costs are assumed to be $5,262 per flood affected property for internal clean-up and $1,316 per flood affected property for external clean-up. External damages are assumed to be $6,579 per flood affected property.

Damage to roads

The damage estimates for roads are driven by the type and length of road inundated as well as the duration of inundation and the velocity of flooding. The Flood RAM report therefore provides damage estimates for both major and minor floods (see Table 19).

31 Clean-up cost are those costs incurred to clean a building and its contents after a flood (Review of Flood RAM).
32 External damage includes damage to fences, pools, spas, and landscaping (Review of Flood RAM).

Table 19: Unit damage cost for roads (per km of road inundated, $2020)

Road Type	Major Flood			Minor Flood		
	Initial road repair	Subsequent accelerated deterioration	Total cost	Initial road repair	Subsequent accelerated deterioration	Total cost
Major highway (4 lane)	289,460	144,730	434,190	144,730	72,365	217,095
Major sealed road	72,365	36,183	108,548	36,183	18,091	54,274
Minor sealed road	39,472	19,736	59,208	19,736	9,868	29,604
Unsealed road	11,841	5,921	17,763	5,921	2,961	8,881

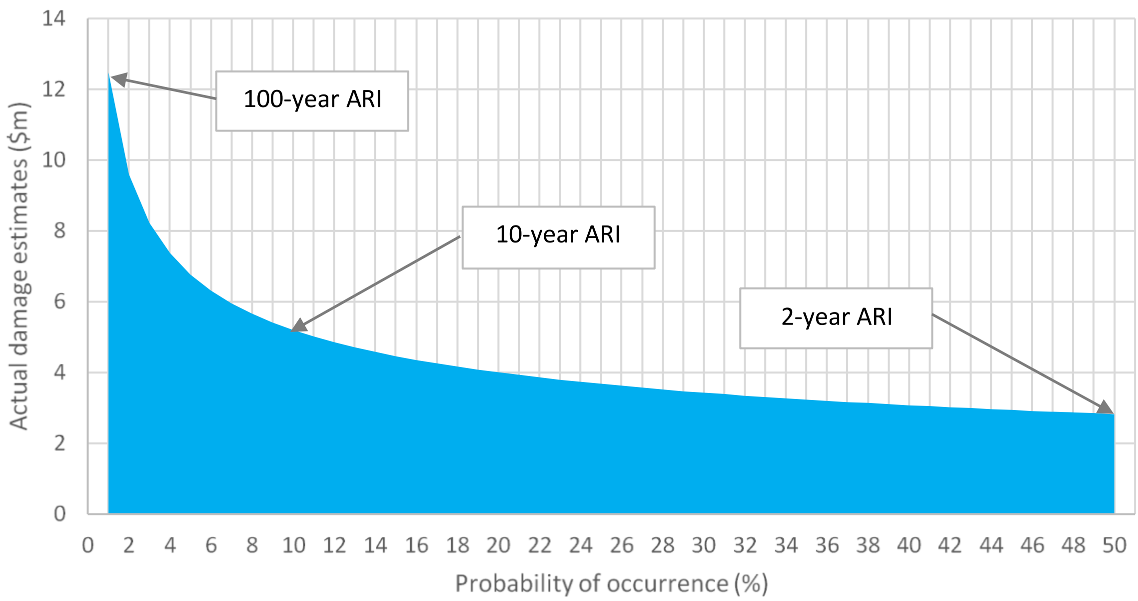
Source: Marsden Jacob Associates, based on DSE (2009)

Average annual damage cost

The economic impact of flooding is estimated based on average annual damage (AAD) estimates. These are calculated based on hydrological or flood modelling of the probability of occurrence of floods of different magnitudes, where (i) smaller floods occur relatively more frequently but result in relatively smaller damages per flood event, and (ii) larger floods occur relatively less frequently but result in relatively larger damages per flood event.

This relationship can be illustrated using a flood damage curve, where the AAD is calculated as the area under the curve. A stylised example is provided in Table 20 below.

Table 20: Flood damage curve and average annual damage (AAD) – illustrative example



A1.6. Unregulated and supplementary water, and overland flows

For water users who rely on unregulated water, supplementary water, and overland flows, the value of water is a function of (i) the time of year it becomes available and (ii) the margin returns from the irrigated crop it is used to grow.

In these regions, it is commonplace to augment water supply reliability through the use of large on-farm storages. Provided these storages are not already at capacity, water will usually be diverted to them whenever it becomes available. However, water in storage incurs losses through seepage and evaporation. The magnitude of these losses is a function of the quality of the storage (e.g. soil type, degree of compaction, clay lining, use of cells, use of covers, etc), weather conditions (temperature, humidity), and the duration of storage (longer storage results in greater losses, all else equal).

If, for example, the key crop grown in a region is cotton, the returns from this crop would be used as the starting point for the valuation, then adjusted to reflect the time of the year water becomes available to irrigate this crop. If the typical growing season for cotton is September to March, this is the optimal window for water to become available, because it can be directly applied to the crop, rather than stored for later use. If, instead, water becomes available in April (directly after the cotton growing season has finished), this water will likely[33] be stored on-farm until the next cotton growing season.

In summary, the value of water over time can be described as follows:

- Most valuable = Spring (to inform planning) and Summer (if a crop has been planted).
- Less valuable = Other times, because the water will need to be stored, which means evaporative and seepage losses need to be factored into the value. For example, water extracted in April must be stored for the longest time, which is why it is least valuable to the irrigator.

Table 21 provides an illustrative example of the value of water to cotton producers throughout the year, where a gross margin of $200/ML applied is assumed, and water accessed (via diversion from a river, or captured from overland flows) during the growing season is the most valuable. At other times of the year, water would need to be stored, with resultant evaporative and seepage losses impairing its productive value.

Table 21: Value of water to cotton producers – illustrative example

Month of extraction/capture	Assumed growing season for cotton?	$/ML
January	Yes – water used immediately	200
February		200
March		200
April	No – water stored for later use	100
May		120

[33] Occasionally, this water will be used to irrigate a winter crop, but storage of water for the next cotton growing season is more likely. Also, gross margin returns from a winter crop are likely to be lower than those of the preferred crop; in this example, cotton.

June		140
July		160
August		180
September	Yes – water used immediately	200
October		200
November		200
December		200

A1.7. Stock and domestic water

The methodological framework used to value stock and domestic (S&D) water is similar to that used for valuing water availability shortfalls to permanent crops. The following methodology is described in the context of beef cattle operations. Subsequently, values for dairy cattle and sheep are also examined.

4.5.1 Relationship between duration of S&D shortfall and value of S&D water

Shortfalls of 3 months to 1 year

The de-stocking of finished young stock, aged stock, and castrated stock will likely have no material impact on farm returns because these animals would likely have been sold imminently or could be sold at a minor price discount compared to a finished animal. By de-stocking these classes during the early stages of an S&D shortfall, the core breeding herd can be maintained for a longer time. However, even after de-stocking non-core stock, it is likely that there will remain some degree of S&D shortfall. Anecdotal evidence provided by NSW Department of Primary Industries (DPI) suggests that the cost of S&D shortfalls over the first year are likely to be of a similar magnitude to relatively short-distance carting (e.g. 20-30km). Based on the economic cost of carting water, it is assumed that the shortfall value of S&D water for shortfalls of duration one year or less is $4,000-6,000/ML.

Shortfalls of 1-2 years

S&D shortfalls of duration between one and two years will be associated with positive shortfall values. Indicative benefits and costs for the two options described above (maintaining herd size vs. partially de-stocking then re-stocking) are provided in Table 22 and Table 23. For Option 2, it is assumed that it takes four years to re-stock the herd – one-quarter of the original herd size in each of the four years after an S&D shortfall.

The relative returns from these two options are then compared in Table 24 to determine the shortfall value of S&D water. An alternative method, based on agistment costs, is also used to sense check the estimates derived using Method 1.

Shortfalls of 2+ years

At the opposite end of the spectrum, it is assumed that S&D shortfalls of duration two years or longer are associated with a shortfall value of $0/ML. The rationale applied here is that S&D shortfalls of such long duration will also be accompanied by feed (pasture, hay, silage) shortages, such that livestock will invariably require cost-prohibitive levels of supplemental feed.[34] In this scenario, feed is the limiting input, rather than S&D water.

Method 1: Valuing S&D water based on the relative returns from maintaining vs. de-stocking and re-stocking

Table 22: Gross margin budget for coastal weaners – improved pasture (Option 1: Maintain herd size)

	Year							
Benefit or cost category	1	2	3	4	5	6	7	8
Benefits	**520**	**480**	**580**	**580**	**580**	**580**	**580**	**580**
Sale of weaners/bulls/cows (mostly weaners)	520	480	580	580	580	580	580	580
Costs	**370**	**370**	**220**	**220**	**220**	**220**	**220**	**220**
Replacement bull	35	35	35	35	35	35	35	35
Livestock and vet costs	25	25	25	25	25	25	25	25
Pasture maintenance	110	110	110	110	110	110	110	110
Livestock selling cost	50	50	50	50	50	50	50	50
Drought feeding costs	150	150	0	0	0	0	0	0
Gross margin (excl. drought feeding costs) ($/hd)	**300**	**260**	**360**	**360**	**360**	**360**	**360**	**360**
Gross margin (incl. drought feeding costs) ($/hd)	**150**	**110**	**360**	**360**	**360**	**360**	**360**	**360**
Net present value (excl. drought feeding costs) ($/hd)		**1,960**		**Net present value (incl. drought feeding costs) ($/hd)**				**1,675**
Levelised gross margin (excl. drought feeding costs) ($/hd)		**370**		**Levelised gross margin (incl. drought feeding costs) ($/hd)**				**315**

[34] This is a necessary simplifying assumption. Although not every drought of 2+ years duration will be accompanied by feed shortages in every catchment/region, this assumption is representative of the majority of droughts.

Table 23: Gross margin budget for coastal weaners – improved pasture (Option 2: Partially de-stock then re-stock)

	Year							
Benefit or cost category	1	2	3	4	5	6	7	8
Benefits	**760**	**690**	**900**	**675**	**595**	**515**	**435**	**580**
Sale of weaners/bulls/cows (mostly weaners)	260	240	0	0	145	290	435	580
Sale of cows culled because of de-stocking	500	0	0	0	0	0	0	0
Avoided replacement heifer raising costs	0	450	900	675	450	225	0	0
Costs	**395**	**270**	**870**	**883**	**895**	**908**	**220**	**220**
Replacement bull	35	35	35	35	35	35	35	35
Livestock and vet costs	25	25	25	25	25	25	25	25
Pasture maintenance	110	110	110	110	110	110	110	110
Livestock selling cost	75	25	0	12.5	25	37.5	50	50
Drought feeding costs	150	75	0	0	0	0	0	0
Replacement heifer (Pregnancy Tested In Calf)	0	0	700	700	700	700	0	0
Gross margin ($/hd)	**365**	**420**	**30**	**-208**	**-300**	**-393**	**215**	**360**
Net present value ($/hd)	**475**							
Levelised gross margin ($/hd)	**90**							

Table 24: Values of S&D water for beef cattle production – coastal region, improved pasture

Variable	Value
Difference in levelised gross margin (without drought feed)	$240/head
Difference in levelised gross margin (including drought feed)	$225/head
Number of cows watered using 1ML/year (grazing on grassland)	20 to 40 cows
Shortfall value of S&D water (without drought feed)	$4,000-10,000/ML
Shortfall value of S&D water (including drought feed) [35]	$4,000-10,000/ML

[35] These values are rounded to the nearest one thousand dollars; however, they illustrate that drought feeding costs have a relatively minor impact on margin returns for coastal beef cattle grazed on improved pasture. Conversely, S&D water shortfall is likely to have a significant impact.

Method 2: Valuing S&D based on agistment costs

Agistment costs are typically in the order of $4 per cow per week, which is around $200 per cow per year. This range of values closely aligns with those estimated using Method 1, which provides a strong degree of confidence that the estimated values are sensible. Shortfall values based on agistment costs, which necessarily also include all feed costs, are $4,000-9,000/ML.

4.5.2 Value functions for stock and domestic water

The above analysis focusses on beef cattle; however, other key users of stock and domestic water are dairy cattle and sheep, which are discussed in detail below.

Beef cattle – coastal region, improved pasture

Assuming that a stock and domestic water shortfall coincides with a feed shortage, which will typically be the case, the appropriate shortfall value to use is that corresponding to both a water and feed shortage. Taking into account the values derived above using both Methods 1 and 2 gives a central estimate of $7,000/ML, with lower and upper bound estimates of $4,000/ML and $10,000/ML, respectively.

$$V_{S\&D,beef\ cattle-coastal,improved} = \begin{cases} \$0/ML & for\ shortfall\ of < 3\ months \\ \$5{,}000/ML & for\ shortfall\ of\ 3\ months\ to\ 1\ year \\ \$7{,}000/ML & for\ shortfall\ of\ 1\ to\ 2\ years \\ \$0/ML & for\ shortfall\ of > 2\ years \end{cases}$$

Beef cattle – coastal region unimproved pasture

The key assumptions for coastal beef cattle grazed on unimproved pasture are outlined in Table 25. The central estimate is $2,500/ML, with lower and upper bounds of $1,500/ML and $2,500/ML, respectively.

$$V_{S\&D,beef\ cattle-coastal,unimproved} = \begin{cases} \$0/ML & for\ shortfall\ of < 3\ months \\ \$5{,}000/ML & for\ shortfall\ of\ 3\ months\ to\ 1\ year \\ \$2{,}500/ML & for\ shortfall\ of\ 1\ to\ 2\ years \\ \$0/ML & for\ shortfall\ of > 2\ years \end{cases}$$

Table 25: Key assumptions for beef cattle in inland NSW, grazed on native pasture

	Year							
Variable	1	2	3	4	5	6	7	8
Gross margin for Option 1 (maintain herd and purchase drought feed)	0	-10[36]	170	170	170	170	170	170
Gross margin for Option 2 (de-stock then re-stock)	75	415	145	-85	-255	-425	105	170

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[36] Based on a feed cost of $150/cow/year.

Difference in gross margin	-75	-425	35	255	425	595	65	0
Difference in levelised gross margin	40							
Number of cows watered using 1ML/year	20 to 40 cows							
Shortfall value of S&D water	$1,500-3,500/ML							

Beef cattle – inland region, native pasture

The key assumptions for inland beef cattle grazed on native pasture are outlined in Table 26. The central estimate is $5,000/ML, with lower and upper bounds of $3,000/ML and $7,000/ML, respectively.

$$V_{S\&D,beef\ cattle-inland,native} = \begin{cases} \$0/ML & for\ shortfall\ of\ < 3\ months \\ \$5{,}000/ML & for\ shortfall\ of\ 3\ months\ to\ 1\ year \\ \$5{,}000/ML & for\ shortfall\ of\ 1\ to\ 2\ years \\ \$0/ML & for\ shortfall\ of\ > 2\ years \end{cases}$$

Table 26: Key assumptions for beef cattle in inland NSW, grazed on native pasture

	Year							
Variable	1	2	3	4	5	6	7	8
Gross margin for Option 1 (maintain herd and purchase drought feed)	295	265[37]	505	505	505	505	505	505
Gross margin for Option 2 (de-stock then re-stock)	500	560	155	-83	-170	-258	355	505
Difference in gross margin	-205	-195	250	588	675	763	150	0
Difference in levelised gross margin	240							
Number of cows watered using 1ML/year	15 to 30 cows							
Shortfall value of S&D water	$3,000-7,000/ML							

[37] Based on a feed cost of $150/cow/year.

Dairy cattle

Growing regions for dairy cattle can be grouped into North NSW and South NSW, with the south having superior returns on a per-cow and per-ML basis. The key assumptions for dairy cattle are outlined in Table 27 and Table 28. For North NSW, the central estimate is $5,000/ML while for South NSW, the central estimate is $8,000/ML.

$$V_{S\&D,North\ dairy\ cattle} = \begin{cases} \$0/ML & for\ shortfall\ of < 3\ months \\ \$5{,}000/ML & for\ shortfall\ of\ 3\ months\ to\ 1\ year \\ \$5{,}000/ML & for\ shortfall\ of\ 1\ to\ 2\ years \\ \$0/ML & for\ shortfall\ of > 2\ years \end{cases}$$

$$V_{S\&D,South\ dairy\ cattle} = \begin{cases} \$0/ML & for\ shortfall\ of < 3\ months \\ \$5{,}000/ML & for\ shortfall\ of\ 3\ months\ to\ 1\ year \\ \$8{,}000/ML & for\ shortfall\ of\ 1\ to\ 2\ years \\ \$0/ML & for\ shortfall\ of > 2\ years \end{cases}$$

Table 27: Key assumptions for dairy cattle in North NSW

	Year					
Variable	1	2	3	4	5	6
Gross margin for Option 1 (maintain herd and purchase drought feed)	200	200[38]	550	550	550	550
Gross margin for Option 2 (de-stock then re-stock)	200	475	140	275	410	550
Difference in gross margin	0	-275	310	275	140	0
Difference in levelised gross margin	125					
Number of cows watered using 1ML/year	20 to 50 cows					
Shortfall value of S&D water	$3,000-7,000/ML					

Table 28: Key assumptions for dairy cattle in South NSW

	Year					
Variable	1	2	3	4	5	6
Gross margin for Option 1 (maintain herd and purchase drought feed)	475	475[39]	825	825	825	825
Gross margin for Option 2 (de-stock then re-stock)	475	750	205	410	620	825
Difference in gross margin	0	-275	620	425	105	0

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[38] Based on a feed cost of $350/cow/year.
[39] Based on a feed cost of $350/cow/year.

Difference in levelised gross margin	220
Number of cows watered using 1ML/year	20 to 50 cows
Shortfall value of S&D water	$5,000-11,000/ML

Sheep

The key assumptions for sheep (wool) are outlined in Table 29. The central estimate is $4,000/ML is based on gross margin budgets for Merino wethers (20 micron).

$$V_{S\&D,Sheep} = \begin{cases} \$0/ML & for\ shortfall\ of < 3\ months \\ \$5{,}000/ML & for\ shortfall\ of\ 3\ months\ to\ 1\ year \\ \$4{,}000/ML & for\ shortfall\ of\ 1\ to\ 2\ years \\ \$0/ML & for\ shortfall\ of > 2\ years \end{cases}$$

Table 29: Key assumptions for sheep

	Year					
Variable	1	2	3	4	5	6
Gross margin for Option 1 (maintain herd and purchase drought feed)	10	10[40]	65	65	65	65
Gross margin for Option 2 (de-stock then re-stock)	10	70	15	35	50	65
Difference in gross margin	0	-60	50	30	15	0
Difference in levelised gross margin	4					
Number of sheep watered using 1ML/year	500 to 1,500 sheep					
Shortfall value of S&D water	$2,000-6,000/ML					

A1.8. Valuing recreation

Valuing impacts on recreation first requires establishment of a causal relationship between water availability[41] and the magnitude of recreational activity. Second, changes in the magnitude of recreational activity can be valued in terms of their economic value. In this report, economic value is estimated using a process known as value transfer. Best practices for value transfer are outlined in Table 30.

[40] Based on a flock-weighted feed cost of $55/sheep/year.
[41] Where this could be total water availability, water levels in a storage used for recreational boating or fishing, or river flow rates.

Economic value

The economic value of recreational activities extend beyond the economic contributions that are measured through exchange transactions.

Recreation activities generate benefits for the individuals engaging in recreation. We call these benefits economic value (see Table 31 and Table 32). Economic value can include the recreation value of water skiing, wake boarding, kayaking, etc. They can also include individual and community benefits; for example, of knowing that riparian areas and water quality are in better condition due to changes in water availability.

In the context of recreation, the main component of economic value of a good or service is measured by the maximum amount people are willing to pay for the good. The difference between the gross economic value / benefit (the amount they are willing to pay) and net economic value / benefit (the amount they are willing to pay less what they actually pay) is called consumer surplus. Consumer surplus is the best available economic measure of value – it shows how much 'better off' people are; in this example, when they engage in recreational boating.

It is important to distinguish between gross and net economic values. For example, consider if water-based recreational activities take place in one location, instead of another. In this case, if the recreation experience is 'about the same' (measured in terms of the maximum amount the individual would be willing to pay to do the activity on that day) and the cost of engaging in recreation is the same, then the economic value (consumer surplus) from the activity is about the same.

In this case, there is no loss of economic value (consumer surplus) from recreation because there is a suitable substitute site nearby. All that has happened is that the location where the recreational value (consumer surplus) is generated shifts from one site in NSW to another site in NSW. The degree to which this site is a suitable substitute will determine the scale of the impact. If the sites are strongly interchangeable, the economic impact on these recreationists will likely be close to nil. A notable exception is when recreation is transferred from a site in NSW to a site outside of NSW. In this case, there will be a net social cost to NSW, which should be captured in a NSW-focussed cost-benefit analysis.

Similar to above, consider if an individual switches from one type of activity to another (e.g. wake boarding to kayaking), or wake boarder numbers decrease but numbers of kayakers and swimmers increase. In this case, the economic outcome is the change in recreational value that occurs. This is measured as the differences between the willingness to pay and costs under the various scenarios proposed above. Again, if the willingness to pay and costs of doing these recreational activities are about the same, the recreation value is not lost, it is simply transferred between recreationists. Further to this point, any changes to asset prices (e.g. house prices) are implicitly captured in economic contribution estimates, so separately estimating impacts on assets prices would result in double-counting of economic impacts.

The Total Economic Value framework provides the conceptual basis for estimating economic values.[42]

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[42] Accessible introductions to the total economic value framework are available on the web including http://www.mfe.govt.nz/publications/fresh-water-rma/option-and-existence-values-waitaki-catchment/3-total-economic-value https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=2ahUKEwiahKztiezdAhWFKHw

The sum of estimated consumer and producer surplus is provided in Table 33.

Value transfer

Contemporary studies valuing potential benefits of NSW recreation activities are summarised following. The estimates in this Appendix can be used to estimate the economic value of recreation changes in NSW. To do this requires use of a process called 'value transfer'.

'Value transfer' is the process of estimating economic values in a location of interest (the policy site) by transferring values from studies already completed in another location (the study site).

This removes the need for primary research. In an ideal world, the economic value of recreation changes would be estimated directly through things like surveys and observations of recreational activity on a river. For best results, this work would be completed over several years. It would be expensive to undertake. For this report – noting its intended use to inform a series of rapid cost-benefit analysis – we rely on value transfer, instead.

There is a need to exercise care when transferring data from one study to another. The evidence suggests that transferring economic value estimates from one context to another can be inaccurate unless there is a high degree of similarity between the study and policy contexts.[43]

Value transfer needs judgement and analysis of both the source study and the policy site. We have sought to minimise value transfer errors in the current recreational value study by applying the best-practice value transfer steps, which are summarised in Table 30.

Table 30: Value transfer best practices

Select 'good quality' studies	The key tests here is whether the study does what it purports to do, which is to estimate the willingness to pay for a particular recreation good. Our criteria for selecting good quality non-market valuation studies include that they are: • in peer-reviewed journals or books. This implies the study is more likely to have been well conducted and the appropriate statistical techniques used. • done after 2000. This reflects that use of improved valuation methodologies (in particular, stated preference valuation studies), where these have improved markedly over time. • sample sizes >500 respondents selected from the general population (for survey-based valuation methods). Larger and more representative samples mean we can generalise values with more confidence. • location appropriate studies. Generally, we look for studies that have similar site-specific characteristics, and similar proximity to populations. More broadly, for environmental valuation work, we look in the order of studies from within the State or Territory, other regions in Eastern Australia, other Australia, then high-income OECD counties. • limited to values that can be readily transferred. Generally, this means values are expressed in $ per hectare, $ per kilometre or $ per household.
Minimise transfer errors	Adapting estimates from one context to another requires technical skills as well as an understanding of the key drivers of values, how they differ between sites, and a

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KHWT7CF4QFjABegQICBAC&url=https%3A%2F%2Fwww.ehp.qld.gov.au%2Fwater%2Fpolicy%2Fpdf%2Fdraft-protecting-ev-gbr-catchment.pdf&usg=AOvVaw3bmRWNufLIcXkNP7OWeNDO

[43] Baker R, Ruting B, *Environmental Policy Analysis: A Guide to Non-Market Valuation*. 2014, Productivity Commission Staff Working Paper: Canberra.

	good dose of common sense. In any value transfer exercise, the person doing the transfer should compare the primary study to the project outcomes they are expecting (for example, water quality or riparian rehabilitation). They should consider whether adjustments should be made for the following: • the type and extent of recreation change (for example, estimates of the value of improvements to a specific wetland should not be extrapolated to an entire river basin without scale adjustments) • the type and extent of change from the status quo (for example, estimates of the value of creating a new wetland in a degraded site should not be transferred to a wetland improvement project where the site is much less degraded without accounting for this through calibration. Calibration factors for Australian NRM are available. • the population impacted (for example, estimates of the value of wetlands in Europe should not be transferred to Australia without making adjustments for differences in standards of living. • the time (for example, values should be adjusted for CPI. In addition, we consider for example whether a study from 25 years ago is still relevant to today, or whether community preferences, and therefore values for waterway values, are likely to have changed over that time). • for distance from the good being valued. Use and non-use distance decay calibration factors are available from international literature. • confidence intervals. The confidence intervals from the original study should be applied, where available. This will give a valuation range that the real value is likely to fall within. This is better than reporting point estimates.
Report value ranges not point estimates, and be clear on limitations	• present a range of estimates –analysis should not rely on a point estimate of the value of the recreation asset in question. Value transfer is not an exact science, and differences between the value estimated by value transfer and the 'true' valuation have been found to be up to 100 per cent, even in the best examples of value transfer. Most likely, minimum, and maximum ranges should be used. • this includes clearly point out that the values transferred were not estimated with reference to the specific recreation changes being examined in the study, and that as a result there remains some uncertainty about the community's willingness to pay. At best, value transfer can provide an indication of the order of magnitude of the community's willingness to pay for environmental goods and services.

Source: Marsden Jacob, adapted from DPMC (2014)[44]

[44] Department of the Prime Minister and Cabinet (2014), *Research Report: Environmental valuation and uncertainty*. OPBR, Department of the Prime Minister and Cabinet: Canberra.

Table 31: Potential transfer values (consumer surplus only) for NSW waterways and catchments

Outcome	Value 2020 AU$	Likely range	Unit of measure	Once-off or number of years	Discussion	Value transfer notes
Recreation on and near waterways	$18	$5-$71	Per day	Per trip	The economic value per recreation day has been estimated based on a recent literature review of the economic value of water-based recreation for Melbourne Water.[45] This work concluded that the economic value of terrestrial visits to waterways and reservoirs is in the order of $18 per head, and the value of water-based recreation (including fishing and swimming) is assumed to be $71 per day for Victoria. The review noted that these values are uncertain as there is limited data on which to base the estimates. We note these estimates are in-line with recreation values for other activities, however. These estimates are also similar to recent work from Queensland for recreation activities at regional Seqwater dams[46] and the recent NSW inland fishery review.[47] We agree with the NSW DPI study on recreational inland fishing values in NSW. There is little primary research into economic values (consumer surplus) of native fish and recreational fishing in inland rivers in NSW and how these might change with changes in water management or other management regimes.	• Higher values assigned to out of region visitors. Values higher than $71 per day could be assigned for 'showcase' fishing – fishing events drawing national visitors, or things like blue-fin tuna fishing • Care should be taken to calculate change in consumer surplus based on induced demand. Induced demand is the new demand that arises across NSW as a result of changes in water quality • Care should be taken if combining the use value with encompassing waterway health WTP, as this will likely result in double counting.

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45 Marsden Jacob Associates, Melbourne Water monetised social and environmental economic value guidance. 2019: Melbourne. (confidential to client). Publicly available reports used to inform the economic value estimates include Gillespie et al. (2017) and Varcoe et al. (2015). Refer to the reference list for full details.

46 Marsden Jacob Associates, The economic value of recreation undertaken on Seqwater's land. 2013: Brisbane. (confidential to client)

47 http://recfishcentral.com/web-content/research/nsw_economic_report_2013.pdf & https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0020/741350/OUTPUT-11324-Forbes-et-al-Report-Preliminary-assessment-of-the-Lake-Eucumbene-summer-recreational-fishery-2015-16.pdf, accessed 20 July 2020.

Recreational expenditures

Improvements in waterway and catchment condition can increase demand for recreation at these locations. When new recreation demand is created, there is an economic impact. This impact is the added expenditure that occurs within a region. For example, recreationists might buy petrol, food, accommodation, and other services when they travel to engage in recreation.

Table 32 summarises potential values that NSW could use to estimate the economic contribution that results when recreation increases because of policy changes. Note, however, that these are not the values that should be used in a cost-benefit analysis. For a cost-benefit analysis, the relevant value is the economic value (i.e. producer surplus[48]), whereas the economic contribution measures additional expenditure. Key points here are:

- The summaries are based on a comprehensive survey of recreational expenditure by participants at 22 Recreational Water Facilities in Victoria in 2016-17.[49]
- The expenditures are lower than those in the recent NSW inland fishing study.[50] We note that many of expenditure studies suffer from methodological limitations that mean the expenditure figures are likely significantly overstated. Until better evidence is available, we recommend using more conservative estimates.
- Recreational expenditure should only be claimed for a waterway or catchment investment/policy change if it induces new recreation within the river catchment for which the economic evaluation is being undertaken. If new recreation does not occur, or if recreation is shifted from another site within the catchment or region, then the expenditure cannot be claimed. This is because the expenditure has simply shifted location within the catchment, it is not new expenditure.
- The expenditure figures include expenditure by water-based and land-based recreationists.

For cost-benefit analysis, producer surplus is the relevant economic value. A rule of thumb for accommodation and retail services is that producer surplus is around 7% of expenditure. This rule of thumb may be used to derive producer surplus estimates. However, since this is only a rule of thumb, sensitivity bounds of 3% and 15% have been used in Table 32.

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48 Producer surplus is the difference between the price a producer receives and their variable cost of production. Therefore, producer surplus will be less (usually much less) than expenditure.

49 Street Ryan, *Wimmera Southern Mallee Socio-Economic Value of Recreational Water*. 2017: Melbourne.

50 http://recfishcentral.com/web-content/research/nsw_economic_report_2013.pdf & https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0020/741350/OUTPUT-11324-Forbes-et-al-Report-Preliminary-assessment-of-the-Lake-Eucumbene-summer-recreational-fishery-2015-16.pdf, accessed 20 July 2020.

Table 32: Estimated Expenditure by Participants at Recreational Water Facilities 2016-17

In-town*	Expenditure Overnight Visitors	Expenditure Active Day Users	Expenditure Passive Day Users	Expenditure Total Day Users	TOTAL	Visit Nights/ Person Nights	Active Day Users	Passive Day Users	$ per visit night	$ per active day users
Wimmera River - Horsham	$445,839	$338,050	$144,398	$482,448	$928,288	10,429	13,510	61,446	$42.75	$25.02
Green Lake	$55,081	$197,662	$0	$197,662	$252,743	1,630	9,544	0	$33.79	$20.71
Taylors Lake	$184,359	$34,255	$0	$34,255	$218,614	6,289	1,612	0	$29.31	$21.25
Wimmera River - Dimboola	$241,485	$65,129	$30,780	$95,909	$337,394	8,197	6,380	13,680	$29.46	$10.21
Nhill Lake	$24,977	$94,372	$21,855	$116,227	$141,204	1,053	6,460	10,025	$23.72	$14.61
Wimmera River	$103,666	$40,457	$19,405	$59,862	$163,528	4,344	1,396	7,295	$23.86	$28.98
Lake Bellfield	$157,181	$46,285	$37,105	$83,390	$240,571	4,453	2,173	14,842	$35.30	$21.30
Lake Fyans	$2,682,263	$59,876	$13,069	$72,944	$2,755,208	66,456	2,681	3,485	$40.36	$22.33
Lake Lonsdale	$44,650	$25,333	$17,200	$42,533	$87,183	1,995	1,500	5,000	$22.38	$16.89
Lake Wartook	$31,321	$11,000	$0	$11,000	$42,321	2,304	660	0	$13.59	$16.67
Walkers Lake	$74,437	$16,343	$0	$16,343	$90,780	3,101	1,430	0	$24.00	$11.43
Donald Park Lake	$118,550	$48,847	$6,379	$55,225	$173,775	4,742	2,197	3,645	$25.00	$22.23
Tchum Lake	$112,565	$48,750	$3,720	$52,470	$165,035	3,830	2,600	1,459	$29.39	$18.75
Lake Watchem	$98,552	$19,125	$0	$19,125	$117,677	3,203	900	0	$30.77	$21.25
Lake Wooroonook	$129,964	$30,670	$0	$30,670	$160,634	3,630	1,094	0	$35.80	$28.03

In-town*	Expenditure Overnight Visitors	Expenditure Active Day Users	Expenditure Passive Day Users	Expenditure Total Day Users	TOTAL	Visit Nights/ Person Nights	Active Day Users	Passive Day Users	$ per visit night	$ per active day users
Lake Wallace	$790,565	$44,430	$25,097	$69,527	$860,092	19,834	2,038	9,842	$39.86	$21.80
Lake Charlegrark	$219,599	$57,201	$0	$57,201	$276,800	6,879	2,215	0	$31.92	$25.82
Glenelg River - Harrow	$114,906	$10,988	$3,953	$14,941	$129,847	4,692	464	1,813	$24.49	$23.68
Brim and Beulah Weirs	$337,739	$92,705	$0	$92,705	$430,444	11,762	6,374	0	$28.71	$14.54
Lake Lascelles	$427,209	$109,811	$0	$109,811	$537,020	6,320	8,052	5,005	$67.60	$13.64
Lake Marma	$78,461	$20,589	$16,626	$37,214	$115,676	2,453	1,365	9,237	$31.99	$15.08
Yarriambiack Creek - Warracknabeal	$458,222	$48,290	$34,472	$82,762	$540,984	18,492	3,512	16,415	$24.78	$13.75
Total	**$6,931,592**	**$1,460,168**	**$374,058**	**$1,834,225**	**$8,765,818**	**196,088**	**78,156**	**163,189**	**$35.35**	**$18.68**
Potential economic values (producer surplus) indexed to $2020									**$ per visit night**	**$ per active day users**
Central estimate (7% of expenditure)									**$2.70 ($1.05-5.15)**	**$1.40 ($0.80-2.15)**
Low estimate (3% of expenditure)									**$1.15 ($0.45-2.20)**	**$0.60 ($0.35-0.95)**

In-town*	Expenditure Overnight Visitors	Expenditure Active Day Users	Expenditure Passive Day Users	Expenditure Total Day Users	TOTAL	Visit Nights/ Person Nights	Active Day Users	Passive Day Users	$ per visit night	$ per active day users
High estimate (15% of expenditure)									**$5.75 ($2.20-11.00)**	**$3.05 ($1.65-4.75)**

Table 33: Potential transfer values for NSW waterways and catchments

Surplus measure	Central	Low	High
Consumer surplus	18	5	71
Producer surplus	2	0	11
Economic value	**20**	**5**	**82**

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