Department of Climate Change, Energy, the Environment and Water

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Economic assessment of options for the NSW Murray and Murrumbidgee regions

Regional Water Strategies Program

May 2024

Acknowledgement of Country

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

Today, they practise the oldest living culture on earth.

The NSW Government acknowledges the First Nations people/Traditional Owners from the NSW Murray and Murrumbidgee regions as having an intrinsic connection with the lands and waters of these areas. The landscape and its waters provide the First Nations people with essential links to their history and help them to maintain and practice their traditional culture and lifestyle.

We recognise the Traditional Owners were the first managers of Country. Incorporating their culture and knowledge into management of water is a significant step towards closing the gap.

Under this program, we seek to establish meaningful and collaborative relationships with First Nations People. We seek to shift our focus to a Country-centred approach; respecting, recognising and empowering cultural and traditional Aboriginal knowledge in water management processes at a strategic level.

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

As we refine and implement the regional water strategy program, we commit to helping support the health and wellbeing of waterways and Country by valuing, respecting and being guided by Traditional

Owners/First Nations people, who know if we care for Country, it will care for us.

We acknowledge that further work is required under this regional water strategy program to inform how we care for Country and ensure First Nations people hold a strong voice in shaping the future for all communities.

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Contents

Introduction

The NSW Government is developing 13 regional and 2 metropolitan water strategies that bring together the best and latest climate evidence, with a wide range of tools and solutions to plan and manage each region's water needs over the next 20 to 40 years.

The economic components of the regional water strategy options assessment process are described in the Options Assessment Process: Overview. This report provides the outcomes of detailed and rapid economic assessments that were used to inform the long list of options that influence the supply demand or allocation of water.

Options that influenced the supply, demand or allocation of water underwent a rapid economic assessment. Additional detailed economic assessments were conducted where the rapid economic assessment, or other assessments, suggested that there was merit in further investigations.

The following NSW Murray and Murrumbidgee long list options underwent rapid and detailed economic assessments:

Action #	Title	Rapid cost benefit analysis	Detailed assessment
Options for the NSW Murray region			
10	Investigate NSW Murray River system water sharing, delivery and accounting arrangements under the Murray-Darling Basin Agreement	✓	✓
13a	Investigate water access licence conversion of 10% of General Security (GS) entitlement converted to High Security (HS) entitlement	✓	✓
13b	Investigate water access licence conversion of 20% of General Security (GS) entitlement converted to High Security (HS) entitlement	✓	✓
Options for the Murrumbidgee region			
13a	Investigate water access licence conversion of 10% of general security entitlements to high security.	✓	✓

Action #	Title	Rapid cost benefit analysis	Detailed assessment
13b	Investigate water access licence conversion of 50% of general security entitlements to high security.	✓	✓
33a	Investigate new 47 GL weir near Gundagai on the lower Tumut River	✓	✓
33b	Investigate new 20 GL weir near Gundagai on the Murrumbidgee River	✓	✓
33c	Investigate new 1000 GL Dam near Gundagai on the Murrumbidgee River	✓	
35	Install gravity pipeline along Tumut River	✓	
36	(i) Enlarged Blowering Dam – 100 GL airspace reserved	✓	✓
	(ii) Enlarged Blowering Dam – 200 GL airspace reserved	✓	✓
36a	This is a combination of options 35 and 36: (i) Tumut gravity pipeline and the enlarged Blowering Dam – 100 GL airspace reserved	✓	
	(ii) Tumut gravity pipeline and the enlarged Blowering Dam – 200 GL airspace reserved	✓	
37	Enlarge Burrinjuck Storage Reservoir	✓	
38	Expand Bundidgerry off-river storage	✓	✓
39	Augment Tombullen Storage and modify operations	✓	✓

The rapid cost benefit analyses were evaluated based on the historical climate scenario (data collected over approximately 130 years). The rapid economic assessment was applied to all relevant options that influence the supply, demand or allocation of water.

The options considered for detailed analysis were informed by a series of benefit–cost analyses against the more comprehensive long-term historical and dry future climate scenarios (that both incorporate 10,000 years of stochastic data, and the dry future climate scenario adjusted with scaling factors).

Option assessment overview

Identifying the key challenges for the region and understanding the base case

The first step in the options assessment process is to define the priority challenges in the region that we need to focus on over the next 40 years.

While all the challenges and options identified in the draft strategy are important, it is not possible or feasible to address every challenge at once. The issues need to be prioritised to first tackle those that are likely to cause the most significant long-term impacts to the region.

Key challenges have been identified by understanding what the future could look like, and what could be the consequences, if we do nothing. This process is quantified in the Economic Base Case which interprets the outcomes of the hydrology for the major extractive users of water. The key challenges were used to filter and match the options in the *Draft NSW Murray and Murrumbidgee regional water strategies*. Additional options identified through stakeholder consultation to address the key challenges identified for the region were also used. This step was critical in making sure that the options selected adequately address the key challenges in the region. It was also the primary analysis used to prioritise the options that could not be quantitatively assessed.

Rapid economic assessment

Once the filtering process was undertaken, the options were assessed to determine if they influence the supply, demand or allocation of water. Options requiring hydrologic modelling were subject to quantitative assessment. Options that influence the supply and demand for water, were initially assessed through a rapid benefit–cost analysis of what they are trying to achieve.

Options aiming to improve the economic activity of the region were evaluated according to how they change the expected total economic benefits in the region. This assessment was made against the historical climate scenario, sometimes referred to as the instrumental record.

These decision criteria were used as a guide only for assessing the economic viability of an option. The outcomes of the rapid benefit–cost analysis are a decision-supporting tool (as opposed to a decision-making tool) and an outcome that is not strictly positive (i.e., with a benefit–cost ratio of less than 1) would not necessarily preclude an option from being progressed to a detailed assessment in Stage 3.

Detailed economic assessment

Options that passed through the filtering and rapid assessment processes were then assessed against the new stochastic and climate change data:

- long-term historical climate projections (stochastic data): these data assume that our future climate is similar to what the science is indicating the long-term paleoclimate was like and are based on a 10,000-year dataset
- a dry future climate scenario (NARCliM[1] modelling): the long-term historical scenario dataset is scaled using dry future climate projections under the SRES A2 climate scenario.

Assessing options against the new stochastic and dry future climate data helped to understand the resilience of the options in more extreme scenarios. This stage of the assessment measured economic outcomes.

Further details about the economic assessment process, outlined here, has been published in the *Options Assessment Process: Overview report*.[2]

Economic analysis overview

The key information that informed the benefit–cost analysis of each option included:

- **Understanding what happens if the approach is to do nothing:** hydrological modelling was undertaken for the two different hydrologic models. These models are sampled to each provide 1,000 40-year forecasts of the future of the region and how much water is available to different licences under the base case and under each option. More detail on the base case is available in the *NSW Murray and Murrumbidgee Economic Base Case*[3].
- **High-level cost estimates** were prepared for each option including capital and operational expenditure for infrastructure options[4], and operational costs for non-infrastructure options. These costs were very broad and high level. Further investigation of any option would require more detailed cost estimates.
- **Benefit estimates:** the economic value of water for towns and industries was developed and used as the primary benefit to assess against the costs. This is referred to as the Regional Water Value Function. A summary of the value of water for each major water user is detailed below. More details about how these values were calculated are in the NSW Murray and Murrumbidgee Economic Base Case.

[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.

[2] The *Options Assessment Process: Overview* can be found at: water.dpie.nsw.gov.au/__data/assets/pdf_file/0006/506463/options-assessment-process.pdf

[3] See Marsden Jacobs Associates. 2020, *Regional Water Value* Function for all regions. Available at: www.dpie.nsw.gov.au/water/plans-and-programs/regional-water-strategies/identifying-and-assessing

[4] The department engaged ARUP to develop high level cost estimates of the options in the draft NSW Murray and Murrumbidgee Regional Water Strategy long list.

Key outcomes of the detailed analysis were defined using two metrics or decision criteria: the net present value and the benefit–cost ratio.

The net present value is the summation of the present value economic outcomes of the option case minus the summation of the present value economic outcomes of the base case. It is the marginal difference between the two outcomes, with the option cost (and the timing of costs and benefits) taken into account. A positive net present value indicates that there is potential economic benefit from pursuing an option, while a negative net present value indicates that the option creates more costs than it generates benefits, when the time value of money is incorporated. Net present value can be expressed as Equation 1:

Equation 1 Net Present Value (NPV)

$$NPV_{option} = (PV_{option\ scenario} - PV_{base\ case}) - PV_{option\ cost}$$

The benefit–cost ratio divides the incremental benefits of an option to the region by the discounted whole-of-life cost (capital and operational expenditure) of the option. A benefit–cost ratio of 1 or greater indicates that the project is economically feasible as the benefits outweigh the costs. Benefit–cost ratio is illustrated in Equation 2:

Equation 2 Benefit–cost Ratio (BCR)

$$BCR = \frac{PV_{benefits}}{PV_{costs}}$$

These decision criteria should be used as a guide only for assessing the economic viability of an option. The outcomes of the rapid benefit–cost analysis are a decision-supporting tool (as opposed to a decision-making tool) and an outcome that is not strictly positive (such as an outcome with a benefit–cost ratio less than 1) did not preclude an option from being progressed to the detailed analysis stage.

In addition to these decision-making tools, the detailed analysis also conducted:

- sensitivity analysis: used to identify the extent to which changes to the key assumptions influence the outcomes of the detailed analysis. The sensitivity analysis was carried out across:
    - the discount rate (3% and 7%)
    - capital and operational expenditure (+30% / -30%)
    - the value of water assigned to each economic activity.
- distributional impacts: used to look at how the option impacts different water users and classes of licences.

The detailed assessment was completed by applying the Regional Water Value Function to the outputs of the hydrologic modelling to determine the incremental change between the base case and the option, while taking into account the cost of the option.

An Economic Impact Assessment, or Input-Output Analysis, was not undertaken as per the NSW Benefit–cost Analysis guidelines.[5] Economic Impact Assessments are concerned with measuring economic activity. They are not a tool to measure economic wellbeing created from projects, nor does it take account the alternative uses (opportunity costs) of resources. Finally, they do not necessarily measure net benefits. For example, poor investments in heavily subsidised fields of endeavour could be associated with greater levels of activity than good investments.

[5] TPG23-08, NSW Government Guide to Cost-Benefit Analysis, page 94.

Economic assumptions

The economic valuation of water to these key user groups (Table 1) has been drawn from the regional water value function and is applied as a $/ML supplied (or not supplied in the case of town water supply and permanent crops). For the NSW Murray and Murrumbidgee, the values for town water supply shortfalls are given in Table 1 and for agricultural users in Table 2.

No attempt has been made to include an assessment of the economic value of environmental impacts within this benefit–cost analysis. This is due to the high level of uncertainty regarding environmental valuations within a benefit–cost analysis context. Separate quantitative and qualitative ecological assessments have been undertaken for options that progressed past the rapid benefit–cost analysis stage.

Table 1. Key water users, NSW Murray and Murrumbidgee region

Region	Key water user	Water licence	Economic benefit of water use
NSW Murray	Town water supply (Albury, Berrigan Shire, Corowa, Deniliquin, Euston, Murray Shire, and Wentworth)	Local water utility	Reduction in economic cost of water supply shortfalls
	Annual crop producers (e.g., cotton)	• General security • Supplementary • Rainfall harvesting	Marginal increased yield of crop due to irrigation, compared to dryland production.
	Permanent crop producers (e.g., almonds)	High security	Marginal increased yield of crop due to irrigation, compared to dryland production – and – Reduction in cost associated with growing replacement crops to maturation due to crop-perishing in dry periods

Region	Key water user	Water licence	Economic benefit of water use
Murrumbidgee	Town water supply (Balranald, Gundagai, Hay, Jerilderie, Jugiong, Morundah to Coonong, and Tumut)	Local water utility	Reduction in economic cost of water supply shortfalls
	Annual crop producers (e.g., cotton)	• General security • Supplementary • Rainfall harvesting	Marginal increased yield of crop due to irrigation, compared to dryland production.
	Permanent crop producers (e.g., almonds)	High security	Marginal increased yield of crop due to irrigation, compared to dryland production – and – Reduction in cost associated with growing replacement crops to maturation due to crop-perishing in dry periods

Table 2. NSW Murray and Murrumbidgee agricultural water supply economic benefit[6]

Region	Crop/Stock	Cropping	Water licence	Marginal economic benefit (of water) ($/ML)
NSW Murray Region	Cotton	Annual	• General security • Supplementary • Rainfall run off	225
	Rice	Annual		175
	Potatoes	Annual		150
	Wheat	Annual		150
	Oats	Annual		150
	Barley	Annual		150

[6] Note: Only the values for the highest value crop were used. Other values on crop types in the region are in Marsden Jacobs Associates (2020) *Regional Water Value Functions*.

Region	Crop/Stock	Cropping	Water licence	Marginal economic benefit (of water) ($/ML)
	Lucerne (Hay)	Annual		150
	Almonds	Permanent	• High security	1100 (1,300)
	Olives	Permanent		1,000 (2,600)
	Viticulture	Permanent		475 (825)
	Nectarines/Peaches	Permanent		450 (2,100)
	Oranges	Permanent		450 (2,100)
Murrumbidgee Region	Cotton	Annual	• General security • Supplementary • Rainfall run off	225
	Rice	Annual		175
	Potatoes	Annual		150
	Wheat	Annual		150
	Oats	Annual		150
	Barley	Annual		150
	Lucerne (Hay)	Annual		150
	Almonds	Permanent	• High security	1,000 (1,300)
	Olives	Permanent		975 (2,500)
	Viticulture	Permanent		500 (850)
	Nectarines/Peaches	Permanent		450 (2,100)
	Oranges	Permanent		450 (2,100)

*Refers to $/ML during shortfall periods

Population increases have been included in accordance with the NSW Government's Common Planning Assumptions' medium population growth forecasts. Where a town has a negative growth forecast, the analysis undertaken assumes that those populations will remain the same, rather than decreasing, to ensure conservative estimates across all outputs.

Infrastructure option costings

The capital and operational expenditure for infrastructure options was derived from a combination of:

- cost models built to allow a consistent comparative assessment across regions. These are not site-specific cost estimates and are not intended to be used beyond the scope of this study. The cost models rely on the relationship between the physical characteristics of infrastructure, such as dam size or pipeline length, and the expected cost to construct, with each category of infrastructure — dams, pipelines, desalination plants, etc. — having its own unique valuation method. These relationships are arrived at through analysis of similar projects and professional assessment. This was applied for long listed options 33b, 33c, 35, 37 and 38.
- High level cost estimates based on a 'Class 5' level estimate of capital expenditure in accordance with the Association for the Advancement of Cost Engineering (AACE) cost estimate classification system, which targets a level of project definition up to 2%. The capital expenditure prepared is a summary of direct and indirect construction costs, however there are several exclusions such as land acquisition cost and environmental offsets. This was applied for long listed options 33a and 36.

Capital and operational expenditure costs of options were discounted to present day values with the following assumptions:

- the option is constructed and fully operational from the start of Year 1 (that is, at Year 0), indicating no discounting is applied to the construction costs.
- operational costs occur annually for the full period of the benefit–cost analysis from Year 1.

A residual value for infrastructure was considered through the addition of an end-of-life value for it, discounted at a linear rate at the end of the analysis period.

Economic assessment results

Options for the NSW Murray region

Option 10: Investigate NSW Murray River system water sharing, delivery and accounting arrangements under the Murray-Darling Basin Agreement

This proposed option would review current water management arrangements under the Murray-Darling Basin (MDB) Agreement in the context of a changing climate and reduced water availability. The subcomponent of this option that was assessed focussed purely on determining the benefit/impact to NSW interests from the removal of provisions in the MDB Agreement concerning the release of additional dilution flows. As such, the results of this assessment are only applicable to this option sub-component, and not the broader components of option 10.

Rapid cost benefit analysis of the option, conducted on the instrumental dataset, found a positive net present value while the benefit–cost ratio is not applicable given the costs of implementing it were assigned a zero-dollar value. See Table 3.

Table 3. Investigate NSW Murray River system water sharing, delivery and accounting arrangements under the Murray-Darling Basin agreement rapid benefit–cost analysis outcomes overview

Option	Description	Net present value ($m)	Benefit–cost ratio
10	Investigate NSW Murray River system water sharing, delivery and accounting arrangements under the Murray-Darling Basin Agreement	32.2	NA

Outcome of the rapid benefit–cost analysis is that the option would gain over $32 million in net present economic value. It should be noted again that this net benefit does not incorporate the administrative costs of introducing the policy.

Table 4 shows the results of distributional analysis for Option 10 using the historical dataset, with the percentage change compared to the base case estimates from the NSW Murray and Murrumbidgee Economic Base Case in the brackets. These outcomes show that there are mild positive changes for all water users, with 0.2% to town water users, 0.4% to annual crop users, and 0.1% to permanent crop users.

Table 4. Distributional analysis for the Investigate NSW Murray River system water sharing, delivery and accounting arrangements under the Murray-Darling Basin agreement option

Option	Town water supply ($m, (% change))	Annual crops ($m, (% change))	Permanent crops ($m, (% change))
10	1.7 (0.2%)	26.1 (0.4%)	4.5 (0.1%)

Option 10 proceeded to detailed assessment. Table 5 provides the summary data for the modelled proposed option under two additional climate scenarios. These results represent the averages across all 1,000 realisations undertaken in the analysis. As each 40-year analysis period has an equal likelihood of occurrence, the averages also represent the expected values — or outcomes — for the proposed option. The outcomes described in the table suggest that the option produces positive expected net present values under both scenarios. The benefit–cost ratios are again not applicable given the zero net present cost of the option.

Table 5. Average results for Investigate NSW Murray River system water sharing, delivery and accounting arrangements under the Murray-Darling Basin agreement

Option	Net present cost ($m)	Long-term historical net present value ($m)	Dry future climate net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate benefit–cost ratio
10	0	40.3	29.4	NA	NA

Table 6 shows a range of outcomes generated by the 1,000 simulations to assess option 10 conducted under two climate scenarios. Under the long-term historical around 20 per cent of the net present values are negative and the remaining 80 per cent produce positive ones. This represents a wide range of possible outcomes. At the most extreme, the option produces a loss of $144.0 million whereas the best decile outcomes achieve $255.9 million in benefits. Similarly, under the dry future climate scenario, around 60 per cent of the total realisations produce positive values, indicating slightly lower possibilities of option 10 being economically viable compared to in the long-term historical scenario.

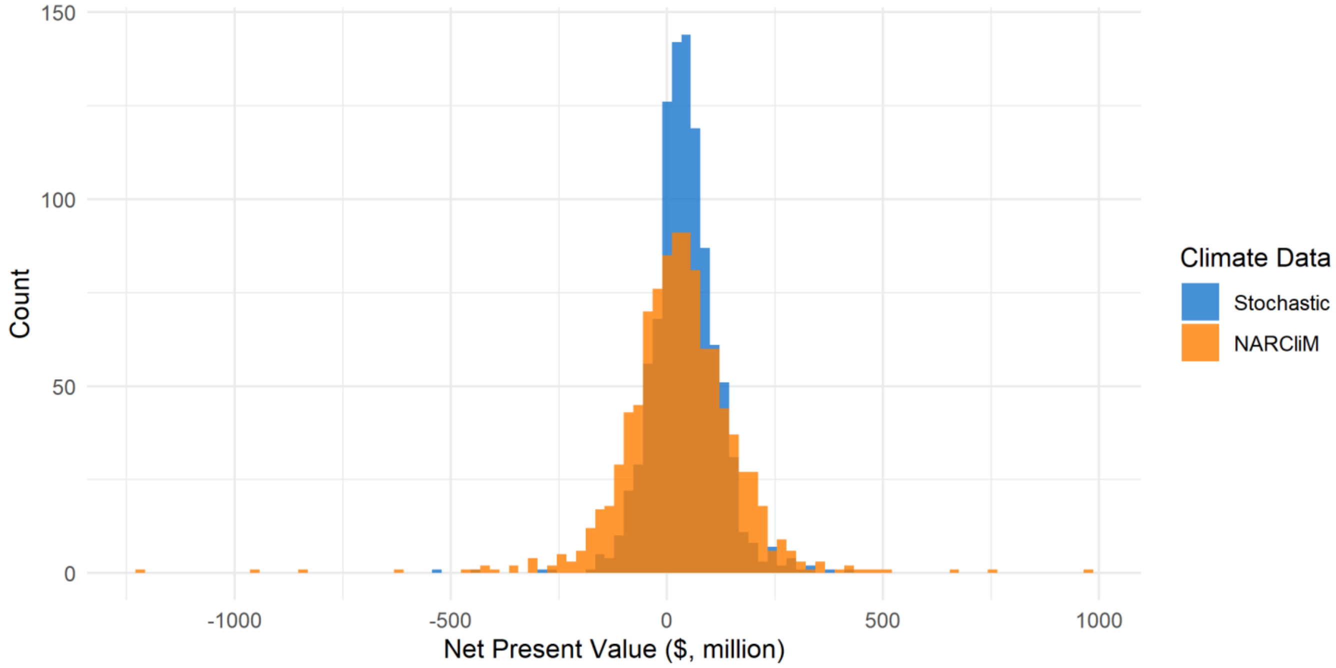
Table 6. Decile and extreme centile results for Investigate NSW Murray River system water sharing, delivery and accounting arrangements under the Murray-Darling Basin agreement

Percentile	Long-term historical net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate net present value ($m)	Dry future climate benefit–cost ratio
1%	-144.0	NA	-359.6	NA
10%	-46.2	NA	-104.9	NA
20%	-11.0	NA	-53.7	NA
30%	7.4	NA	-21.4	NA
40%	22.9	NA	4.0	NA
50%	37.0	NA	29.4	NA
60%	52.9	NA	52.5	NA
70%	70.2	NA	81.2	NA
80%	93.5	NA	117.0	NA
90%	129.2	NA	172.6	NA
99%	255.9	NA	358.0	NA

In addition to, shows the distribution of net present values generated by option 10 under the 2 climate scenarios. Option 10 produces higher average net present value in the long-term historical scenario and performs slightly better on the left side of the distribution compared to that under the dry future climate scenario. This is different from a typical case where an option under a dry future climate would usually outperform the long-term historical one. This is because the drier climate and associated increased risk to town water supply security would be mitigated by the proposed option.

Figure 1 shows that the net present values of option 10 have a wider distribution of outcomes under the dry future climate scenario compared to that under the long-term historical one, with both positive and negative outcomes being more extreme.

Figure 1. Net present value histogram - Investigate NSW Murray River system water sharing, delivery and accounting arrangements under the Murray-Darling Basin agreement



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Sensitivity analysis

The sensitivity analysis is used to identify the extent to which changes to the key assumptions influence the outcomes of the detailed assessment. The sensitivity analysis was undertaken for the combined option which included the following cases:

- higher (7%) and lower (3%) discount rates
- higher (+30%) and lower (-30%) combined option costs
- higher and lower economic costs, the magnitude of which varies depending on the marginal value altered.

Table 7 provides the summary results of option 10 for the central case and sensitivity analysis under the long-term historical and dry future climate scenarios. The analysis suggests that net present values under both scenarios are sensitive to changes in discount rate and economic values. For example, while the central case of option 10 under the long-term historical scenario is $40.3 million, if economic values of water usage (e.g., values of irrigated crops) decrease to a lower level, the average net present value of option 10 shrinks to $23.9 million. Under both climate scenarios the lowest average net present value happens when there is a high discounting rate (7%), and highest happens when there is a low discounting rate (3%). Nevertheless, in both scenarios, and with all sensitivities, the option consistently produces results with positive average net present values.

Table 7. Sensitivity analysis on Investigate NSW Murray River system water sharing, delivery and accounting arrangements under the Murray-Darling Basin agreement across the long-term historical and dry future climate scenarios

Long-term historical

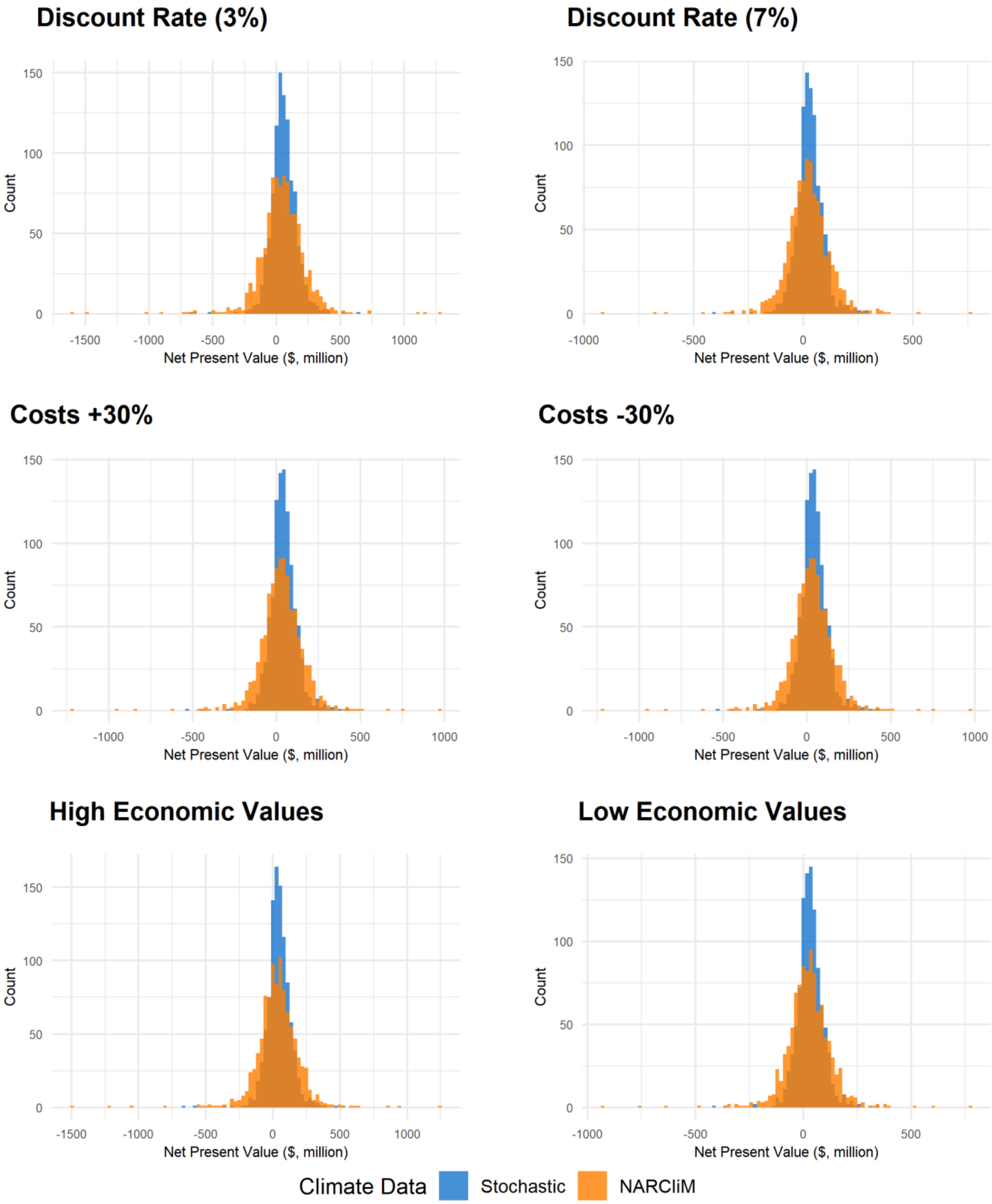
Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	0	40.3	NA	NA	NA	NA
Low discount rate (3%)	0	55.4	NA	NA	NA	NA
High discount rate (7%)	0	30.4	NA	NA	NA	NA
Option cost (+30%)	0	40.3	NA	NA	NA	NA
Option cost (-30%)	0	40.3	NA	NA	NA	NA
Economic values (high)	0	45.4	NA	NA	NA	NA
Economic values (low)	0	31.5	NA	NA	NA	NA

Dry future climate

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	0	29.4	NA	NA	NA	NA
Low discount rate (3%)	0	43.1	NA	NA	NA	NA
High discount rate (7%)	0	20.8	NA	NA	NA	NA
Option cost (+30%)	0	29.4	NA	NA	NA	NA
Option cost (-30%)	0	29.4	NA	NA	NA	NA
Economic values (high)	0	35.9	NA	NA	NA	NA
Economic values (low)	0	23.9	NA	NA	NA	NA

Figure 2 shows the net present value outcomes of the sensitivity analysis as histograms, supporting the results of Table 7 demonstrating that the option could be economically viable given all sensitive factors included in the analysis and under both climate scenarios. It should also be noted that the high (+30%) and low (-30%) option cost cases would generate the same results as in the central case, because the implementing cost of option 10 is assigned with a zero value.

Figure 2. Investigate NSW Murray River system water sharing, delivery and accounting arrangements under the Murray-Darling Basin agreement sensitivity case net present value shown as histograms



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Distributional analysis

Table 8 shows the results of distributional analysis of the option under the long-term historical and dry future climate scenarios. This assessment looks at how the option impacts different water users and classes of licences. In total, the analysis reveals minimal improvements when compared to the baseline estimates from the NSW Murray and Murrumbidgee Economic Base Case. Impacts to different user groups range from 0.0% to at most 0.7%, and with a total percentage of change around 0.4% under both climate scenarios.

Table 8. Average distributional impacts from Investigate NSW Murray River system water sharing compared to the economic base case across both scenarios

Long-term historical

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	-887.5	7013.1	4661.9	10787.4
Option outcomes ($m)	-887.2	7048.1	4666.8	10827.7
Change ($m)	0.3	35.0	4.9	40.3
% Change	0.0%	0.5%	0.1%	0.4%

Dry future climate

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	-1136.4	4626.2	3958.6	7448.4
Option outcomes ($m)	-1133.5	4626.7	3984.5	7477.7
Change ($m)	2.9	0.5	25.9	29.3
% Change	0.3%	0.0%	0.7%	0.4%

Option 13a: Investigate water access licence conversion of 10% of General Security (GS) entitlement converted to High Security (HS) entitlement

This option aims to give regulated river water users the ability to improve the security of their entitlements. It involves the voluntary conversion of 10% of consumptive general security (GS) entitlements to high security (HS) entitlements. To ensure Sustainable Diversion Limit (SDL) compliance, we derived a conversion factor for the converted entitlements and increased the storage reserve by the additional HS entitlements.

The rapid benefit–cost analysis shown in Table 9, conducted on the historical record, produced a positive net present value. The benefit–cost ratio is not applicable because the cost of implementation is assigned a zero-dollar value.

Table 9. Rapid benefit–cost analysis outcomes overview of 10% of General Security (GS) entitlement converted to High Security (HS) entitlement, NSW Murray region

Action	Description	Net present value ($m)	Benefit–cost ratio
13a	10% of General Security (GS) entitlement converted to High Security (HS) entitlement	2403.4	NA

Table 10 shows the results of the distributional analysis for option 13a using the historical dataset. The permanent crop user benefits significantly from the option with a 64% improvement compared to the baseline results in the NSW Murray economic base case, while for town water users the change is negligible with a percentage only 0.3% and for annual crops water users the net economic gain is negative (-7.4%).

Table 10. Rapid benefit–cost analysis distributional analysis of 10% of General Security (GS) entitlement converted to High Security (HS) entitlement, NSW Murray region

Action	Town water supply ($m, (% change))	Annual crops ($m, (% change))	Permanent crops ($m, (% change))
13a	3.1 (0.3%)	-525.0 (-7.4%)	2925.3 (64.1%)

Option 13 proceeded to detailed assessment. Table 11 provides the summary data using the two alternative scenarios, and the outcomes suggest that the option produces positive average net present values under both the scenarios, with slightly better performance in the dry future climate scenario.

Table 11. Average results 10% of General Security (GS) entitlement converted to High Security (HS) entitlement, NSW Murray region

Option	Net present cost ($m)	Long-term historical net present value ($m)	Dry future climate net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate benefit–cost ratio
13a	0	2390.3	2549.3	NA	NA

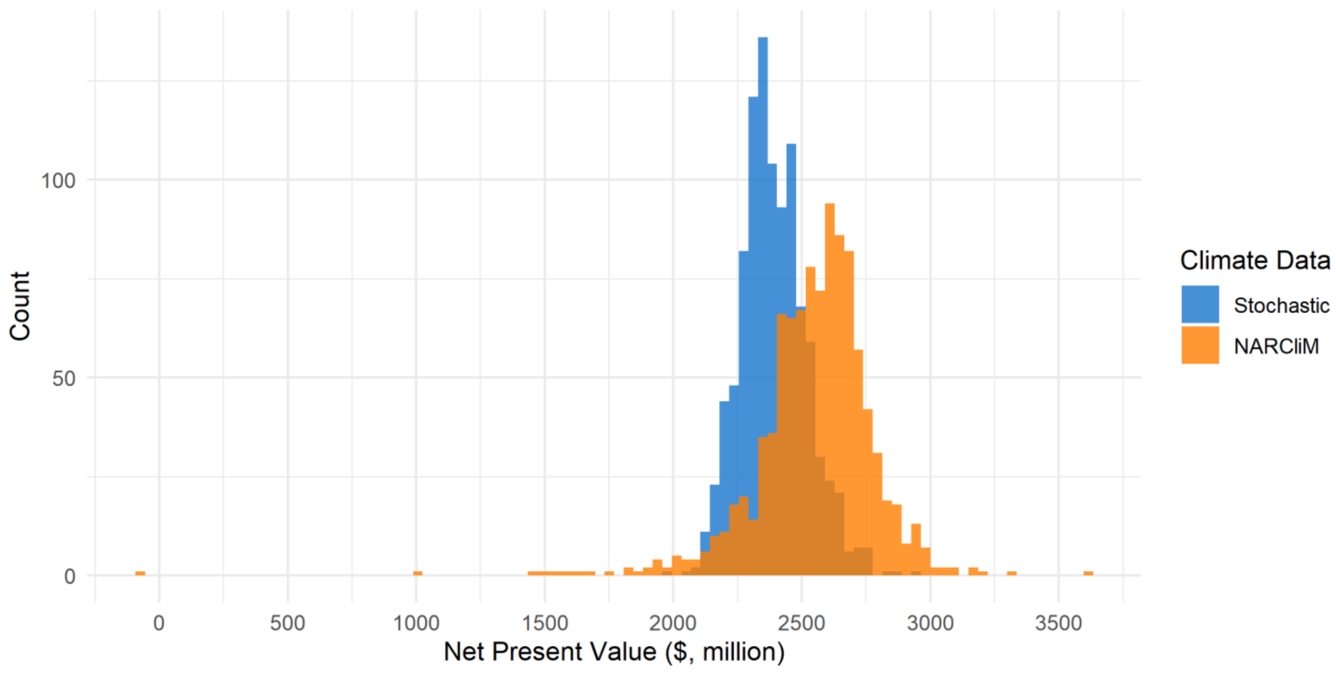
Table 12 presents the deciles and extreme centiles of net present values generated by option 13a. It shows that from the 1% to 99% percentiles the option would consistently generate positive realisations under both scenarios. This indicates that the possibility of option 13a being economically viable is very high. The benefit–cost ratios under both scenarios are not applicable because a zero-value implementation cost assigned to this option.

Table 12. Decile and extreme centile results for 10% of General Security (GS) entitlement converted to High Security (HS) entitlement, NSW Murray region

Percentile	Long-term historical net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate net present value ($m)	Dry future climate benefit–cost ratio
1%	2135.4	NA	1822.8	NA
10%	2234.2	NA	2297.2	NA
20%	2287.1	NA	2415.3	NA
30%	2319.7	NA	2469.8	NA
40%	2350.0	NA	2524.0	NA
50%	2375.7	NA	2575.5	NA
60%	2415.5	NA	2618.4	NA
70%	2455.7	NA	2660.6	NA
80%	2489.2	NA	2705.0	NA
90%	2549.4	NA	2782.1	NA
99%	2737.6	NA	3005.0	NA

Figure 3 provides additional information regarding the distribution of net present values generated by option 13a under the long-term historical and dry future climate scenarios. It reinforces the fact that under both, the option produces mostly positive realisations, confirming its economic viability. It should be noted that the option under the dry future climate scenario outperforms that under the long-term historical one with larger value of mean, median and maximum, but also with higher level of variation (i.e., more uncertainties).

Figure 3. Net present value histogram - 10% of General Security (GS) entitlement converted to High Security (HS) entitlement, NSW Murray region



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Sensitivity analysis

Sensitivity analysis was undertaken for the combined option which included the following cases:

- higher (7%) and lower (3%) discount rates
- higher (+30%) and lower (-30%) combined option costs
- higher and lower economic costs, the magnitude of which varies depending on the marginal value altered.

The outcomes of sensitivity analysis are shown in Table 13. The highest net present value results from option 13a occurs in the low discount rate (3%) case while the lowest value is in the high discount rate (7%) case. These results suggest that the performance of option 13a is most sensitive to the change of discount rate, with the rationale that high discount rates would effectively lower present values of future economic benefits generated by the option and vice versa. Nevertheless, in both datasets and with all sensitivities the option 13a would still produce results with positive expected net present values.

Table 13. Sensitivity analysis on 10% of General Security (GS) entitlement converted to High Security (HS) entitlement, NSW Murray region

Long-term historical

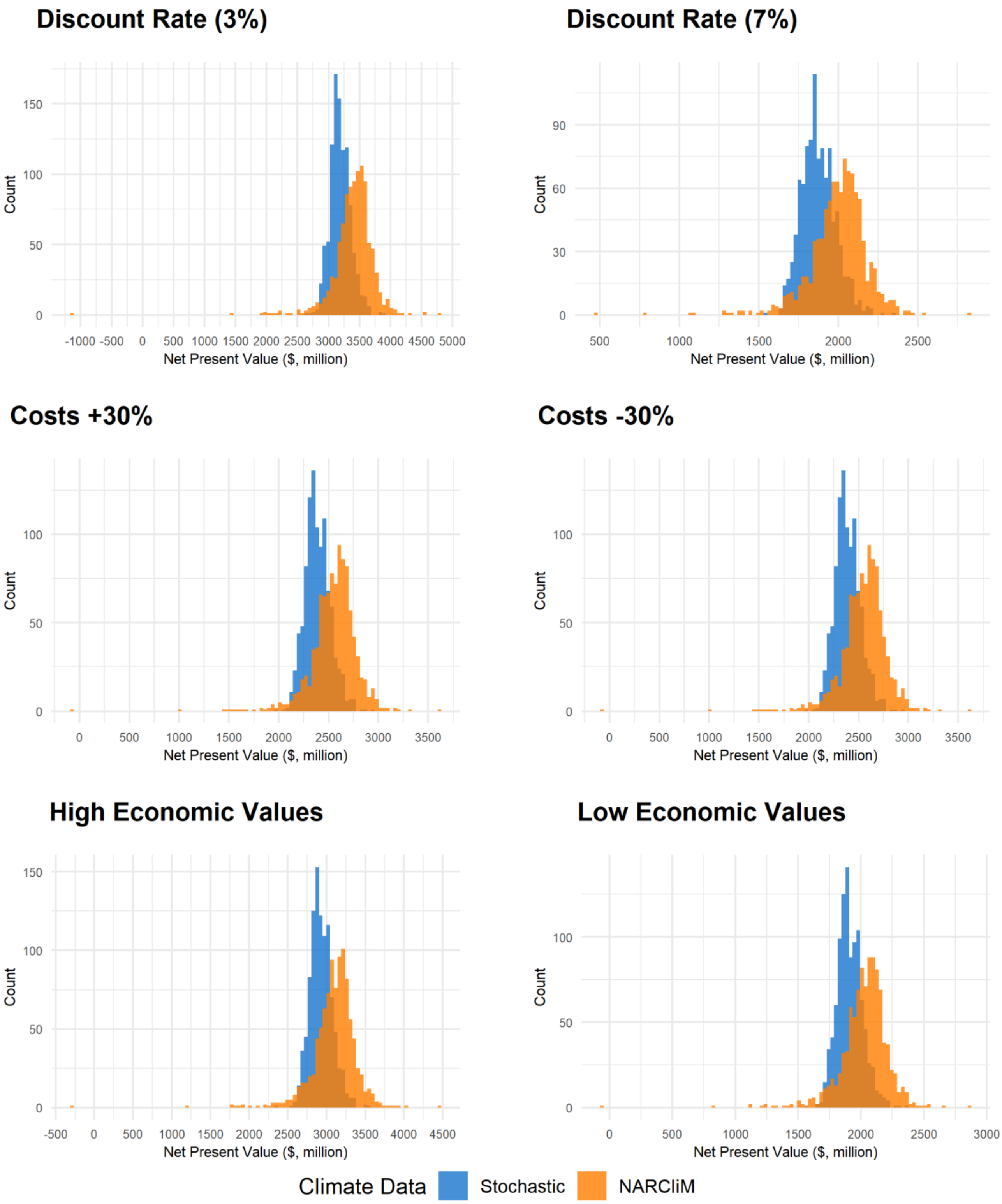
Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit-cost ratio average	Benefit-cost ratio minimum	Benefit-cost ratio maximum	% of benefit-cost ratio with benefit-cost ratio > 1
Central	0	2390.3	NA	NA	NA	NA
Low discount rate (3%)	0	3189.8	NA	NA	NA	NA
High discount rate (7%)	0	1874.3	NA	NA	NA	NA
Option cost (+30%)	0	2390.3	NA	NA	NA	NA
Option cost (-30%)	0	2390.3	NA	NA	NA	NA
Economic values (high)	0	2931.3	NA	NA	NA	NA
Economic values (low)	0	1910.9	NA	NA	NA	NA

Dry future climate

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	0	2549.3	NA	NA	NA	NA
Low discount rate (3%)	0	3400.8	NA	NA	NA	NA
High discount rate (7%)	0	1999.1	NA	NA	NA	NA
Option cost (+30%)	0	2549.3	NA	NA	NA	NA
Option cost (-30%)	0	2549.3	NA	NA	NA	NA
Economic values (high)	0	3093.9	NA	NA	NA	NA
Economic values (low)	0	2024.7	NA	NA	NA	NA

Histograms of sensitivity analysis outcomes are shown in Figure 4, supporting the results of Table 13 demonstrating that the option is robust given all sensitive factors included in the analysis and under both climate scenarios, but performs significantly better in the dry future climate scenario.

Figure 4. 10% of General Security (GS) entitlement converted to High Security (HS) entitlement sensitivity case net present value shown as histograms, NSW Murray region



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Distributional analysis

Table 14 shows the outcomes of average distributional impacts of option 13a under the long-term historical and dry future climate scenarios across the three different water user groups. The results suggest there are negligible changes for town water users in both modelled climate scenarios. While annual crops results show decreased economic outcomes (around -5% to -8%) for both modelled climate scenarios, the permanent crops groups see improvements compared to the baseline estimates ranging from 63% to 70%.

Table 14. Average distributional impacts from 10% of General Security (GS) entitlement converted to High Security (HS) entitlement across both datasets, NSW Murray region

Long-term historical

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	-887.5	7013.1	4661.9	10787.4
Option outcomes ($m)	-886.2	6456.0	7607.9	13177.7
Change ($m)	1.3	-557.1	2946.0	2390.3
% Change	0.1%	-7.9%	63.2%	22.2%

Dry future climate

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	-1136.4	4626.2	3958.6	7448.4
Option outcomes ($m)	-1099.6	4381.9	6715.4	9997.7
Change ($m)	36.8	-244.3	2756.8	2549.3
% Change	3.2%	-5.3%	69.6%	34.2%

Option 13b: Investigate water access licence conversion of 20% of General Security (GS) entitlement converted to High Security (HS) entitlement

This option aims to give regulated river water users the ability to improve the security of their entitlements. It involves the voluntary conversion of 20% of consumptive general security (GS) entitlements to high security (HS) entitlements. To ensure SDL compliance we derived a conversion factor for the converted entitlements and increased the storage reserve by the additional HS entitlements.

The rapid benefit–cost analysis, conducted on the historical record, produced a positive net present value while the benefit–cost ratio is not applicable due to a zero-dollar value assigned to the implementation cost. See Table 15.

Table 15. Rapid benefit–cost analysis outcomes overview for the 20% of General Security (GS) entitlement converted to High Security (HS) entitlement option, NSW Murray region

Action	Description	Net present value ($m)	Benefit–cost ratio
13b	20% of General Security (GS) entitlement converted to High Security (HS) entitlement	5137.3	NA

Table 16 shows the distributional outcomes across the different water user groups using the historical dataset. It shows that option 13b results in negligible improvements for towns and communities and negative impacts to the annual crop user group. However permanent crops experience significant improvement with a percentage change of 136.8% in net present value compared to the baseline estimates.

Table 16. Rapid benefit–cost analysis distributional analysis for the 20% of General Security (GS) entitlement converted to High Security (HS) entitlement option, NSW Murray region

Option	Town water supply ($m, (% change))	Annual crops ($m (% change))	Permanent crops ($m (% change))
13b	3.8 (0.4%)	-1109.5 (-15.7%)	6243.1 (136.8%)

Option 13b proceeded to detailed assessment. Table 17 provides the summary data for the modelled proposed option using the two additional scenarios. The outcomes suggest that option 13b would also produce positive expected net present values under both the long-term historical and the dry future climate scenarios. However, with a dry future climate, performance of the option is expected to slightly improve.

Table 17. Average results for the 20% of General Security (GS) entitlement converted to High Security (HS) entitlement option, NSW Murray region

Option	Net present cost ($m)	Long-term historical net present value ($m)	Dry future climate net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate benefit–cost ratio
13b	0	5130.7	5515.3	NA	NA

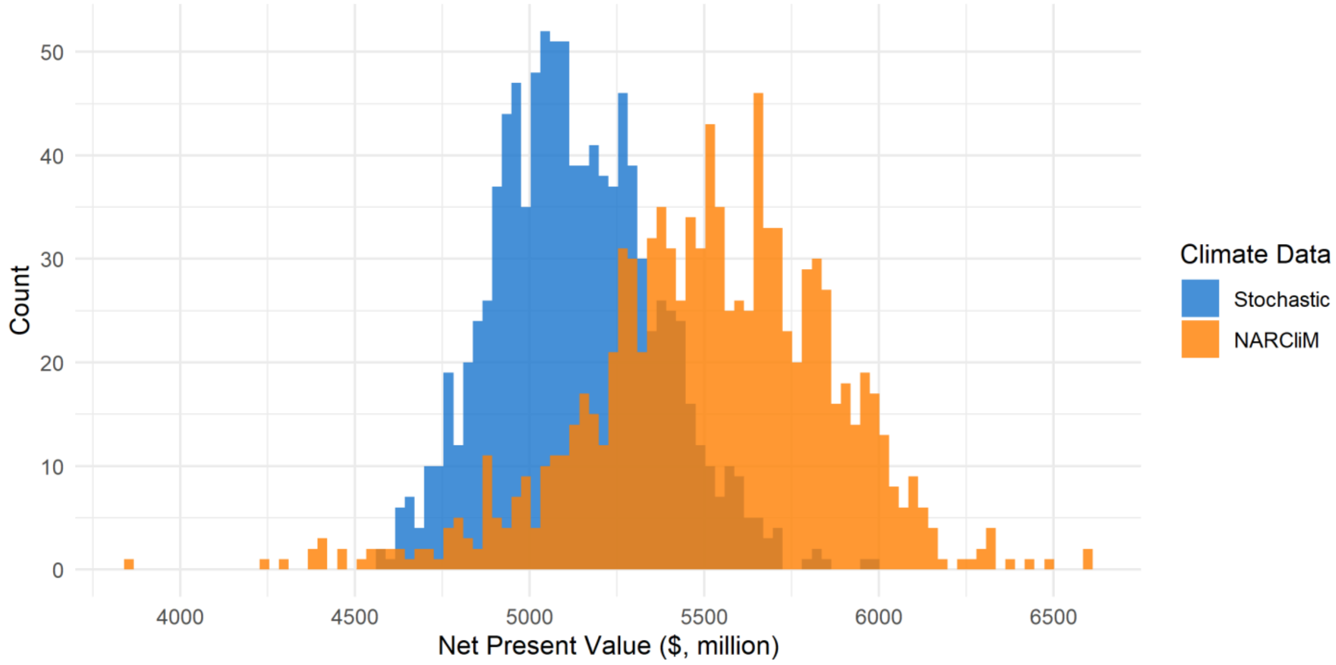
Table 18 and Figure 5 describe the distribution of net present values of option 13b under both the long-term historical and dry future climate scenarios. Table 18 suggests that from the 1% to 99% percentiles the option generates net present values that are positive. Figure 5 further confirms that under both climate scenarios, all net present values produced by option 13b lie strictly within the positive range. This suggests a very high possibility that the option is economically viable.

Table 18. Decile and extreme centile results for 20% of General Security (GS) entitlement converted to High Security (HS) entitlement, NSW Murray region

Percentile	Long-term historical net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate net present value ($m)	Dry future climate benefit–cost ratio
1%	4648.8	NA	4504.2	NA
10%	4851.6	NA	5086.7	NA
20%	4935.7	NA	5260.8	NA
30%	4998.7	NA	5360.4	NA
40%	5058.1	NA	5448.7	NA
50%	5110.3	NA	5528.9	NA
60%	5181.2	NA	5623.2	NA
70%	5252.6	NA	5700.0	NA
80%	5323.4	NA	5808.6	NA
90%	5433.3	NA	5935.4	NA
99%	5682.9	NA	6281.8	NA

Figure 5 shows that the option achieves better result under the dry future climate scenario. In the long-term historical scenario only around 60% of results are above $5,000 million. Under a dry future climate more than 90% of all results are higher than this value. This is because potential loss associated with a drier climate under the dry future climate scenario is being effectively mitigated by the proposed option.

Figure 5. Net present value histogram - 20% of General Security (GS) entitlement converted to High Security (HS) entitlement, NSW Murray region



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Sensitivity analysis

Sensitivity analysis was undertaken for the combined option which included the following cases:

- higher (7%) and lower (3%) discount rates
- higher (+30%) and lower (-30%) combined option costs
- higher and lower economic costs, the magnitude of which varies depending on the marginal value altered.

Table 19 provides the sensitivity analysis outcomes of option 13b for the long-term historical and dry future climate scenarios. The case corresponding to highest average net present value is when the discount rate is as low as 3%, and the case with lowest net present value is when the discount rate raised to 10% compared to a central case of 7%. These outcomes suggest that the performance of option 13b is most sensitive to changes in discount rate. Nevertheless, the proposed option consistently produced positive expected net present values under all sensitivity cases and in both scenarios.

Table 19. Sensitivity analysis on 20% of General Security (GS) entitlement converted to High Security (HS) entitlement, NSW Murray region

Long-term historical

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit-cost ratio average	Benefit-cost ratio minimum	Benefit-cost ratio maximum	% of benefit-cost ratio with benefit-cost ratio > 1
Central	0	5130.7	NA	NA	NA	NA
Low discount rate (3%)	0	6848.8	NA	NA	NA	NA
High discount rate (7%)	0	4022.0	NA	NA	NA	NA
Option cost (+30%)	0	5130.7	NA	NA	NA	NA
Option cost (-30%)	0	5130.7	NA	NA	NA	NA
Economic values (high)	0	6290.1	NA	NA	NA	NA
Economic values (low)	0	4101.6	NA	NA	NA	NA

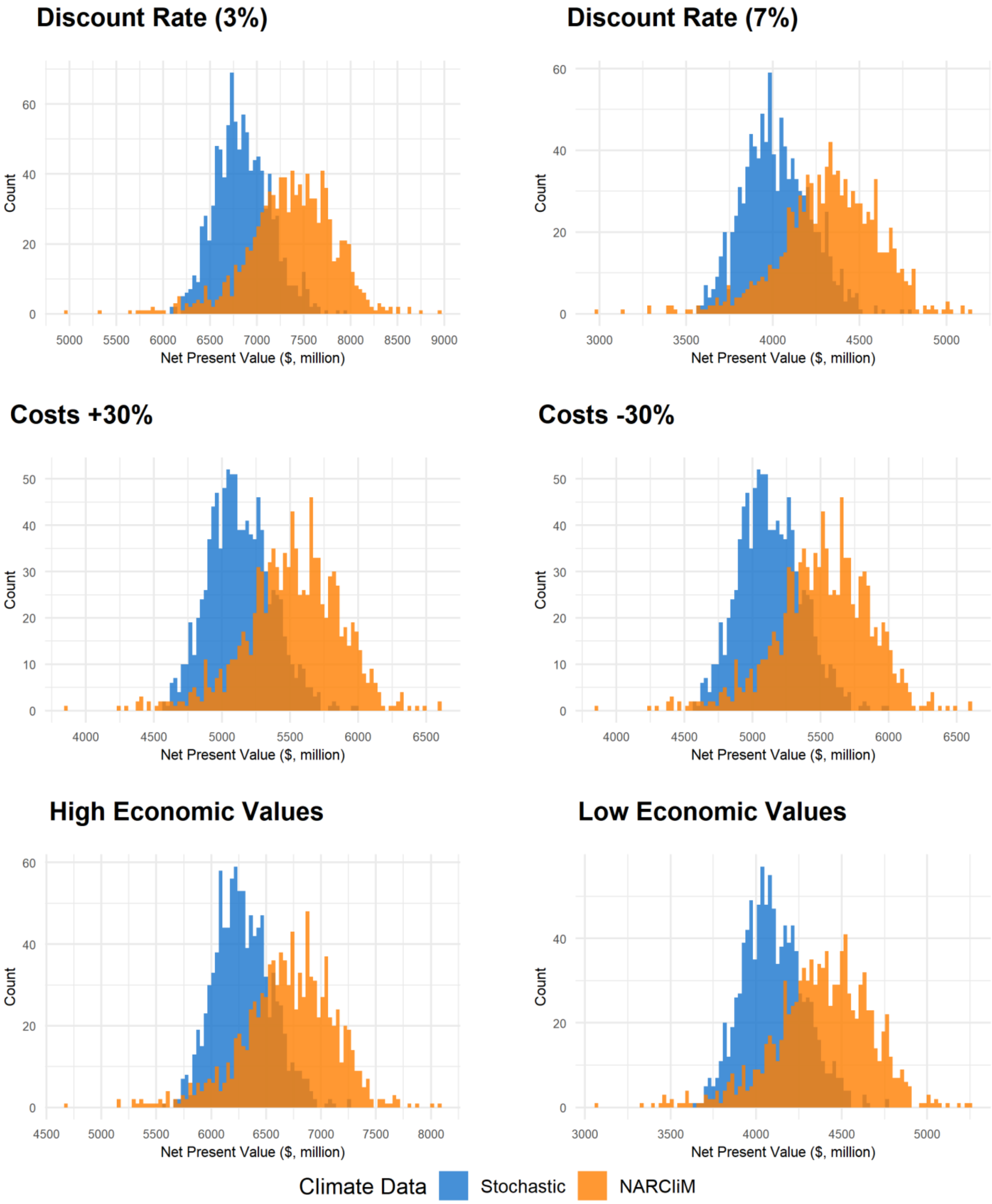
Dry future climate

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit-cost ratio average	Benefit-cost ratio minimum	Benefit-cost ratio maximum	% of benefit-cost ratio with benefit-cost ratio > 1
Central	0	5515.3	NA	NA	NA	NA

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Low discount rate (3%)	0	7358.5	NA	NA	NA	NA
High discount rate (7%)	0	4324.3	NA	NA	NA	NA
Option cost (+30%)	0	5515.3	NA	NA	NA	NA
Option cost (-30%)	0	5515.3	NA	NA	NA	NA
Economic values (high)	0	6697.9	NA	NA	NA	NA
Economic values (low)	0	4385.9	NA	NA	NA	NA

Histograms of net present values given 6 sensitivity cases under both climate scenarios are shown in Figure 6, supporting the results of Table 19. This demonstrates, while outcomes of option 13b are sensitive to discount rate and economic values, under both scenarios the option still demonstrates economic viability as all generated values lie strictly within the positive range. It also reinforces that the option produces net present values with higher level dispersion under the dry future climate scenario.

Figure 6. 20% of General Security (GS) entitlement converted to High Security (HS) entitlement sensitivity case net present value shown as histograms, NSW Murray region



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Distributional analysis

Table 20 displays the outcomes of average distributional impacts of option 13b under two climate scenarios across the three water user groups. The results show that while the option brings mild improvements to town water user groups (0.3% in the long-term historical scenario and 5.4% in the dry future climate scenario), for annual crops users the impacts from option 13b are negative under both. On the other hand, the permanent crops irrigators would benefit from the option with a percentage change of 135% under the long-term historical scenario and 153% under the dry future climate scenario, when compared to the NSW Murray baseline estimates.

Table 20. Average distributional impacts 20% of General Security (GS) entitlement converted to High Security (HS) entitlement option across both datasets, NSW Murray region

Long-term historical

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	-887.5	7013.1	4661.9	10787.4
Option outcomes ($m)	-884.9	5836.7	10966.3	15918.1
Change ($m)	2.6	-1176.4	6304.4	5130.7
% Change	0.3%	-16.8%	135.2%	47.6%

Dry future climate

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	-1136.4	4626.2	3958.6	7448.4
Option outcomes ($m)	-1074.6	4057.4	9980.9	12963.7
Change ($m)	61.8	-568.8	6022.3	5515.3
% Change	5.4%	-12.3%	152.1%	74.1%

Options for the Murrumbidgee region

Option 13a: Investigate water access licence conversion of 10% of general security entitlements to high security

This option aims to give regulated river water users the ability to improve the security of their entitlements. It involves the voluntary conversion of 10% of consumptive general security (GS) entitlements to high security (HS) entitlements. To ensure SDL compliance, we derived a conversion factor for the converted entitlements and increased the storage reserve by the additional HS entitlements.

The result of the rapid benefit–cost analysis as shown in Table 21 is that the option produces a positive net present value of $993.3 million. The implementing cost associated with option 13a is assigned with zero-dollar value and therefore the benefit–cost ratio is non-applicable. However, it should be noted that this net benefit does not incorporate the administrative costs of introducing the policy.

Table 21. Rapid benefit–cost analysis outcomes overview for the 10% of General Security (GS) entitlement converted to High Security (HS) entitlement option, Murrumbidgee region

Option	Description	Net present value ($m)	Benefit–cost ratio
13a	Investigate water access licence conversion of 10% of general security entitlements to high security	993.3	NA

Table 22 shows the outcomes of distributional analysis for option 13a using the historical data. These results reveal that the option brings negligible change for town water users, moderate negative change (-6.9%) to annual crops irrigators, and some improvement to permanent crops irrigators with a percentage change of 18% compared to the baseline estimates.

Table 22. Distributional analysis for the Investigate water access licence conversion of 10% of general security entitlements to high security option, Murrumbidgee region

Option	Town water supply ($m, (% change))	Annual crops ($m, (% change))	Permanent crops ($m, (% change))
13a	Negl	-261.4 (-6.9%)	1254.6 (18.0%)

Note: “Negl.” refers to negligible (generally less than half the smallest unit or decimal of the heading).

Option 13a proceeded to detailed assessment for Murrumbidgee region. Table 23 provides the summary data for the proposed option under the two additional climate scenarios. The results show that option 13a generates positive economic benefits for Murrumbidgee region under both scenarios, while achieving better outcomes in the long-term historical scenario.

Table 23. Average results for Investigate water access licence conversion of 10% of general security entitlements to high security, Murrumbidgee region

Option	Net present cost ($m)	Long-term historical net present value ($m)	Dry future climate net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate benefit–cost ratio
13a	0	1008.5	892.8	NA	NA

Table 24 displays the decile and extreme centiles of the net present values generated by option 13a for the Murrumbidgee region given the two additional climate scenarios. The table suggests that in both scenarios and from 1% to 99% of percentiles that the option consistently generates positive net present values. This implies that the possibility of option 13a being economically viable for the Murrumbidgee region is very high. However, it should be noted that the costs of this policy have not been quantified.

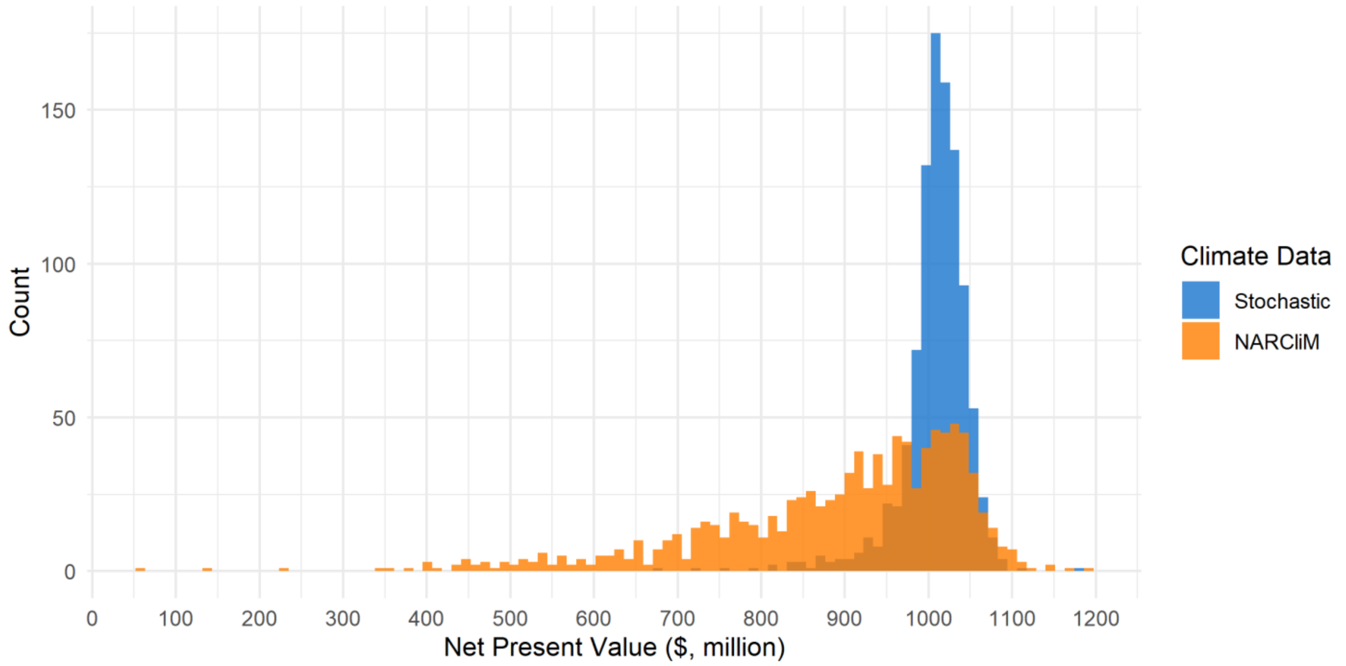
Table 24. Decile and extreme centile results of 10% of General Security (GS) entitlement converted to High Security (HS) entitlement, Murrumbidgee region

Percentile	Long-term historical net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate net present value ($m)	Dry future climate benefit–cost ratio
1%	848.3	NA	433.0	NA
10%	969.3	NA	687.5	NA
20%	990.3	NA	777.7	NA
30%	999.7	NA	846.1	NA
40%	1007.0	NA	895.4	NA
50%	1013.0	NA	929.4	NA
60%	1020.4	NA	962.5	NA
70%	1027.7	NA	994.6	NA
80%	1036.2	NA	1021.3	NA

Percentile	Long-term historical net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate net present value ($m)	Dry future climate benefit–cost ratio
90%	1047.6	NA	1045.8	NA
99%	1078.3	NA	1100.5	NA

Figure 7 provides further detail about the distribution of net present values generated by option 13a under the two climate scenarios for the Murrumbidgee region. While these results lie within positive range for both datasets, under the dry future climate scenario, option 13a would generate net present values that are of significantly higher variation compared to that under the long-term historical scenario. Results in the long-term historical scenario mostly cluster around $1,000 million and the shape of distribution is nearly symmetric, while in the dry future climate scenario the net present values could range from $300 million to $1,200 million, with a distribution that is left-skewed.

Figure 7. Net present value histogram - 10% of General Security (GS) entitlement converted to High Security (HS) entitlement, Murrumbidgee region



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Sensitivity analysis

The sensitivity analysis was undertaken for the combined option which included the following cases:

- higher (7%) and lower (3%) discount rates
- higher (+30%) and lower (-30%) combined option costs

- higher and lower economic costs, the magnitude of which varies depending on the marginal value altered.

Table 25 provides the summary results of option 13a for the central case and sensitivity analysis under the long-term historical and dry future climate scenarios. Under both climate scenarios, the best scenario happens when there is a low discounting rate (3%), which will result in an average net present value of $1,346.9 million in the long-term historical and $1188.2 in the dry future climate. The worst scenario occurs in the high discount rate (7%) case but the corresponding net present value is very close to that from the low economic value cases. These results suggest that the performance of option 13a in the Murrumbidgee region is particularly sensitive to a low discount rate. Nevertheless, under both climate scenarios the option is still robust.

Table 25. Sensitivity analysis on 10% of General Security (GS) entitlement converted to High Security (HS) entitlement, long-term historical and dry future climate scenarios, Murrumbidgee region

Long-term historical

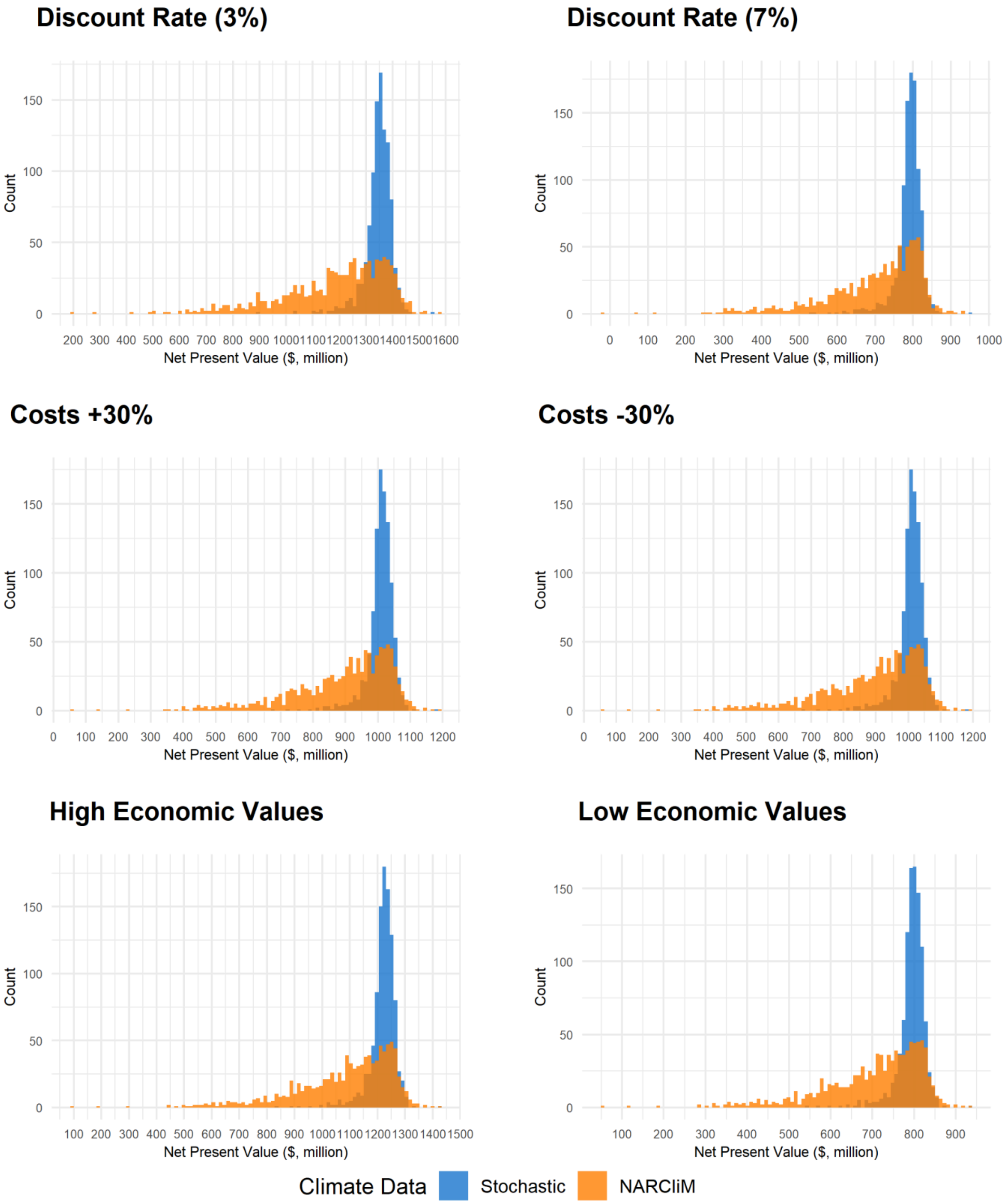
Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	0	1008.5	NA	NA	NA	NA
Low discount rate (3%)	0	1346.9	NA	NA	NA	NA
High discount rate (7%)	0	790.2	NA	NA	NA	NA
Option cost (+30%)	0	1008.5	NA	NA	NA	NA
Option cost (-30%)	0	1008.5	NA	NA	NA	NA
Economic values (high)	0	1220.0	NA	NA	NA	NA
Economic values (low)	0	794.4	NA	NA	NA	NA

Dry future climate

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	0	892.8	NA	NA	NA	NA
Low discount rate (3%)	0	1188.2	NA	NA	NA	NA
High discount rate (7%)	0	702.2	NA	NA	NA	NA
Option cost (+30%)	0	892.8	NA	NA	NA	NA
Option cost (-30%)	0	892.8	NA	NA	NA	NA
Economic values (high)	0	1081.6	NA	NA	NA	NA
Economic values (low)	0	704.6	NA	NA	NA	NA

Histograms of the sensitivity analysis outcomes are shown in Figure 8, supporting the results of Table 25 showing that the option could be economically viable given all sensitive factors included in the analysis and under both climate scenarios. It also reinforces the fact that results under the dry future climate scenario demonstrate greater level of uncertainty compared to that under the long-term historical one.

Figure 8. 10% of General Security (GS) entitlement converted to High Security (HS) entitlement sensitivity case net present value shown as histograms, Murrumbidgee region



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Distributional analysis

Table 26 shows the results of distributional analysis of option 13a under the long-term historical and dry future climate scenarios in Murrumbidgee region. For town water users, changes under both scenarios are negligible. While annual crop groups see decreased economic outcomes under both (-6.8% in the long-term historical and -8.1% in the dry future climate scenario), permanent crops user groups benefit from positive changes of 17.9% in the long-term historical and 16.9% in the dry future climate scenario. In total, the Murrumbidgee region sees mild positive changes as a result of option 13a with around 10% compared to the baseline estimates under both modelled scenarios. The transfer costs associated with converting entitlements has not been included in the assessment, as per NSW Treasury cost-benefit guidelines.

Table 26. Average distributional impacts from 10% of General Security (GS) entitlement converted to High Security (HS) entitlement compared to the economic base case across both datasets

Long-term historical

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	0.0	3538.4	6992.6	10531.0
Option outcomes ($m)	0.0	3297.0	8242.5	11539.5
Change ($m)	Negl	-241.4	1249.9	1008.5
% Change	Negl	-6.8%	17.9%	9.6%

Dry future climate

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	-0.3	2369.3	6421.9	8790.9
Option outcomes ($m)	-0.3	2177.7	7506.3	9683.7
Change ($m)	Negl	-191.6	1084.4	892.8
% Change	Negl	-8.1%	16.9%	10.2%

Note: “Negl.” refers to negligible (generally less than half the smallest unit or decimal of the heading).

Option 13b: Investigate water access licence conversion of 50% of general security entitlements to high security.

The purpose of this proposed option was to give regulated river water users the ability to improve the security of their entitlements. It involves the voluntary conversion of 50% of consumptive general security (GS) entitlements to high security (HS) entitlements. To ensure SDL compliance, we derived a conversion factor for the converted entitlements and increased the storage reserve by the additional HS entitlements. The conversion factor used for this option is 0.82.

Results of the rapid benefit–cost analysis shown in Table 27 suggest that the net present value of option 13b using the historical dataset is $5,625 million. The implementing cost associated with option 13a is assigned with zero-dollar value and therefore the benefit–cost ratio is non-applicable. However, it should be noted that this net benefit does not incorporate the administrative costs of introducing the policy.

Table 27. Rapid benefit–cost analysis outcomes overview for the 50% of General Security (GS) entitlement converted to High Security (HS) entitlement option

Option	Description	Net present value ($m)	Benefit–cost ratio
13b	Investigate water access licence conversion of 50% of general security entitlements to high security	5625.1	NA

Table 28 shows the outcomes of distributional analysis for option 13b using the historical data. These results reveal that the option brings negligible change for town water users, noticeable negative impact (-39.4%) to annual crops water users, and significant improvements to permanent crop water users with a percentage change equivalent to 102% of the baseline estimates from the Murrumbidgee economic base case.

Table 28. Distributional analysis for the 50% of General Security (GS) entitlement converted to High Security (HS) entitlement

Option	Town water supply ($m, (% change))	Annual crops ($m, (% change))	Permanent crops ($m, (% change))
13b	Negl	-1486.5(-39.4%)	7111.6(102.2%)

Note: "Negl." refers to negligible (generally less than half the smallest unit or decimal of the heading).

Option 13b proceeded to detailed assessment for the Murrumbidgee region. Table 29 provides the summary data under the two additional climate scenarios. These results show that option 13b generates positive expected net present values for the Murrumbidgee region under both scenarios, while it is expected to achieve better outcomes in the long-term historical.

Table 29. Average results for the 50% of General Security (GS) entitlement converted to High Security (HS) entitlement

Option	Net present cost ($m)	Long-term historical net present value ($m)	Dry future climate net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate benefit–cost ratio
13b	0	5712.9	4633.8	NA	NA

Table 30 displays the decile and extreme centiles of the net present values generated by option 13b for the Murrumbidgee region given the two climate scenarios. While in both scenarios the option produces positive net present values from 1% to 99% percentiles, under the dry future climate, it generates results with significant higher levels of variation, with a range from $1,516 million to $6,002.8 compared to a range from $4,907.0 to $5,989.0 million in the long-term historical.

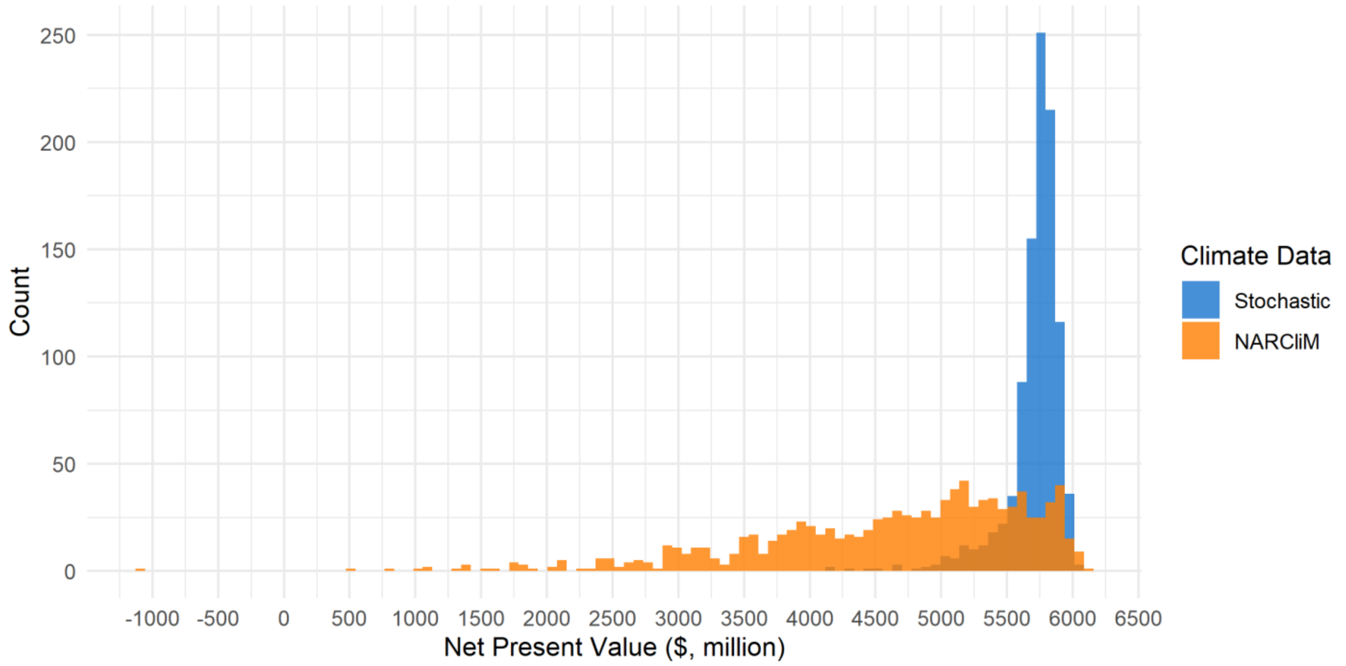
Table 30. Decile and extreme centile results of the 50% of General Security (GS) entitlement converted to High Security (HS) entitlement

Percentile	Long-term historical net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate net present value ($m)	Dry future climate benefit–cost ratio
1%	4907.0	NA	1516.8	NA
10%	5493.9	NA	3181.4	NA
20%	5634.8	NA	3831.7	NA
30%	5690.8	NA	4195.1	NA
40%	5727.4	NA	4583.8	NA
50%	5756.2	NA	4861.1	NA
60%	5785.3	NA	5107.9	NA
70%	5813.9	NA	5296.4	NA
80%	5850.1	NA	5534.0	NA
90%	5897.6	NA	5778.8	NA

Percentile	Long-term historical net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate net present value ($m)	Dry future climate benefit–cost ratio
99%	5989.0	NA	6002.8	NA

Figure 9 shows the distribution histogram of net present values generated by option 13b under the two climate scenarios for the Murrumbidgee region. It further reinforces that net present values produced in the long-term historical scenario distribute within a significantly narrower range compared to that in the dry future climate scenario. Specifically, more than 90% of results generated in the long-term historical scenario cluster within the range of $5,000 to $5,999.

Figure 9. Net present value histogram - 50% of General Security (GS) entitlement converted to High Security (HS) entitlement, Murrumbidgee region



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Sensitivity analysis

The sensitivity analysis was undertaken for the combined option which included the following cases:

- higher (7%) and lower (3%) discount rates
- higher (+30%) and lower (-30%) combined option costs
- higher and lower economic costs, the magnitude of which varies depending on the marginal value altered.

Table 31 shows the results of option 13b for the central case and sensitivity analysis under the long-term historical and dry future climate scenarios for the Murrumbidgee region. Under both climate scenarios, the most ideal happens in the low discount rate (3%) cases, resulting in an average net present value of $7,629.7 million in the long-term historical and $6,138.0 in the dry future climate. This suggests that the option would be particularly sensitive to a low discount rate.

Table 31. Sensitivity analysis on 50% of General Security (GS) entitlement converted to High Security (HS) entitlement, long-term historical and dry future climate datasets

Long-term historical

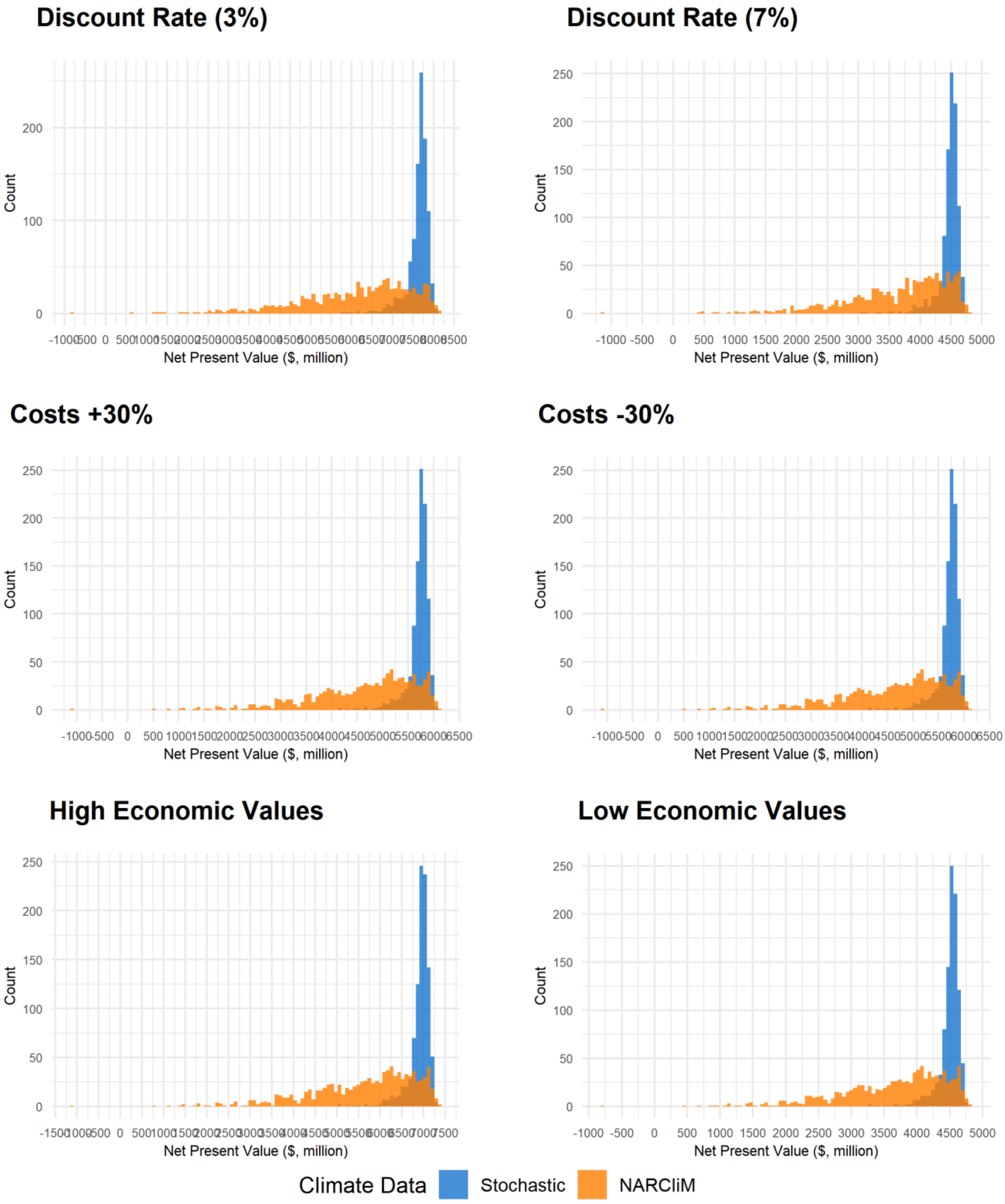
Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	0	5712.9	NA	NA	NA	NA
Low discount rate (3%)	0	7629.7	NA	NA	NA	NA
High discount rate (7%)	0	4476.4	NA	NA	NA	NA
Option cost (+30%)	0	5712.9	NA	NA	NA	NA
Option cost (-30%)	0	5712.9	NA	NA	NA	NA
Economic values (high)	0	6914.0	NA	NA	NA	NA
Economic values (low)	0	4500.9	NA	NA	NA	NA

Dry future climate

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	0	4633.8	NA	NA	NA	NA
Low discount rate (3%)	0	6138.0	NA	NA	NA	NA
High discount rate (7%)	0	3662.3	NA	NA	NA	NA
Option cost (+30%)	0	4633.8	NA	NA	NA	NA
Option cost (-30%)	0	4633.8	NA	NA	NA	NA
Economic values (high)	0	5629.2	NA	NA	NA	NA
Economic values (low)	0	3662.6	NA	NA	NA	NA

Histograms of the net present values of the sensitivity analysis are shown in, supporting the results of Table 31. This shows that the option is very robust given all sensitive factors included in the analysis and under both climate scenarios. It also demonstrates that results under the dry future climate scenario lie within a much greater range, while net present values in the long-term historical tend to cluster closely around the mean and median.

Figure 10. 50% of General Security (GS) entitlement converted to High Security (HS) entitlement sensitivity case net present value shown as histograms



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Distributional analysis

Table 32 shows the results of distributional analysis of option 13b under the long-term historical and dry future climate scenarios. These outcomes suggest that option 13b brings a total percentage change of around 54.2% in the long-term historical and 52.7% in the dry future climate scenario to the Murrumbidgee region compared to the baseline estimates. However these percentage changes don't necessarily imply that water users are strictly better off because of the implementation of the option. It should be noted that annual crops water user groups predict negative changes (-39.3% in long-term historical and -44.1% in dry future climate), while the town water users have negligible improvement. The only user group that strictly benefit from option 13b is the permanent crops.

Table 32. Average distributional impacts from 50% of General Security (GS) entitlement converted to High Security (HS) entitlement compared to the economic base case across both datasets

Long-term historical

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	0.0	3538.4	6992.6	10531.0
Option outcomes ($m)	0.0	2147.1	14096.8	16243.9
Change ($m)	Negl	-1391.3	7104.2	5712.9
% Change	Negl	-39.3%	101.6%	54.2%

Dry future climate

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	-0.3	2369.3	6421.9	8790.9
Option outcomes ($m)	-0.5	1324.8	12100.4	13424.7
Change ($m)	Negl	-1044.5	5678.5	4633.8
% Change	Negl	-44.1%	88.4%	52.7%

Note: "Negl." Refers to negligible (generally less than half the smallest unit or decimal of the heading).

Option 33a: Investigate new 47 GL weir near Gundagai on the lower Tumut River

The objective of Option 33 is to increase the amount of buffer storage downstream of flow constraints on the Tumut River to improve efficiency in the regulated river system operations. To achieve this, a 47 GL on-river storage on the Tumut River was added, just upstream of its confluence with the Murrumbidgee River. This buffer storage would be utilised to assist in the delivery of water from Blowering Dam to downstream water users during periods of high demand.

Table 33 provides the results of rapid assessment, using the historical data series, which gives a negative net present value of $-269.2 million and a less-than-one benefit–cost ratio equal to 0.1. These outcomes together suggest that option 33a would generate present economic benefits that are less than the total cost.

Table 33. Rapid benefit–cost analysis outcomes overview for the Investigate new 47 GL weir near Gundagai on the lower Tumut River option

Option	Description	Net present value ($m)	Benefit–cost ratio
33a	An on-river storage of 47 GL capacity on the Tumut River near the Murrumbidgee River confluence	-269.2	0.1

Outcomes of distributional analysis of option 33a using the historical data are shown in Table 34. These results indicate that none of the water user groups in the Murrumbidgee region would materially benefit from the option. While the annual crops group predicts a negative change of -0.5% compared to the baseline estimate, the permanent crops group see a negligible positive impact about 0.6% and the town water user experiences negligible change.

Table 34. Distributional analysis for the Investigate new 47 GL weir near Gundagai on the lower Tumut River option

Option	Town water supply ($m, (% change))	Annual crops ($m, (% change))	Permanent crops ($m, (% change))
33a	Negl	-20.7(-0.5%)	42.7 (0.6%)

Note: "Negl." refers to negligible (generally less than half the smallest unit or decimal of the heading).

Option 33a proceeded to detailed assessment and Table 35 displays the summary data under the two additional climate scenarios. Although the net present cost of option 33a is $291.2 million, implementing the option would result in an average net present value of $-271.8 million in the long-term historical and $110.8 million in the dry future climate scenario. The benefit- cost ratios under the two scenarios are 0.1 and 1.4, respectively. While positive net present value and larger-than-one benefit–cost ratio are considered as indicators of economic feasibility, the two scenarios give opposite predictions of option 33a's economic viability in terms of the average values. A potential explanation is that higher risks and losses associated with a drier future climate would be mitigated by the proposed option, creating a situation that the economic benefits outweigh the cost of implementation under the dry future climate scenario.

Table 35. Average results for Investigate new 47 GL weir near Gundagai on the lower Tumut River

Option	Net present cost ($m)	Long-term historical net present value ($m)	Dry future climate net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate benefit–cost ratio
33a	291.2	-271.8	110.8	0.1	1.4

Table 36 provides the net present values as well as benefit–cost ratios decile and extreme centile results. In the long-term historical scenario, from the 1% to 99% percentile option 33a generates negative net present values and benefit–cost ratios that are strictly less than one, implying low possibility that the option would be economic feasible. Under the dry future climate scenario performance of the option improves, as consistent to the average results from Table 35. Around 50% of total results predict positive net present values and benefit–cost ratios larger than one, suggesting higher economic viability of option 33a under a dry future climate.

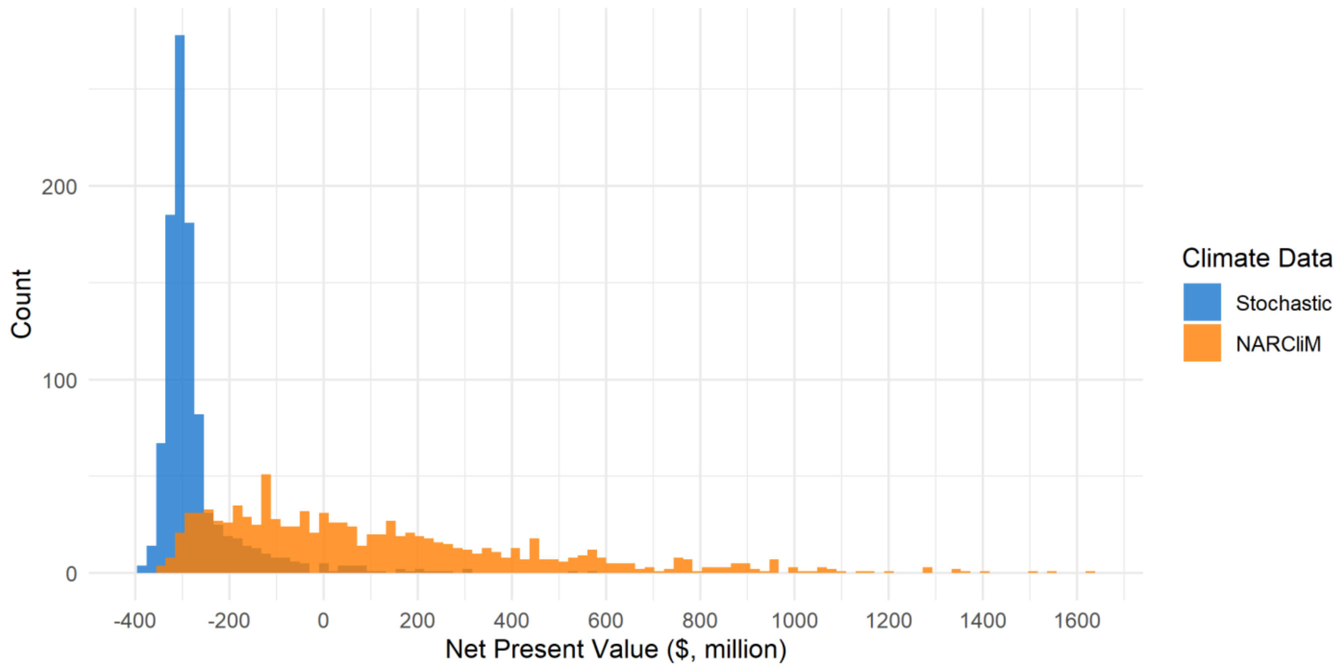
Table 36. Decile and extreme centile results of Investigate new 47 GL weir near Gundagai on the lower Tumut River

Percentile	Long-term historical net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate net present value ($m)	Dry future climate benefit–cost ratio
1%	-360.7	-0.2	-317.3	-0.1
10%	-333.9	-0.2	-252.0	0.1
20%	-322.0	-0.1	-183.4	0.4
30%	-313.9	-0.1	-121.2	0.6
40%	-306.2	-0.1	-46.0	0.8
50%	-299.2	0.0	24.9	1.1
60%	-290.5	0.0	119.4	1.4

Percentile	Long-term historical net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate net present value ($m)	Dry future climate benefit–cost ratio
70%	-279.2	0.0	218.9	1.8
80%	-259.0	0.1	365.8	2.3
90%	-181.5	0.4	579.9	3.0
99%	158.5	1.5	1194.1	5.1

Figure 11 provides additional information regarding to the distribution of net present values generated by option 33a under the two climate scenarios. It further reinforces that the majority of net present values in the long-term historical data lie within a negative range. This suggests a low possibility that the discounted economic benefits of option 33a would outweigh the net present cost. Alternatively, with the dry future climate scenario more results are in the positive range. It should be noted that the distribution of net present values in the dry future climate scenario behaves with more variation compared to that in the long-term historical.

Figure 11. Net present value histogram - Investigate new 47 GL weir near Gundagai on the lower Tumut River



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Sensitivity analysis

The sensitivity analysis was undertaken for the combined option which included the following cases:

- higher (7%) and lower (3%) discount rates
- higher (+30%) and lower (-30%) combined option costs
- higher and lower economic costs, the magnitude of which varies depending on the marginal value altered.

Table 37 shows the results of option 33a for the central case and sensitivity analysis under the long-term historical and dry future climate scenarios. In the long-term historical, with all sensitivities, the average net present values are negative with the average benefit ratios all less than one. While the percentage of benefit–cost ratio is higher than one gives an indication that the option is possibly economically viable, Table 37 suggests that under all sensitivity cases, option 33a has very low chances of being economically feasible.

In the dry future climate scenario all sensitivity cases except for the high discount rate (7%) predict positive average net present values and benefit–cost ratios that are strictly higher than one. The chances of benefit–cost ratios larger than one are also significantly improved with 3 out of 6 sensitivity cases having percentages higher than 50%.

Table 37. Sensitivity analysis on investigate new 47 GL weir near Gundagai on the lower Tumut River, long-term historical and dry future climate datasets

Long-term historical

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	291.2	-271.8	0.1	-0.4	3.0	2.8
Low discount rate (3%)	257.3	-230.3	0.1	-0.5	4.0	5.4
High discount rate (7%)	304.1	-289.6	0.1	-0.3	2.4	1.8
Option cost (+30%)	378.6	-359.1	0.1	-0.3	2.3	1.5
Option cost (-30%)	203.8	-184.4	0.1	-0.5	4.2	4.9

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Economic values (high)	291.2	-267.4	0.1	-0.4	3.5	3.6
Economic values (low)	291.2	-276.1	0.1	-0.3	2.3	1.5

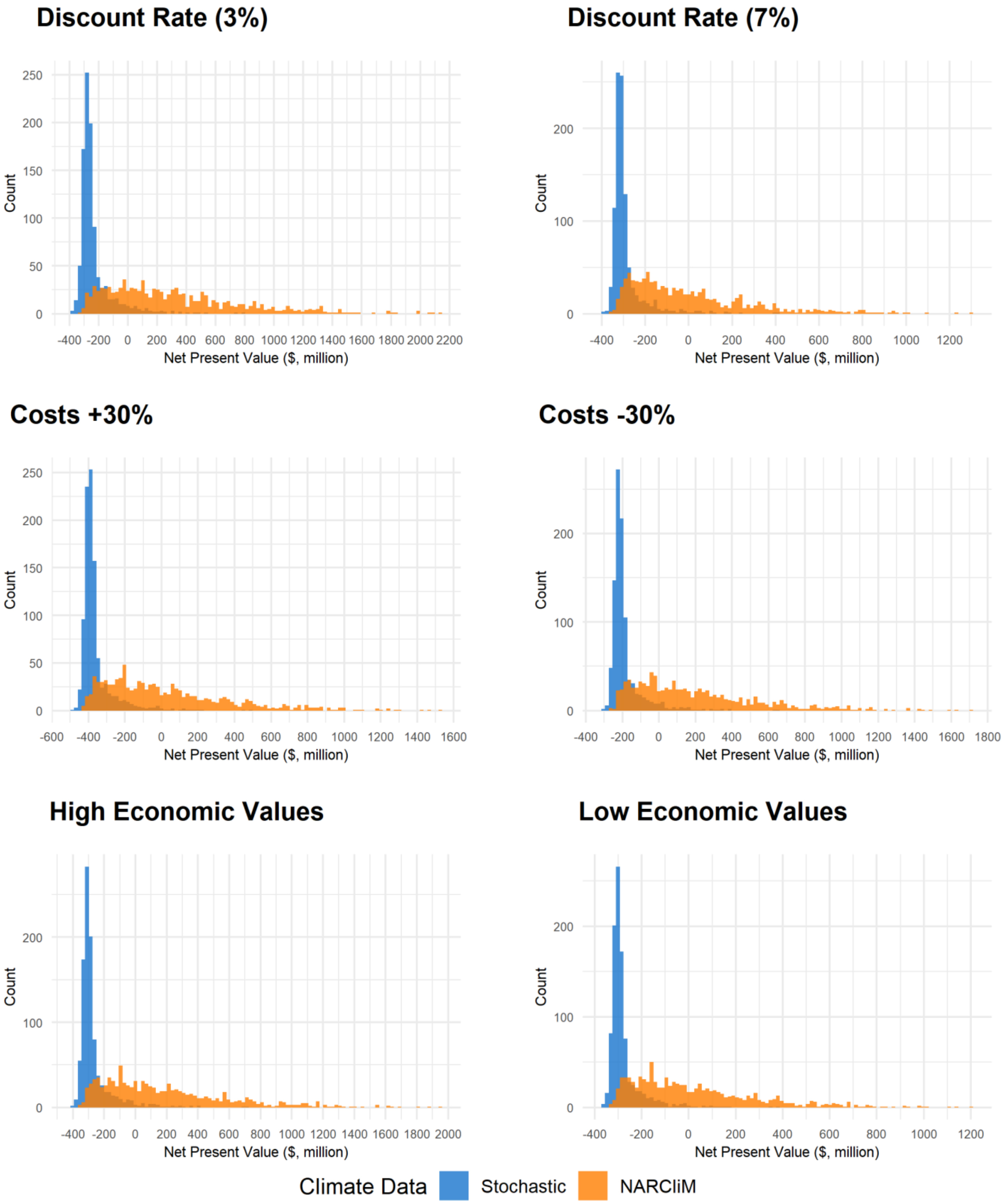
Dry future climate

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	291.2	110.8	1.4	-0.2	6.6	53.2
Low discount rate (3%)	257.3	302.0	2.2	-0.3	9.3	69.7
High discount rate (10%)	304.1	-2.5	1.0	-0.2	5.3	39.5
Option cost (+30%)	378.6	23.5	1.1	-0.2	5.1	43.0
Option cost (-30%)	203.8	198.2	2.0	-0.3	9.4	64.4
Economic values (high)	291.2	178.7	1.6	-0.2	7.7	59.5

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Economic values (low)	291.2	21.2	1.1	-0.2	5.1	43.4

Histograms of net present values of all 6 sensitivity cases in both climate scenarios are provided in Figure 12. This demonstrates that performance of option 33a depends heavily on the climate assumption and indicates high potential uncertainty in the net economic benefits of implementing the option.

Figure 12. Investigate new 47 GL weir near Gundagai on the lower Tumut River sensitivity case net present value shown as histograms



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Distributional analysis

Table 38 shows the results of distributional analysis of option 33a under the long-term historical and dry future climate scenarios. These outcomes suggest that in total the option brings negligible improvements to Murrumbidgee water users under both scenarios. The group with the highest economic benefit is the permanent crops water user ($386.4 million) in the dry future climate scenario, but the percentage change when compared to the base case outcome is only about 6%.

Table 38. Average distributional impacts from Investigate new 47 GL weir near Gundagai on the lower Tumut River compared to the economic base case across both datasets

Long-term historical

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	0.0	3538.4	6992.6	10531.0
Option outcomes ($m)	0.0	3521.8	7028.6	10550.4
Change ($m)	Negl	-16.6	36.0	19.4
% Change	Negl	-0.5%	0.5%	0.2%

Dry future climate

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	-0.3	2369.3	6421.9	8790.9
Option outcomes ($m)	0.0	2384.6	6808.3	9192.9
Change ($m)	0.3	15.3	386.4	402.0
% Change	99.1%	0.6%	6.0%	4.6%

Note: "Negl." refers to negligible (generally less than half the smallest unit or decimal of the heading).

Option 33b: Investigate new 20 GL weir near Gundagai on the Murrumbidgee River

The aim of this option is to provide re-regulation storage downstream of flow constraints on the Tumut River to improve efficiency and enable delivery of higher flows during peak demand periods in regulated river system operations. This option involves investigating a new 20 GL weir near Gundagai on the Murrumbidgee River to create buffer storage downstream of flow constraints in the Tumut River. This buffer storage would be utilised to assist in the delivery of water from Blowering Dam to downstream water users during periods of high demand. The cost of this option is estimated at $124.1 million.

The outcomes of the rapid benefit–cost analysis shown in Table 39 suggest that option 33b results in a negative net present value of $138.7 million and a benefit–cost ratio equal to -0.1. These outcomes together show that the present value of economic benefit of option 33b is outweighed by its present cost of implementation.

Table 39. Rapid benefit–cost analysis outcomes for an on-river dam of 20 GL capacity on the Murrumbidgee River

Option	Description	Net present value ($m)	Benefit–cost ratio
33b	An on-river dam of 20 GL capacity on the Murrumbidgee River near Gundagai	-138.7	-0.1

Outcomes of distributional analysis using the historical dataset for option 33b are shown in Table 40. These indicate that the option would bring negligible changes to all water users of the Murrumbidgee region under historical records. Specifically, these impacts to town water users are negligible while to annual crop users are -0.9% and to permanent crop users are 0.3% compared to the baseline estimates.

Table 40. Distributional analysis for an on-river dam of 20 GL capacity on the Murrumbidgee River

Option	Town water supply ($m, (% change))	Annual crops ($m, (% change))	Permanent crops ($m, (% change))
33b	Negl	-34.7(-0.9%)	20.1 (0.3%)

Note: "Negl." refers to negligible (generally less than half the smallest unit or decimal of the heading).

Option 33b proceeded to detailed assessment and Table 41 provides summary data under the two additional climate scenarios. These results indicate that under both scenarios option 33b produces negative average net present values as well as benefit- cost ratios that are strictly lower than one.

Table 41. Average results for an on-river dam of 20 GL capacity on the Murrumbidgee River

Option	Net present cost ($m)	Long-term historical net present value ($m)	Dry future climate net present value ($m)	Long-term historical benefit-cost ratio	Dry future climate benefit–cost ratio
33b	124.1	-135.0	-124.6	-0.1	0

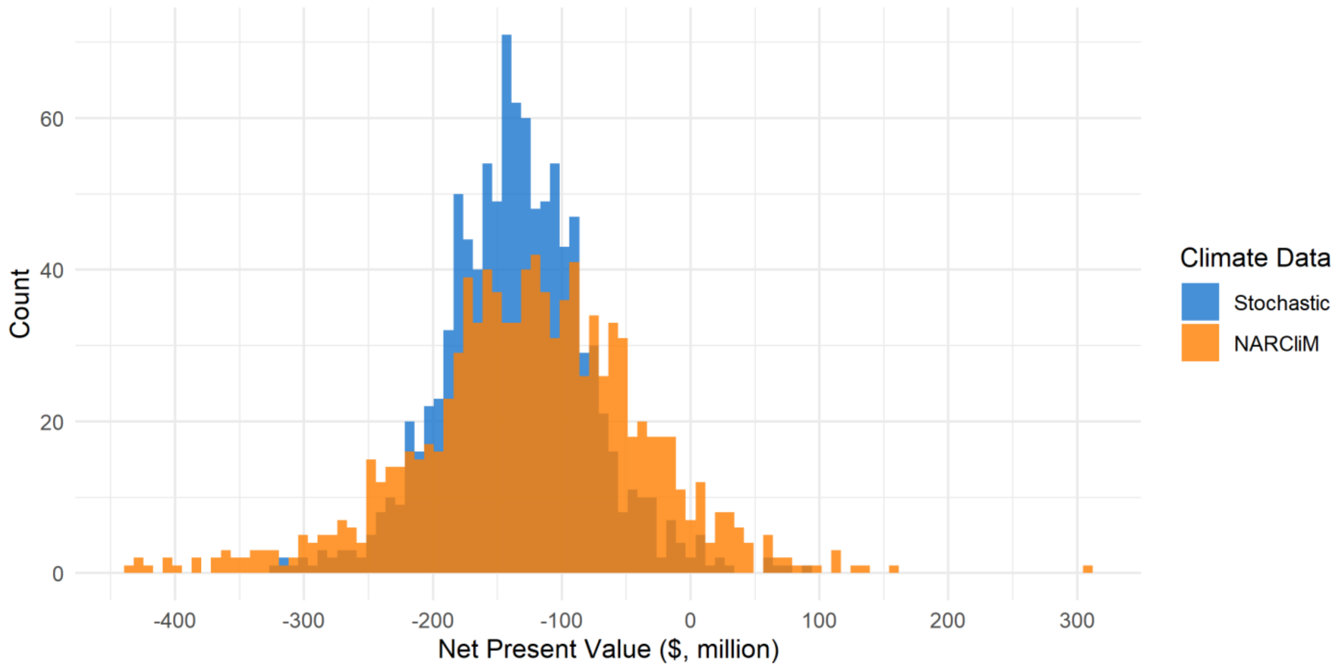
Table 42 displays the decile and extreme centiles of the net present values generated by option 33b for the Murrumbidgee region under the two climate scenarios. In both datasets from 1% to at least 90% percentiles the option generates negative net presents values as well as benefit–cost ratios strictly lower than one. These results indicate that option 33b is of very low possibility of being economically viable under both climate scenarios, supporting the average outcomes from Table 41.

Table 42. Decile and extreme centile results of an on-river dam of 20 GL capacity on the Murrumbidgee River

Percentile	Long-term historical net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate net present value ($m)	Dry future climate benefit–cost ratio
1%	-280.6	-1.3	-365.4	-1.9
10%	-201.0	-0.6	-232.3	-0.9
20%	-177.7	-0.4	-185.8	-0.5
30%	-161.3	-0.3	-163.7	-0.3
40%	-147.4	-0.2	-142.9	-0.2
50%	-134.9	-0.1	-121.9	0.0
60%	-123.2	0.0	-102.8	0.2
70%	-107.8	0.1	-81.8	0.3
80%	-92.8	0.3	-55.4	0.6
90%	-69.5	0.4	-20.4	0.8
99%	6.2	1.1	74.5	1.6

Figure 13 shows the distribution histogram of net present values of option 33b under the two climate scenarios. The figure further supports results from Table 42 demonstrating that in both the long-term historical and dry future climate most of net present values produced lie within the negative ranges. The performance of the option under the dry future climate is slightly better as it has relatively more counts of positive net present values compared to the long-term historical.

Figure 13. Net present value histogram - an on-river dam of 20 GL capacity on the Murrumbidgee River



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Sensitivity analysis

The sensitivity analysis was undertaken for the combined option which included the following cases:

- higher (7%) and lower (3%) discount rates
- higher (+30%) and lower (-30%) combined option costs
- higher and lower economic costs, the magnitude of which varies depending on the marginal value altered.

Table 43 displays the results of option 33b for the central case and sensitivity analysis under the long-term historical and dry future climate scenarios. In both, and with all sensitivities, the option produces negative net present values as well as average benefit–cost ratios that are strictly lower than one. The highest percentage of benefit–cost ratio higher than one is when the discount rate is as low as 3% in the dry future climate and this case only corresponds to a value of 16.6%. These results together suggest a low possibility that option 33b could be economically viable.

Table 43. Sensitivity analysis on an on-river dam of 20 GL capacity on the Murrumbidgee River

Long-term historical

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	124.1	-135.0	-0.1	-1.6	1.7	1.5
Low discount rate (3%)	109.6	-117.7	-0.1	-2.2	2.4	4.5
High discount rate (7%)	129.6	-142.3	-0.1	-1.4	1.4	0.6
Option cost (+30%)	161.3	-172.3	-0.1	-1.3	1.3	0.5
Option cost (-30%)	86.9	-97.8	-0.1	-2.3	2.5	4.1
Economic values (high)	124.1	-136.0	-0.1	-1.9	2.0	2.4
Economic values (low)	124.1	-132.6	-0.1	-1.3	1.4	0.5

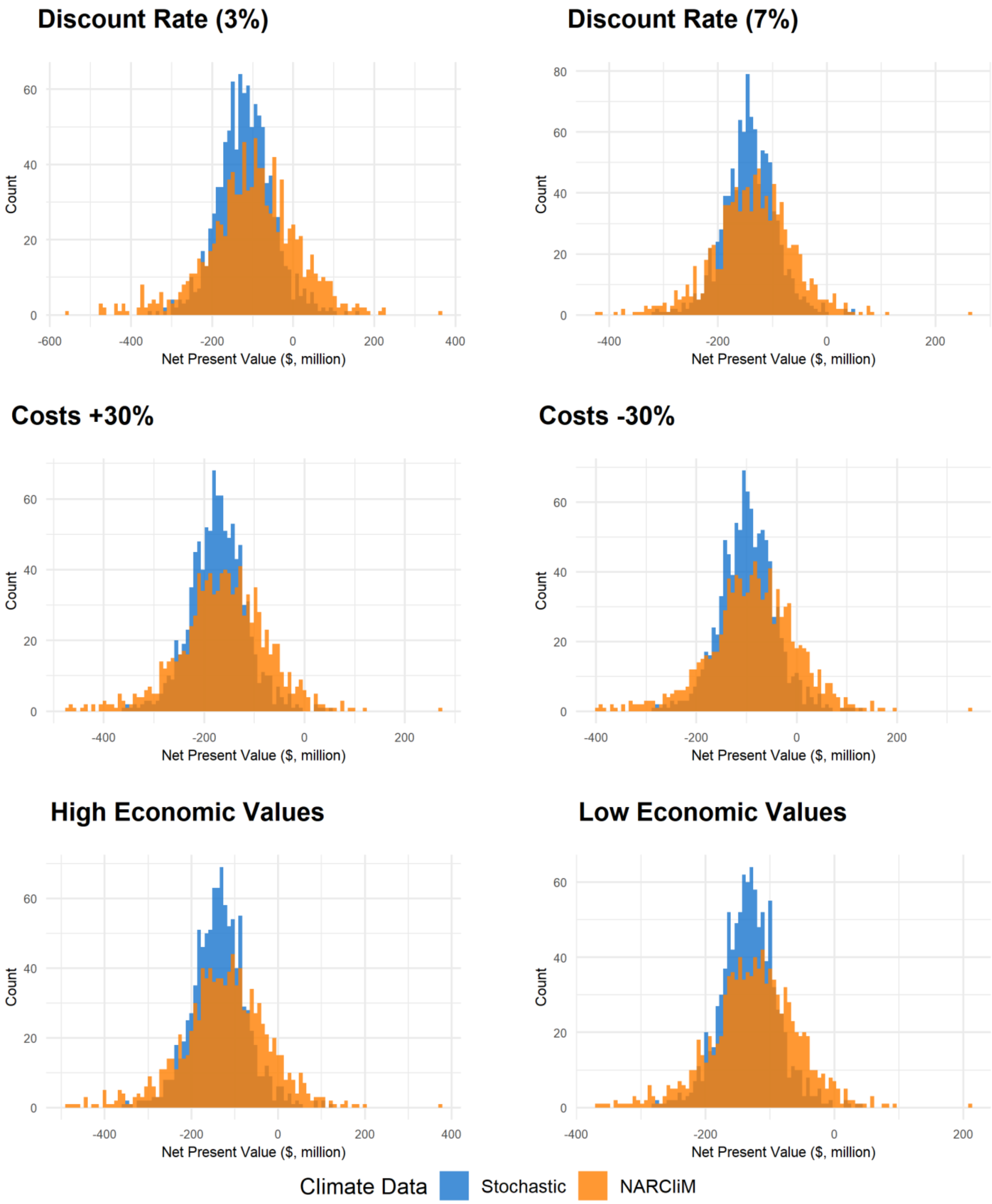
Dry future climate

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	124.1	-124.6	0.0	-2.5	3.5	6.3

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit-cost ratio with benefit–cost ratio > 1
Low discount rate (3%)	109.6	-101.4	0.1	-4.1	4.3	16.6
High discount rate (7%)	129.6	-135.7	-0.1	-2.3	3.0	3.1
Option cost (+30%)	161.3	-161.8	0.0	-2.0	2.7	2.6
Option cost (-30%)	86.9	-87.4	0.0	-3.6	4.9	14.2
Economic values (high)	124.1	-123.3	0.0	-2.9	4.0	9.6
Economic values (low)	124.1	-124.5	0.0	-2.0	2.7	2.7

Histograms of the net present values of the sensitivity analysis are shown in Figure 14, supporting the results of Table 43 demonstrating that the expected net present values generated in all cases and under both scenarios are negative. Though the situation is slightly improved in the dry future climate, under both scenarios there is a very low chance that option 33b could bring positive net economic benefits to water users in the Murrumbidgee region.

Figure 14. An on-river dam of 20 GL capacity on the Murrumbidgee River sensitivity case net present value shown as histograms



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Distributional analysis

Table 44 shows the results of distributional analysis of option 33b under the long-term historical and dry future climate scenarios. These outcomes suggest while there are some economic benefits associated with the proposed option these benefits are tempered by certain drawbacks. The economic outcomes in terms of percentage change compared to the baseline estimates for annual crops range from a -0.4% to -1% and for permanent crops, from an increase of 0.1% to 0.3%. However, the total change under both scenarios remains negative, indicating that the economic benefits of option 33b are limited.

Table 44. Average distributional impacts from an on-river dam of 20 GL capacity on the Murrumbidgee River compared to the economic base case across both datasets

Long-term historical

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	0.0	3538.4	6992.6	10531.0
Option outcomes ($m)	0.0	3523.6	6996.4	10520.0
Change ($m)	Negl	-14.8	3.8	-11.0
% Change	Negl	-0.4%	0.1%	-0.1%

Dry future climate

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	-0.3	2369.3	6421.9	8790.9
Option outcomes ($m)	-0.3	2346.4	6444.2	8790.3
Change ($m)	Negl	-22.9	22.3	-0.6
% Change	Negl	-1.0%	0.3%	0.0%

Note: "Negl." refers to negligible (generally less than half the smallest unit or decimal of the heading).

Option 33c: Investigate new 1000 GL Dam near Gundagai on the Murrumbidgee River

The objective of this option is to improve water security in the regulated Murrumbidgee region. This option involves investigating a new 1,000 GL dam near Gundagai on the Murrumbidgee River. The net present cost associated with this option is a dollar value of $2703.2 million.

The results of the rapid benefit–cost analysis shown in Table 45 suggest that option 33c will result in a net present value of $-2712.1 million and a benefit–cost ratio equal to zero. These outcomes together indicate limited economic viability of option 33c.

Table 45. Rapid benefit–cost analysis outcomes for the on-river dam of 1000 GL capacity on the Murrumbidgee River near Gundagai option

Option	Description	Net present value ($m)	Benefit–cost ratio
33c	An on-river dam of 1000 GL capacity on the Murrumbidgee River near Gundagai	-2712.1	0.0

Table 46 displays outcomes of the distributional analysis of the proposed option. These results indicate that the option would bring negligible changes to all water users under historical data. The breakdown of these impacts is a negligible effect to town water users, a negative change of 0.5% to the annual crops and a small positive change of 0.1% to permanent crops compared to the baseline estimates.

Table 46. Distributional analysis for the on-river dam of 1000 GL capacity on the Murrumbidgee River near Gundagai option

Option	Town water supply ($m, (% change))	Annual crops ($m, (% change))	Permanent crops ($m, (% change))
33c	Negl	-19.1 (-0.5%)	10.2(0.1%)

Note: "Negl." refers to negligible (generally less than half the smallest unit or decimal of the heading).

Option 33c did not proceed into detailed assessment under the long-term historical and dry future climate scenarios because of its poor performance in the rapid benefit–cost analysis.

Option 35: Install gravity pipeline along Tumut River

This option aims to improve the delivery of water out of Blowering Dam and improve harmonisation of Blowering and Burrinjuck dam levels to increase system-wide water availability This involves investigating a 2,000 ML/day additional outlet on Blowering Dam and gravity pipeline that returns water to the lower Tumut River just upstream of the Murrumbidgee River confluence.

Table 47 shows the results of the rapid benefit–cost analysis of option 35. With a net present cost of $13571.7 million the option generates a net present value of $-13611.7 million and a benefit–cost ratio equal to 0. This extreme negative net present value and low benefit cost ratio suggests very limited economic viability of the proposed option.

Table 47. Rapid benefit–cost analysis outcomes for the gravity pipeline along the Tumut River option

Option	Description	Net present value ($m)	Benefit–cost ratio
35	Gravity pipeline along the Tumut River	-13611.7	0.0

Outcomes of the distributional analysis of option 35 using the historical records are shown in Table 48. These results indicate that none of the water user groups in the Murrumbidgee region would benefit from the proposed option. While the town water user experiences negligible level of change, the breakdown of benefits attributed to both the annual and permanent crops are negative (-0.9% for annual crops and -0.1% for permanent crops, respectively).

Table 48. Distributional analysis for the gravity pipeline along the Tumut River option

Option	Town water supply ($m, (% change))	Annual crops ($m, (% change))	Permanent crops ($m, (% change))
35	Negl	-35.0(-0.9%)	-5.0(-0.1%)

Note: "Negl." refers to negligible (generally less than half the smallest unit or decimal of the heading).

Option 35 did proceed to detailed assessment under the long-term historical and dry future climate scenarios because of its poor performance in the rapid benefit–cost analysis.

Option 36(i): Raise Blowering Dam - 100 GL airspace reserved for SHL releases

Option 36(i) forms one component of Option 36.

The objective of option 36 is to improve water security in the regulated Murrumbidgee region. This option involves investigating the raising of the Blowering Dam spillway by 4.5m to create an extra 200 GL of capacity (not a raise of the broader dam wall). It considers two variations in the pre-release compensation reserve airspace for Snowy Hydro Limited (SHL) electricity generation:

- 100 GL of airspace – Option 36(i)
- 200 GL of airspace – Option 36(ii)

The results of the rapid benefit–cost analysis shown in Table 49 suggest that with a net present cost of $116.3 million option 36(i) generates a negative net present value of $-233.3 million and a benefit–cost ratio equal to -1. These outcomes together show that the present value of economic benefit of option 36(i) is outweighed by its net present cost of implementation.

Table 49. Rapid benefit–cost analysis outcomes for the Enlarged Blowering Dam - 100 GL airspace reserved for SHL releases option

Option	Description	Net present value ($m)	Benefit–cost ratio
36(i)	Enlarged Blowering Dam - 100 GL airspace reserved for SHL releases	- 233.3	-1.0

Distributional impact outcomes of option 36(i) are shown in Table 50. These results indicate that the option would bring negligible changes to all water users in the Murrumbidgee region under historical data. Compared to the baseline estimates, these impacts to town water users are negligible, annual crop users are -3.1% and permanent crop users are approximately 0%.

Table 50. Distributional analysis for the Enlarged Blowering Dam - 100 GL airspace reserved for SHL releases option

Option	Town water supply ($m, (% change))	Annual crops ($m, (% change))	Permanent crops ($m, (% change))
36(i)	Negl	-116.9 (-3.1%)	-0.2 (0.0%)

Note: "Negl." refers to negligible (generally less than half the smallest unit or decimal of the heading).

Option 36(i) proceeded to detailed assessment. Table 51 provides summary results under the two additional climate scenarios. These outcomes suggest that given a net present cost of $116.3 million, option 36(i) generates negative average net present values ($-203.6 in the long-term historical and $-194.1 in the dry future climate scenario) and benefit–cost ratios that are strictly lower than one under both scenarios examined. These results validate that option 36(i) has limited economic viability.

Table 51. Average results for the Enlarged Blowering Dam - 100 GL airspace reserved for SHL releases

Option	Net present cost ($m)	Long-term historical net present value ($m)	Dry future climate net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate benefit–cost ratio
36(i)	116.3	-203.6	-194.1	-0.8	-0.7

Table 52 displays the decile and extreme centiles outcomes of option 36(i) given two climate scenarios. In both datasets from 1% to at least 99% percentiles the option produces negative net presents values as well as benefit–cost ratios that are for most of the time strictly less than one (the only case when the ratio equals exactly to one is on the 99% percentile in the dry future climate). These results indicate that option 36(i) has a very low possibility of economic feasibility under both climate scenarios, supporting the average outcomes from Table 51.

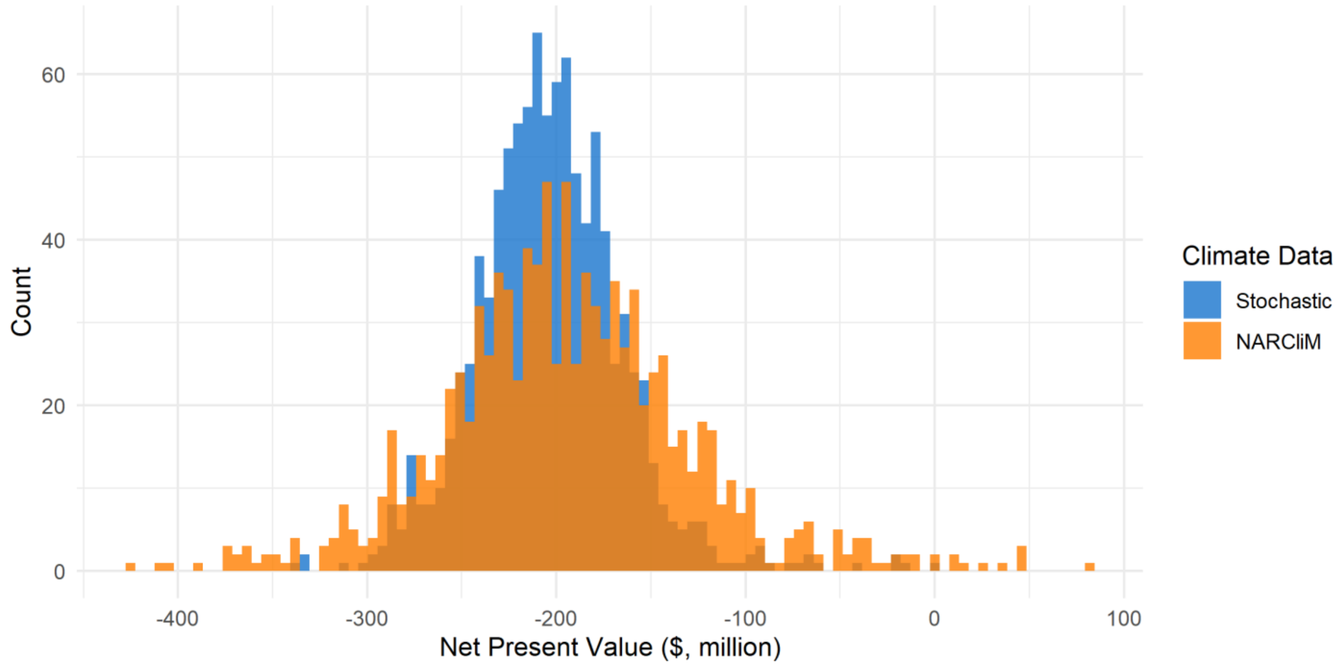
Table 52. Decile and extreme centile results of enlarged Blowering Dam - 100 GL airspace reserved for SHL releases

Percentile	Long-term historical net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate net present value ($m)	Dry future climate benefit–cost ratio
1%	-289.4	-1.5	-366.0	-2.2
10%	-249.0	-1.1	-270.5	-1.3
20%	-233.0	-1.0	-242.9	-1.1
30%	-222.3	-0.9	-226.6	-1.0
40%	-213.3	-0.8	-210.7	-0.8
50%	-204.9	-0.8	-196.6	-0.7
60%	-196.3	-0.7	-182.1	-0.6
70%	-186.0	-0.6	-166.0	-0.4
80%	-175.5	-0.5	-147.8	-0.3

Percentile	Long-term historical net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate net present value ($m)	Dry future climate benefit–cost ratio
90%	-159.2	-0.4	-117.4	0.0
99%	-86.0	0.3	-1.1	1.0

Figure 15 shows the distribution histogram of net present values generated by option 36(i) under the two different climate scenarios. The figure shows that under both scenarios most counts of net present values lie within the negative ranges, clustering between $-250 to $-150 million. While in the dry future climate the option performs slightly better, none of the climate scenarios would suggest a materially high economic viability of the proposed option.

Figure 15. Net present value histogram – enlarged Blowering Dam – 100 GL airspace reserved for SHL releases



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Sensitivity analysis

The sensitivity analysis was undertaken for the combined option which included the following cases:

- higher (7%) and lower (3%) discount rates
- higher (+30%) and lower (-30%) combined option costs
- higher and lower economic costs, the magnitude of which varies depending on the marginal value altered.

Table 53 displays the sensitive analysis results of option 36(i) under both scenarios. In both, and with all sensitivities, the option produces negative average net present values as well as benefit–cost ratios that are strictly lower than one. The percentages of benefit–cost ratio that are larger than one for all sensitivity cases and under both scenarios are very low with the highest value equal to only 2%. This indicates an extremely limited possibility that the proposed option would be economically feasible.

Table 53. Sensitivity analysis on enlarged Blowering Dam - 100 GL airspace reserved for SHL releases

Long-term historical

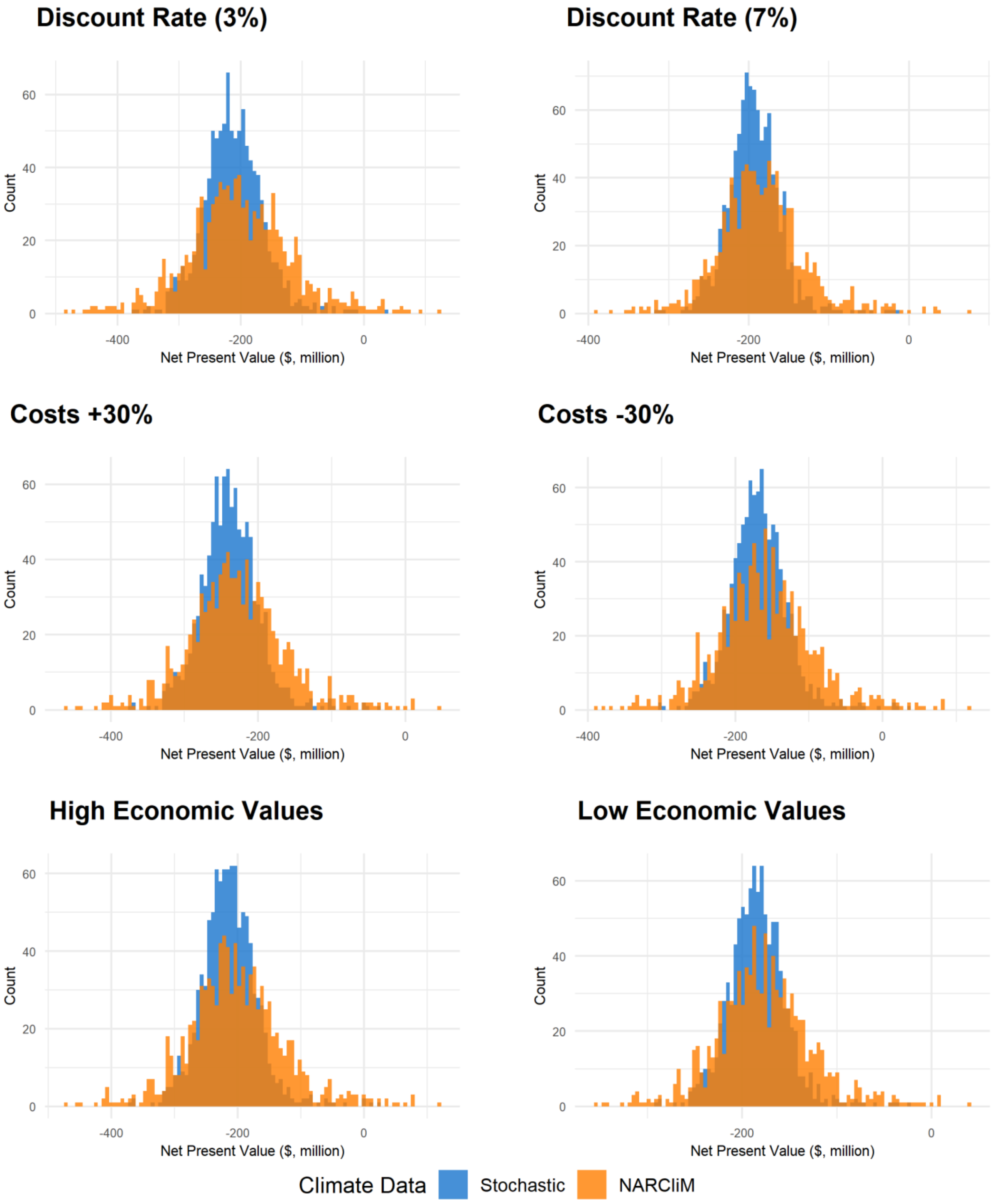
Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	116.3	-203.6	-0.8	-1.9	1.0	0.0
Low discount rate (3%)	94.0	-212.0	-1.3	-3.0	1.4	0.1
High discount rate (7%)	126.5	-193.7	-0.5	-1.5	0.9	0.0
Option cost (+30%)	151.1	-238.4	-0.6	-1.5	0.8	0.0
Option cost (-30%)	81.4	-168.7	-1.1	-2.7	1.4	0.4
Economic values (high)	116.3	-213.1	-0.8	-2.2	1.2	0.4
Economic values (low)	116.3	-184.2	-0.6	-1.5	0.8	0.0

Dry future climate

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	116.3	-194.1	-0.7	-2.7	1.7	1.0
Low discount rate (3%)	94.0	-201.8	-1.2	-4.2	2.3	1.8
High discount rate (7%)	126.5	-184.7	-0.5	-2.1	1.6	0.7
Option cost (+30%)	151.1	-229.0	-0.5	-2.0	1.3	0.5
Option cost (-30%)	81.4	-159.2	-1.0	-3.8	2.5	2.0
Economic values (high)	116.3	-201.7	-0.7	-3.0	2.1	1.8
Economic values (low)	116.3	-176.8	-0.5	-2.1	1.3	0.5

Histograms of the net present value outcomes of the sensitivity analysis are shown in Figure 16. The figure validates results from Table 53 demonstrating that in all sensitivity cases, and under either climate scenarios, the expected net present values generated by option 36(i) are negative with very few counts of results falling in the positive range. These distribution histograms, as well as results from Table 53, suggest that option 36(i) would still perform poorly even under more favourable situations, that is, reduced cost, lower discount rate, and higher economic values of water usage.

Figure 16. Enlarged Blowering Dam – 100 GL airspace reserved for SHL releases sensitivity case net present value shown as histograms



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Distributional analysis

Table 54 shows the results of distributional analysis of option 36(i) under the long-term historical and dry future climate scenarios. These outcomes suggest that the total net economic benefits for the proposed option under both climate scenarios are negative. The only user group who would benefit mildly from the option is the permanent crops under the dry future climate scenario, with a percentage change of 0.3% compared to the baseline estimates.

Table 54. Average distributional impacts from an Enlarged Blowering Dam – 100 GL airspace reserved for SHL compared to the economic base case across both datasets

Long-term historical

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	0.0	3538.4	6992.6	10531.0
Option outcomes ($m)	0.0	3449.0	6994.7	10443.7
Change ($m)	Negl	-89.4	2.1	-87.3
% Change	Negl	-2.5%	0.0%	-0.8%

Dry future climate

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	-0.3	2369.3	6421.9	8790.9
Option outcomes ($m)	-0.3	2274.3	6439.0	8713.0
Change ($m)	Negl	-95.0	17.1	-77.9
% Change	Negl	-4.0%	0.3%	-0.9%

Note: “Negl.” Refers to negligible (generally less than half the smallest unit or decimal of the heading).

Option 36(ii): Raise Blowering Dam – 200 GL airspace reserved for SHL releases

Option36(ii) forms one component of Option 36.

The objective of option 36 is to improve water security in the regulated Murrumbidgee region. This option involves investigating raising the Blowering Dam spillway by 4.5m to create an extra 200 GL of capacity (not a raise of the broader dam wall). It considers two variations in the pre-release compensation reserve airspace for Snowy Hydro Limited (SHL) electricity generation:

- 100 GL of airspace – Option 36(i)
- 200 GL of airspace – Option 36(ii)

Results of the rapid benefit–cost analysis is that option 36(ii) would generate a net present value of $-254.3 million and a benefit–cost ratio equals to -1.2, as shown in Table 55. These results imply that the option demonstrates very limited economic viability in the instrumental dataset.

Table 55. Rapid benefit–cost analysis outcomes overview for the Enlarged Blowering Dam – 200 GL airspace reserved for SHL releases option

Option	Description	Net present value ($m)	Benefit–cost ratio
36(ii)	Enlarged Blowering Dam – 200 GL airspace reserved for SHL releases	-254.3	-1.2

Table 56 shows the distributional outcome for the Murrumbidgee region as a result of option 36(ii). In the historic record none of the water users in the Murrumbidgee region would benefit from the option. The impact on town water users is negligible and negative to both annual crops (-3.6% change) and permanent crops (-0.1% change).

Table 56. Distributional analysis for enlarged Blowering Dam - 200 GL airspace reserved for SHL releases

Option	Town water supply ($m, (% change))	Annual crops ($m, (% change))	Permanent crops ($m, (% change))
36(ii)	Negl	-134.2 (-3.6%)	-3.7 (-0.1%)

Note: "Negl." refers to negligible (generally less than half the smallest unit or decimal of the heading).

This option proceeded to detailed assessment using the two additional climate scenarios and the summary data is shown in Table 57. These results show that under both scenarios option 36(ii) generates negative expected net present values and benefit–cost ratios that are strictly lower than one.

Table 57. Average results for enlarged Blowering Dam - 200 GL airspace reserved for SHL releases

Option	Net present cost ($m)	Long-term historical net present value ($m)	Dry future climate net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate benefit–cost ratio
36(ii)	116.3	-206.8	-222.5	-0.8	-0.9

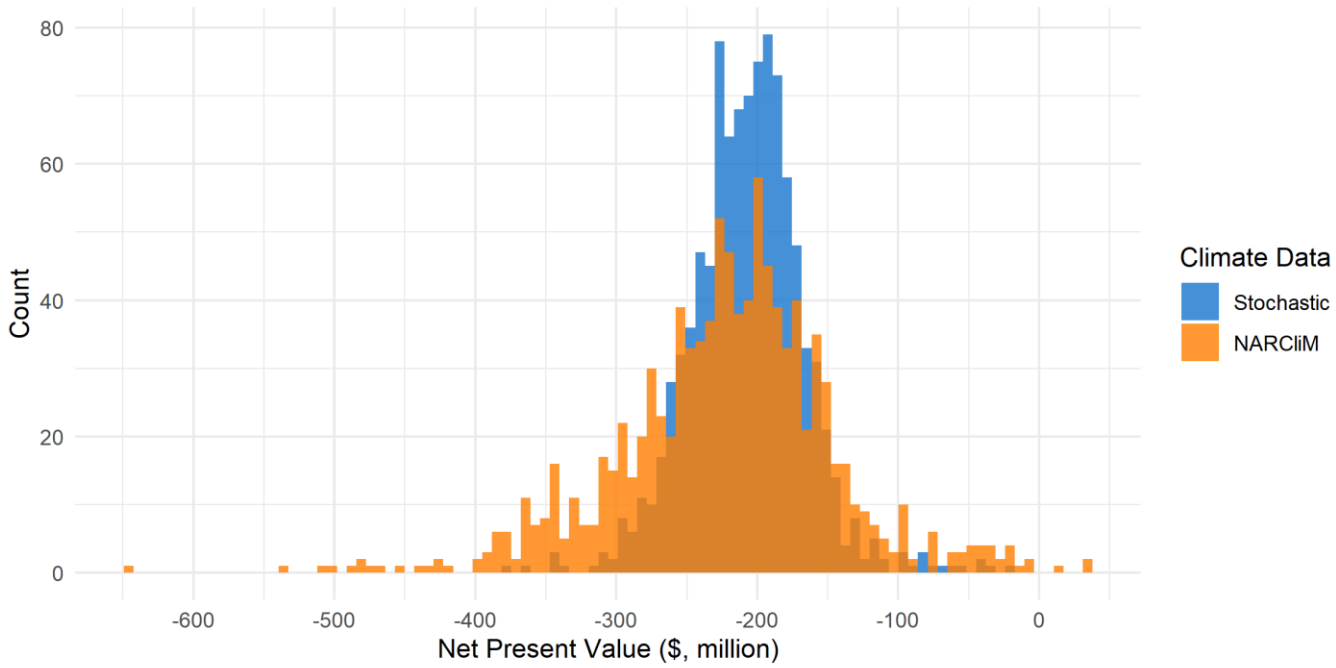
Table 58 displays the decile and extreme centiles of the net present values generated by option 36(ii). The table suggests under both scenarios from the 1% to 99% percentiles the option results in negative net present values and benefit–cost ratios that are smaller than one. These results imply that the option produces negative net economic benefits. Though the dry future climate scenario performs slightly better than the long-term historical, there is still strong evidence suggesting the economic viability of Option 36(ii) is highly limited with no positive net present values produced in any percentile.

Table 58. Decile and extreme centile results enlarged Blowering Dam - 200 GL airspace reserved for SHL releases

Percentile	Long-term historical net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate net present value ($m)	Dry future climate benefit–cost ratio
1%	-304.7	-1.6	-441.2	-2.8
10%	-256.2	-1.2	-316.7	-1.7
20%	-237.7	-1.0	-276.1	-1.4
30%	-226.2	-1.0	-251.7	-1.2
40%	-215.2	-0.9	-231.9	-1.0
50%	-206.0	-0.8	-217.8	-0.9
60%	-196.7	-0.7	-200.8	-0.7
70%	-187.6	-0.6	-187.0	-0.6
80%	-176.8	-0.5	-168.4	-0.5
90%	-161.2	-0.4	-141.8	-0.2
99%	-84.7	0.3	-27.4	0.8

Figure 17 provides further details about the distribution of net present values of Option 36(ii), suggesting that most of results generated lie in negative ranges in both scenarios. While there are some counts of positive net present values at the extreme right-tail under the dry future climate scenario, it does not change the limited possibility of option 36(ii) being economically feasible.

Figure 17. Net present value histogram - enlarged Blowering Dam - 200 GL airspace reserved for SHL releases



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Sensitivity analysis

The sensitivity analysis was undertaken for the combined option which included the following cases:

- higher (7%) and lower (3%) discount rates
- higher (+30%) and lower (-30%) combined option costs
- higher and lower economic costs, the magnitude of which varies depending on the marginal value altered.

Table 59 provides results of sensitive analysis of option 36(ii). Under both climate scenarios, and in all sensitivity cases, the average net present values are negative, and the benefit–cost ratios are strictly lower than one. The percentages of benefit–cost ratios higher than one appear to be extremely small in all scenarios, with the largest value only 1.5%. These results show the chance option 36(ii) would produce positive net economic benefits to the Murrumbidgee region are statistically small.

Table 59. Sensitivity analysis on enlarged Blowering Dam - 200 GL airspace reserved for SHL releases, long-term historical and dry future climate datasets

Long-term historical

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	116.3	-206.8	-0.8	-2.2	0.8	0.0
Low discount rate (3%)	94.0	-216.3	-1.3	-3.6	0.9	0.0
High discount rate (7%)	126.5	-196.3	-0.6	-1.7	0.8	0.0
Option cost (+30%)	151.1	-241.7	-0.6	-1.7	0.6	0.0
Option cost (-30%)	81.4	-171.9	-1.1	-3.2	1.2	0.1
Economic values (high)	116.3	-217.1	-0.9	-2.6	1.0	0.1
Economic values (low)	116.3	-186.7	-0.6	-1.7	0.6	0.0

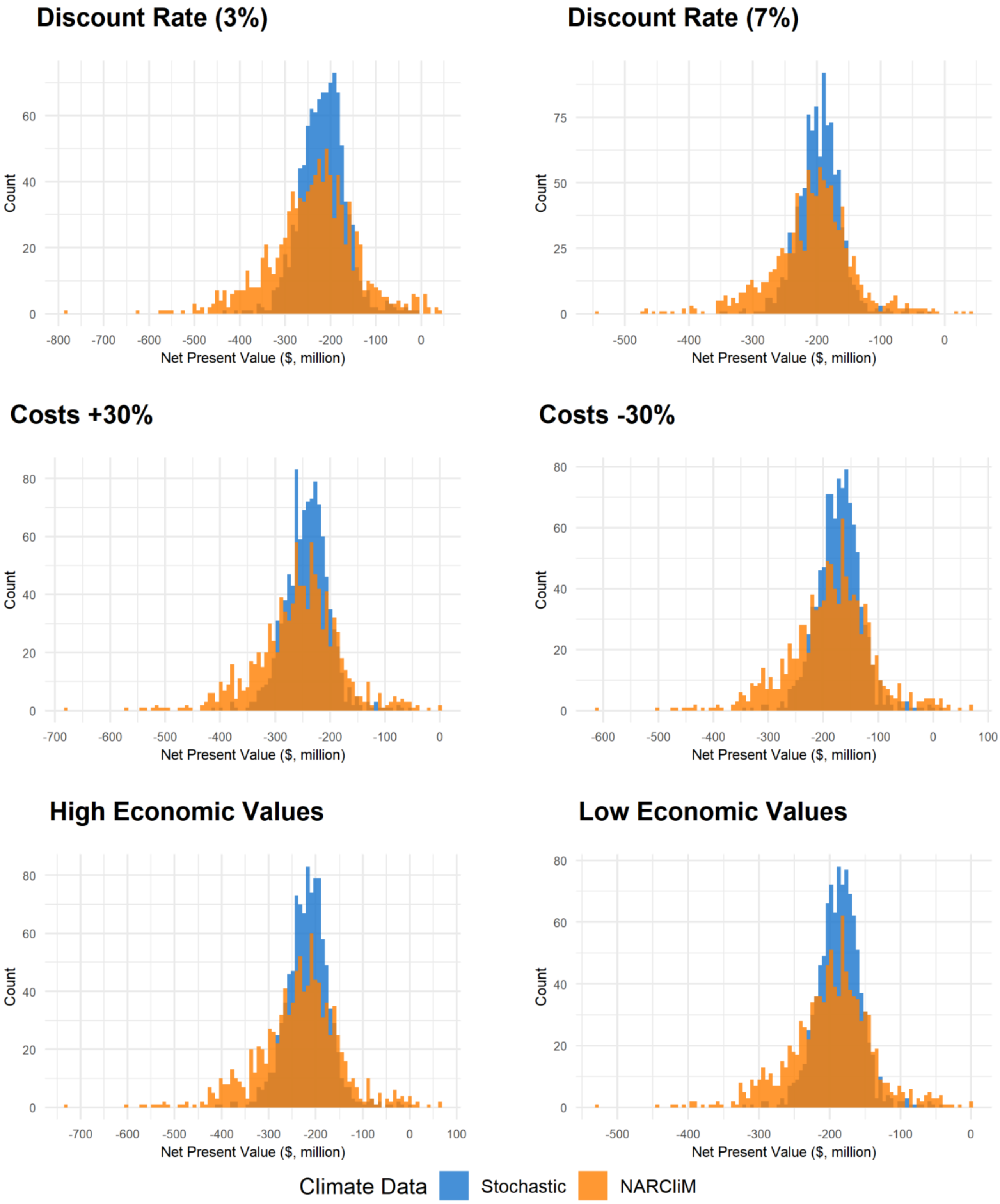
Dry future climate

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	116.3	-222.5	-0.9	-4.6	1.3	0.3

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit-cost ratio with benefit–cost ratio > 1
Low discount rate (3%)	94.0	-238.6	-1.5	-7.3	1.5	1.1
High discount rate (7%)	126.5	-207.8	-0.6	-3.3	1.4	0.3
Option cost (+30%)	151.1	-257.4	-0.7	-3.5	1.0	0.0
Option cost (-30%)	81.4	-187.6	-1.3	-6.5	1.9	1.5
Economic values (high)	116.3	-235.4	-1.0	-5.3	1.6	0.6
Economic values (low)	116.3	-198.9	-0.7	-3.5	1.0	0.1

Histograms of the outcomes of the sensitivity analysis are shown in Figure 18, supporting the results of Table 59, that the expected net present values of all sensitive cases under both scenarios are negative. Where there are cases with more favourable situations (for example., a lower discount rate), the counts of positive realisations do slightly increase, but it is still not strong enough to support the economic viability of option 36(ii).

Figure 18. Enlarged Blowering Dam - 200 GL airspace reserved for SHL releases, long-term historical and dry future climate datasets sensitivity case net present value shown as histograms, Murrumbidgee region



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Distributional analysis

Table 60 shows the results of distributional analysis of option 36(ii) under the long-term historical and dry future climate scenarios. For town water users, changes under both scenarios are negligible. Annual crop user groups see decreased economic outcomes under both (-2.5% in the long-term historical and -3.7% in the dry future climate) and permanent crops user groups are also subject to small negative changes (-0.1% in the long-term historical and -0.3% in the dry future climate). These add up to total negative percentage changes in economic benefits for water users in the Murrumbidgee under both climate scenarios.

Table 60. Average distributional impacts from Enlarged Blowering Dam - 200 GL airspace reserved for SHL releases compared to the economic base case across both datasets

Long-term historical

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	0.0	3538.4	6992.6	10531.0
Option outcomes ($m)	0.0	3451.4	6989.0	10440.4
Change ($m)	Negl	-87.0	-3.6	-90.6
% Change	Negl	-2.5%	-0.1%	-0.9%

Dry future climate

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	-0.3	2369.3	6421.9	8790.9
Option outcomes ($m)	-0.3	2281.2	6403.7	8684.6
Change ($m)	Negl	-88.1	-18.2	-106.3
% Change	Negl	-3.7%	-0.3%	-1.2%

Note: "Negl." refers to negligible (generally less than half the smallest unit or decimal of the heading).

Option 36a(i): Combined gravity pipeline along Tumut River and raised Blowering Dam - 100 GL airspace

This forms one component of option 36a. Option 36a is a combination of options 35 and option 36 (Tumut gravity pipeline and the enlarged Blowering Dam). It also explores the two Blowering airspace options:

- 100 GL airspace – Option 36a(i)
- 200 GL airspace – Option 36a(ii)

The objective of this option is to improve the delivery of water out of Blowering Dam and harmonisation of Blowering and Burrinjuck dam levels to increase system-wide water availability. The option also aims to improve water security in the regulated Murrumbidgee region. The net present cost is $13,688 million. Outcomes of the rapid benefit–cost analysis shown in Table 61 suggest that option 36a(i) results in a net present value of $-13,697.6 and a benefit–cost ratio of 0. While this extremely negative net present value is contributed by a large net present cost, it still suggests limited economic feasibility of the proposed option.

Table 61. Rapid benefit–cost analysis outcomes for the combined gravity pipeline along Tumut River and raised Blowering Dam - 100 GL airspace option

Option	Description	Net present value ($m)	Benefit–cost ratio
36a(i)	Combined gravity pipeline along Tumut River and raised Blowering Dam - 100 GL airspace	-13697.6	0.0

Table 62 displays the outcomes of distributional analysis using the historic record of the proposed option. These results indicate that the option would bring either negligible or negative change to all water users within the Murrumbidgee region using the historical records. The breakdown of these impacts is a negligible effect to town water users, a small negative change of 0.2% to annual crops and approximately 0% change to permanent crops compared to the baseline estimates.

Table 62. Distributional analysis for the combined gravity pipeline along Tumut River and raised Blowering Dam - 100 GL airspace

Option	Town water supply ($m, (% change))	Annual crops ($m, (% change))	Permanent crops ($m, (% change))
36a(i)	Negl	-8.9(-0.2%)	-0.7(0.0%)

Note: "Negl." refers to negligible (generally less than half the smallest unit or decimal of the heading).

Option 36a(i) did not proceed to detailed economic assessment under the long-term historical and dry future climate scenarios because of its poor performance in the rapid benefit–cost analysis.

Option 36a(ii): Combined gravity pipeline along Tumut River and raised Blowering Dam - 200 GL airspace

This forms one component of Option 36a. Option 36a is a combination of options 35 and option 36 (Tumut gravity pipeline and the enlarged Blowering Dam). This also explores the two Blowering airspace options:

- 100 GL airspace – Option 36a(i)
- 200 GL airspace – Option 36a(ii)

The objective of this option is to improve the delivery of water out of Blowering Dam and harmonisation of Blowering and Burrinjuck dam levels to increase system-wide water availability. The option also aims to improve water security in the regulated Murrumbidgee region. The net present cost of the proposed option is $13,688 million. Outcomes of the rapid benefit–cost analysis shown in Table 63 suggests that Option 36a(ii) results in a net present value of $-13,706.2 and a benefit–cost ratio of zero. Like that in option 36a(i), this extremely negative net present value suggests very limited economic viability of the proposed option.

Table 63. Rapid benefit–cost analysis outcomes for the combined gravity pipeline along Tumut River and raised Blowering Dam - 200 GL airspace option

Option	Description	Net present value ($m)	Benefit–cost ratio
36a(ii)	Combined gravity pipeline along Tumut River and raised Blowering Dam - 200 GL airspace	-13706.2	0.0

Table 64 displays the distributional effect using the historical dataset of option 36a(ii). These results suggest similar interpretation as option 36a(i): none of the water users benefit from the proposed option in terms of economic outcomes. The breakdown of these impacts is a negligible effect to town water user and small negative changes to annual and permanent crops (-0.2% and -0.1%, respectively) compared to the baseline estimates.

Table 64. Distributional analysis for the combined gravity pipeline along Tumut River and raised Blowering Dam - 200 GL airspace

Option	Town water supply ($m, (% change))	Annual crops ($m, (% change))	Permanent crops ($m, (% change))
36a(ii)	Negl	-9.0 (-0.2%)	-9.2 (-0.1%)

Note: "Negl." refers to negligible (generally less than half the smallest unit or decimal of the heading).

Option 36a(ii) did not proceed to detailed economic assessment under the long-term historical and dry future climate scenarios because of its poor performance in the rapid benefit–cost analysis.

Option 37: Enlarge Burrinjuck Storage Reservoir

The aim of this option is to improve water security in the regulated Murrumbidgee region. This option involves the investigation of adding 674 GL of additional storage capacity to Burrinjuck Dam making a full supply volume of 1700 GL.

Outcomes of the rapid benefit–cost analysis using the historical dataset is shown in Table 65, suggesting a net present value of $-3524.1 and a benefit–cost ratio of 0, given a net present cost of $3,431.8 million associated with option 37. This large negative net present value, together with low benefit–cost ratio, indicates that the proposed option lacks economic viability.

Table 65. Rapid benefit–cost analysis outcomes for the expand Burrinjuck Storage Reservoir option

Option	Description	Net present value ($m)	Benefit–cost ratio
37	Expand Burrinjuck Storage Reservoir	-3524.1	0.0

Table 66 displays the distributional impact of option 37 using historical data. These results indicate that the option brings either negligible or small negative changes to all water users within the Murrumbidgee region. The breakdown of these impacts has a negligible impact on town water users, a small negative change of 2.9% to the annual crops and a small positive change of 0.3% to permanent crop users compared to the baseline estimates.

Table 66. Distributional analysis for expand Burrinjuck Storage Reservoir

Option	Town water supply ($m, (% change))	Annual crops ($m, (% change))	Permanent crops ($m, (% change))
37	Negl	-110.4 (-2.9%)	18.1 (0.3%)

Note: "Negl." refers to negligible (generally less than half the smallest unit or decimal of the heading).

Option 37 did not proceed to detailed economic assessment under the long-term historical and dry future climate scenarios because of its poor performance in the rapid benefit–cost analysis.

Option 38: Expand Bundidgerry off-river storage

This option aims to increase the amount of buffer storage downstream of flow constraints on the Murrumbidgee River to improve efficiency in regulated river system operations. It involves investigating the expansion of the storage capacity within Bundidgerry Creek to increase the local supply capacity close to the Murrumbidgee Irrigation Area (MIA). This would help provide flexibility in supply of water to the MIA, in lieu of delivery constraints further upstream, particularly during periods of peak demand. The net present cost associated with option 38 is $280.4 million.

Results of the rapid benefit–cost analysis of the proposed option are shown in Table 67, suggesting a net present value of $-257 million and a benefit–cost ratio of 0.1. These results imply limited economic viability of the proposed option.

Table 67. Rapid benefit–cost analysis outcomes overview for the expand Bundidgerry off-river storage option

Option	Description	Net present value ($m)	Benefit–cost ratio
38	Expand Bundidgerry off-river storage	-257.0	0.1

Table 68 shows distributional analysis outcomes of option 38 using the historical data. The table suggests that agricultural water users in the Murrumbidgee gain mild economic benefits from the proposed option (0.2% for both the annual and permanent crop users) while change to town water users are negligible.

Table 68. Distributional analysis for expand Bundidgerry off-river storage

Option	Town water supply ($m, (% change))	Annual crops ($m, (% change))	Permanent crops ($m, (% change))
38	Negl	7.2 (0.2%)	16.2 (0.2%)

Note: "Negl." refers to negligible (generally less than half the smallest unit or decimal of the heading).

The option proceeded to detailed assessment using the two additional climate scenarios and the summary data is shown in Table 69. These results represent the averages across all 1,000 realisations undertaken in the analysis. As each 40-year analysis period has an equal likelihood of occurrence, the averages also represent the expected values — or outcomes — for the proposed option. This implies that the expected net present values of option 38 under the two additional scenarios are all negative ($-253.3 under the long-term historical scenario and $-179.9 under the dry future climate scenario) with benefit–cost ratios that are lower than one.

Table 69. Average results for expand Bundidgerry off-river storage

Option	Net present cost ($m)	Long-term historical net present value ($m)	Dry future climate net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate benefit–cost ratio
38	280.4	-253.3	-179.9	0.1	0.4

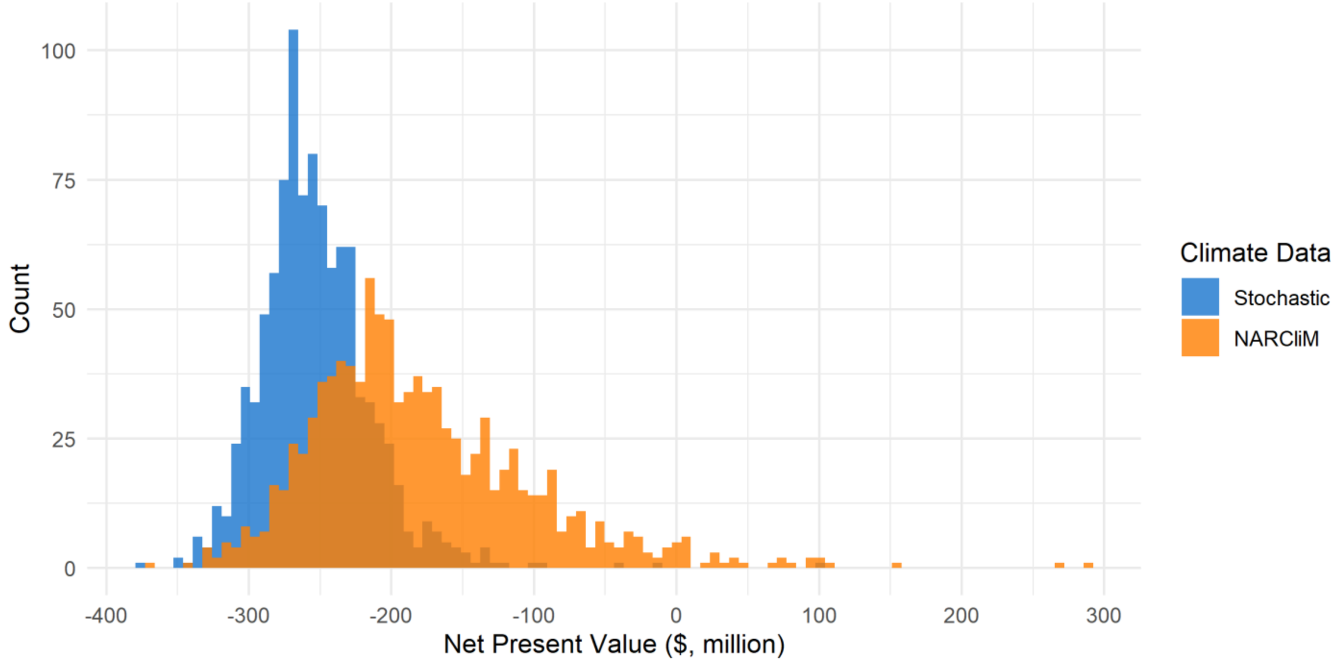
Table 70 displays the decile and extreme centiles of the net present values generated by option 38 given the two additional climate scenarios. The data suggests under the long-term historical scenario from the 1% to more than 99% percentiles the option results in negative net present values and benefit–cost ratios that are smaller than one. In the dry future climate scenario performance of the proposed option is improved: at least starting from the 99% percentile the net present values turn into positive and benefit–cost ratios are higher than one. However these results still suggest that the economic viability of option 38 is highly limited and depends on climate assumptions.

Table 70. Decile and extreme centile results of expand Bundidgerry off-river storage

Percentile	Long-term historical net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate net present value ($m)	Dry future climate benefit–cost ratio
1%	-331.8	-0.2	-314.3	-0.1
10%	-297.4	-0.1	-262.0	0.1
20%	-282.4	0.0	-242.0	0.1
30%	-272.7	0.0	-224.1	0.2
40%	-266.3	0.1	-210.3	0.3
50%	-257.2	0.1	-194.4	0.3
60%	-249.2	0.1	-175.2	0.4
70%	-237.6	0.2	-153.8	0.5
80%	-227.2	0.2	-121.4	0.6
90%	-207.7	0.3	-80.8	0.7
99%	-136.5	0.5	70.7	1.3

Figure 19 provides additional information about the distribution of net present values generated under the two climate scenarios. While the distribution of results in the long-term historical scenario is closer to a symmetric shape, clustering around $-250 million, in the dry future climate scenario the net present values are distributed in a much wider range and skewed to the right, with some counts of positive values. The possibility of option 38 ending with very negative outcomes in the dry future climate scenario is smaller compared to that in the long-term historical one. This is suggested by fewer counts of extreme negative values in the dry future climate scenario. The figure suggests that performance of the proposed option is diverse under different climate scenarios and tends to achieve overall better outcomes under a dry future climate.

Figure 19. Net present value histogram - expand Bundidgerry off-river storage



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Sensitivity analysis

The sensitivity analysis was undertaken for the combined option which included the following cases:

- higher (7%) and lower (3%) discount rates
- higher (+30%) and lower (-30%) combined option costs
- higher and lower economic costs, the magnitude of which varies depending on the marginal value altered.

Table 71 provides summary data of option 38 for the central case and sensitivity analysis under the long-term historical and dry future climate scenarios. Although in both scenarios, and in all sensitivity cases, the expected net present values are negative, the performance of the option is moderately improved under the dry future climate scenario. The percentages of benefit–cost ratio are higher in the long-term historical scenario and range from 0.1% to 0.3%. Under the dry future climate scenario the possibilities vary across 0.8% to 13%. These outcomes indicates that performance of option 38 depends heavily on the climate assumption.

Table 71. Sensitivity analysis on expand Bundidgerry off-river storage

Long-term historical

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	280.4	-253.3	0.1	-0.3	1.4	0.1
Low discount rate (3%)	251.7	-215.1	0.2	-0.4	1.7	0.3
High discount rate (7%)	290.6	-269.5	0.1	-0.3	1.2	0.1
Option cost (+30%)	364.6	-337.4	0.1	-0.3	1.1	0.1
Option cost (-30%)	196.3	-169.2	0.1	-0.5	2.0	0.3
Economic values (high)	280.4	-249.7	0.1	-0.4	1.6	0.3
Economic values (low)	280.4	-259.3	0.1	-0.3	1.1	0.1

Dry future climate

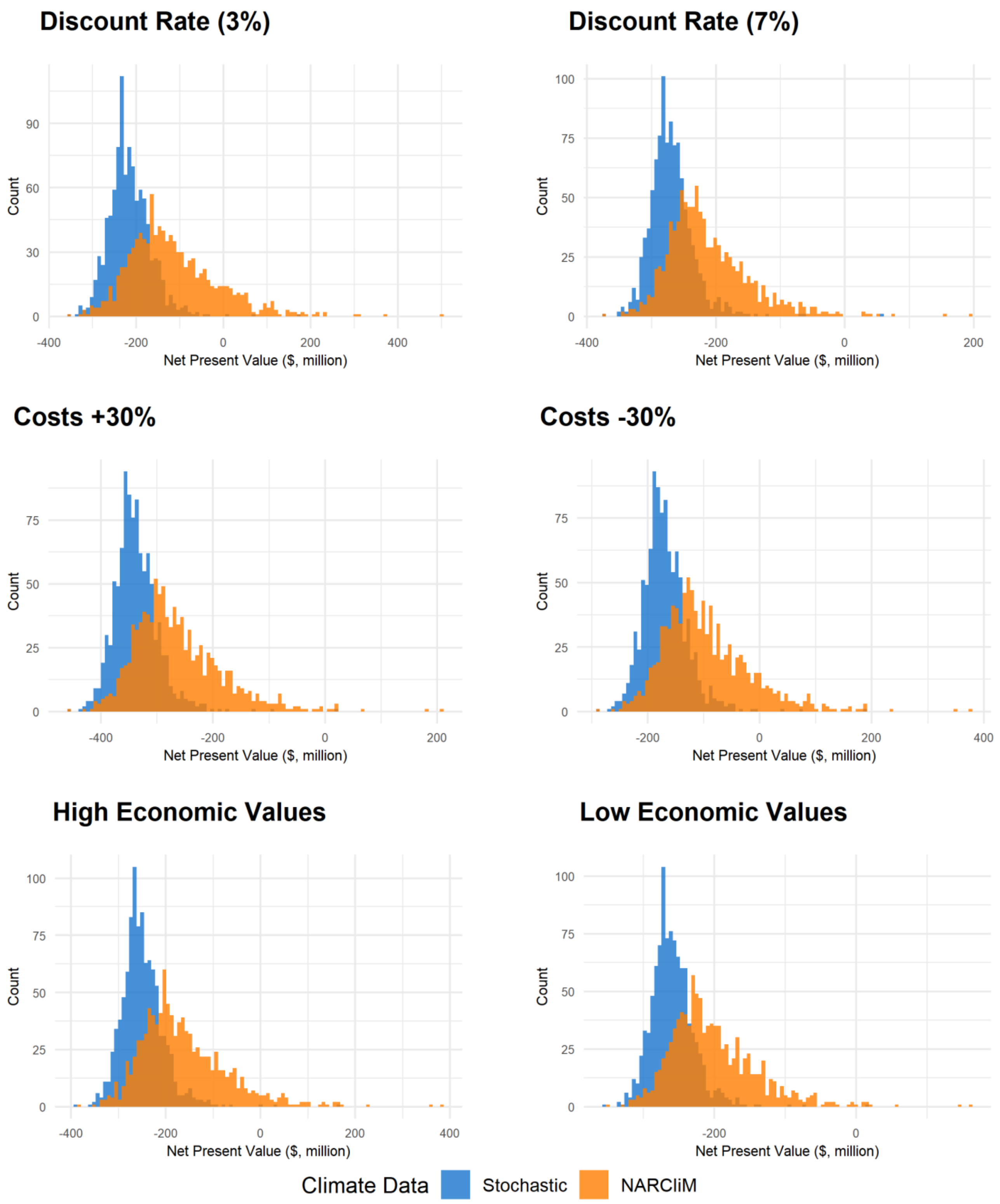
Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	280.4	-179.9	0.4	-0.3	2.0	3.0

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit-cost ratio with benefit–cost ratio > 1
Low discount rate (3%)	251.7	-116.4	0.5	-0.4	3.0	13.0
High discount rate (7%)	290.6	-212.3	0.3	-0.3	1.7	0.8
Option cost (+30%)	364.6	-264.0	0.3	-0.3	1.6	0.8
Option cost (-30%)	196.3	-95.8	0.5	-0.5	2.9	10.3
Economic values (high)	280.4	-163.9	0.4	-0.4	2.4	5.3
Economic values (low)	280.4	-202.3	0.3	-0.3	1.6	0.8

Figure 20 provides additional details on the distribution of net present values in all sensitivity cases under both climate scenarios, supporting results from Table 71.

demonstrating that the expected net present values are negative in both datasets given all sensitivity cases. However, in the dry future climate scenario performance of the option is moderately improved.

Figure 20. Expand Bundidgerry off-river storage, long-term historical and dry future climate datasets sensitivity case net present value shown as histograms



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Distributional analysis

Table 72 shows the results of distributional analysis of option 38 under the long-term historical and dry future climate scenarios. These outcomes reveal that under both scenarios there are negligible changes in economic outcomes for towns water users and small percentage increases in annual and permanent crops ranging from 0.1% to 1.2%. Overall option 38 brings small positive changes to water users in the Murrumbidgee region when compared to the baseline estimates.

Table 72. Average distributional impacts from expand Bundidgerry off-river storage compared to the economic base case across both datasets

Long-term historical

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	0.0	3538.4	6992.6	10531.0
Option outcomes ($m)	0.0	3555.5	7002.6	10558.1
Change ($m)	Negl	17.1	10.0	27.1
% Change	Negl	0.5%	0.1%	0.3%

Dry future climate

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	-0.3	2369.3	6421.9	8790.9
Option outcomes ($m)	-0.2	2389.7	6501.9	8891.4
Change ($m)	Negl	20.4	80.0	100.5
% Change	Negl	0.9%	1.2%	1.1%

Note: "Negl." refers to negligible (generally less than half the smallest unit or decimal of the heading).

Option 39: Augment Tombullen storage and modify operations

Option 39 aims to increase the amount of buffer storage downstream of flow constraints on the Murrumbidgee River to improve efficiency in regulated river system operations. The original option was to increase the storage size of Tombullen storage as well as modify storage operation rules to improve water quality. However, in order to model an augmented storage, significant design and operation specifications would be needed which aren't available at this time. Therefore an augmented storage wasn't assessed and only operational changes to increase through-flow, to improve water quality, were considered.

The operating rule was changed by adding a target regulated supply volume of 10,000 ML for October through April to increase flushing flows.

The net present cost associated with option 39 was assigned a zero-dollar value and the rapid benefit–cost analysis produced a modest negative net present value of $-5.5, as shown in Table 73. The benefit–cost ratio is not applicable in this case due to a zero-dollar cost assigned. These results suggest that option 39 demonstrates limited economic viability using instrumental data.

Table 73. Rapid benefit–cost analysis outcomes overview for the augment Tombullen storage and modify operational changes option

Option	Description	Net present value ($m)	Benefit–cost ratio
39	Augment Tombullen Storage and modify operational changes	-5.5	NA

Table 74 shows the distributional analysis outcome of option 39 using the historical data. The table suggests that water users experience either negligible or small negative change as a result of the proposed option. Town water has negligible change, annual crop user has a percentage change of -0.1% and the permanent crop user has a zero-change compared to the baseline estimates.

Table 74. Distributional analysis for augment Tombullen storage and modify operational changes

Option	Town water supply ($m, (% change))	Annual crops ($m, (% change))	Permanent crops ($m, (% change))
39	Negl	-3.2 (-0.1%)	-2.3 (0.0%)

Note: "Negl." refers to negligible (generally less than half the smallest unit or decimal of the heading).

The option proceeded to detailed assessment using two additional climate scenarios and the results are displayed in Table 75. Under the long-term historical scenario, the expected net present value of option 39 is $-1.4 million, while under the dry future climate scenario it turns out to be a positive value of $1.5 million. These outcomes imply that the economic viability varies depending on the climate assumptions. Note that the average benefit–cost ratios are both not applicable due to the assigned zero-dollar-value cost of option 39.

Table 75. Average results for augment Tombullen storage and modify operational changes

Option	Net present cost ($m)	Long-term historical net present value ($m)	Dry future climate net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate benefit–cost ratio
39	0	-1.4	1.5	NA	NA

Table 76 shows the decile and extreme centiles of net present values generated by option 39 in the two additional climate scenarios. Under the long-term historical scenario, from 1% to at least the 50% percentile net present values generated by the proposed option are negative, while the rest of them appears to be positive. For the dry future climate scenario, starting from at least the 50% percentile net present values are positive. These outcomes suggest that chance of option 39 being economically viable (that is, generate positive net present values) depends on the assumption of future climate.

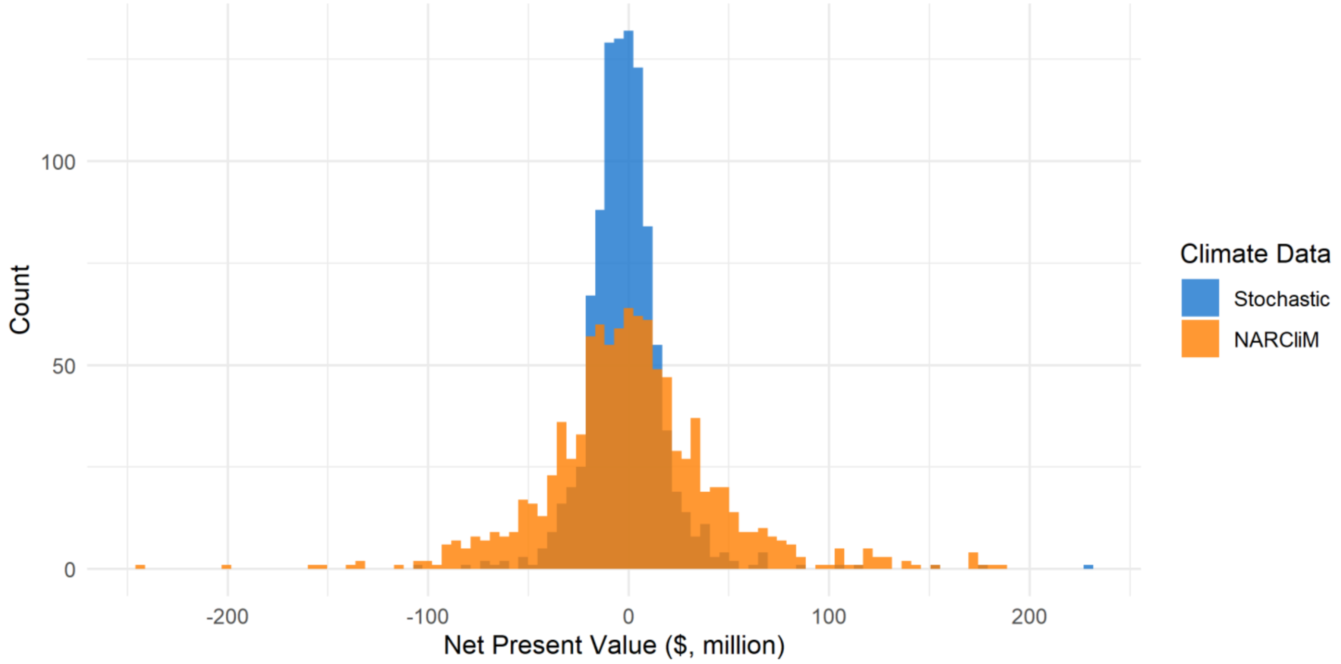
Table 76. Decile and extreme centile results of augment Tombullen storage and modify operational changes

Percentile	Long-term historical net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate net present value ($m)	Dry future climate benefit–cost ratio
1%	-45.5	NA	-98.7	NA
10%	-19.8	NA	-45.8	NA
20%	-13.7	NA	-26.9	NA
30%	-10.0	NA	-16.1	NA
40%	-5.9	NA	-8.2	NA
50%	-2.4	NA	0.2	NA
60%	0.8	NA	8.0	NA
70%	4.7	NA	16.2	NA
80%	9.4	NA	29.4	NA

Percentile	Long-term historical net present value ($m)	Long-term historical benefit–cost ratio	Dry future climate net present value ($m)	Dry future climate benefit–cost ratio
90%	17.4	NA	48.4	NA
99%	62.5	NA	139.2	NA

Figure 21 provides further information about the distribution of net present values generated under the two climate scenarios. It shows that in both there are some results that lie in the positive range while some lie in the negative range. This indicates uncertainty in economic viability of option 39. While the dry future climate scenario produces net present values with positive mean and median, the distribution is also of higher-level variation. This suggests that while the option is expected to perform slightly better in the dry future climate scenario, the uncertainties would also increase.

Figure 21. Net present value histogram - augment Tombullen storage and modify operational changes



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Sensitivity analysis

The sensitivity analysis was undertaken for the combined option which included the following cases:

- higher (7%) and lower (3%) discount rates
- higher (+30%) and lower (-30%) combined option costs
- higher and lower economic costs, the magnitude of which varies depending on the marginal value altered.

Table 77 provides the summary data of option 39 for the central case and sensitivity analysis under the long-term historical and dry future climate scenarios. While benefit–cost ratios for option 39 are not applicable due to its assigned zero-dollar value cost, the main indicator to be looked at is the expected net present values within sensitivity cases. These results show that under the long-term historical scenario, with all sensitivities, the produced net present values turn out to be negative on average. For the dry future climate scenario, the average net present values are positive in all sensitivity cases, implying the option is of slightly higher chance of being economically viable. Also to note is the average net present values in the dry future climate scenario are indifferent among the central, low discount and high discount rates. This suggests that expected net present value of the option is insensitive to the discount rate under the dry future climate scenario.

Table 77. Sensitivity analysis on augment Tombullen storage and modify operations

Long-term historical

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	0.0	-1.4	NA	NA	NA	NA
Low discount rate (3%)	0.0	-2.0	NA	NA	NA	NA
High discount rate (7%)	0.0	-1.0	NA	NA	NA	NA
Option cost (+30%)	0.0	-1.4	NA	NA	NA	NA
Option cost (-30%)	0.0	-1.4	NA	NA	NA	NA
Economic values (high)	0.0	-1.5	NA	NA	NA	NA

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Economic values (low)	0.0	-1.1	NA	NA	NA	NA

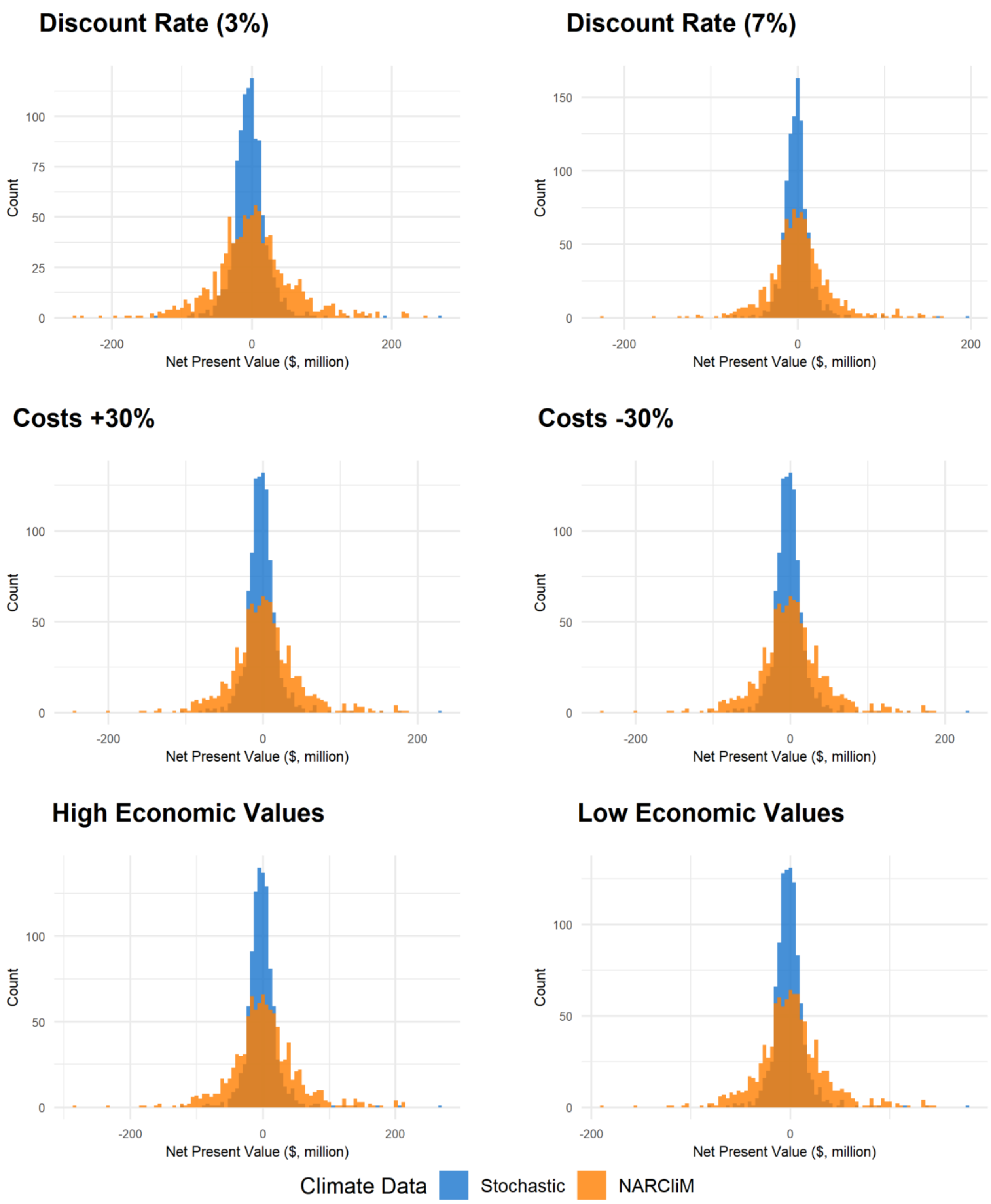
Dry future climate

Sensitivity case	Present value capital cost ($m)	Net present value ($m)	Benefit–cost ratio average	Benefit–cost ratio minimum	Benefit–cost ratio maximum	% of benefit–cost ratio with benefit–cost ratio > 1
Central	0.0	1.5	NA	NA	NA	NA
Low discount rate (3%)	0.0	1.5	NA	NA	NA	NA
High discount rate (7%)	0.0	1.5	NA	NA	NA	NA
Option cost (+30%)	0.0	1.5	NA	NA	NA	NA
Option cost (-30%)	0.0	1.5	NA	NA	NA	NA
Economic values (high)	0.0	2.1	NA	NA	NA	NA
Economic values (low)	0.0	1.2	NA	NA	NA	NA

Figure 22 provides additional details on the distribution of net present values of all sensitivity cases in the two climate scenarios, supporting results from

Table 77. This demonstrates that the expected net present values are stable between the two climate scenarios and within all sensitive cases. There is moderate positive value in the dry future climate scenario and moderate negative value in the long-term historical scenario.

Figure 22. Augment Tombullen storage and modify operations, long-term historical and dry future climate datasets sensitivity case net present value shown as histograms



Note: Stochastic refers to the long-term historical scenario and NARCliM refers to the dry future climate scenario

Distributional analysis

Table 78 shows the results of distributional analysis of option 39. These outcomes reveal mixed and minimal changes in economic outcomes across both climate scenarios. For town water users there are negligible changes in both. For annual crop irrigators the economic outcomes are negative under both scenarios, and for permanent crops the outcomes are both positive. The changes in the three user groups add up to a small negative total change ($-1.4 million) in economic outcome under the long-term historical scenario and a small positive total change ($1.5 million) under the dry future climate scenario.

Table 78. Average distributional impacts from augment Tombullen storage and modify operations compared to the economic base case across both datasets

Long-term historical

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	0.0	3538.4	6992.6	10531.0
Option outcomes ($m)	0.0	3535.1	6994.5	10529.6
Change ($m)	Negl	-3.3	1.9	-1.4
% Change	Negl	-0.1%	0.0%	0.0%

Dry future climate

	Town water supply ($m)	Annual crops ($m)	Permanent crops ($m)	Total ($m)
Base case ($m)	-0.3	2369.3	6421.9	8790.9
Option outcomes ($m)	-0.3	2364.1	6428.5	8792.3
Change ($m)	Negl	-5.2	6.6	1.5
% Change	Negl	-0.2%	0.1%	0.0%

Note: "Negl." refers to negligible (generally less than half the smallest unit or decimal of the heading).

Conclusions

The information presented in this technical document has helped provide a strategic analysis of options that could merit further investigation through the NSW Murray and Murrumbidgee Regional Water Strategy.

The conclusions from this report should be read in conjunction with the following accompanying technical documents:

- Economic base case assessment for the NSW Murray and Murrumbidgee regions
- Hydrologic analysis of options for the NSW Murray Regional Water Strategy
- Hydrologic analysis of options for the Murrumbidgee Regional Water Strategy