Department of Planning and Environment

dpie.nsw.gov.au

Economic base case

Border Rivers region

July 2022

Acknowledgement of Country

The NSW Government acknowledges Aboriginal people as Australia's first people and the traditional owners and custodians of the country's lands and water. Aboriginal people have lived in NSW for over 60,000 years and have formed significant spiritual, cultural, and economic connections with its lands and waters. Today, they practise the oldest living cultures on earth.

The NSW Government acknowledges the Bigambul, Githabul Gomeroi, Kambuwal, Kwiambal and Ngarabal people as having an intrinsic connection with the lands and waters of the Namoi Regional Water Strategy area. The landscape and its waters provide the Bigambul, Githabul Gomeroi, Kambuwal, Kwiambal and Ngarabal people with essential links to their history and help them to maintain and practise their culture and lifestyle.

The NSW Government recognises that the Traditional Owners were the first managers of Country and that incorporating their culture and knowledge into management of water in the region is a significant step for closing the gap.

Published by NSW Department of Planning and Environment

dpie.nsw.gov.au

Economic base case

First published: July 2022

Department reference number: PUB22/645

Cover image: Image courtesy of Robert Clearly, Department of Planning and Environment, Kings Plains National Park, NSW

Contents

Executive summary

This report details the economic base case used for the hydrological and economic modelling undertaken to support the assessment of the long list of options for *the draft Border Rivers Regional Water Strategy*.

The Border Rivers Regional Water Strategy is not a business case and this economic base case analysis has not been undertaken at the level of detail required for a business case. However, it is the first step in strategically analysing alternative options for the Border Rivers. The analysis still needs to be robust and sufficiently specific to compare the merits of different options. The approach outlined in this document aims to strike the right balance between a high level, strategic assessment and region-specific information. It aims to determine an economic base case that represents an estimate of future surface water availability and the economic value of that availability.

The first step in any economic analysis is to understand what the future could look like and the potential consequences of doing nothing. This is known as the 'base case'. The economic base case used for the regional water strategies represents what the future could look like for towns and water-based industries if nothing is done to address issues related to the supply, demand or allocation of water over the next four decades.

For the purposes of the regional water strategies, three plausible futures have been examined. All of these futures are referred to as the base case. Portfolios of options considered in the Borders Rivers Regional Water Strategy and that can be hydrologically modelled will be assessed against these three futures:

1. Historical data: this scenario assumes that future climate will be similar to the climate data that has been recorded over the last 130 years
2. Stochastic data — long-term historic climate projections: this scenario assumes that future climate will be similar to what the science indicates our long-term paleoclimate was like and is based on a 10,000-year dataset
3. NARCliM[1] data — a dry climate change scenario: this scenario assumes a dry, worst-case climate change the future and is also based on a 10,000-year dataset.

In the past, water infrastructure and policy changes in the region have only been assessed against historical data (records of rainfall, temperature and other climate conditions going back to the 1890s). However, the stochastic data and the NARCliM data give a much better understanding of the water risks that could be faced by the region.

[1] NARCliM (NSW and ACT Regional Climate Modelling) is a partnership between the NSW, ACT and South Australian governments and the Climate Change Research Centre at the University of NSW. NARCliM produces robust regional climate projections that can be used to plan for the range of likely climate futures. Further information about NARCliM modelling can be found at climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/About-NARCliM.

The base case assumes existing infrastructure and policy settings, but includes medium population growth projections for the region from the NSW Government's Common Planning Assumptions.

To understand the consequences for the Border Rivers region of doing nothing, we have modelled the three most significant water user groups within the region:

- town water supply (as water shortfall): Ashford (regulated); Boggabilla (regulated); Mungindi (regulated); Glenn Innes (unregulated); and Tenterfield (unregulated)–where shortfall refers to a town being unable to meet its unrestricted demand from surface water supply
- irrigators of annual crops (as water supplied): assumed to be cotton, as this is the primary annual crop grown in the region
- irrigators of permanent crops (as water supplied): assumed to be pecans due to similar product being produced in nearby Moree.

The first step in developing the economic base case is to understand how water availability changes for these water users under the future scenarios–also referred to as hydrologic modelling. The modelling results show that towns and agricultural producers in the Border Rivers are, on average, likely to access to water less often (or have increased supply reliability) under the dry climate change scenario. A summary of the average amount of water available for each aggregated water user group under the future scenarios is shown in Table A.

Table A. Average annual water provided to water user groups under future scenarios

Water users	Stochastic scenario: long-term historical climate projections	NARCliM scenario: dry climate change	Difference between stochastic and NARCliM	Percentage difference between stochastic and NARCliM
Town water supply (shortfall, ML/year)	9.5	50.8	41.3	438.0
Annual crop producers (supplied, GL/year)	195.3	128.2	-68.7	-34.0
Permanent crop producers (supplied, GL/year)	0.4	0.4	0.0	0.0

The second step in developing the economic base case is to undertake an economic analysis to understand how this change in water availability translates into dollar values and impacts on the economy. Economic analysis was undertaken in accordance with the framework set out in *Regional Water Value Function* (Marsden Jacobs Associates, 2020). The evaluation period for each analysis was 40 years with a discount rate of 7%. Economic valuations per megalitre (ML) of water for each water user group were:

- town water supply: escalating cost is dependent on the size of the town and the size of the shortfall as this value is applied to the volume of water not supplied–(the shortfall
- annual crop producers (cotton): $350/ML
- permanent crop producers (pecans): $1,300/ML or $2,800/ML in shortfall

As shown in Table B, the economic impacts, on average, are higher under the climate change scenario than under the stochastic scenario, reflecting the lower availability of water.

Table B. Average total (40 years) economic outcomes per water user group

Water users	Stochastic scenario: long-term historical climate projections	NARCliM scenario: dry climate change	Difference between stochastic and NARCliM	Percentage difference between stochastic and NARCliM
Town water supply ($m)	0.67	4.96	4.30	646.0
Annual crop producers ($m)	928.0	607.8	-320.2	-35.0
Permanent crop producers ($m)	7.1	6.8	-0.3	-4.0

All modelled towns in the region are predicted to experience declines in economic outcomes due to water restrictions and the need to source alternative water supplies under both the stochastic and NARCliM scenarios, with a significantly greater economic loss under the dry climate change scenario. Agricultural producers would also experience a decline in economic outcomes under a climate change scenario, reflecting a reduction in agricultural production due to decreased water supply. Annual crop producers would be worse off (due to the larger allocation of less secure water required to grow these crops), with flow-on economic impacts for regional economies.

Introduction

Context

This report details the economic base case used for the hydrological and economic modelling undertaken to support the assessment of the long list options presented in the *draft Border Rivers Regional Water Strategy*.

This report has been prepared to document the process used and support decision making for the Border Rivers Regional Water Strategy about options that may impact the supply, demand or allocation of water and that can be represented adequately within catchment-level hydrologic modelling. A range of other options in the regional water strategy do not impact on the supply, demand or allocation of water in the region. A separate assessment process has been undertaken for these options and detailed in the Options Assessment Process report. However, the information documented in this report may also support analysis of those other options.

The economic base case has been prepared in accordance with the requirements outlined in:

- TPP18-06: NSW Government Business Case Guidelines (NSW Treasury, 2018)
- TPP17-03: NSW Government Guide to Cost–Benefit Analysis (NSW Treasury, 2017).

The economic base case and why is it important

The economic base case represents what the future could look like for towns and water-based industries if nothing is done to address issues related to the supply, demand or allocation of water over the next four decades. The economic base case is generated by combining the value different extractive water users place on water against the water availability forecasts for the region. It assumes current infrastructure and water policy settings but includes changes to population projections. The water demands of user groups are generally set as fixed, with some exceptions where population growth in towns is forecast. This approach allows all potential options to be compared consistently and any benefits, costs or other effects from an individual option to be assessed against their impact to the economic base case.

The economic base case will be used as the central scenario in the cost–benefit analysis for the hydrologic modelling of portfolios.

The Regional Water Value function

The Regional Water Value function[2] places a value on the amount of water forecast to be available. The forecasts are developed through hydrologic modelling. These estimated values:

- **focus on key water users** — not every water user in a region is analysed because the hydrologic modelling only captures changes in water availability for key water users in each region
- **reflect how users make decisions** and how they use water in practice — this water user behaviour has been studied and included in the Department of Planning, Industry and Environment's water models.

The values produced in the Regional Water Value function are for key water users. In the Border Rivers region, these users are:

- town water supply
- irrigators of annual crops — assumed to be cotton, as this is the primary crop grown in the region
- irrigators of permanent crops — assumed to be pecans due to similar product being produced in nearby Moree.

The Regional Water Value function values reflect how water is used in practice by the key water user groups. For example, irrigators of annual crops scale their operations each year depending on water availability, whereas irrigators of permanent crops change their operations following a sustained change in high reliability of water. As a result, irrigators with permanent plantings are more vulnerable in periods of supply shortfalls. This reflects how the economic value of water adjusts as forecast availability changes.

This approach will not necessarily capture every detail about water use or individual water users in the region. Such a level of detail is more appropriately considered in a comprehensive business case. However, the approach used does provide a robust and high-level strategic assessment of the impacts of major infrastructure or policy changes across the region.

Using climate change modelling to create expectations of the amount of water available

The NSW Government has invested in new climate datasets and improved hydrologic modelling that provide a more sophisticated understanding of historic climate variability, as well as likely future climate risks. The *draft Border Rivers Regional Water Strategy's* reliability assessments for towns and communities in the region are based on this new climate data, scaled down to the regional level and used in the modelling of surface water. This data and modelling includes consideration of long-term historic paleoclimate data (where available) and climate change impacts to develop scenarios of plausible extreme climate events.

[2] Marsden Jacobs Associates (2020). *Regional Water Value Function.*

Using the SOURCE streamflow modelling platform, the rainfall runoff (recorded at gauging stations across the catchment) is calibrated with historical streamflow data. The calibrated hydrologic model is then used to generate two series of streamflow sequences: one incorporating historic paleoclimate data and the other adding climate change scenario impacts. These two climate scenarios are referred to as the stochastic and the NARCliM models respectively.

The stochastic and NARCliM models are used to create expectations about the amount of water available in the future. The hydrologic modelling creates 1,000 replicates of 40-year duration daily climate inputs (sampled with a moving window of 10 years from the 10,000-year historic estimates) to create a broad range of feasible possibilities for the next four decades.[3]

Translating hydrologic modelling to user group outcomes

The hydrologic modelling estimates town surface water availability over the next 40 years. Town water availability was estimated by simulating extraction volumes and restrictions curves associated with the levels of storage in the Border Rivers' major dams (Pindari and Glenlyon dams).

The amount of water supplied to high security water entitlements and allocation shortfalls were calculated with restriction curves, similar to town and community water supply, to infer shortfalls in water supplied to those licences. This provides the data for the economic analysis.

General security entitlements are estimated according to the amount of water that is supplied to users based on the level of modelled water availability in the region. It is assumed that general security entitlement holders decide on an annual basis how they will use the water and what crops they will grow.[4]

No significant mining or other industrial activities are reliant on substantial water supplies in the Border Rivers region.

For the purposes of the regional water strategies (which are broad, region-wide strategic studies), the economic base case does not capture every user of water in a region. It also does not include quantitative analysis of groundwater. Rather, it provides an indication of surface water risks. Future business cases and detailed studies will need to conduct further analysis on if groundwater or other alternative water sources can fill the shortfalls identified in this analysis. However, the economic base case represents a robust estimate of future surface water availability and the economic value of that availability.

[3] See DPIE (2020). *New climate analysis informs NSW's regional water strategies*, available at: industry.nsw.gov.au/__data/assets/pdf_file/0018/321093/nsw-climate-model-report.pdf

[4] Marsden Jacobs Associates (2020). *Regional Water Value Function.*

Border Rivers Region — key details

Border Rivers region

The Border Rivers region (Figure 1) is located in northern NSW, bound by the Queensland border to the north and west, the western slopes of the Great Dividing Range to the east, and the Gwydir catchment to the south. The Border Rivers catchment is located within both NSW and Queensland, with the NSW portion covering 24,500 square kilometres or just under half of the total catchment area. The region is located within the traditional lands of the Bigambul, Githabul, Kambuwal, Gomeroi, Kwiambal and Ngarabal nations.

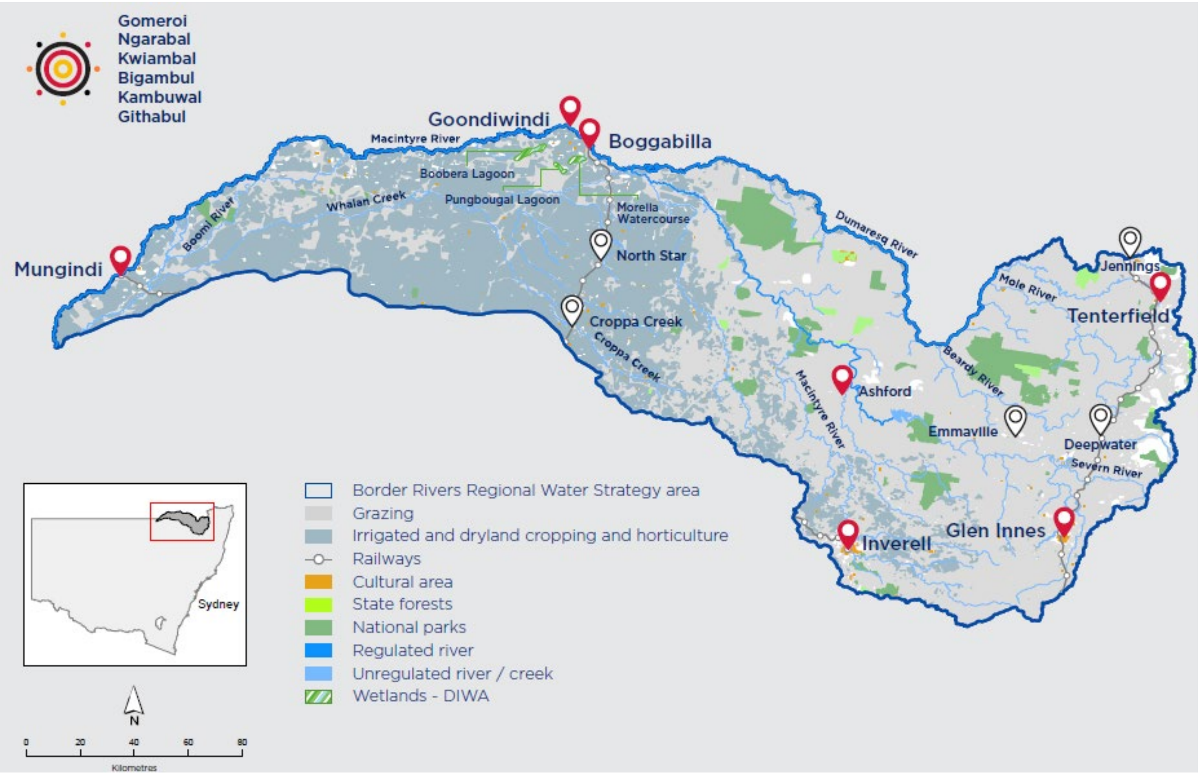

Figure 1 Map of the Border Rivers region

The region is home to the nationally significant Morella Watercourse, Boobera Lagoon and Pungbougal Lagoon, all of which are located on the Macintyre River floodplain and are some of the few permanent waterbodies in the northern Murray–Darling Basin.

The most significant economic activity in the Borders Rivers region is related to the agricultural industry, including (but not limited to) large-scale irrigation crops, grazing, food processing, broadacre and small-scale cropping.

The region’s population is approximately 32,000. Inverell, with 11,660 people, is the largest town and an important employment and services hub for outlying areas. Other key towns in the region are Glen Innes, Tenterfield, Boggabilla, Ashford and Mungindi. Goondiwindi and Stanthorpe are also significant regional towns in the Borders Rivers catchment. However, these towns are located in Queensland and have not been assessed as part of this regional water strategy.

Extractive users of water

The hydrologic outcomes and subsequent economic impacts have been considered in the context of the region's major water user groups:

- town water supplies
- agricultural users:
    - producers of annual crops
    - producers of permanent crops.

Note that stock and domestic users are such a small part of water use in the Border Rivers region they have not been included in the model.

In each base case scenario, the economic benefit or cost of water supplied or not supplied has been quantified in $/ML for each user.[5]

Towns and communities

The economic base case for towns and communities is developed according to the systems from where they draw their surface water supplies:

- regulated Border Rivers system: Boggabilla, Mungindi and Ashford
- unregulated water systems within the Border Rivers: Glen Innes and Tenterfield (these systems are modelled individually).

A number of towns have not been included in the analysis. For example, while Inverell is located in the Border Rivers region, draws its water supply from Copeton Dam in the Gwydir region and is not considered in this document. Goondiwindi and Stanthorpe are located outside of the state of NSW. The demands of these towns are included in the water models; however, assessment of the impacts of the regional water strategy options on these towns is not included in this economic base case analysis.

There are also townships and discrete communities in the region with populations that are too small to be considered in current modelling, including North Star, Croppa Creek, and Toomelah. These communities have been omitted to enable the strategy to focus on region-wide impacts. We assume that the region-wide impacts will also be reflected to some extent in these smaller communities; however, this assumption will need to be tested in any detailed business cases recommended to progress options from the regional water strategy.

The economic base case assigns different values for the costs of replacing surface water for towns and communities when supply shortfalls are modelled. The cost of a shortfall is dependent on the

[5] Detailed information on the development of the value of water for different extractive users can be found in *Regional Water Value Functions* (Marsden Jacob Associates, 2020).

size of the town or community and the length of shortfall being experienced. For example, for small towns it is assumed that local water utilities can manage brief periods of shortfalls through water carting. The management response to longer shortfall periods is assumed to require a more permanent, costlier solution. For larger towns, carting may not be a feasible option under any circumstances. Details of towns considered within this document and their associated shortfall costs are shown in Table 1.

Table 1. Economic cost of town water supply shortages in the Border Rivers region

Time in water shortage	Ashford	Boggabilla	Mungindi	Glen Innes	Tenterfield
Population*	659	551	443	5,161	2,914
System type	Regulated	Regulated	Regulated	Unregulated	Unregulated
0–6 months (restrictions)	$1,500/ML	$1,500/ML	$1,500/ML	$1,500/ML	$1,500/ML
6–12 months (restrictions)	$3,500/ML	$3,500/ML	$3,500/ML	$3,500/ML	$3,500/ML
Greater than 12 months	$16,000/ML (alternative supply)	$16,000/ML (alternative supply)	$16,000/ML (alternative supply)	$16,000/ML (alternative supply)	$16,000/ML (alternative supply)
Continued shortages (greater than 24 months)	$10,000/ML (carting)	$10,000/ML (carting)	$10,000/ML (carting)	$16,000/ML (alternative supply)	$16,000/ML (alternative supply)

*2016 populations, sourced from Australian Bureau of Statistics (ABS) census data. *Australian Statistical Geography Standard 2019 Urban Centres and Localities*

Water supply is assumed to be restricted within the regulated system when the level of water in key storages falls below certain storage levels. These assumptions are based on how the dams have been operated in previous droughts, with restrictions imposed on different user groups. Where there are no precedents[6], professional assessments were made about storage levels that would trigger restrictions. The assumed restrictions regime in the Border Rivers region is shown in Table 2.

Water supply restrictions for unregulated systems are based on cease-to-pump rules or local independent water supply sources, where they exist.

Table 2. Assumed restrictions regime

Dam	Storage level	Associated restrictions
Pindari Dam	≥ 30 GL	No reductions in allocations
	< 30 GL	100% reduction to Mungindi

[6] For instance, at extremely low levels of storage that have not occurred in the historic record but that do occur in either the stochastic or NARCliM models

Dam	Storage level	Associated restrictions
	< 10 GL	100% reduction to Mungindi and Boggabilla
	< 0.5 GL	100% reduction to Mungindi, Boggabilla, and Ashford
Glenlyon Dam	≥ 25 GL	No reductions in allocations
	< 25 GL	100% reduction to Mungindi
	< 14 GL	100% reduction to Mungindi and Boggabilla

Agricultural users

The economic benefit of water for agriculture varies depending on the crop. The marginal economic benefit per megalitre of water supplied for an annual crop will not change with a shortfall in supply, as the area cropped is adjusted to match the amount of water available. For permanent crops, a shortfall in supply will increase the marginal economic benefit per megalitre of water, which recognises the replacement cost of establishing the crop. Table 3 shows the majority of agricultural crops grown in the Border Rivers region, water licences and the economic value of water.

Table 3. Border Rivers agricultural water supply economic benefit

Crop/stock	Cropping	Water licence	Marginal economic benefit (of water) ($/ML)
Cotton	Annual	• General security A • General security B • Supplementary • Floodplain harvesting • Rainfall runoff	$350
Wheat	Annual		$175
Sorghum	Annual		$150
Barley	Annual		$150
Pecan	Permanent	High security	$1,300 ($2,800 in shortfall)

Source: Marsden Jacobs Associates (2020). *Regional Water Value Function.*

The highest economic values for annual and permanent crops in the Border Rivers region are:

- annual crops: cotton ($350/ML)
- permanent crops: pecans ($1,300/ML, $2,800/ML in shortfall).

Both crop types have sensitivities associated with their producer surplus, estimated at the long-run profitability derived from a megalitre of water, as detailed in the *Regional Water Value Functions.*[7] Annual crops grown in the region include cotton, wheat, sorghum and barley with a producer surplus ranging from $100/ML to $400/ML. However, cotton was deemed as the dominate crop in the region and was used as the basis of the calculations in the economic base case. There are few permanent

[7] Marsden Jacobs Associates (2020). *Regional Water Value Function.*

crops grown in the region. For this economic base case analysis, it is assumed pecans are grown.[8] These crops generate producer surpluses of between $1,100/ML to $1,600/ML for the water supplied, but $2,300/ML to $3,300/ML when shortfalls occur.

There are no water allocations provided for high security licences when Pindari Dam's storage level falls below 30 GL and Glenlyon Dam's storage level falls below 25 GL.

[8] Pecans were considered suitable for areas of the Border Rivers region based on feedback received by the (then) DPIE during Mole River Dam market sounding and on suitability mapping in *Pecan industry expansion* (DPI, 2016. Available at: dpi.nsw.gov.au/__data/assets/pdf_file/0006/586518/Pecan-industry-expansion.pdf)

Hydrologic and economic base case outcomes

This section outlines the estimated hydrologic and economic outcomes from the economic base case hydrologic modelling for the key users in the Border Rivers region for the historical (observed), stochastic (long-term paleoclimate) and NARCliM (climate change) scenarios.

There are 10,000 years of data in the stochastic and climate change datasets. This data has been split into 1,000 40-year realisations or 'windows' for each major water user.[9]

All economic calculations use a 7% discount rate, as recommended by NSW Treasury.[10]

Town and community hydrologic base case outcomes

The hydrologic modelling indicates that towns within the region are likely to experience low levels of surface water supply shortfalls, with a moderate increase in magnitude predicted due to climate change. The average length and magnitude of each town's expected annual shortfall for the 1000 40-year windows under the stochastic and NARCliM models are shown in Table 4 and Table 5. Table 6 summarises the difference between the stochastic and NARCliM modelling results.

On average, surface water can provide typically all but 1% of the towns' unrestricted demand for water in the stochastic climatic conditions. Under the NARCliM (climate change) conditions, there is an increase in the length of time towns cannot supply all of their demand from surface water, with Boggabilla seeing shortfalls of 2.7% and Mungindi 4.2%. Tenterfield is predicted to experience the highest magnitude of shortfalls that, on average, may be a 2.1% shortfall under stochastic conditions and a 11.3% shortfall under NARCliM (climate change) conditions.

The amount of time towns are expected to spend within a period of shortfall is closely linked to the magnitude of the shortfall. Under stochastic conditions, shortfalls are likely less than 1% of the time, with the length of time increasing by a few percentage points (depending on the town) under climate change conditions. For instance, Mungundi might experience a cumulative 15 days of discontinuous shortfalls over any 10-year period under stochastic conditions; however, under a NARCliM climate scenario, this shortfall would be expected to increase to about six months.

[9] Each realisation or 'window' covers a single 40-year hydrologic simulation. There are 1,000 of these realisations for each of the stochastic and NARCliM datasets. The windows are drawn from 40-year rolling periods extracted from the 10,000-year generated climatic datasets, with an approximate nine-year overlap between periods.

[10] NSW Treasury (2017) *TPP17-03: NSW Government Guide to Cost -Benefit Analysis*

Table 4. Town water supply hydrologic base case outcomes — stochastic scenario

Town	Average annual shortfall (ML)	Average annual demand (ML)	Shortfall as % of demand	Average months per year with shortfall	Average % of the year with shortfall
Ashford	0.0	120	0.0	0.0	0.0
Boggabilla	0.5	200	0.3	0.0	0.3
Mungindi	1.5	298	0.5	0.1	0.5
Glen Innes	0.0	665	0.0	0.1	0.4
Tenterfield	7.5	365	2.1	0.3	2.3

Table 5. Town water supply hydrologic base case outcomes — NARCliM scenario

Town	Average annual shortfall (ML)	Average annual demand (ML)	Shortfall as % of demand	Average months per year with shortfall	Average % of the year with shortfall
Ashford	0.0	120	0.0	0.0	0.0
Boggabilla	5.3	195	2.7	0.3	2.7
Mungindi	12.0	284	4.2	0.7	4.2
Glen Innes	0.5	667	0.1	0.2	1.5
Tenterfield	38.3	370	10.3	1.4	11.3

Table 6. Town water supply hydrologic base case outcomes — difference between NARCliM and stochastic scenarios

Town	Average annual shortfall (ML)	Average annual demand (ML)	Shortfall as % of demand	Average months per year with shortfall	Average % of the year with shortfall
Ashford	0.0	0	0.0	0.0	0.0
Boggabilla	4.8	5.0	2.4	0.3	2.4
Mungindi	10.5	14.1	3.7	0.6	3.7
Glen Innes	0.5	2.0	0.1	0.1	1.1
Tenterfield	30.8	5.0	8.2	1.1	9.0

Figure 2 illustrates the key town water supply shortfalls of the 1,000 40-year windows for individual towns, and the combined towns, in the stochastic (in yellow) and NARCliM (in blue) scenarios. Figure

2 shows these scenarios as cumulative totals over the 40-year simulation period. The key outcomes are:

- minimum: the best-case scenario
- median: the exact middle scenario
- maximum: the worst-case scenario.

These scenarios allow an understanding of the spread of outcomes (what could happen) over all of the 40-year windows simulated for the region and how towns might experience the predicted economic outcomes of the climate models over time. In short, it shows that over the next 40 years, the number of times a town might run out of surface water could be anywhere between the dotted lines. In instances where there are no (or very low) shortfalls, lines may overlap.

Similar to the data in Table 4, the graphs in Figure 2 show that expected shortfalls for town water supplies under the stochastic dataset are typically low, with nearly half of all 40-year windows producing no shortfalls for any town in the region. This is shown by the solid yellow line that is flat for the 40-year window in most graphs in the series, meaning that the town is not experiencing any water supply shortages for that period. Where the line is not visible, it is being obscured by the minimum outcome (or best-case scenario) of the NARCliM dataset (also indicating no town water supply shortfalls for this period).

The maximum outcome (worst-case scenario) for the NARCliM dataset generally show a significant increase in expected town supply shortfalls when compared with the worst-case stochastic scenarios, depending on the town. For example, Boggabilla may experience a cumulative shortfall of 2,000 ML in its worst performing NARCliM 40-year window, compared with a 500 ML shortfall for the worst-case stochastic 40-year window, an increase of nearly four times.

The collection of graphs in Figure 2 indicate that individual town water supplies appear to be relatively secure under the stochastic dataset compared to the NARCliM dataset. However, for both datasets nearly half of all possible scenarios examined result in no, or very little, surface water supply issues for all towns, with the possible exception of Tenterfield.

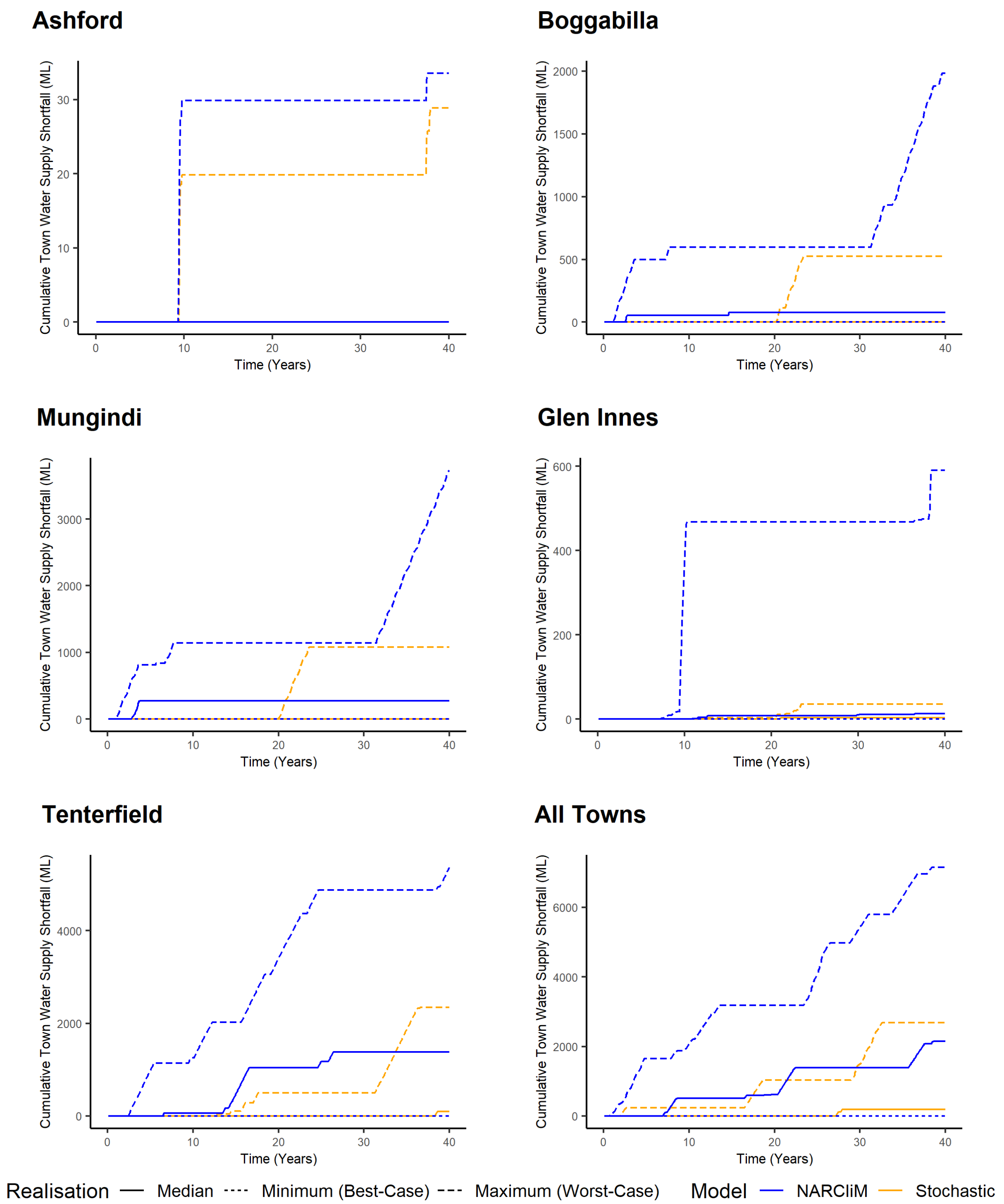

Figure 2. Town supply cumulative 40-year shortfall series (ML)

Town and community economic base case outcomes

The estimated average economic impact of water supply shortfalls for towns within the Border Rivers region over a 40-year period are shown in Table 7. All towns are predicted to experience declines in economic outcomes due to water restrictions and the requirement to source alternative water supplies under both the stochastic and NARCliM scenarios.

Under the NARCliM scenario, the economic loss is at least twice that of the stochastic scenario results for each town. Mungindi is anticipated to experience the largest economic increase of towns within the regulated system and Tenterfield is anticipated to experience the largest economic loss of towns operating independently.

Tenterfield will be the most impacted town, accounting for approximately 65% of the combined average town water shortfall costs for the region.

Table 7. Economic base case outcomes — town water supply average 40-year shortfall, net present costs

Town	Stochastic ($m)	NARCliM ($m)	Difference ($m)	Difference (%)
Ashford	0.0	0.0	0.0	-*
Boggabilla	0.03	0.42	0.39	1214
Mungindi	0.11	1.20	1.08	951
Glen Innes	0.0	0.01	0.01	-*
Tenterfield	0.52	3.33	2.82	545
Total	0.67	4.96	4.30	646

*Insignificant increase

The distributions of the expected economic outcomes for each model as shown in the histogram in Figure 3 (stochastic in orange and NARCliM in blue). The histogram condenses the economic costs of town water supply shortfalls for all 1,000 40-year windows by grouping results into ranges of values (in this case, 20 ranges per data series). Figure 3 illustrates that both the magnitude and uncertainty (that is, the spread) of the average cost of town water supply shortfalls increases under the NARCliM forecasts. The increase in the spread of town water supply costs under a NARCliM scenario reflects the predicted increase in the number and severity of shortfalls where water supply is required to be supported by a more expensive alternative source.

Figure 3 indicates that the worst economic outcomes for town water supply shortfalls would be approximately $10 million for the stochastic scenario and $27.5 million for the NARCliM scenario. Similar to the hydrologic results, the worst-case NARCliM outcomes are significantly higher than the worst-case stochastic outcomes.

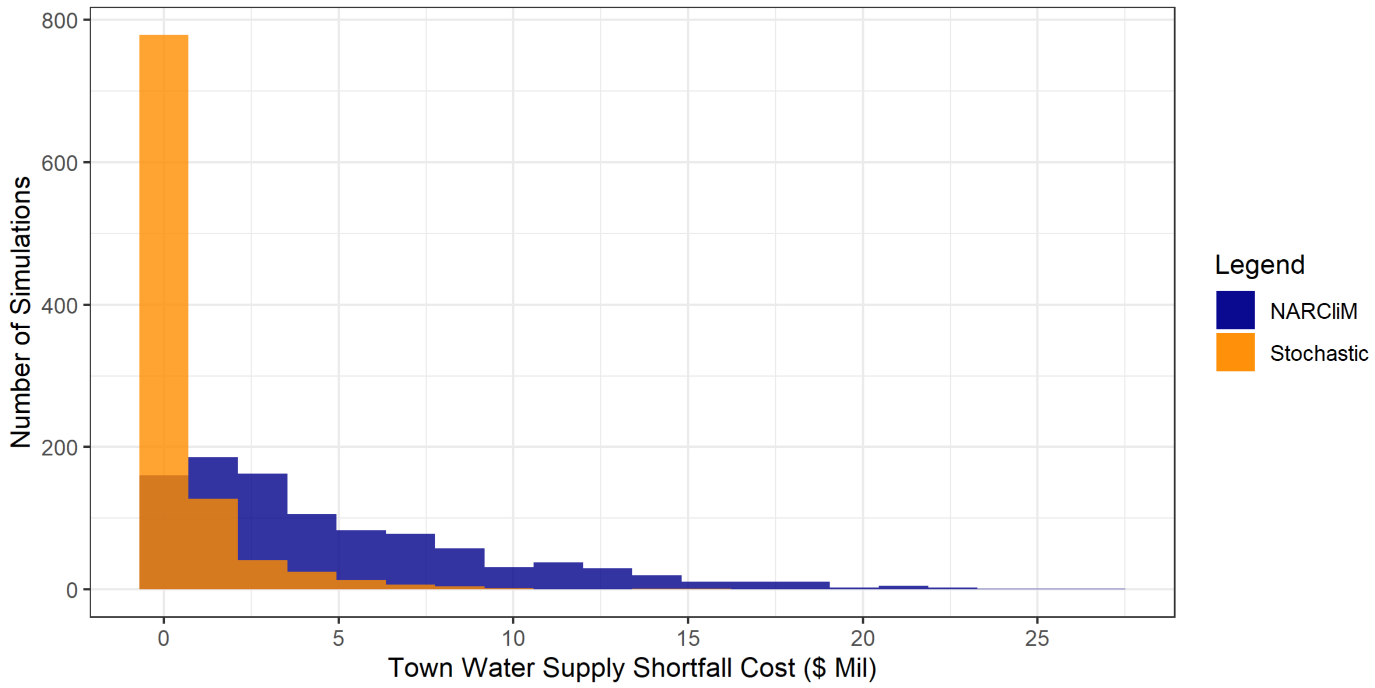

Figure 3. Total average towns water supply, net present costs

Table 8 to Table 10 provide additional information on the length of shortfalls and the percentage of time that each town would spend under each restrictions regime outlined in Table 2 (when experiencing a shortfall). As the tables show, the average length — and therefore the average economic cost per megalitre — of shortfalls increase from the stochastic scenarios to the NARCliM scenarios. Typically, the length of time that towns continuously do not have access to surface water increases as the droughts lengthen under the climate change scenario.

Using Mungindi as an example, the town water supply experiences an 18% decrease in shortfall durations lasting 0–6 months (incurring an economic cost of $1,500/ML) going from the stochastic scenarios to the NARCliM scenarios. This reduction is offset by an increase in longer droughts, that is droughts lasting 12–24 months (8%) (costing $16,000/ML) or more than 24 months (costing $10,000/ML) (9%). This indicates that Mungindi is likely to experience longer and more costly droughts.

Table 8. Economic base case outcomes — town water supply average share of restriction level under the stochastic scenarios

Town	Shortfall duration (economic cost $/ML)			
	0–6 months ($1,500/ML)	6–12 months ($3,500/ML)	> 12 months ($16,000/ML)	> 24 months ($10,000/ML) Or ($16,000/ML for Tenterfield and Glenn Innes
Ashford	100%	0%	0%	0%
Boggabilla	74%	18%	7%	0%
Mungindi	66%	22%	11%	1%
Glen Innes	100%	0%	0%	N/A
Tenterfield	72%	17%	11%	N/A

Table 9. Economic base case outcomes — town water supply average share of restriction level under the NARCliM scenario

Town	Shortfall duration (economic cost $/ML)			
	0–6 months ($1,500/ML)	6–12 months ($3,500/ML)	> 12 months ($16,000/ML)	> 24 months ($10,000/ML) Or ($16,000/ML for Tenterfield and Glenn Innes
Ashford	100%	0%	0%	0%
Boggabilla	64%	18%	14%	4%
Mungindi	48%	22%	19%	11%
Glen Innes	100%	0%	0%	N/A
Tenterfield	51%	24%	25%	N/A

Table 10. Economic base case outcomes — town water supply average share of restriction level — difference between NARCliM and stochastic scenarios

Town	Shortfall duration (economic cost $/ML)			
	0–6 months ($1,500/ML)	6–12 months ($3,500/ML)	> 12 months ($16,000/ML)	> 24 months ($10,000/ML) Or ($16,000/ML for Tenterfield and Glenn Innes
Ashford	0%	0%	0%	0%
Boggabilla	-10%	0%	7%	3%
Mungindi	-18%	0%	8%	9%
Glen Innes	0%	0%	0%	N/A
Tenterfield	-21%	7%	14%	N/A

Agricultural hydrologic base case outcomes

The following section describes the hydrologic impacts on the agricultural industry within the Border Rivers region. Agriculture has been separated into two groups for this region:

- annual crops (cotton)
- permanent crops (pecans).

The estimated annual average volume of water these producers use under both the stochastic and NARCliM (climate change) scenarios are given in Table 11.

Agricultural water users are expected to receive considerably less water under the NARCliM climate change scenario than the stochastic scenario, with an average use difference of approximately 70 GL per year (a 34% reduction). Annual crop water use is sourced from general security A, general security B, supplementary and floodplain harvesting water access licence shares, as well as rainfall runoff. Water for permanent crops is sourced from high-security access licence shares, which account for less than 1% of Border Rivers region's licence shares.

Table 11. Average annual agricultural water use volumes — stochastic and NARCliM scenarios

Crop classification	Water use metric	Stochastic	NARCliM	Difference	Difference (%)
Annual crops (GL/year)	Average	195.3	128.2	-67.1	-34
	Maximum	255.2	209.2	-46.1	-18
	Median	196.8	127.2	-69.6	-35
	Minimum	126.7	62.0	-64.7	-51
	Standard deviation	25.6	25.8	0.2	1
Permanent crops (GL/year)	Average	0.4	0.4	0.0	-5
	Maximum	0.4	0.4	0.0	0
	Median	0.4	0.4	0.0	-4
	Minimum	0.4	0.3	-0.1	-29
	Standard deviation	0.0	0.0	0.0	NA

Histograms of the modelled annual agricultural water use within Border Rivers region (orange for stochastic and blue for NARCliM scenarios) is shown in Figure 4 and Figure 5 for annual and permanent crops respectively. The figures group the results of the 40-year realisations into 20 'bins' to provide an overview of the outcomes for the 1000 realisations of each model. They indicate that the amounts of water used on average for both annual and permanent crops are predicted to reduce under the climatic conditions present in the NARCliM model. The amount of variation is expected to remain roughly the same between the two datasets.

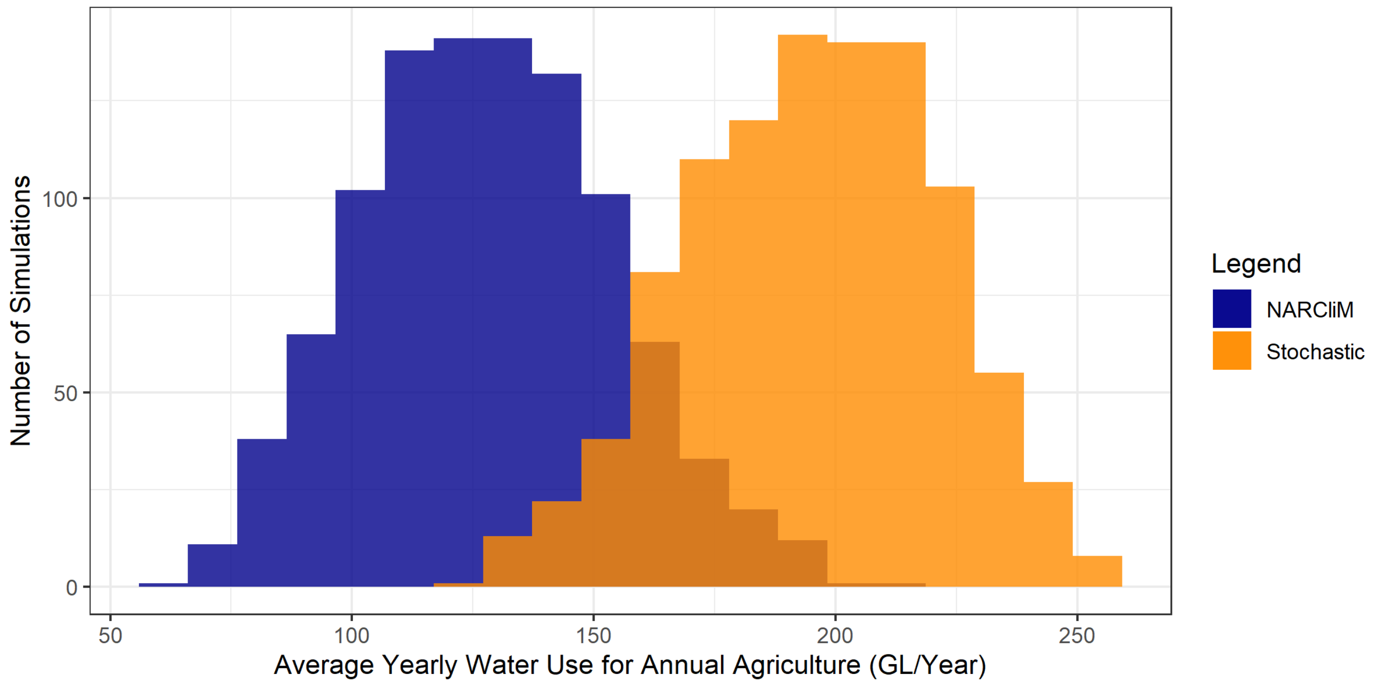

Figure 4. Annual crop water use under stochastic and NARCliM scenarios

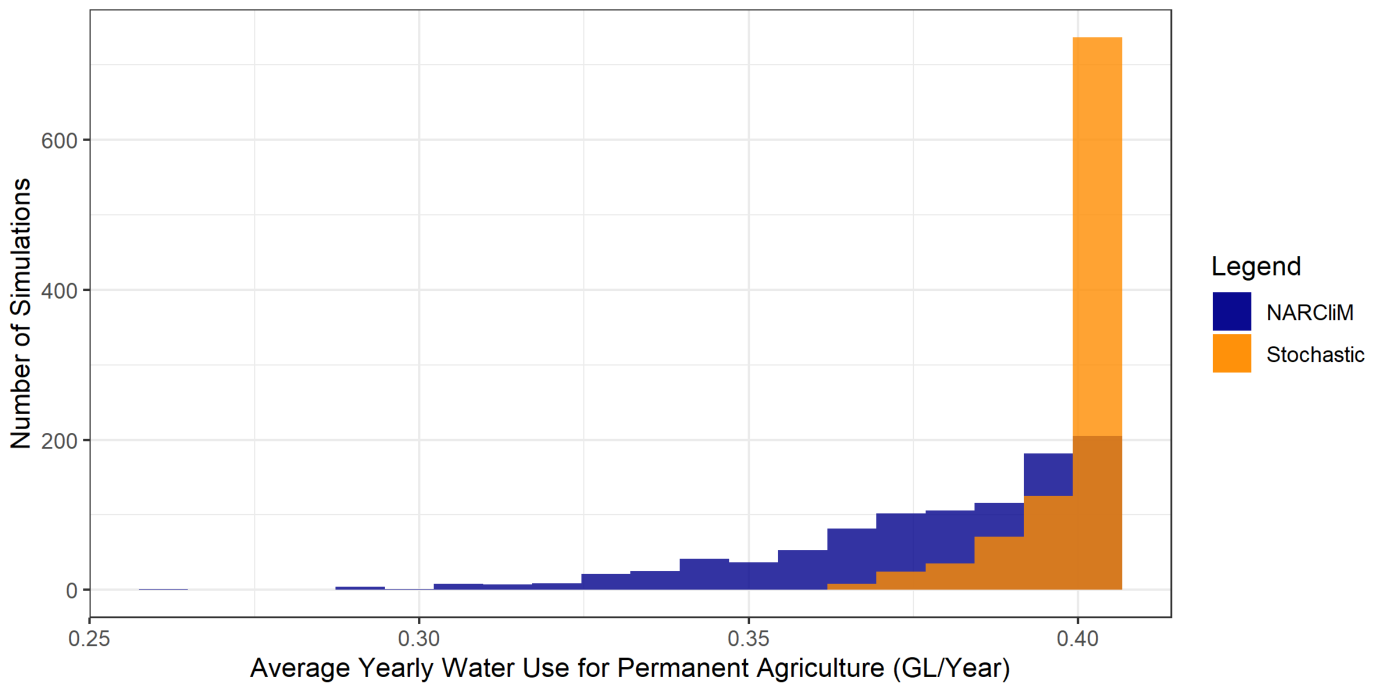

Figure 5. Permanent crop water use under stochastic and NARCliM scenarios

Three outcomes of expected cumulative water use for producers of annual and permanent crops are presented in Figure 6 and Figure 7 for both the stochastic (orange) and NARCliM (blue) hydrologic models. The outcomes are:

- minimum: the best-case scenario
- median: the exact middle scenario
- maximum: the worst-case scenario.

These results illustrate that the climate predictions under the NARCliM scenario result in less water availability for the production of annual crops. The median cumulative expected water use for annual crops under the NARCliM scenario is below the minimum result for the stochastic scenario, suggesting a significant decrease in water availability for annual crops under the NARCliM scenario compared to historical climate projections.

In Figure 7, the impact of climate change on permanent crops is less visible, with the modelling indicating very similar outcomes under both scenarios. The worst-case (minimum) NARCliM scenario captures a period of approximately 10 years where permanent crops do not receive a high-security allocation.

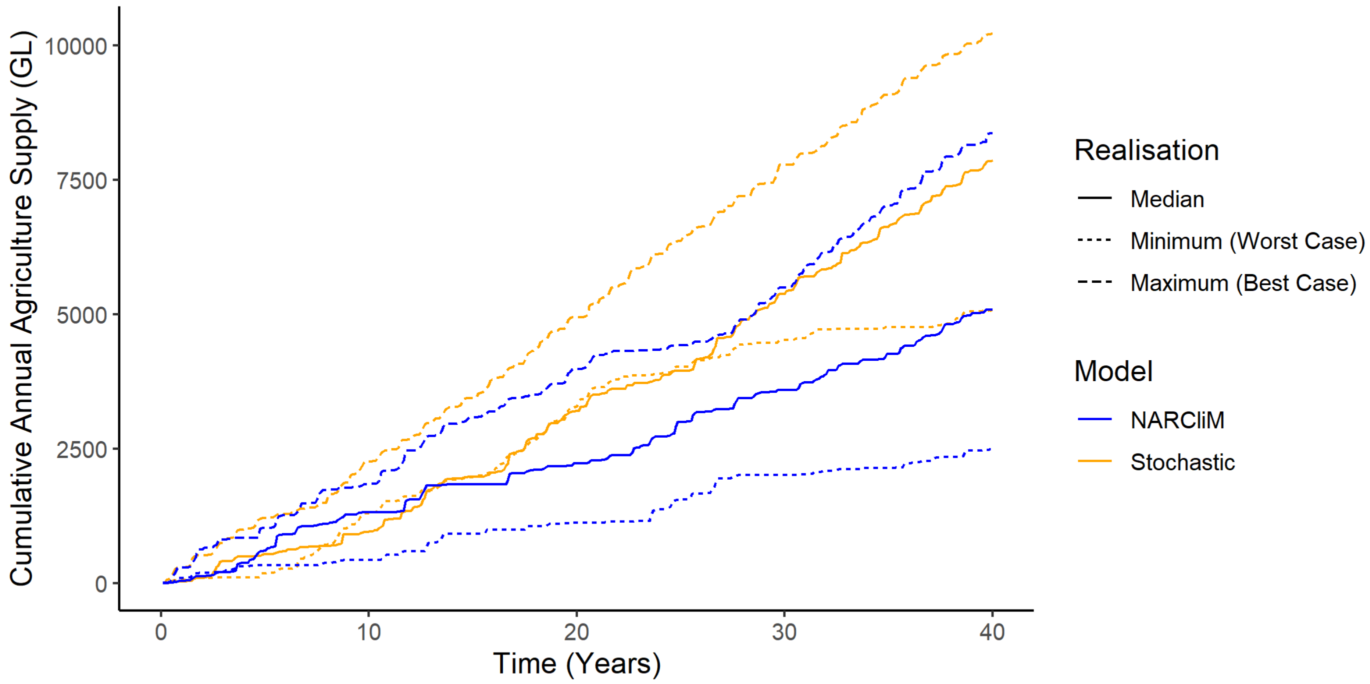

Figure 6. Annual crop water use under cumulative stochastic and NARCliM scenarios

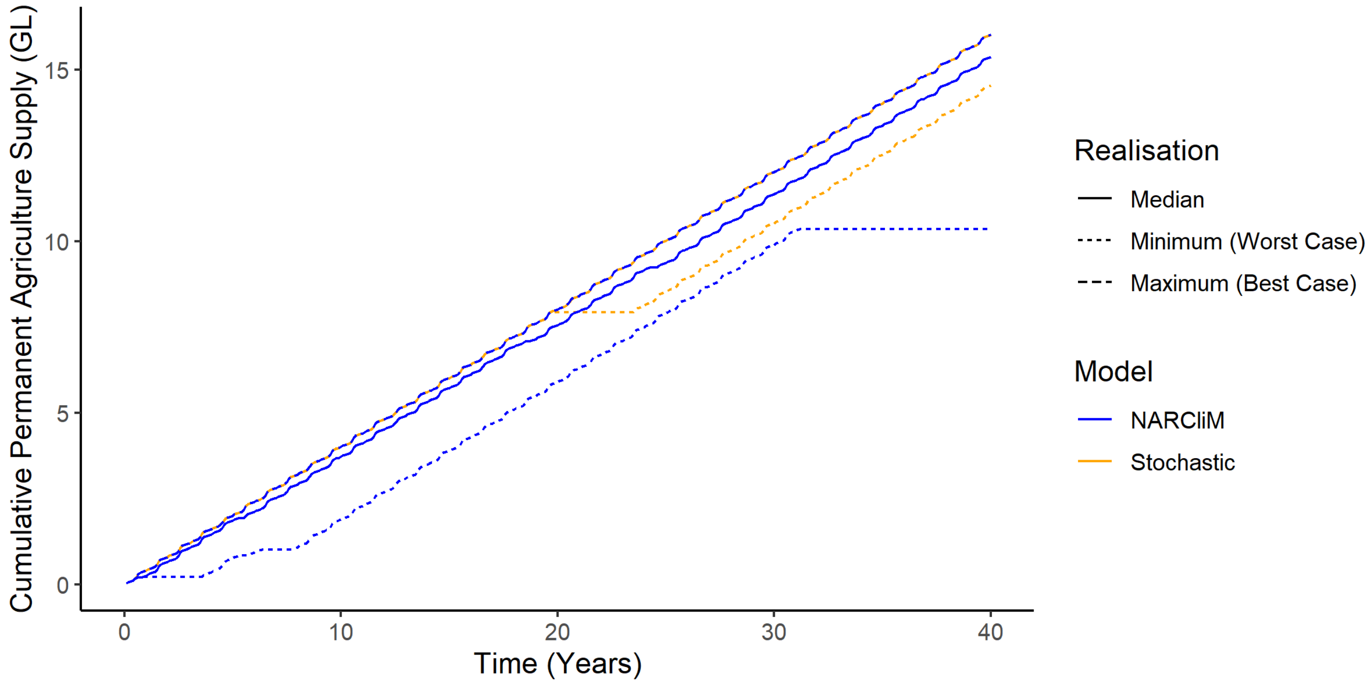

Figure 7. Permanent crop water use under cumulative stochastic and NARCliM scenarios

Agricultural economic base case outcomes

Average economic values of water for agricultural producers within the Border Rivers region over the 40-year analysis period are shown in Table 13. The small amount of high-security water allocations within the catchment translates to a small producer surplus for permanent crops (pecans) despite its high economic value on a per unit basis. Conversely, annual crops (cotton) represent a large economic addition for the region due to the larger allocation of less secure water assumed to be used for growing the crop.

Under the NARCliM scenario, a decrease in the average economic value for annual crop producers (35%) and permanent crop producers (27%) reflects the reduction of agricultural production due to decreased water supply under a NARCliM scenario.

Summaries of the distributions of possible outcomes for agricultural producers are shown in Figure 8 for annual crops and Figure 9 for permanent crops. These figures illustrate the wide range of possible economic outcomes under the NARCliM and stochastic scenarios. The predicted increase in economic activity due to irrigation for producers of annual crops under stochastic conditions ranges from approximately $550 million to $1,300 million, with an average value of $928 million over the forecast 40 years. For the NARCliM scenario results, the value of water for producers of annual crops shifts lower, with values ranging from $250 million to $1,000 million and an average value of $608 million. There is far less variability for permanent crops. The upper bound for both the stochastic and NARCliM scenarios is approximately $8.5 million. While the lower bound is between $6 million and $6.5 million under the stochastic scenario and around $4.6 million under the NARCliM scenario. This reflects the greater reliability of high-security entitlements.

Table 12. Economic base case outcomes — agriculture net present producer surplus averages over 40 years ($m)

Crop classification	Stochastic scenario ($m)	NARCliM scenario ($M)	Difference between the stochastic and NARCliM scenarios ($m)	Difference (%)
Annual crops	928.0	607.8	-320.2	-35.0
Permanent crops	7.0	6.0	-1.1	-15.4
Total	935	614	-321	-50

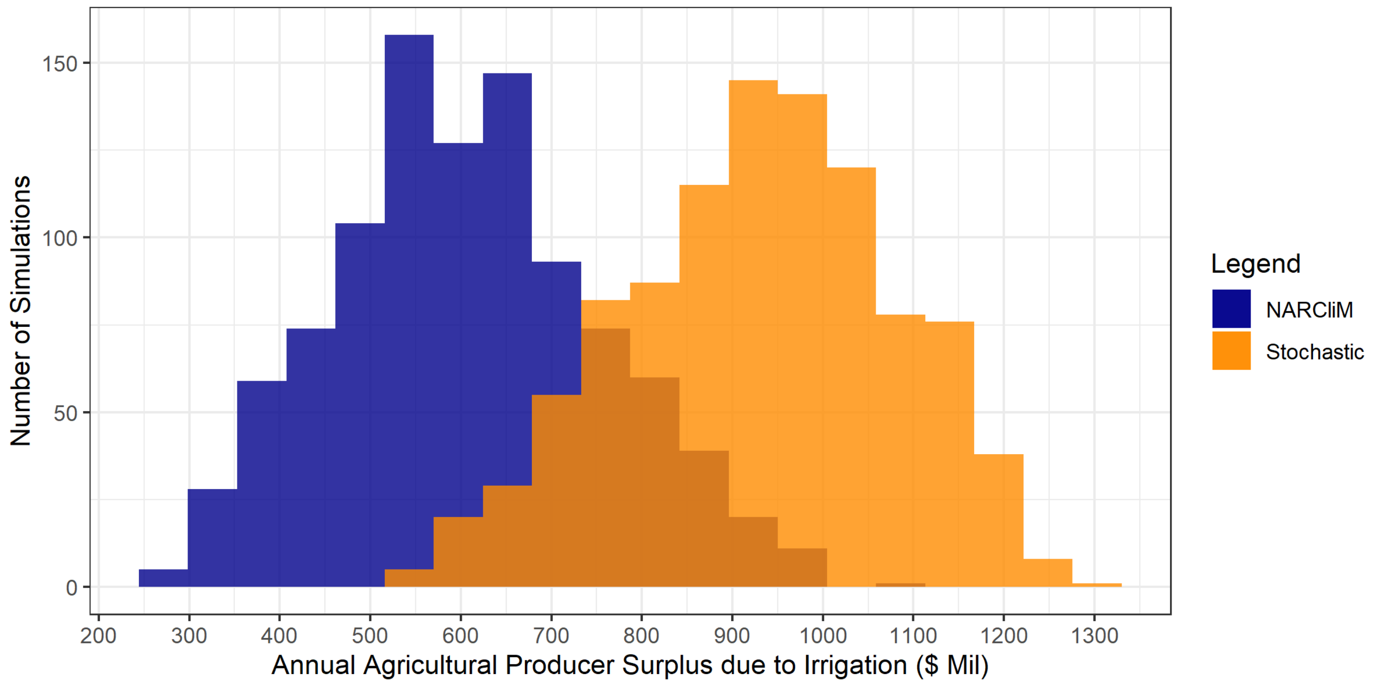

Figure 8. Annual crops net present producer surplus over 40 years

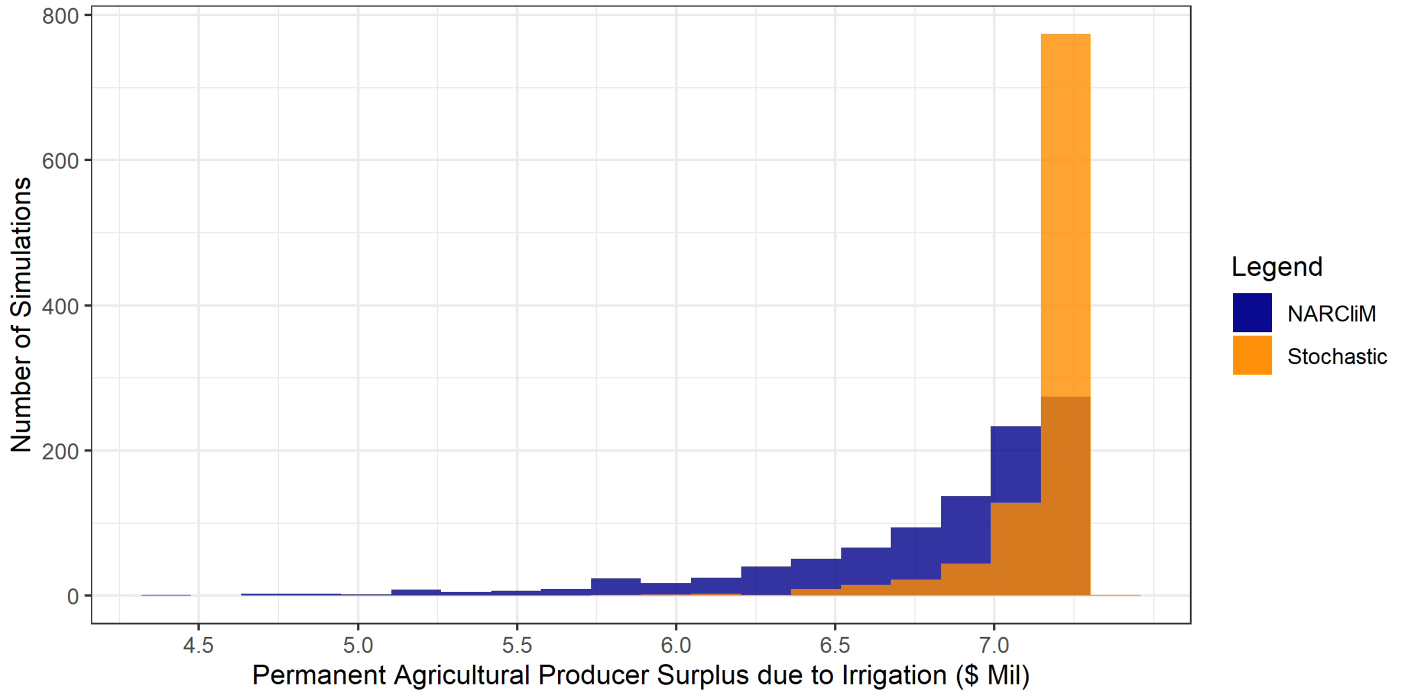

Figure 9. Permanent crops net present producer surplus over 40 years

Assumptions and uncertainties

The analyses in the regional water strategies is based on the best available information at the time. As with all types of analyses, a range of assumptions, uncertainties and qualifications are made.

Assumptions adopted within this economic base case analysis include:

- Town water supply shortfalls consider only modelled surface water availability and do not include any consideration of existing alternative supply sources such as groundwater or desalination plants. The purpose of the analysis was to identify how secure the surface water supply is for each town. Further analysis needs to be undertaken to understand how these risks can be met by existing alternative water sources that the towns already access.
- Population increases have been included in accordance with the NSW Government's Common Planning Assumptions' medium population growth forecasts. Towns within the Border Rivers region are predicted to have reductions in population; for these towns, it is assumed that population growth will be flat rather than decreasing.
- Current uses of water, in both general security and high security entitlements, are assumed to be constant over the 40 years examined. In practice, it is likely that technology and global demand for food and fibre will change the nature of the crops produced in the Border Rivers region, therefore changing amount of water used. Estimating these changes is beyond the regional water strategies project.

Uncertainties and qualifications relevant to this study include:

- The town water supply shortfall analysis presented is not a replacement for secure yield analysis undertaken by local water utilities as part of Integrated Water Cycle Management strategies; however, it can be used as an input into determining the secure yield.
- Economic outcomes are likely to be highly sensitive to the discount rate considered. The producer surpluses are based on long-run estimates. In practice, the profitability of each crop will vary year by year. Estimating these changes is beyond the scope of the regional water strategies project.