Department of Planning and Environment

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Regional Water Strategies Program

Hydrologic analysis of options for the Far North Coast Regional Water Strategy – Richmond River valley

January 2023

Acknowledgement of Country

The NSW Government acknowledges **First Nations people as its first Australian people** and the traditional owners and custodians of the country's lands and water. **We have recognised that 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 practice the oldest living culture on earth.

The NSW Government acknowledges the First Nations people/Traditional Owners from the Far North Coast Region as having an intrinsic connection with the lands and waters of the Far North Coast Regional Water Strategy area. 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 and by incorporating their culture and knowledge into management of water in the region is a significant step for closing the gap.

Under this regional water strategy, we seek to establish meaningful and collaborative relationships with **First Nations people**. We will 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, present and emerging 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, 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 that if we care for Country, it will care for us.

We acknowledge that further work is required under this regional water strategy to inform how we care for Country and ensure **Traditional Owners/First Nations people** hold a strong voice in shaping the future for **Indigenous/Aboriginal** and non-Aboriginal communities.

Published by NSW Department of Planning and Environment

dpie.nsw.gov.au

Title: Hydrologic analysis of options for the Far North Coast Regional Water Strategy – Richmond River valley

First published: January 2023

Department reference number: PUB22/1284

More information: water.dpie.nsw.gov.au/plans-and-programs/regional-water-strategies

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1 Introduction

What are regional water strategies?

Across NSW, valuable and essential water resources are under pressure. A more variable climate, as well as changing industries and populations, mean we face difficult decisions and choices about how to balance the different demands for this vital resource and manage water efficiently and sustainably into the future.

The Far North Coast Regional Water Strategy is one of a suite of catchment-based strategies across the state. The strategies identify critical challenges that we need to tackle over the coming decades and outline the priorities and actions that we will undertake to respond to those challenges. The best and latest climate evidence, along with a wide range of tools and solutions, has been used to chart a progressive implementation of actions for the region's water needs over the next 20 years and beyond.

Purpose of this options modelling report

The Far North Coast regional water strategy aims to have a comprehensive, balanced package of options that delivers on five key objectives:

- deliver and manage water for local communities
- enable economic prosperity
- recognise and protect Aboriginal water rights, interests and access to water
- protect and enhance the environment
- affordability

The strategy actions aim to deliver benefits and complementary actions across all stakeholder groups. To support the regional water strategies, we have developed hydrologic models for each major catchment in a region. We have used these models to:

- improve our understanding of the water systems in the region
- understand the effects that different water management options could have on the environment and on the supply, demand and allocation of water.

This report outlines how the different management options were conceptualised and built in the model. It also discusses the assumptions we needed to make and presents a summary of the hydrologic results. More detailed discussion on the implications of the results for the economic and environmental assessments is presented in the detailed economic and ecological analysis for the Far North Coast.[1]

Methodology

The assessment approach aims to define risks to essential water supplies and the regional economy from climate variability and drought in the Richmond River valley. This considered existing infrastructure and the potential for mitigating risks by augmenting water supply infrastructure or making operational changes. The hydrological assessment was a key tool for understanding the effects that options may have on existing water supply risks, on water users and on the environment in the Richmond River valley.

All hydrologic and water supply assessment modelling was completed using the eWater Source modelling platform. The model was developed as a tool for planning and evaluating water resource management policies at the river basin scale. In addition to assessing water quantity, this model can be applied to regulated and unregulated streams to understand water quality and environmental issues.

Not all options presented in the long list of options[2] have been modelled. Ten options for the Richmond catchment have been modelled. These have been selected primarily on their capacity to influence the supply, demand or allocation of water.

The options modelling was carried out in two stages. In the first stage, modelling was undertaken for each preferred option and the results were assessed for water security and fed into initial economic assessment of the modelled options. Based on the initial assessment, a series of portfolios was developed for further assessment. These portfolios combined a number of different options.

In stage 2, modelling was undertaken for the selected portfolios to better understand the impacts of the portfolios on water supply risks to water users in the Richmond catchment. This modelling also informed the economic assessment of options and for assessing ecological impacts.

We used three climatic datasets to test the resilience of the system and proposed options. The hydrologic modelling in the Far North Coast region is based on:

- historical data from the instrumental record (130 years): this provided initial insight into current water supply performance and risks, potential improvements under augmentation options and relative benefits between defined options
- long-term historic climate projections (stochastic data): these assume that our future climate is similar to what the science is indicating our long-term paleoclimate was like and are based on a 10,000-year dataset.

[1] Department of Planning and Environment 2022, *Far North Coast Regional Water Strategy: Detailed economic and ecological analysis*, www.dpie.nsw.gov.au/water/plans-and-programs/regional-water-strategies, accessed 9 December 2022.

[2] Department of Planning, Industry and Environment 2020, *Draft Regional Water Strategy — Far North Coast: Long list of options*, www.dpie.nsw.gov.au/water/plans-and-programs/regional-water-strategies, accessed 9 December 2022.

- a dry climate change scenario (NARCliM modelling): this assumes that there is a dry, worst-case climate change scenario in the future and is also based on a 10,000-year dataset

We also performed stochastic hydro-economic assessment by splitting the 10,000-year datasets into 1,000 40-year segments. This allowed us to assess the impact to each major water user using 1,000 40-year realisations or 'windows'. The 40-year time horizon reflects NSW Treasury guidelines for a long period of time to measure the consequence of an option.

The configuration, assumptions and results summaries of the options modelling are presented in detail in the sections below. Discussions on the implications of these results for water supply, economics and the environment are presented in the detailed economic and ecological analysis for the Far North Coast.[3]

[3] Department of Planning and Environment 2022, *Far North Coast Regional Water Strategy: Detailed economic and ecological analysis*, www.dpie.nsw.gov.au/water/plans-and-programs/regional-water-strategies, accessed 9 December 2022.

2 Background

Richmond River valley

The Richmond River valley is located on the Far North Coast of NSW. It is located between Tweed Heads and Grafton and is bounded by the Richmond Range to the west. The Richmond River begins at the NSW–Queensland border and flows southeast for around 170 km to the ocean at Ballina. The coastal extent of the catchment reaches from Evans Head in the south, to just south of Cape Byron in the north.

The Richmond catchment drains an area of over 7,000 km^2 from the Border Ranges in the north to the Richmond Range in the west and south. The upland ranges and the plateau north of Lismore remain mostly forested while the lower coastal plains are cleared for agriculture. Elevations range from over 1,000 m in the Border Ranges to near sea level on the coastal floodplain.

The main tributary of the Richmond River is the Wilsons River, which contributes around 60% of the flows in the lower river. The Wilsons River enters the Richmond on the coastal plain at Coraki. Other important tributaries are Eden Creek west of Kyogle, and Shannon Brook and Bungwalbin Creek, which drain the southern part of the catchment and enter the tidal reach of the river.

The Richmond River has an extensive tidal zone which extends beyond Tatham on the Richmond River and Lismore on the Wilsons River. The small coastal catchment of the Evans River is connected to the Richmond River at Woodburn by a canal. This canal is operated to mitigate flooding and improve drainage in the mid-Richmond River area. The Evans River flows for around 20 km and enters the ocean at Evans Head.

The catchment includes popular tourist destinations such as Ballina, and supports a high residential population attracted by the region's coastal lifestyle. Towns within the Richmond River include:

- Ballina
- Lismore
- Casino
- Kyogle
- Nimbin
- Coraki.

Figure 1 shows the location of the Richmond River valley, as well as the locations of key water supply storages and some towns within the valley. Lismore and Ballina are the largest urban centres in the catchment. The Richmond River valley also provides potable water for areas of the Brunswick River valley through Rocky Creek Dam.

WaterNSW operates Toonumbar Dam to supply water for stock and domestic use, and irrigation along Iron Pot Creek and Eden Creek. Two other storages in the Wilsons River catchment — Rocky Creek Dam and Emigrant Creek Dam — are operated by Rous County Council to provide town water for the region.

The Richmond River valley supports diverse land use, including livestock grazing (dairy and beef); horticulture; dryland agriculture (including sugar cane); forestry; and irrigated agriculture. On the Alstonville Plateau, a significant horticultural industry uses groundwater to irrigate fruit and nut crops. Dairy farms on irrigated pastures are found along the alluvial flats of the Richmond and Wilson Rivers. Rous County Council is a major water user, extracting water to supply urban centres of the region.

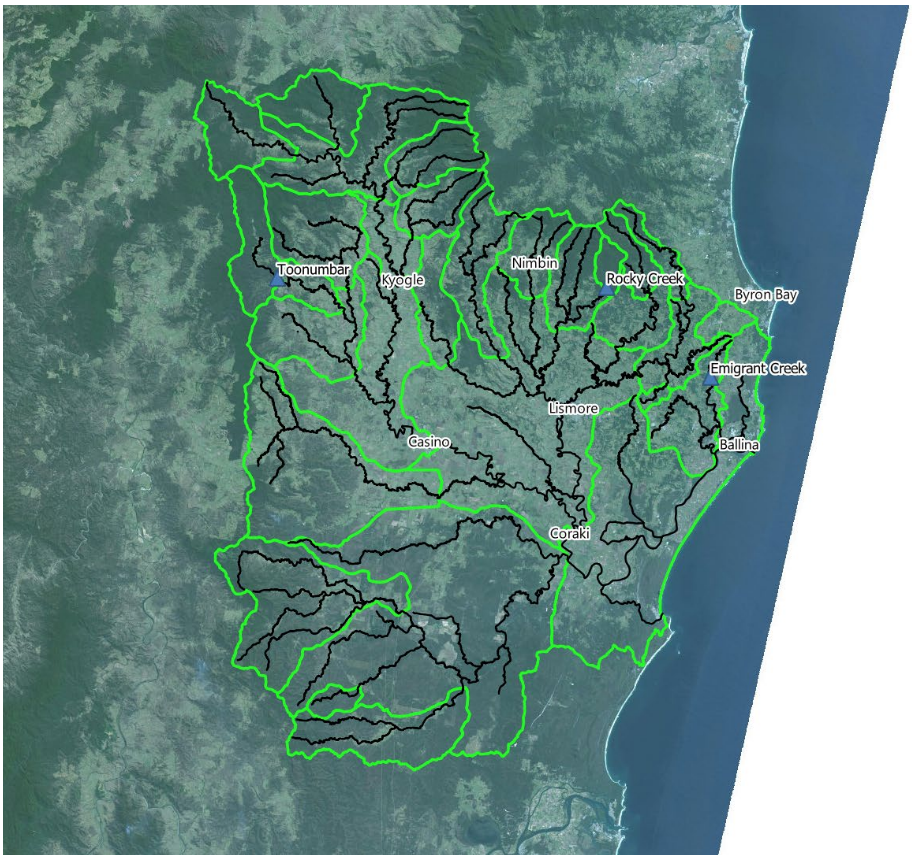

Figure 1. Richmond River valley overview map

While Toonumbar Dam supplies water to a small number of rural water users in the upper Richmond River, most of the rivers and creeks within the catchment are unregulated and pressure from extraction can occur in times of low flow.

Water sharing plans have been introduced to balance the needs of water users and the environment. They establish rules for sharing water between the environmental needs of the river or aquifer and water users, and also between different types of water use such as town supply, rural domestic supply, stock watering, industry and irrigation.

The relevant water sharing plan for this catchment is the *Richmond River Area Unregulated, Regulated and Alluvial*.[4]

[4] Department of Planning and Environment 2010, *Water Sharing Plan for the Richmond River Unregulated, Regulated and Alluvial Water Sources 2010* , www.legislation.nsw.gov.au/view/html/inforce/current/sl-2020-0702, accessed 9 December 2022.

Baseline model

The Richmond Regulated and Unregulated River System baseline model was developed to cover the full range of runoff conditions, as well as the operational rules of the water sharing plan and behaviour of extractive users. The Richmond River Source model was built in 2020 using the eWater Source modelling platform. One of the key objectives of developing a new model is to build a high-quality, robust and fit-for-purpose model, which is suitable for running a wide range of scenarios to inform various decisions related to policy, planning and strategies including regional water strategies.

The model for the Richmond Regulated and Unregulated River System was developed using a systematic approach involving a number of steps. The key stages of the model development were:

- model conceptualisation
- data collation and review for flow modelling
- flow model calibration
- collation and review of data for demand modelling and demand model calibration
- implementation of management rules and ordering calibration
- full model calibration and validation.

The model schematic is displayed in Figure 2.

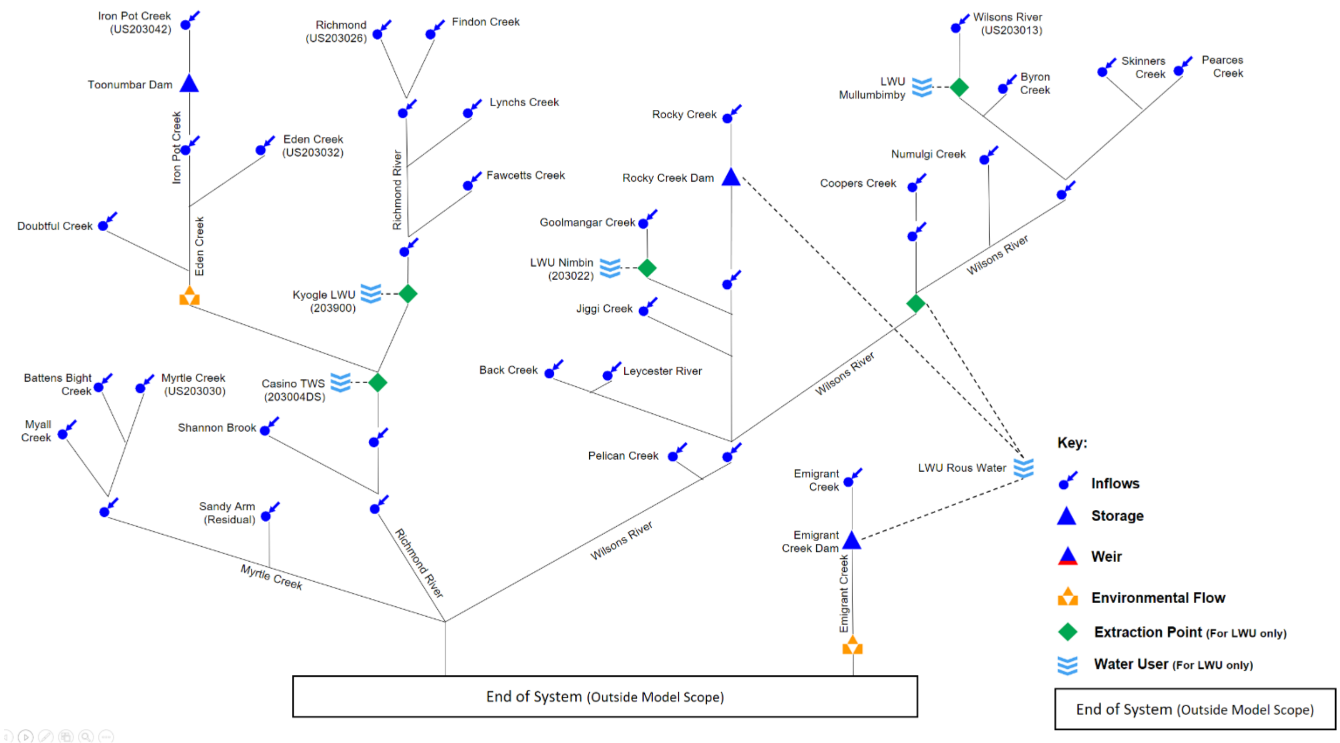

Figure 2. Schematic diagram of Richmond River model

The model includes three water supply storages:

- Toonumbar Dam
- Rocky Creek Dam
- Emigrant Creek Dam.

A summary of the gauges used for calibration is presented in Table 1 below.

Table 1. Hydrologic data used in baseline model calibration

Data type	Data source	Usage in model	Period start	Period end
Storage level	Hydstra 203042 130.00	Toonumbar Dam Storage inflow derivation (SID)	28/07/1976	
Storage volume	Hydstra 203042 136.00	Toonumbar Dam SID	1/01/1998	1/12/2004
Storage releases	Hydstra 203023 151.00	Toonumbar Dam SID, demand calibration, reach calibration	1/05/1968	
Storage level	Rous County Council	Rocky Creek Dam SID, Emigrant Creek Dam SID, demand calibration	1/01/2010	
Storage releases	Rous County Council	Rocky Creek Dam SID, Emigrant Creek Dam SID, demand calibration	1/01/2010	
Streamflow	Hydstra 203002 151.00	Headwater (HW) calibration	11/02/1920	
	Hydstra 203006 151.00	HW calibration	31/05/1943	04/06/198 5
	Hydstra 203007 151.00	HW calibration	30/05/1947	05/06/198 5
	Hydstra 203009 151.00	HW calibration	22/08/1951	04/06/198 5
	Hydstra 203010 151.00	HW calibration	23/08/1951	
	Hydstra 203012 151.00	HW calibration	28/08/1951	
	Hydstra 203013 151.00	HW calibration	08/02/1952	27/10/1988
	Hydstra 203015 151.00	HW calibration	05/11/1957	05/06/198 5
	Hydstra 203022 151.00	HW calibration	07/06/1967	14/04/1983
	Hydstra 203026 151.00	HW calibration	23/05/1969	04/06/198 5
	Hydstra 203027 151.00	HW calibration	24/05/1969	04/06/198 5
Streamflow	Hydstra 203028 151.00	HW calibration	27/05/1969	04/06/198 5
	Hydstra 203030 151.00	HW calibration	29/05/1969	
	Hydstra 203032 151.00	HW calibration	05/12/1970	03/05/1991
	Hydstra 203036 151.00	HW calibration	15/05/1972	10/01/1979
	Hydstra 203038 151.00	HW calibration	26/07/1972	24/09/198 7
	Hydstra 203041 151.00	HW calibration	24/05/1972	

Data type	Data source	Usage in model	Period start	Period end
	Hydstra 203044 151.00	HW calibration	15/04/1983	26/10/1992
	Hydstra 203045 151.00	HW calibration	06/04/1984	10/11/1992
	Hydstra 203004 151.00	Reach calibration	26/05/1943	
	Hydstra 203005 151.00	Reach calibration	29/05/1943	
	Hydstra 203014 151.00	Reach calibration	22/08/1957	
	Hydstra 203018 151.00	Reach calibration	17/09/1966	04/06/1985
	Hydstra 203024 151.00	Reach calibration	17/05/1969	
	Hydstra 203034 151.00	Reach calibration	18/12/1970	
	Hydstra 203035 151.00	Reach calibration	27/01/1971	03/05/1991
	Hydstra 203900 151.00	Reach calibration	27/05/1969	

The model includes demand for town water supplies and irrigation for:

- Kyogle
- Casino
- Nimbin
- Mullumbimby
- Rocky Creek Dam water treatment plant
- Ballina
- Byron
- Lismore
- Richmond River valley.

3 Assessment framework

List of options for modelling

A list of the options has been identified for modelling in Richmond River valley from the long list of options presented in the draft Far North Coast Regional Water Strategy (see Table 2).[5] The option numbers included in the table are aligned with the option numbers of the long list of options included in the draft. Each of the modelled options are discussed in Section 4. Initially, the modelling was undertaken for each of the selected options individually. A series of preferred portfolios (by combining various options) were developed based on the cost-benefit analysis of individual options for final assessment. The details of the portfolio modelling are presented in Section 5.

Table 2. List of modelled options

Option number	Description
1	Interconnection of independent water supplies in the region to the Rous County Council network
2	Interconnection of Rous County Council and Tweed Shire Council bulk water supplies
3	Use Toonumbar Dam to augment town water supplies
6, 7, 8, 9, 23, 34, 35	Various options to reduce local water utility extractions from the river
10	Decentralised desalination
11	Regional desalination
14	New Dunoon Dam on Rocky Creek
16	Provide recycled wastewater for industry and rural users
19	Raise Toonumbar Dam level
21	Establish and/or increase environmental water releases from major storages in the Far North Coast

Instrumental climate

'Instrumental climate' refers to daily climate data for the period of instrumental meteorological recordings available (1889–2020) to use as input into the rainfall–runoff models to generate runoff to a river system model and to use as direct climate input to river system model simulation. For options assessment, 14 replicates of 40-year periods were sampled from this data to provide a preliminary basis to evaluate options for shortlisting for portfolios. It also provided a faster way of testing the setups and performance of the options.

[5] Department of Planning and Environment 2020, Draft Regional Water Strategy, *Far North Coast: Long list of Options, October 2020.* www.dpie.nsw.gov.au/water/plans-and-programs/regional-water-strategies, accessed 15 December 2022.

Stochastic (long-term)

'Stochastic climate' refers to the 10,000 years of daily stochastic generated climate used to evaluate the final viability of portfolios as well as define a base case.[6] For portfolios assessment, 1,000 replicates of 40-year periods were sampled from this data to provide a comprehensive assessment of Richmond River valley outcomes across many possible climate realisations.

Stochastic (long-term) with climate change projections

'Stochastic climate data with climate change projections' has been generated by multiplying the stochastic time series of 10,000 years with average monthly scaling factors derived from NSW and Australian Regional Climate Modelling (NARCliM) climate projection for 2060–2079 compared to the baseline period of 1990–2009 for each climate time series for every climate station used in the modelling. The average monthly scaling factors represent the mean of three regional climate models of CSIRO-MK3 GCM used in NARCliM 1.0. This set of stochastic data with climate projections are used in conjunction with the stochastic data to evaluate the final viability of portfolios, as well as to define the future base case. For options assessment, 1,000 replicates of 40-year periods were sampled from this data to provide a comprehensive assessment of Richmond River valley outcomes across many possible climate realisations.

Outputs for option assessment

The outputs for all model runs undertaken for economic assessment are shown in Table 3. 'Ordered' refers to the demand generated for the output type, 'supplied' refers to the ordered water that was successfully supplied, and 'shortfall' refers to the difference between supplied and ordered. For all other outputs, a description is provided in the table. These outputs are provided at a daily timestep.

Table 3. List of the modelled outputs generated for economic assessment

Output name	Units	Description
Stock and domestic supplied	ML	
Stock and domestic ordered	ML	
Stock and domestic shortfall	ML	
General security supplied	ML	
High security supplied	ML	
High security ordered	ML	
High security shortfall	ML	
General security allocation	Proportion	General security allocation in ML/share (0–1)

[6] Leonard, M., Westra, S., and Bennett. B. 2020. *Methodology Report for Multisite Rainfall and Evapotranspiration Data Generation of the Northern Basin*, University of Adelaide; Leonard, M., Westra, S., and Bennett. B. 2020. *Annex D Far North Coast Region Stochastic Evaluation*, University of Adelaiden.

Output name	Units	Description
Regulated rainfall volume	ML	Rainfall captured in soil moisture stores in the regulated system crop models
Kyogle supplied	ML	
Kyogle ordered	ML	
Kyogle shortfall	ML	
Rous bulk water supplied	ML	
Rous bulk water ordered	ML	
Rous bulk water shortfall	ML	
Casino supplied	ML	
Casino ordered	ML	
Casino shortfall	ML	
Nimbin supplied	ML	
Nimbin ordered	ML	
Nimbin shortfall	ML	
Mullumbimby supplied	ML	
Mullumbimby ordered	ML	
Mullumbimby shortfall	ML	
Unregulated supplied	ML	
Unregulated rainfall volume	ML	Rainfall captured in soil moisture stores in the unregulated system crop models
Unregulated idealised crop required	ML	Theoretical irrigation requirement if no rainfall occurred and access to irrigation was unrestricted

4 Options modelling

Option 1: Interconnection of independent water supplies in the region to the Rous County council network

Description

Byron Shire, Ballina Shire, Lismore City, and Richmond River valley councils all operate at least one town water supply that is not connected to the Rous County Council bulk water supply network. These independent supplies generally suffer from water security issues. Connecting these towns into the regional Rous County Council network would increase their water security and resilience.

Towns identified as being suitable for connection to the Rous County Council network are Casino, Kyogle, Mullumbimby and Nimbin/Channon. These towns have supply capacities of:

- Option 1a: Brunswick Head to Mullumbimby (~4.25 ML/d)
- Option 1b: South Lismore to Casino (15 ML/d)
- Option 1c: Casino to Kyogle (3 ML/d)
- Option 1d: The Channon to Nimbin (~0.5 ML/d).

For the remainder of this report, these options will be just reported by their option numbers.

Key assumptions

Within the model, towns are connected to the Rous Bulk Water network and use the following assumptions:

- because they are at the ends of the network, it is assumed that they are supplied **after** the existing Rous Bulk Water connections take water
- because they are supplied after the existing Rous Bulk Water connections take water and because the existing demand is always larger than the Wilsons River diversions to Nightcap Water Treatment Plant, the model conceptualises that these nodes take directly from Rocky Creek Dam

All sub-option nodes take from the unregulated river flows before taking water from the Rous Bulk Water network.

Model setup

Conceptualisation of this option is displayed in Figure 3 to Figure 5. The existing supply point has a demand restriction set to the live storage in the off-stream storage or weir at the town causing it to order from the new supply point connected to Rocky Creek Dam when a shortfall would occur.

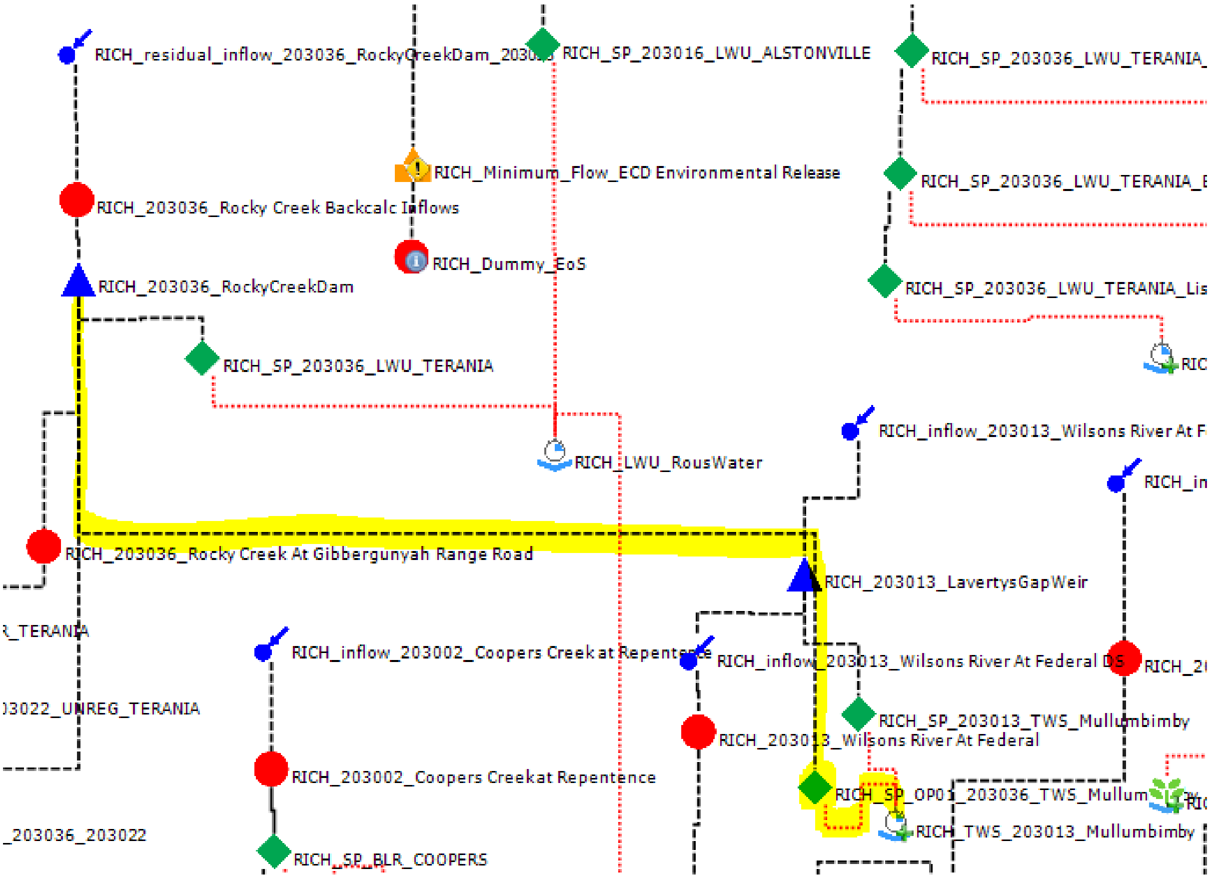

Figure 3. Option 1a conceptualisation: node-link network showing the additional links and nodes highlighted in yellow

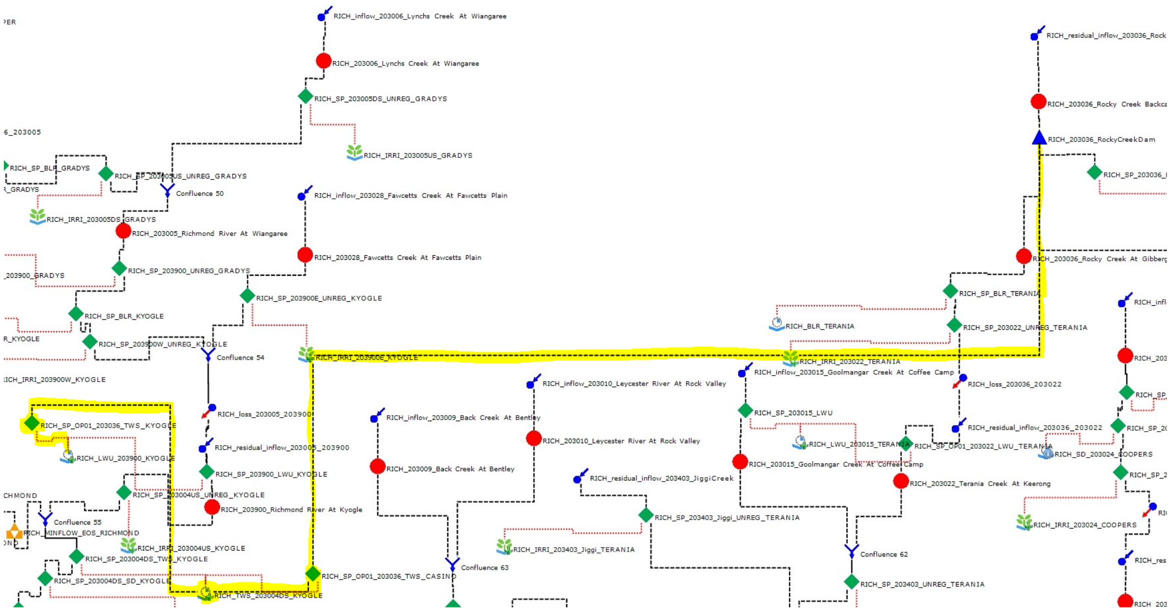

Figure 4. Option 1b/1c conceptualisation: node-link network showing the additional links and nodes highlighted in yellow

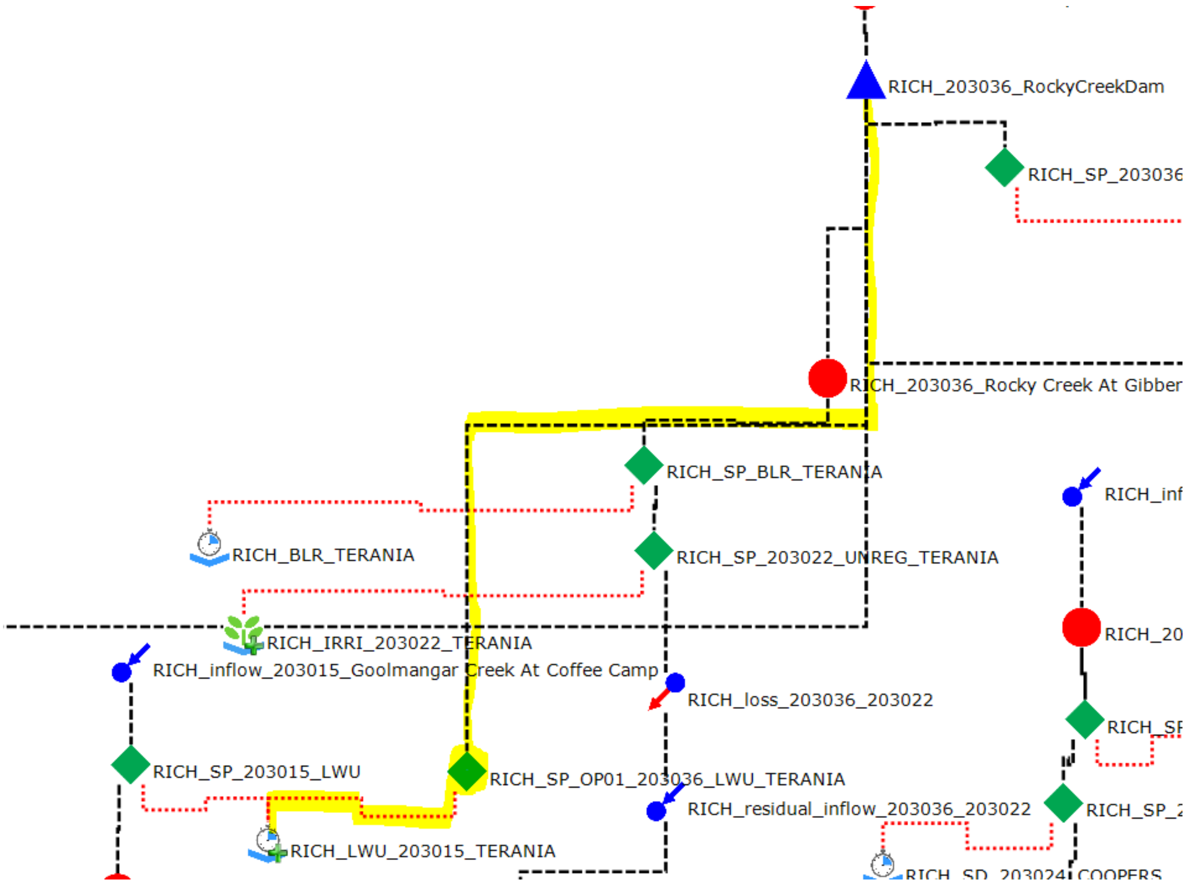

Figure 5. Option 1d conceptualisation: node-link network showing the additional links and nodes highlighted in yellow

Key results

As none of the towns in Richmond incur any supply shortfall during the instrumental period, a test was completed where model inflows were removed and storages started full to force the options to extract from Rocky Creek Dam. Figure 6 shows that the supply points use up the capacity of Rocky Creek Dam in lieu of other sources.

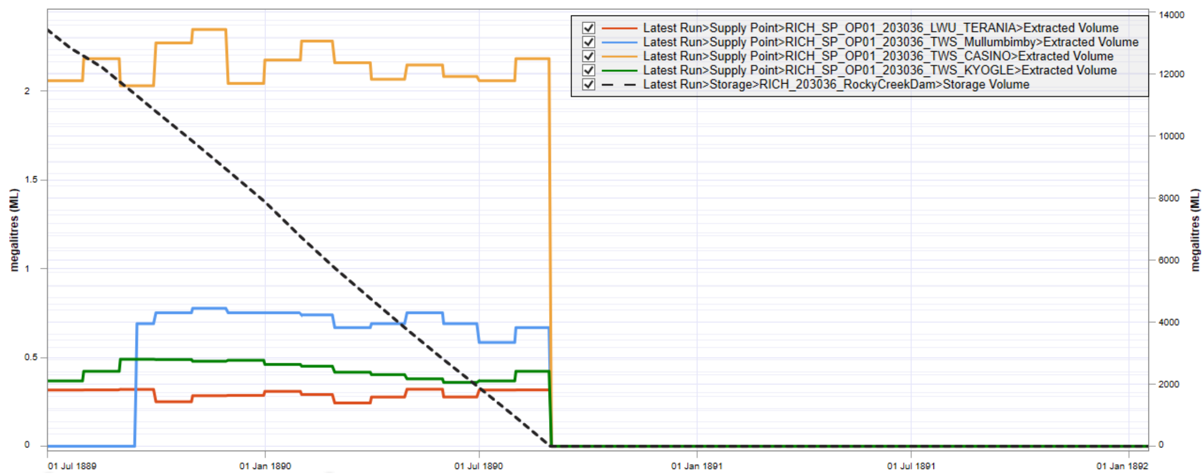

Figure 6. Option 1 testing

The results of the modelling for option 1 for instrumental climate do not show any difference compared to the baseline as there were no supply shortfall for any of the local water utilities for the period of instrumental climate.

Option 2: Interconnection of Rous County Council and Tweed Shire Council Bulk water supplies

Description

This option is to connect the two major regional water supply systems: Rous County Council and Tweed Shire Council. This option improves system resilience by increasing and diversifying the water supplies available in both the Tweed and Rous regions. It can also improve the feasibility of a regional desalination scheme by making the desalinated water available to both systems.

Interconnection of Rous County Council and Tweed Shire Council Bulk water supplies is a complicated issue involving combining two river system models (Richmond and Tweed) together.

Key assumptions

Because most flow would be from Tweed to Richmond, a simplified one-way pipeline is modelled at this stage whereby demands from the Richmond model without the Tweed supply are put into the Tweed model. Then the amount supplied from the Tweed model for that demand is fed back into the Richmond model at the Rous Bulk Water demand node as shown in the Richmond conceptualisation in Figure 7. Two types of demand structures are used:

- Option 2a: Tweed attempting to supply as much of Rous Bulk Water demand as possible
- Option 2b: Tweed only supplying when Rous Bulk Water demand has a shortfall.

In the remainder of this report, these options will be reported by their option numbers.

Model setup

The conceptualisation of Option 2 is shown in Figure 7.

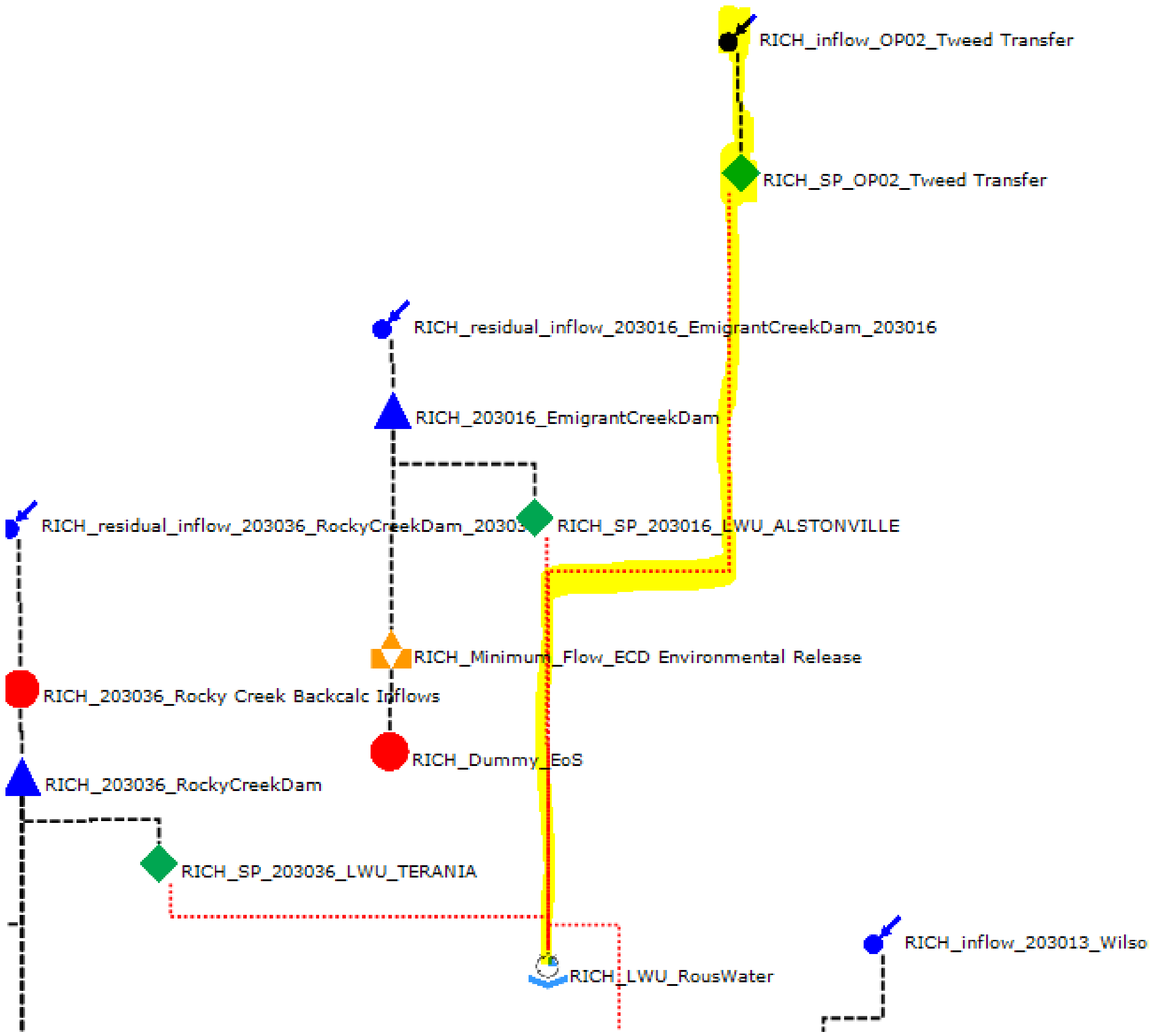

Figure 7. Option 2 conceptualisation: node-link network of the base case Richmond River model modified to include transfer from the Tweed River system

Key results

The results of options 2a&b for instrumental climate don't show any difference compared to the baseline as there were no supply shortfalls for any of the LWUs for the period of instrumental climate.

Option 3: Use Toonumbar Dam to augment town water supplies

Description

There are a number of connection opportunities to use Toonumbar to augment town water supplies:

- pipe from the dam wall to Casino water treatment plant

- pipe from the dam wall to Rocky Creek Dam
- pipe from the end of Eden Creek to Casino water treatment plant
- pipe from the end of Eden Creek to Rocky Creek Dam
- deliver along existing river to Jabour Weir at Casino (non-build option).

From these opportunities, two sub-options were modelled.

- Option 3aiii: Deliver along existing river to Jabour Weir at Casino
- Option 3b: Pipeline from upstream of Jabour Weir to Rocky Creek Dam.

In the remainder of this report, these options are reported by their option numbers.

Key assumptions

Given that the operational behaviour of this system is currently unknown, it was assumed that the town will order 500 ML of water to refill the weir when the weir drops below 1,200 ML out of 1,700 ML of effective storage.

Model setup

Option 3aiii: Deliver water via Richmond River to Jabour Weir

A new high security licence was created for the Casino town water supply. For testing purposes, this licence was set at 1,000 ML and replaced the dormant 1,000 ML environmental water account.

The confluence of Iron Pot Creek and Eden Creek was changed to be regulated, passing orders upstream to Toonumbar Dam. A new regulated extraction point was placed upstream of the existing unregulated extraction point. This regulated node is non-extractive and will order water to Jabour Weir under certain conditions.

The conceptualisation of Option 3aiii is shown in Figure 8.

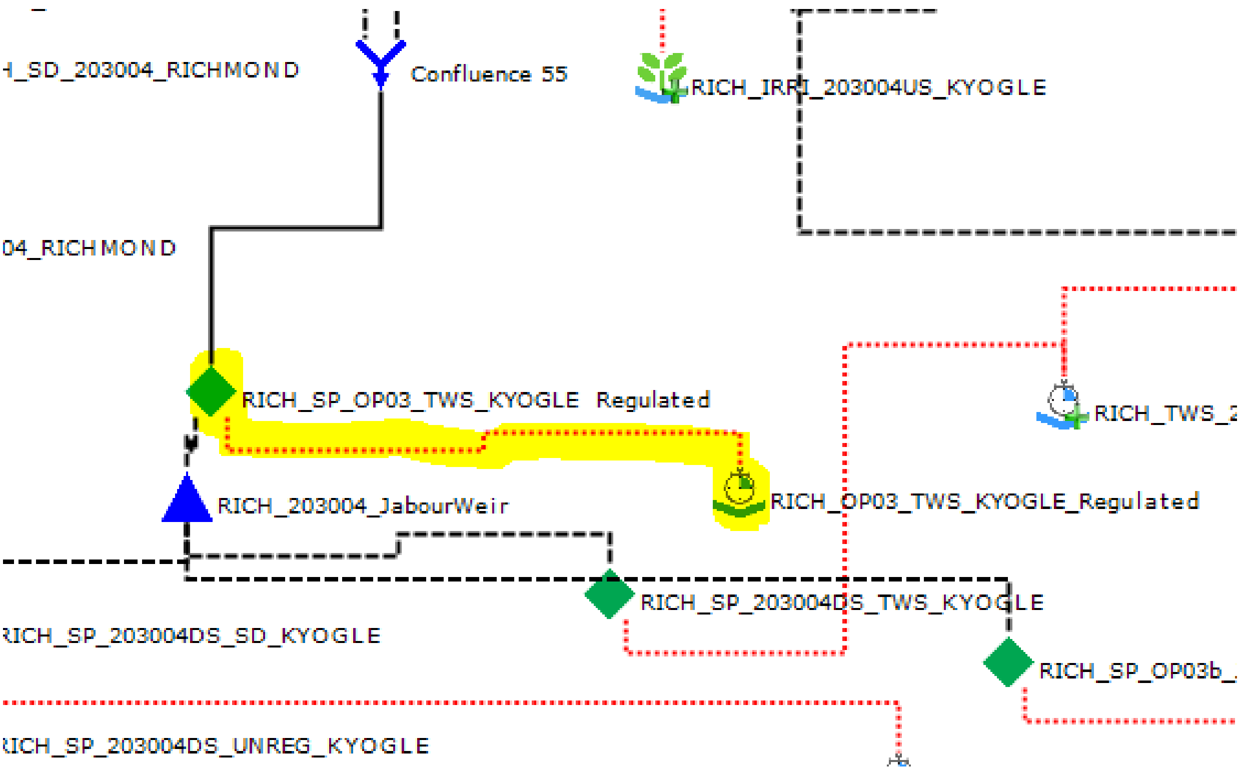

Figure 8. Option 3aiii conceptualisation with extra nodes and links shown in yellow

Option 3b: Pipeline from u/s of Jabour Weir to Rocky Creek Dam

At Jabour Weir, an unregulated supply point was added. This supply point sends water to Rocky Creek Dam via a water user with 100% return efficiency that confluences with the headwater inflows into the storage.

The orders for the node are based on pumping 33 ML/d when Rocky Creek Dam falls below a certain storage threshold. For testing, this threshold is set to the full supply level of Rocky Creek Dam.

The conceptualisation of Option 3b is shown in Figure 9.

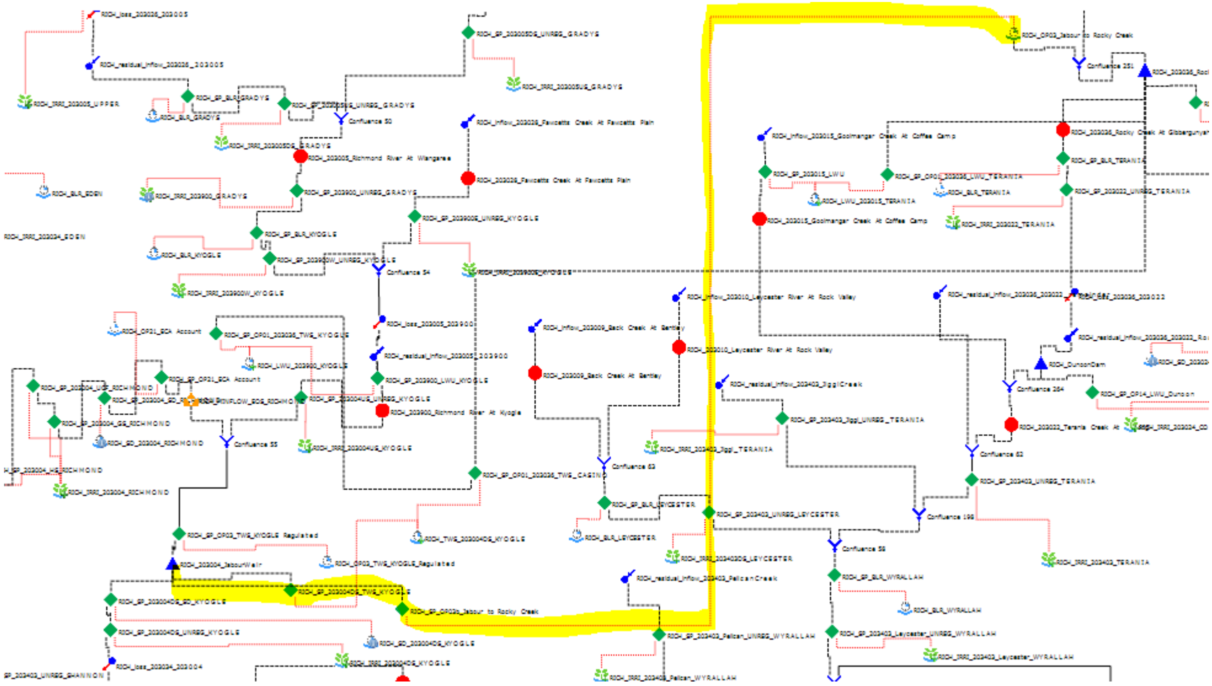

Figure 9. Option 3b conceptualisation with extra nodes and links shown in yellow

Key results

As Jabour Weir never falls below 1,200 ML in the instrumental period, a test was run with reduced inflows to force the operational behaviour. Figure 10 shows that the dam will order at 1,200 ML to fill itself up until Rocky Creek Dam is drained.

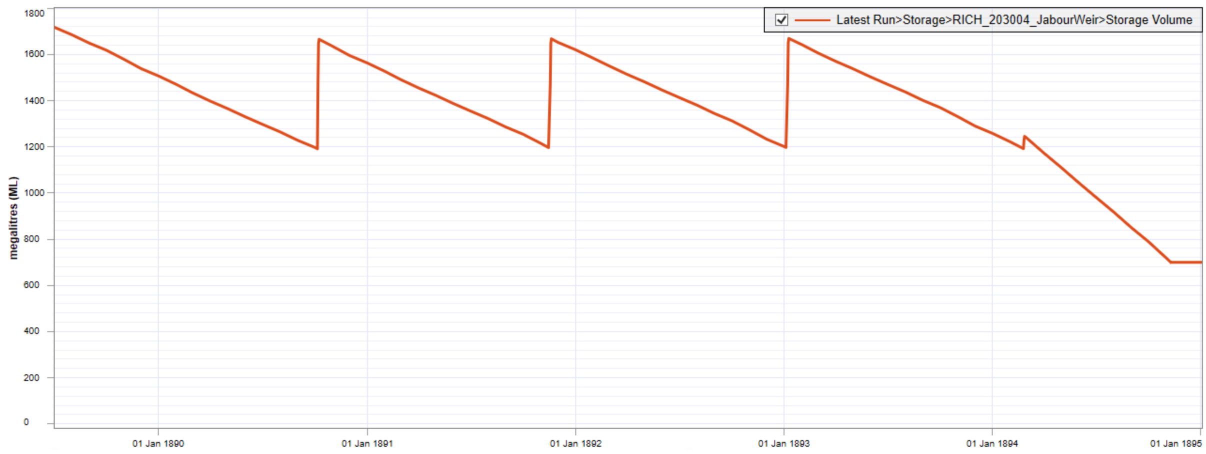

Figure 10. Option 3a testing

Rocky Creek Dam is topped up by option 3b. Figure 11 shows that Rocky Creek Dam is kept at 95% while Rocky Creek Dam can supply volume in this no-inflow scenario.

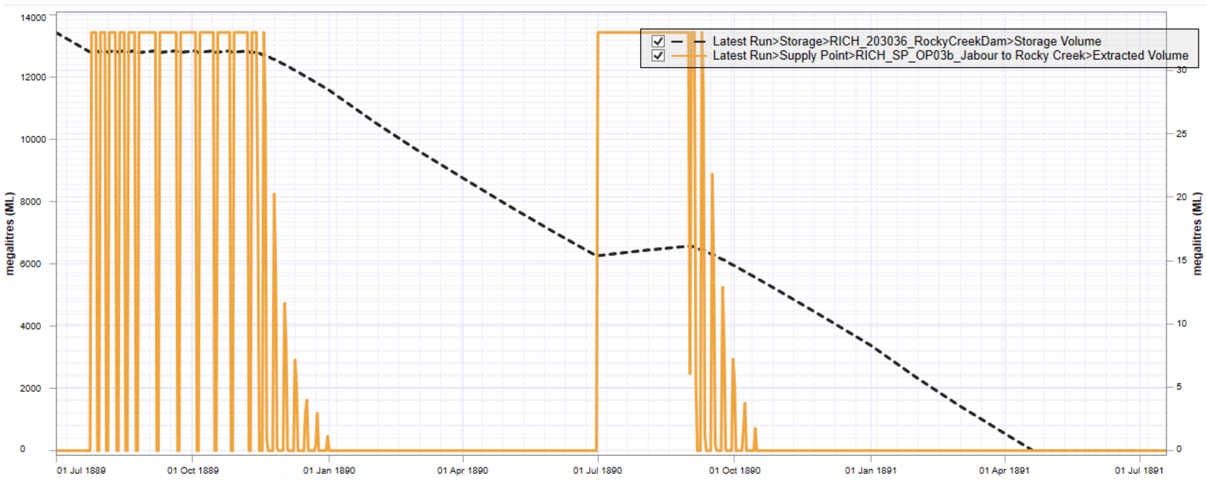

Figure 11. Option 3b testing

Table 4 shows the changes in unregulated supply under Option 3 compared to the baseline.

Table 4. Summary of Option 3 results for the period of instrumental climate

	Base case	Option 3a	Difference	Option 3b	Difference
Unregulated supplied (ML/y)	10,085	10,085	0	9,863	-222

Options 7 and 8: Use of recycled water to reduce extraction from the river for town water supply

Description

Option 7

Highly treated wastewater from sewage treatment plants has the potential to be a reliable, safe and mostly climate-independent water source. The level of treatment required depends on whether the water will be stored or conveyed by rivers or groundwater, and what the end uses are. Water for drinking requires higher levels of treatment and purification that water used by agriculture and industry. Indirect potable reuse involves augmenting drinking water supplies through:

- managed aquifer recharge, whereby purified recycled water is used to recharge groundwater aquifers before it is extracted, treated again to *Australian Drinking Water Guidelines*[7] and added to the water supply network
- discharging purified recycled water directly into or upstream of an existing dam or other major water store, where it mixes with surface water before being treated again to *Australian Drinking Water Guidelines*[8] and supplied to customers.

[7] National Health and Medical Research Council, National Resource Management Ministerial Council, *Australian Drinking Water Guidelines Paper 6*, National Water Quality Management Strategy, updated November 2018. www.waterquality.gov.au/guidelines/drinking-water, accessed 15 December 2022.

[8] National Health and Medical Research Council, National Resource Management Ministerial Council, *Australian Drinking Water Guidelines Paper 6*, National Water Quality Management Strategy, updated November 2018. www.waterquality.gov.au/guidelines/drinking-water, accessed 15 December 2022.

Option 7 would investigate potential locations for new or expanded reuse schemes from sewage treatment plants, including at East and South Lismore, Alstonville, Ballina, Lennox Head, Casino, Byron Bay and Brunswick Heads.

Option 8

Option 8 would investigate the injection of purified recycled water from sewage treatment plants into the drinking water supply network. This option can leverage the existing water supply network, which covers many of the sewage treatment plants in the region, to distribute potable recycled water across the region.

Option 8 could include a pilot project to test and promote adopting wastewater reuse more broadly across the Far North Coast region, which could build confidence and trust in the ability of local water utilities to provide safe and reliable purified recycled water for drinking purposes. Rous County Council are currently developing plans for a pilot water reclamation plant at the Perradenya Estate in Caniaba, approximately 12 km from Lismore. Using the Perradenya Estate as a test case, Rous County Council intends to demonstrate ecologically sustainable water management by producing recycled water for all purposes, including drinking water. Rous County Council hopes to partner with the NSW Government and Southern Cross University to deliver the project.

Key assumptions

Because local water utility extractions are lumped into larger regions, the following assumptions have been made:

- East Lismore (3.25 ML/d), South Lismore (3.25 ML/d) and Perradenya Estate (0.2 ML/d) all supply the Lismore node
- Ballina (13.5 ML/d) and Lennox Head (10.5M L/d) and Alstonville (3.6 ML/d) supply Ballina Shire
- Byron (13.1 ML/d) and Brunswick Heads (7.2 ML/d) supply Byron Shire.

Model setup

Option 7 and 8 are modelled as alternative supplies to the existing Rous Bulk Water demand nodes, with a higher priority than the Rous Bulk Water system. Figure 12 shows the conceptualisation of these options.

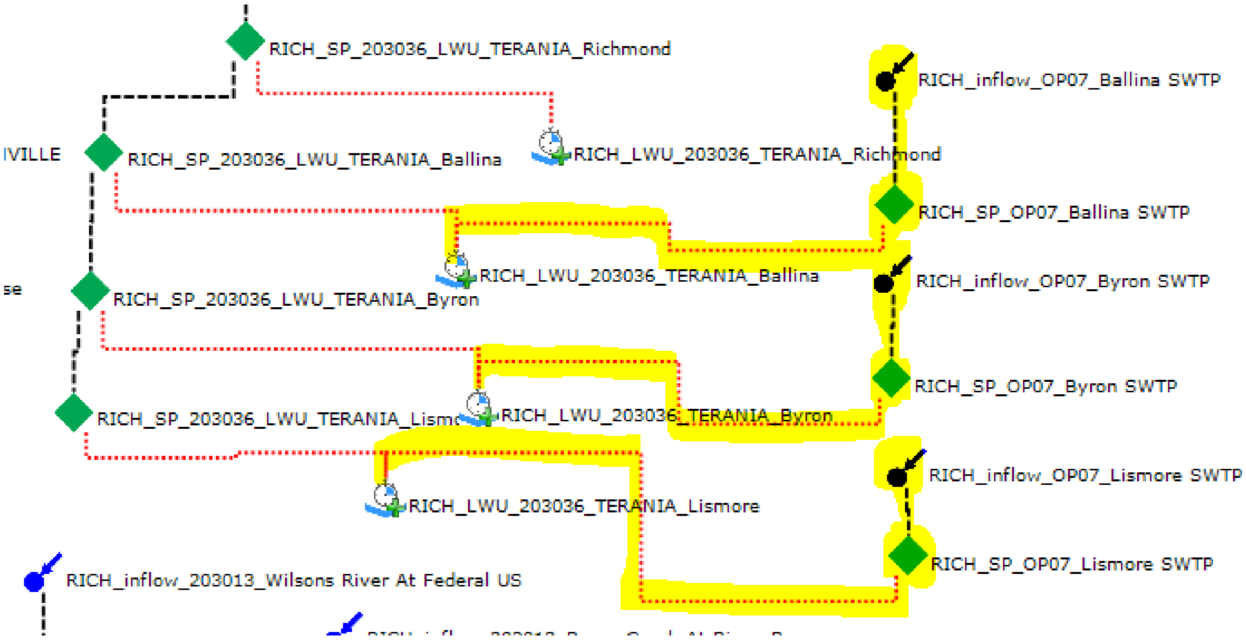

Figure 12. Option 7 and 8 conceptualisation with extra nodes and links highlighted in yellow

Key results

The reduction in demand using these alternate supplies can be seen in Figure 13, which shows the demand reaching the Rous Bulk Water network — that is, after the option contributions are taken into account.

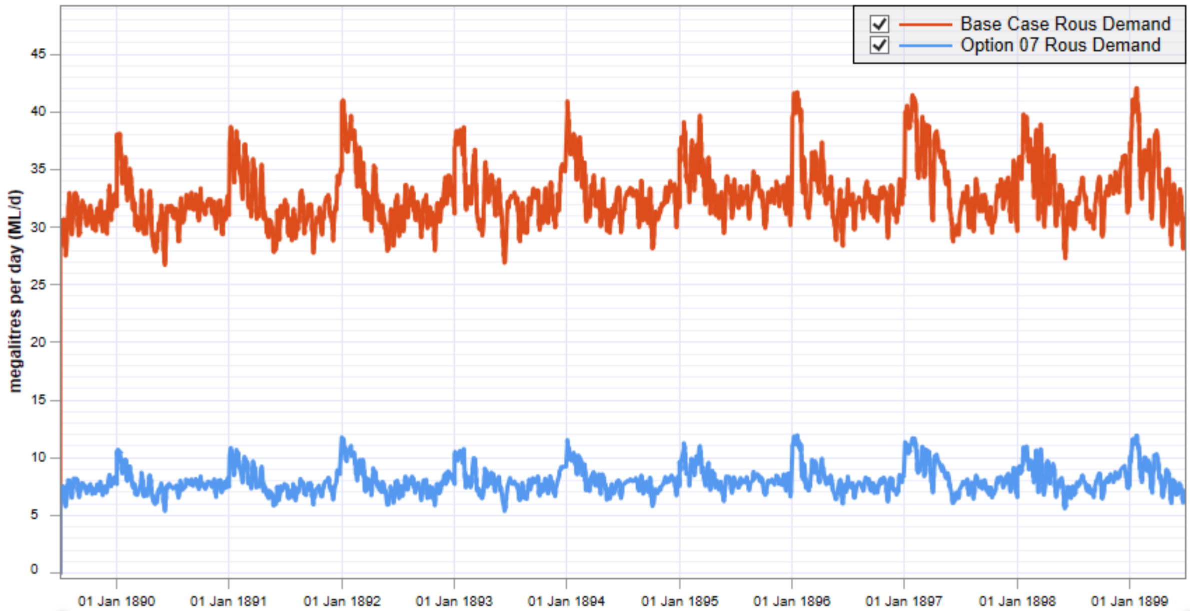

Figure 13. Option 7 testing

As shown in Table 4, under Option 7 there is significant reduction in ordered and supplied compared to the baseline, which relates to the reduction in demand from the existing infrastructure due to the wastewater treatment plants.

Table 4. Summary of Option 7 results for the period of instrumental climate

	Base case	Option 7	Difference
Rous supplied (ML/yr)	12,671	3,085	-9,586
Rous ordered (ML/yr)	12,671	3,085	-9,586

Option 10: Decentralised desalination augmenting the Rous Bulk Water network

Description

Desalination can be an attractive option for coastal regions as it offers a virtually unlimited, climate-independent source of water. Decentralised, small-scale, often modular, desalination plants can be sited close to water demand. It is possible to site several of these plants across the region to supply local demand or to feed into the Rous County Council bulk water supply network. Decentralised desalination plants can be scaled-up as the water demand of a town or region grows or to respond to prolonged droughts or extreme events.

Key assumptions

The desalination plant would run off a series of triggers such as when Rocky Creek Dam is below a certain level or if a particular town is at stage 3 restrictions and therefore there is a risk of encroaching on household or industrial uses. The desalination plants could be step scaled over time from 5 to 10 to 15ML/day, according to the appropriate trigger.

Model setup

Conceptualisation of the model is shown in Figure 14.

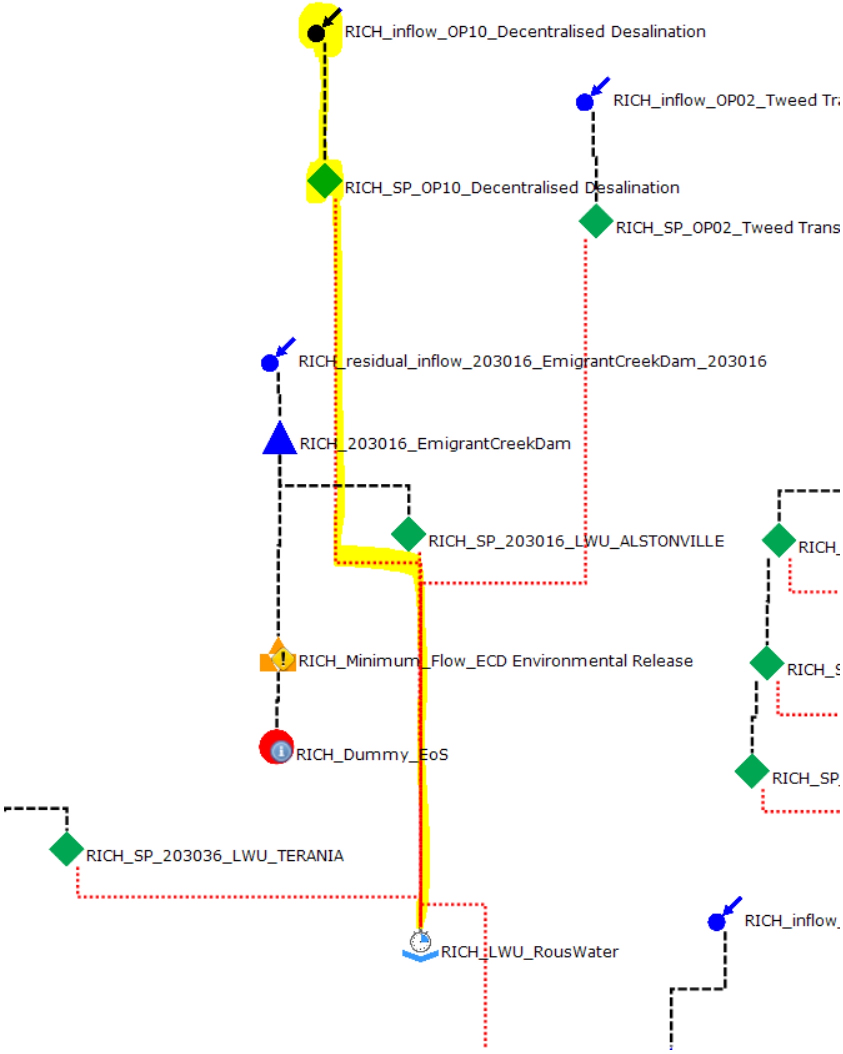

Figure 14. Option 10 conceptualisation with extra nodes and links shown in yellow

Key results

The demand reduction for Rocky Creek extractions due to partial demand being met by the desalination plant is shown in Figure 15.

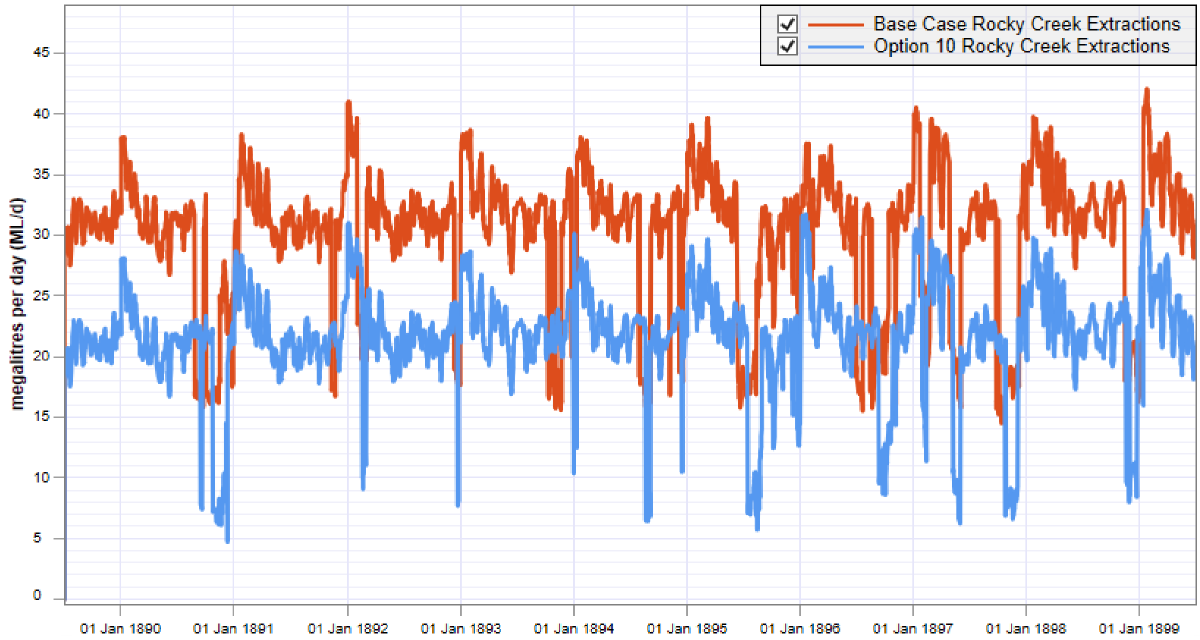

Figure 15. Option 10 testing

Option 11: Regional desalination

Description

Desalination offers a virtually unlimited, climate-independent source of water. A regional desalination facility would be able to supplement supply for the entire region, connected to the bulk water supply network and improve resilience of town water supplies in the Far North Coast region.

The option model includes regional desalination, augmenting the Rous Bulk Water network and the Tweed River system.

Key assumptions

It is assumed that the split of a number of capacities between Ocean Shores and Pottsville feeds into both the Tweed and Rous river systems based on a ratio of the existing water usage in the system as seen in Table 5. It is assumed that the desalination plant runs every day and directly supplements usage in the system — that is, it does not go into the major storages.

Table 5. Regional desalination distribution

Richmond total (ML/y)	13,055
Tweed total (ML/y)	9,537
Richmond %	57.8%
Tweed %	42.2%
Richmond desalination supply at maximum capacity of 70 ML/d (ML/d)	40.45
Tweed desalination supply at maximum capacity of 70 ML/d (ML/d)	29.55

Model setup

Option 11 is modelled in the Richmond River as a constant inflow with the highest priority of extractions Rous Bulk Water. Conceptualisation of the option is shown in Figure 16.

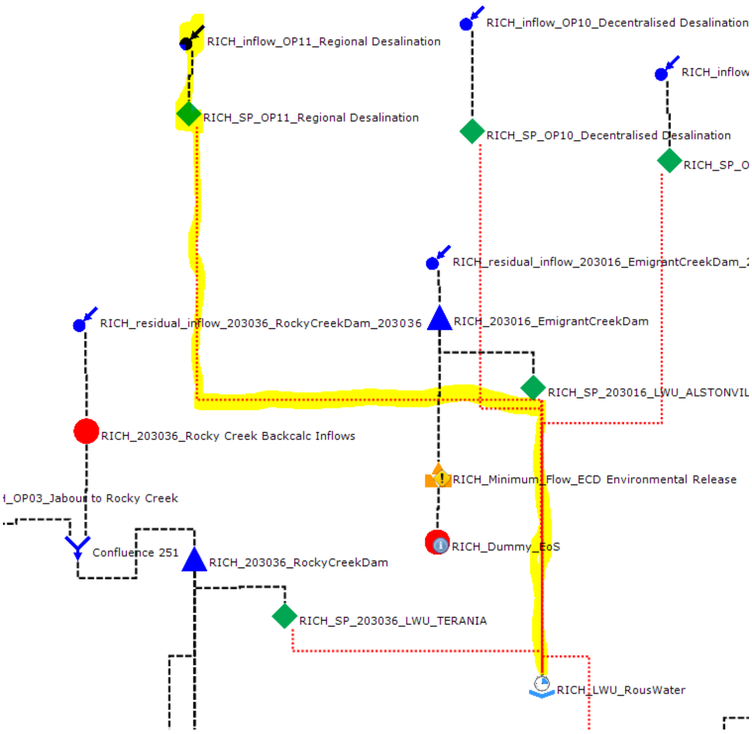

Figure 16. Option 11 conceptualisation with extra nodes and links shown in yellow

Key results

The demand reduction in Rocky Creek Dam due to majority of the demand being met by the desalination plant is shown in Figure 17.

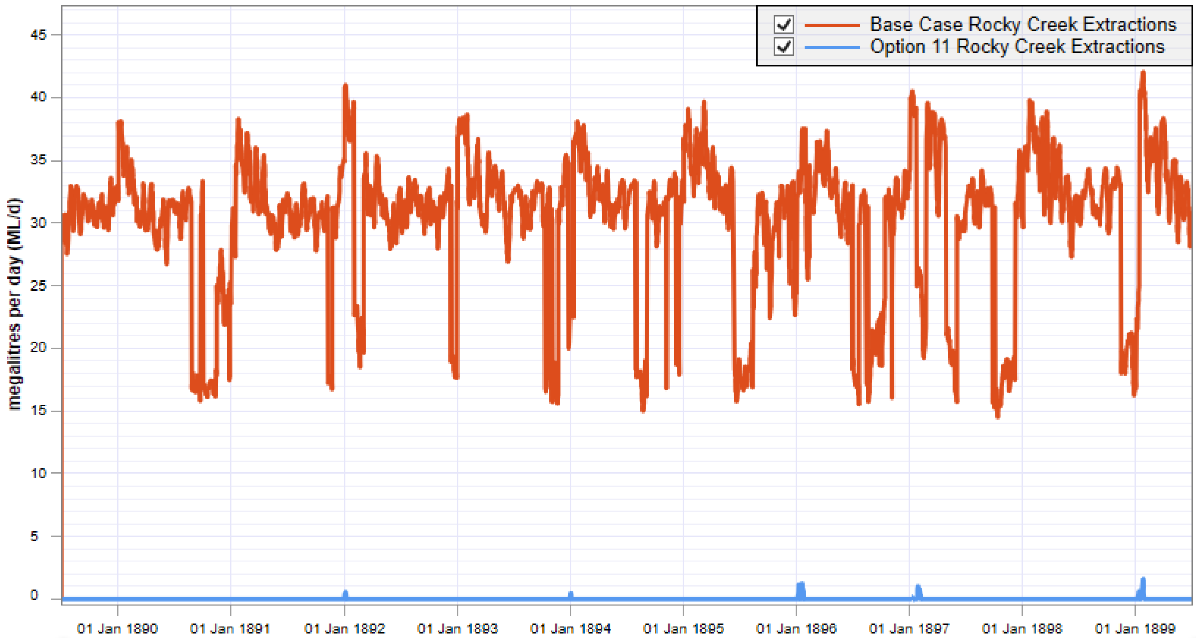

Figure 17. Option 11 testing

Option 14: New Dunoon Dam on Rocky Creek

Description

Option 14 includes a new dam called Dunoon Dam, which was first proposed in 1995. The proposed site is on Rocky Creek, downstream of the existing Rocky Creek Dam. Three different full-storage capacity options have been proposed: 20 GL, 50 GL and 85 GL.

Key assumptions

Only the 50 GL option was modelled. It is assumed that the rainfall and therefore catchment runoff response is similar per hectare to the calibrated downstream headwater gauge no. 203022.

Model setup

The catchment area for the dam is shown in Figure 18. The runoff model for headwater catchment gauge no. 203022 was partitioned according to area as shown in Table 6 to approximate local runoff into Dunoon Dam.

Table 6. Dunoon Dam catchment area partitioning

	Area (km^2)	Proportion of total
Dunoon Dam catchment	18.2	14.6%
Remained of HW203022 catchment	106.6	85.4%

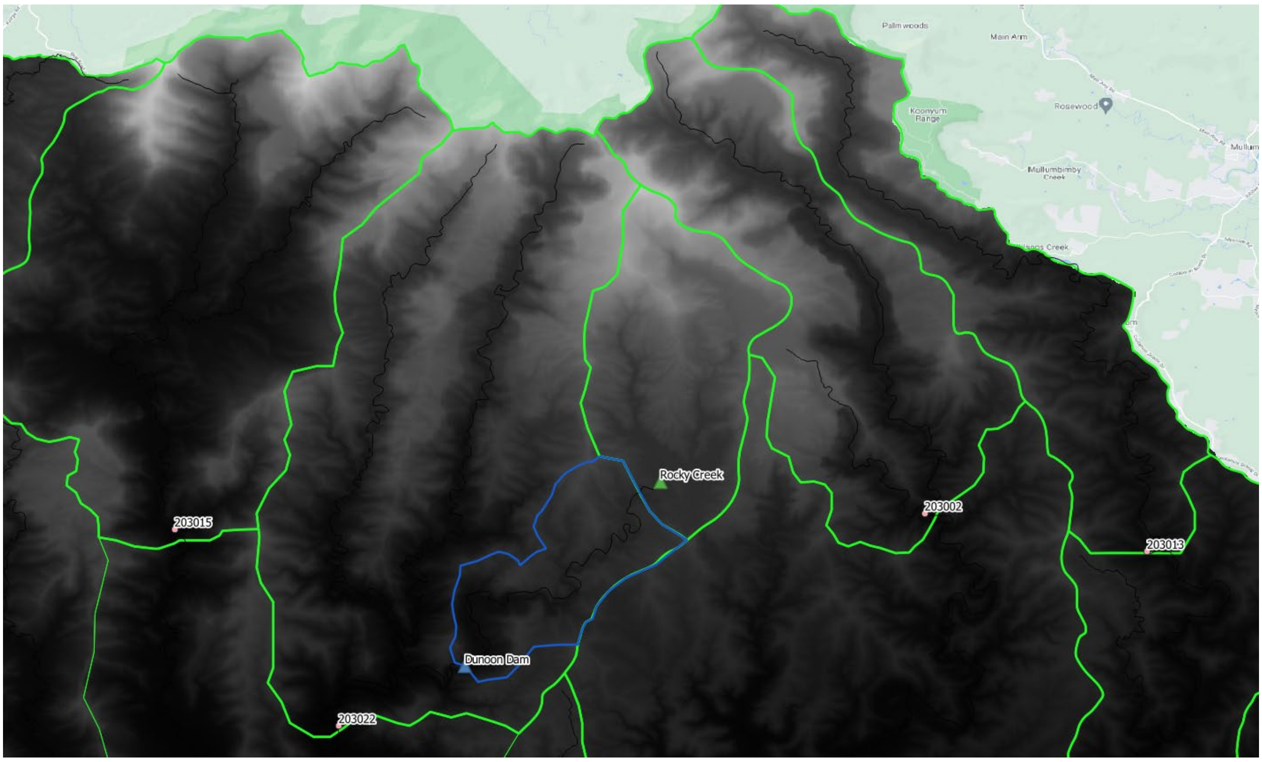

Figure 18. Dunoon Dam catchment area

Conceptualisation of this system in the modelling is shown in Figure 19.

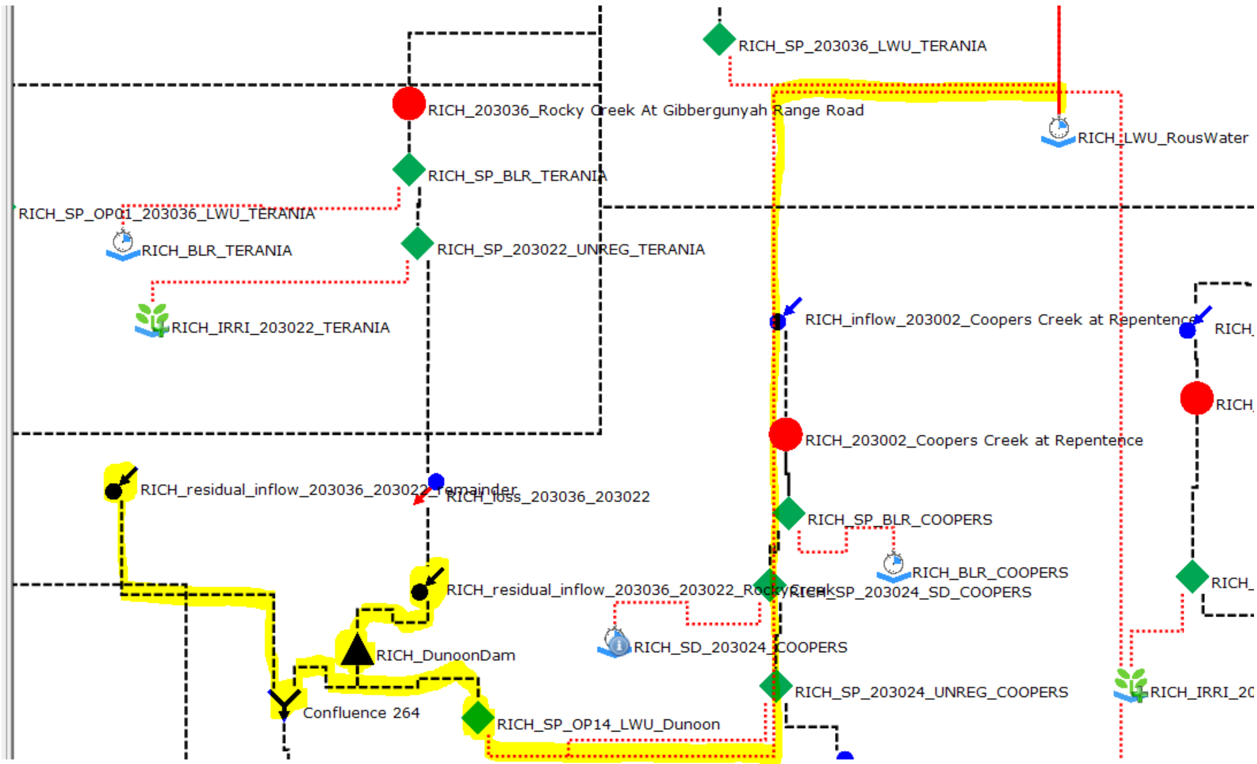

Figure 19. Option 14 conceptualisation with extra nodes and links shown in yellow

The new method of operations of the Rous Bulk Water system is shown in Figure 20. This is implemented in the model via a trigger on the pump capacity of the Dunoon Dam valve that is displayed in Figure 21; this supply point is given a priority higher than Rocky Creek, but a lower priority than Emigrant Creek.

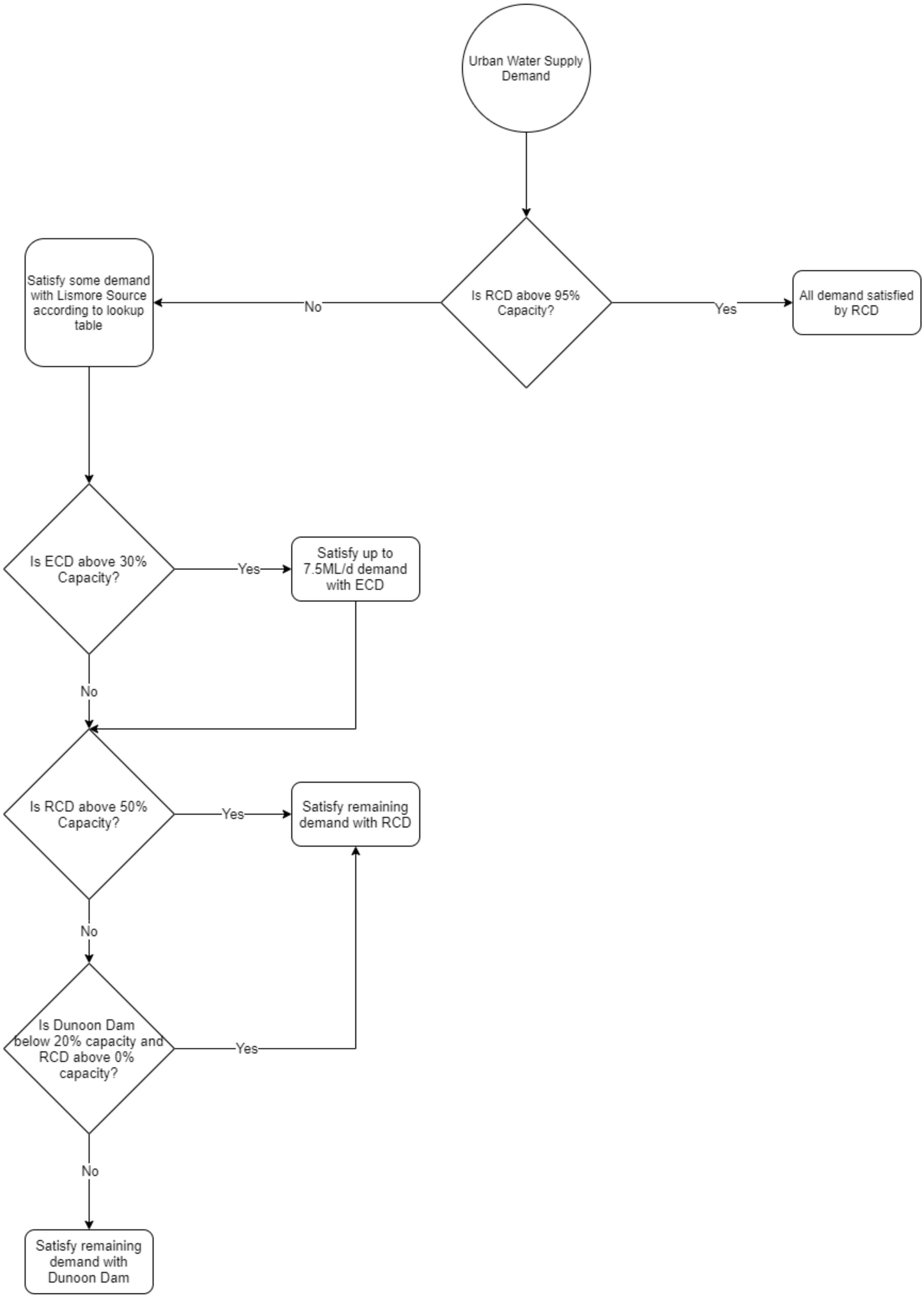

Figure 20. Option 14 Dunoon Dam Rous Bulk Water logic flowchart

Note: RCD = Rocky Creek Dam; ECD = Emigrant Creek Dam

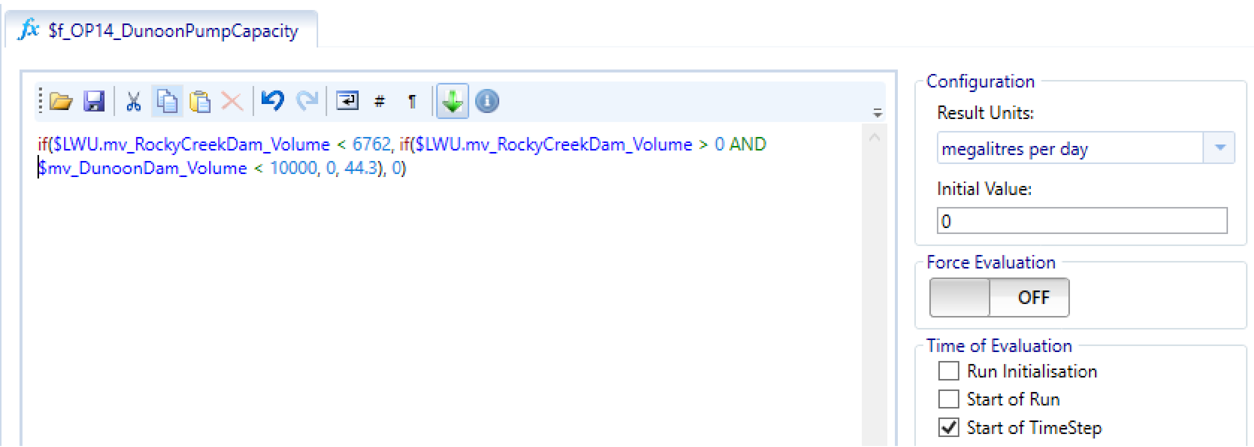

Figure 21. Option 14 Dunoon Dam pump capacity function

Storage dimensions for the proposed Dunoon Dam are shown in Table 8.

Table 8. Dunoon Dam storage dimensions

Level (m)	Volume (ML)	Surface area (km^2)
38	0	0
39	0.5	0.0005
40	1	0.001
41	2	0.002
42	9	0.016
43	37	0.041
44	90	0.072
45	182	0.116
46	323	0.176
47	522	0.229
48	778	0.301
49	1107	0.371
50	1506	0.447
51	1983	0.53
52	2551	0.627
53	3212	0.72
54	3957	0.797
55	4775	0.875
56	5670	0.951
57	6637	1.021
58	7669	1.087
59	8766	1.154
60	9927	1.217

Level (m)	Volume (ML)	Surface area (km^2)
61	11147	1.276
63	13759	1.397
64	15155	1.46
65	16614	1.531
66	18140	1.592
67	19719	1.646
68	21350	1.699
69	23031	1.754
70	24765	1.807
71	26549	1.861
72	28385	1.914
73	30271	1.965
74	32205	2.015
75	34186	2.065
76	36214	2.115
77	38291	2.166
78	40417	2.219
79	42595	2.272
80	44821	2.322
81	47095	2.373
82	49417	2.424
83	51787	2.475
84	54206	2.526
85	56674	2.577
86	59188	2.628
87	61752	2.679
88	64362	2.731
89	67024	2.784

The 50 GL option spillway is shown in Table 7.

Table 7. Dunoon Dam 50 GL spillway option

Level (m)	Discharge (ML/d)
38.00	0
82.25	0
83.00	2,862
84.00	10,201
85.00	20,095
86.00	31,999
87.00	45,617
88.00	60,756
89.00	77,275

Key results

Because Rocky Creek Dam is not stressed sufficiently in the instrumental period, the inflows to the storage were turned off to test the operations, as shown in Figure 22 where Dunoon Dam cuts in at 50% Rocky Creek Dam capacity.

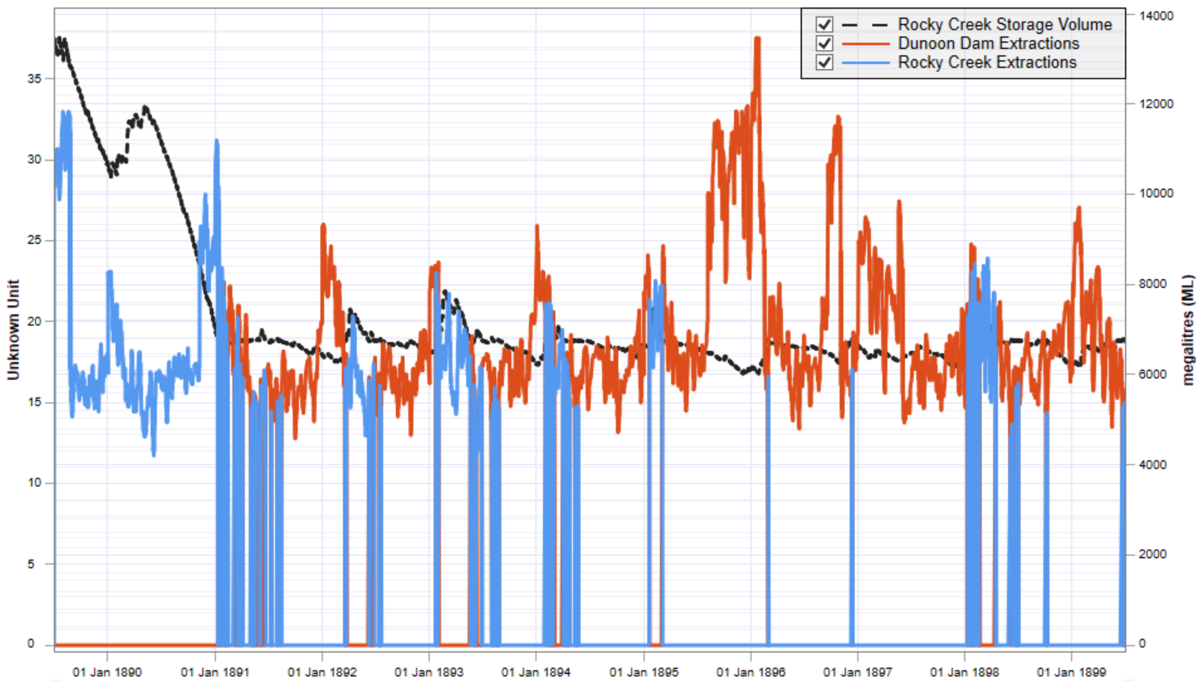

Figure 22. Option 14 testing

Option 16: Provide purified recycled wastewater for industry and rural users

Description

Highly purified recycled wastewater from sewage treatment plants has the potential to be a reliable, safe and climate-independent water source. The use of treated wastewater for industry and rural users presents an opportunity to both support industry growth and reduce pressure on town water supplies and other water sources.

Option 16 to provide purified recycled wastewater for industry and rural users could include:

- identifying industrial or rural water users within or in close proximity to towns who would benefit from a reliable supply of treated wastewater
- constructing third-pipe reticulation systems to supply treated wastewater to industrial water users within towns or in close proximity to towns
- supporting industrial water users to develop closed-loop systems to recycle their own water where possible
- developing localised wastewater reuse networks in industrial estates to supply industrial water users
- constructing distribution pipes to rural areas to supply recycled wastewater to rural water users — this water could be supplied to individual properties from large header tanks and could be used for irrigation or for non-potable domestic uses
- ensuring rural households can access recycled wastewater supplies for non-potable uses. This could either be through the rural distribution network described above, or by supporting rural households to install onsite water recycling systems.
  Option 16 would provide benefits to both rural and town users by increasing the overall security of supply. For modelling purposes, Option 16 is similar to Option 7 and Option 8, but provides water to irrigators instead of a town water supply.

Key assumptions

Only the treatment plants in East Lismore, South Lismore and Perradenya Estate are close to modelled irrigator nodes. Therefore, only one irrigator node was supplied in the model.

Model setup

The RICH_IRRI_203403DS_CORAKI irrigator node gains an inflow with a constant demand equal to the Lismore supply in Option 7 and Option 8. Conceptualisation of the option is shown in Figure 23. It has a higher priority than the unregulated take from the take.

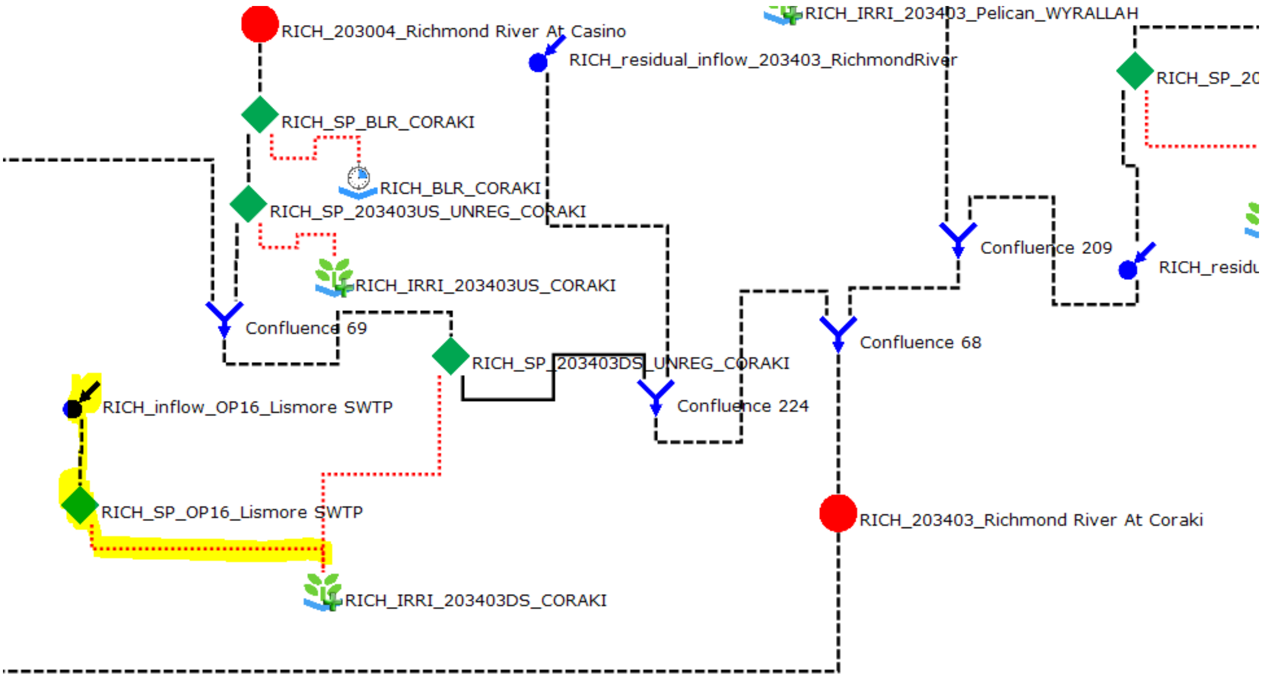

Figure 23. Option 16 conceptualisation with extra nodes and links shown in yellow

Key results

A portion of the crop requirements are being met by the treatment plant shown in Figure 24.

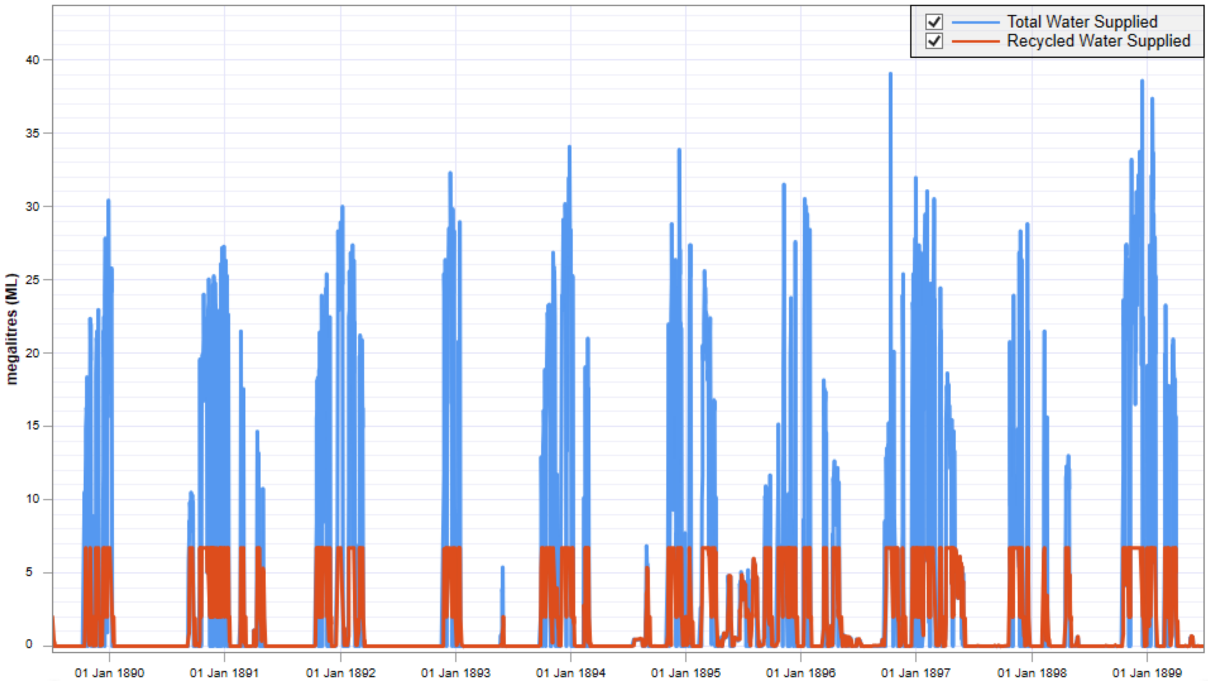

Figure 24. Option 16 testing

As shown in Table 8, unregulated rainfall harvested volume increases due to the increased yield of the supplemented crop — that is, crops that are healthier have higher evapotranspiration. The unregulated supply figure does not include the sewage water treatment plant flows.

Table 8. Summary of Option 16 results for the period of instrumental climate

	Base case	Option 16	Difference
Unregulated rainfall volume (ML/y)	19,091	19,149	58

Option 19: Raise Toonumbar Dam level

Description

Option 19 is to raise Toonumbar Dam to increase storage capacity and encourage additional usage uptake. By increasing the size of the dam and associated water security, dam usage becomes more attractive to business and facilitates the introduction of new users to the regulated system (e.g. town water suppliers).

This options model includes raising Toonumbar Dam full supply level from 129.63 m to 135.091 m. This increases full supply level storage volume from 11,066 ML to 19,800 ML.

Key assumptions

Toonumbar's existing level versus volume versus surface area curve more than covers the proposed increase in full supply level to obtain 19,800 ML of total storage. Therefore, no changes to the dam geometry are made in this option. Only the spillway is altered for the new height corresponding to the desired volume as the full supply level. The existing spillway curve also more than covers this height, given that no updated spillway curve was provided it is assumed that the existing spillway curve is still representative, except for those heights below the new full supply level, which are prevented from spilling.

A comparison of the spillway curves is shown in Figure 25. No changes to the model node-link structure are made.

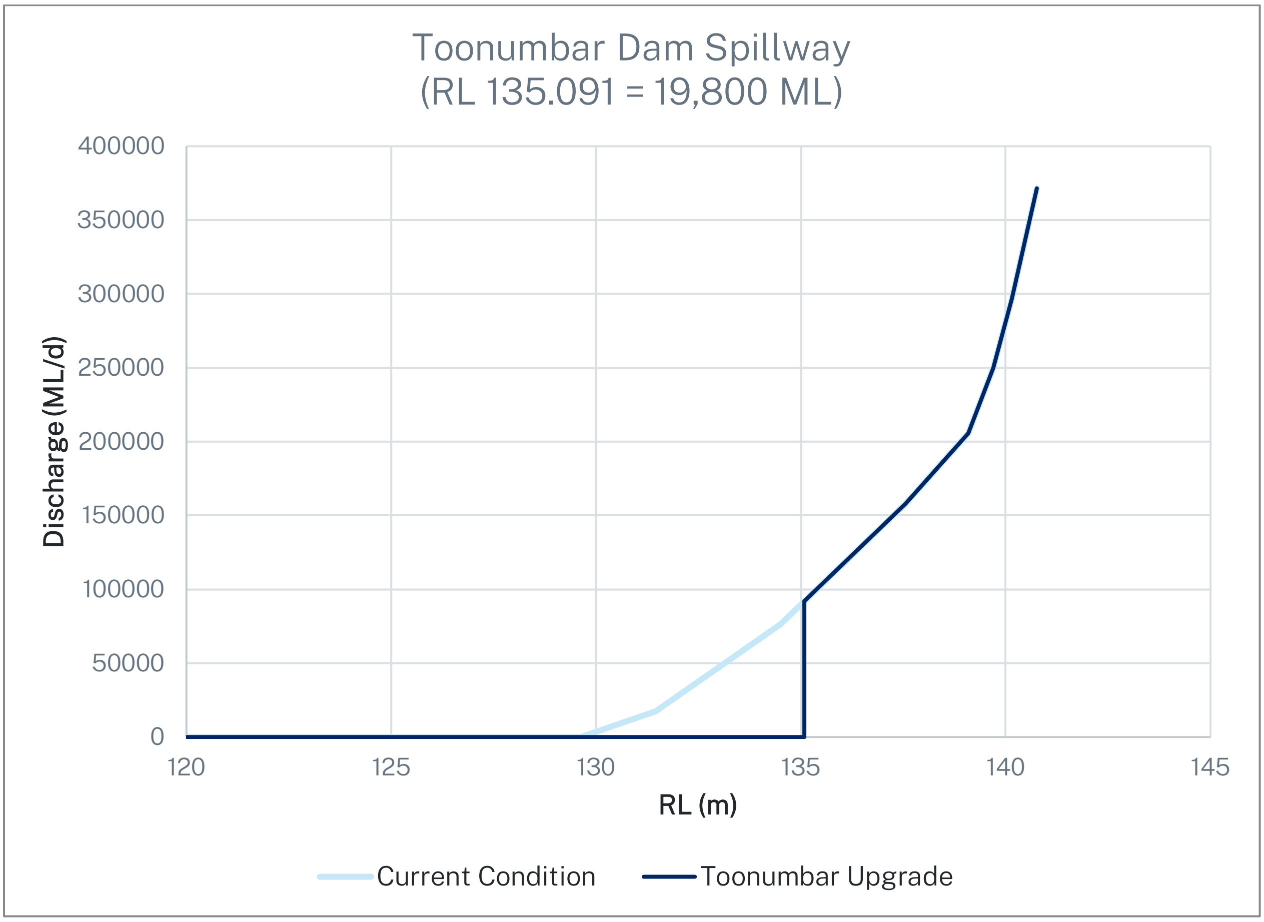

Figure 25. Option 19: Toonumbar Dam Upgrade Spillway Comparison

Model setup

The spillway was altered as outlined in the assumptions, but no other changes were made in the model.

Key results

The increased storage volume in Toonumbar is shown in Figure 26.

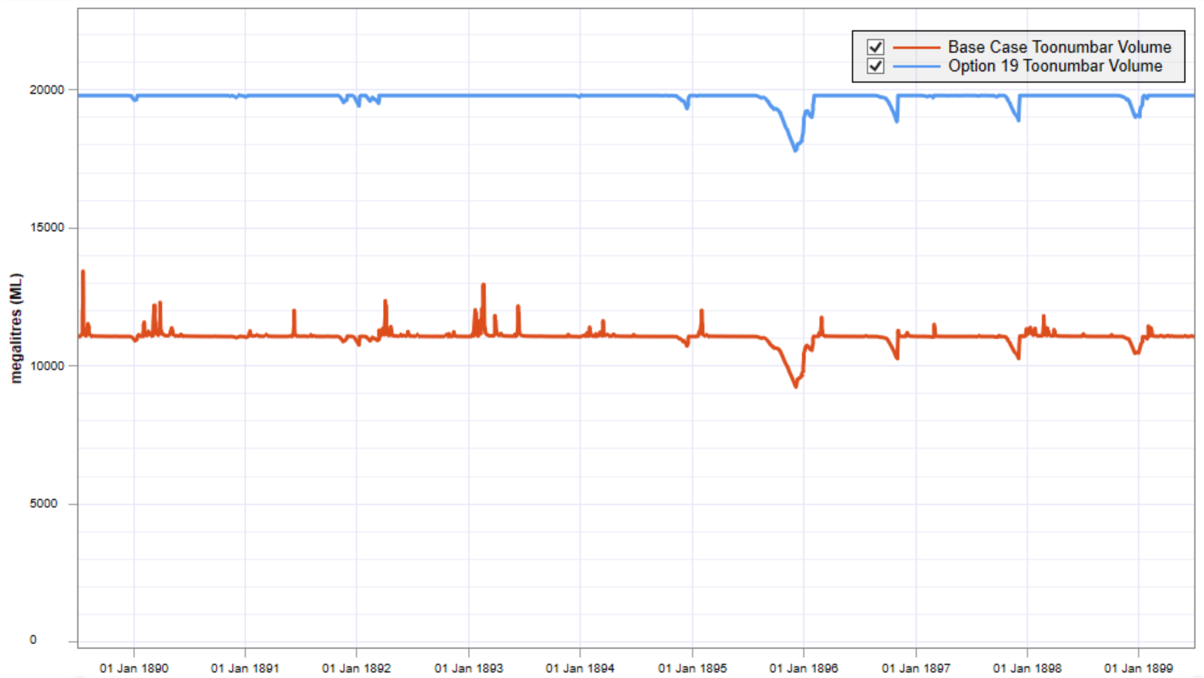

Figure 26. Option 19 testing volume

Option 19 strongly increases reliability of the general security allocations in Toonumbar as shown in Figure 27.

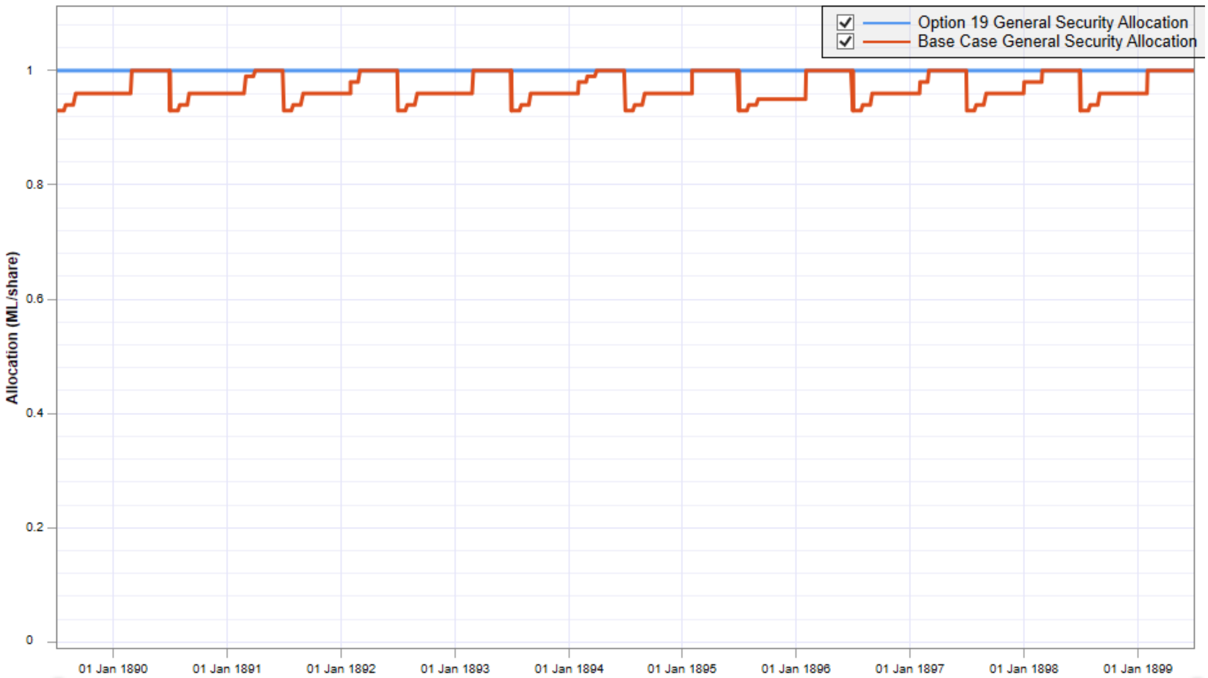

Figure 27. Option 19 testing allocation

A summary of the option results is shown in Table 9. Due to raising the dam and reducing spill frequency, the high security take has increased in lieu of uncontrolled flow access, counted under general security. This is likely just an artefact of the modelling that assumes that behaviour of irrigators will stay the same under options.

Table 9. Summary of Option 19 results for the period of instrumental climate

	Base case	Option 19	Difference
General security supplied	365	358	-7
High security supplied	112	114	2
High security ordered	112	114	2
High security shortfall	0	0	0
General security allocation (sum/yr)	350	365	15
Regulated rainfall volume	1,241	1,242	1
Unregulated supplied	10,085	10,086	1
Unregulated rainfall volume	19,091	19,090	-1

Option 21: Establish or increase environmental water releases from major storages in the Far North Coast

Description

Option 21 is to establish or increase environmental release requirements or environmental contingency allowances from major storages in the Far North Coast region. Release requirements would be informed by an assessment of risks to the riverine ecosystems located downstream of the storages and the ability to mitigate these risks by changing operating rules.

This option attempts to model the Toonumbar Environmental Contingency Allowance (ECA) account as if it had not expired. In reality, Option 19 would likely be linked to water quality events that are not within the scope of this model.

Key assumptions

It is assumed that the ECA account will be used to flush the system in November each year. This assumption is based on correspondence with planners.

Model setup

A new water user is added to the regulated system that orders 125 ML/d over 8 days and is linked to the previously dormant ECA account. Conceptualisation of this option is shown in Figure 28.

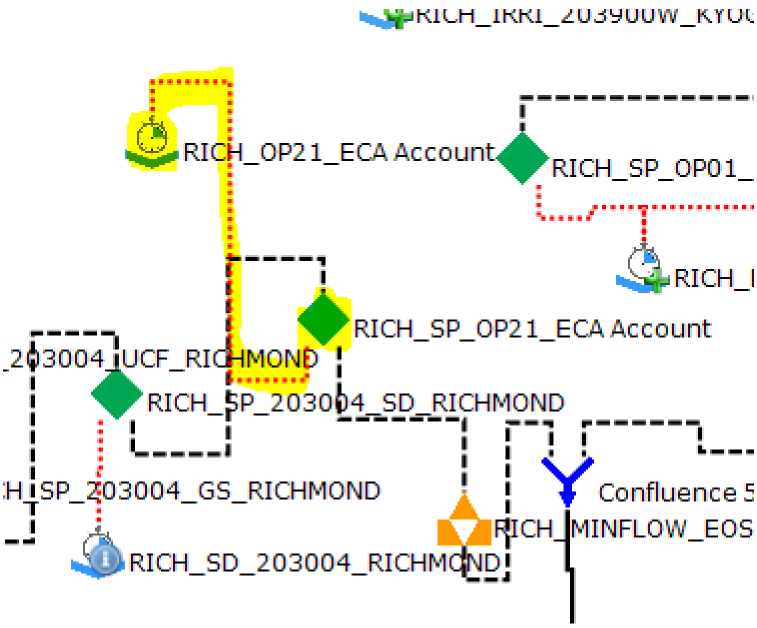

Figure 28. Option 21 conceptualisation with extra nodes and links shown in yellow

Key results

The ECA flush is released each November, as seen in Figure 29.

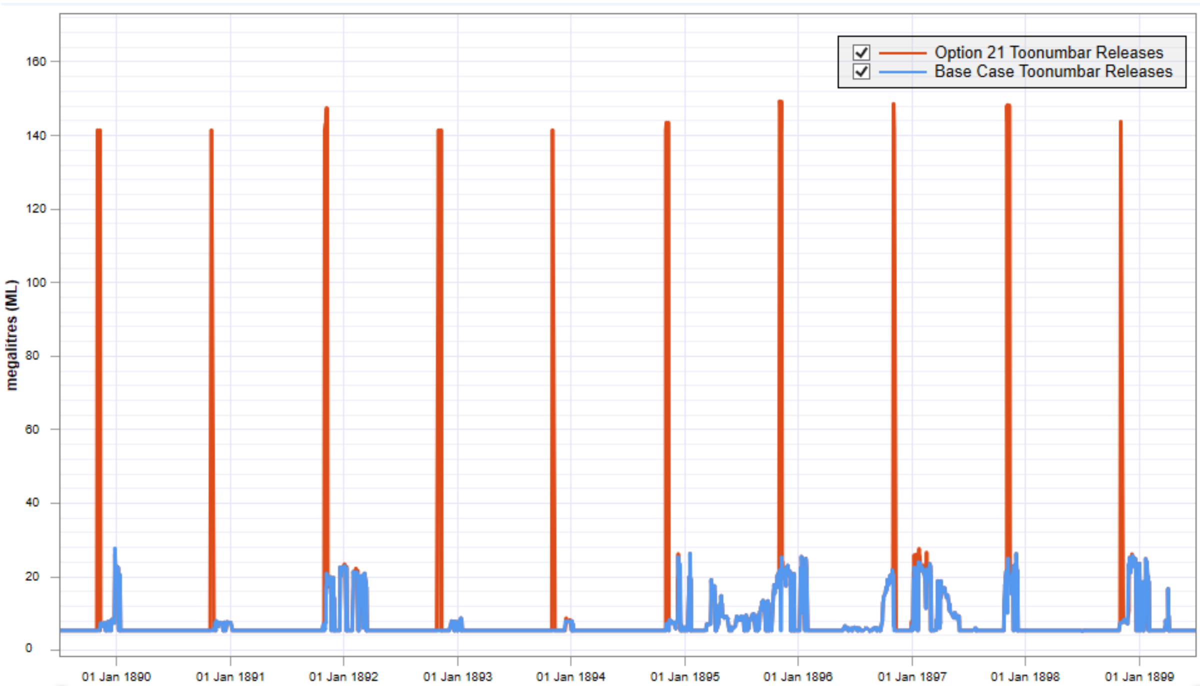

Figure 29. Option 21 testing

A summary of the results for Option 21 is shown in Table 10. The slight lowering of the general security allocation due to the extra water being released annual from Toonumbar Dam under this option causes a slight increase in high security water usage and a slight decrease in general security water usage. The flushing flow becomes unregulated flow downstream of Casino causing positive benefits for the unregulated supply.

Table 10. Summary of Option 21 results for the period of instrumental climate

	Base case	Option 21	Difference
General security supplied	365	363	-2
High security supplied	112	113	1
High security ordered	112	113	1
High security shortfall	0	0	0
General security allocation (sum/yr)	350.4	350.0	-0.4
Unregulated supplied	10,085	10,137	52
Unregulated rainfall volume	19,091	19,098	7

5 Preferred portfolios — assessment with instrumental, stochastic and NARCliM climate

Description

This section describes the construction of portfolio option conceptualisations for the Richmond River valley. References to local government authority demand projections represent 40-year annual demand projections using expected demand growth as given by Rous County Council. References to common planning assumption demand projections refer to 40-year annual demand projections using expected population growth as given by the NSW Government. A comparison of the two population projections is shown in Table. After rapid cost–benefit analysis of the results of the individual options model simulations, five options were identified as preferred options for further assessment: Option 1, Option 3aiii, Option 14, Option 19 and Option 21. The options were grouped to form six portfolios as shown in Table 11.

Table 11. Portfolio demand projections

Year	Rous Local Government Area predicted demand (ML/y)	NSW common planning assumption predicted demand (ML/y)
2020	12,247	12,175
2030	13,595	12,430
2040	14,500	12,684
2050	15,286	12,939
2060	16,054	13,194

A summary of the combination of options for the portfolio is shown in Table 12.

Table 12. Portfolio construction summary

Portfolio	Options included	Population projection
1	Base case	Rous
2	1, 14	NSW
3	1, 14	Rous
4	1	NSW
5	1	Rous
6	3aiii, 19, 21	NSW

Base case using local government authority demand projections

The existing base case scenario was run using local government authority demand projections instead of common planning assumption demand projections.

Connection of independent town water supply with major augmentation in the Richmond River system

Portfolio 2 combines Option 1 and Option 14 using the common planning assumption demand projections. As Option 1 components are directly connected to Rocky Creek Dam, Dunoon Dam is unable to provide water to the users connected in Option 1. This is not considered to be an issue as it would only cause a problem in the case where Rocky Creek Dam is completely drained despite Dunoon Dam taking the entirety of Rous Bulk Water demand below 50% capacity.

Connection of independent town water supply with major augmentation in the Richmond River system using local government authority demand projections

Portfolio 3 was modelled in the same way as Portfolio 2, but local government authority demand projections have been used.

Maximising use of the proposed Clarrie Hall Dam augmentation

Portfolio 4 consists of Option 1 using the common planning assumptions, used to provide input on Rous Bulk Water shortfalls to inform the Tweed River model extractions required from the Clarrie Hall Dam portfolio.

Maximising use of the proposed Clarrie Hall Dam augmentation using LGA demand projections

Portfolio 5 was modelled in the same way as portfolio 4, but local government authority demand projections have been used.

Maximising use of Toonumbar Dam

Portfolio 6 is a combination of Option 3aiii, Option 19 and Option 21 using the common planning assumption demand projections. Option 3aiii has changed to be a 2 GL account, sufficient to cover the Casino supply in most years by itself and does not absorb the sleeper ECA account as that is needed for Option 21. No other licences are issued for the increased Toonumbar Dam storage. This change is shown in Table 13.

Table 13. Portfolio 6 licence changes

Values in ML	Jabour Weir regulated account	ECA account	Total Toonumbar licences
Base case	0	1,000	10,242
Option 3 (Jabour Weir regulated)	1,000	0	10,242
Option 21 (use ECA account)	0	1,000	10,242
Portfolio 6	2,000	1,000	12,242

Key results of portfolio simulations

The baseline model and the portfolio models were simulated using three sets of multiple replicates of climate data of 40-year duration for economic analysis:

- 14 replicates for instrumental climate
- 1,000 replicates for stochastic climate
- 1,000 replicates for stochastic climate with NARCliM climate projections.

A summary of the key portfolio results for the unregulated system is shown in Table 14 and Table 15. The values represent the average volumes in ML/year. The regulated system was not the focus of these portfolios. Portfolio 6 primarily seeks to improve shortfalls at Casino and improve downstream unregulated reliability.

Table 14. Portfolio results summary for the period of instrumental climate data (P1-P6 represent the portfolio numbers)

Instrumental average volume (ML/year)	Base case	P 1	P 2	P 3	P 4	P 5	P 6
Kyogle supplied	324	324	324	324	324	324	324
Kyogle ordered	324	324	324	324	324	324	324
Kyogle shortfall	0	0	0	0	0	0	0
Rous supplied	12,671	14,324	12,671	14,324	12,671	14,324	12,671
Rous ordered	12,671	14,324	12,671	14,324	12,671	14,324	12,671
Rous shortfall	0	0	0	0	0	0	0
Casino supplied	2,107	2,107	2,107	2,107	2,107	2,107	2,107
Casino ordered	2,107	2,107	2,107	2,107	2,107	2,107	2,107
Casino shortfall	0	0	0	0	0	0	0
Nimbin supplied	180	180	180	180	180	180	180
Nimbin ordered	180	180	180	180	180	180	180
Nimbin shortfall	0	0	0	0	0	0	0
Mullumbimby supplied	387	387	387	387	387	387	387
Mullumbimby ordered	387	387	387	387	387	387	387

Instrumental average volume (ML/year)	Base case	P 1	P 2	P 3	P 4	P 5	P 6
Mullumbimby shortfall	0	0	0	0	0	0	0
Unregulated supplied	10,085	10,085	10,085	10085	10,085	10,085	10,137
Unregulated rainfall volume	19,091	19,091	19,091	19,091	19,091	19,091	19,098
Unregulated idealised crop required	31,814	31,814	31,814	31814	31,814	31,814	31,814

Table 15. Portfolio results summary for the period of stochastic climate data (P1-P6 represent the portfolio numbers)

Stochastic average volume (ML/year)	Base case	P 1	P2	P 3	P 4	P 5	P 6
Kyogle supplied	323	323	323	323	323	323	323
Kyogle ordered	323	323	323	323	323	323	323
Kyogle shortfall	0	0	0	0	0	0	0
Rous supplied	12,672	14,321	12,678	14,342	12,671	14,321	12,672
Rous ordered	12,678	14,342	12,678	14,342	12,678	14,342	12,678
Rous shortfall	7	21	0	0	7	21	7
Casino supplied	2,114	2,114	2,114	2,114	2,114	2,114	2,114
Casino ordered	2,114	2,114	2,114	2,114	2,114	2,114	2,114
Casino shortfall	0	0	0	0	0	0	0
Nimbin supplied	180	180	180	180	180	180	180
Nimbin ordered	180	180	180	180	180	180	180
Nimbin shortfall	0	0	0	0	0	0	0
Mullumbimby supplied	389	389	390	390	390	390	389
Mullumbimby ordered	390	390	390	390	390	390	390
Mullumbimby shortfall	1	1	0	0	0	0	1
Unregulated supplied	9,571	9,571	9,572	9,572	9,572	9,572	9,658
Unregulated rainfall volume	19,389	19,389	19,389	19,389	19,389	19,389	19,423
Unregulated idealised crop required	31,747	31,747	31,747	31,747	31,747	31,747	31,747

Table 16. Portfolio results summary for the period of stochastic climate data with NARCliM scaling (P1-P6 represent the portfolio numbers)

NARCliM-scaled average volume (ML/year)	Base case	P 1	P 2	P 3	P 4	P 5	P 6
Kyogle supplied	333	333	333	333	333	333	333
Kyogle ordered	333	333	333	333	333	333	333
Kyogle shortfall	0	0	0	0	0	0	0
Rous supplied	12,765	14,475	12,774	14,504	12,764	14,474	12,765
Rous ordered	12,775	14,504	12,775	14,504	12,775	14,504	12,775
Rous shortfall	10	30	0	1	11	31	10
Casino supplied	2,191	2,191	2,191	2,191	2,191	2,191	2,191
Casino ordered	2,191	2,191	2,191	2,191	2,191	2,191	2,191
Casino shortfall	0	0	0	0	0	0	0
Nimbin supplied	184	184	184	184	184	184	184
Nimbin ordered	184	184	184	184	184	184	184
Nimbin shortfall	0	0	0	0	0	0	0
Mullumbimby supplied	397	397	398	398	398	398	397
Mullumbimby ordered	398	398	398	398	398	398	398
Mullumbimby shortfall	1	1	0	0	0	0	1
Unregulated supplied	10,466	10,466	10,467	10,467	10,467	10,467	10,582
Unregulated rainfall volume	19,716	19,716	19,717	19,717	19,717	19,717	19,767
Unregulated idealised crop required	33,417	33,417	33,417	33,417	33,417	33,417	33,417

Outputs for economic analysis for preferred portfolios

The economic outputs for portfolios are supplied as 1,000 replicates of 40-year daily replicates with the same initial storage conditions. These are:

- Toonumbar Dam: 11,066 ML
- Rocky Creek Dam: 13,524 ML
- Emigrant Creek Dam: 862 ML.

These values are based on storage volumes as at 01/01/2020. The outputs are those shown in the summary tables above. The climate scenarios supplied are both stochastic and NARCliM-scaled stochastic.

Outputs for ecological analysis of preferred portfolios

The baseline model and the portfolio models were simulated using two sets of single sequence climate data for ecological analysis:

- 10,000-year stochastic climate
- 10,000-year stochastic climate with NARCliM climate projections.

In the 10,000-year single-sequence simulation annual population projections that were used in the 40-year economic simulations were not incorporated. The ecological outputs for portfolios are supplied as a single 10,000-year daily time series outputting modelled flow at the following gauges:

- 203002; 203004; 203009; 203010; 203012; 203013; 203015; 203022; 203024; 203030; 203032; 203034; 203035; 203038; 203041; 203044; 203045; 203403; 203450; 203470; 203900; 203014; 203005; 203006; 203026; 203027; 203028; 203023; 203036; 203042.

The climate scenarios supplied are both stochastic and NARCliM-scaled stochastic.

6 Summary of options assessments

Table 17 and Table 18 present the average annual values of the simulated outputs of different categories from the base case and option models. Table 17 presents the outputs from the base case and option model simulations using instrumental climate for the regulated system of Richmond River valley and the results from the unregulated system are presented in Table 18.

Table 17. Summary results from the base case and option model simulations using instrumental climate for the regulated system of Richmond River valley (mean ML/yr)

	Base case	Option 1	Option 2b	Option 2	Option 3b	Option 3	Option 7	Option 10	Option 11	Option 14	Option 16	Option 19	Option 21
Stock and domestic supplied	14	14	14	14	14	14	14	14	14	14	14	14	14
Stock and domestic ordered	14	14	14	14	14	14	14	14	14	14	14	14	14
Stock and domestic shortfall	0	0	0	0	0	0	0	0	0	0	0	0	0
General security supplied	365	365	365	365	365	365	365	365	365	365	365	358	363
High security supplied	112	112	112	112	112	112	112	112	112	112	112	114	113
High security ordered	112	112	112	112	112	112	112	112	112	112	112	114	113
High security shortfall	0	0	0	0	0	0	0	0	0	0	0	0	0
General security allocation (sum/yr)	350	350	350	350	350	350	350	350	350	350	350	365	350
Regulated rainfall volume	1,241	1,241	1,241	1,241	1,241	1,241	1,241	1,241	1,241	1,241	1,241	1,242	1,241

Table 18. Options unregulated summary results mean (ML/yr) using the instrumental climate

	Base case	Option 1	Option 2b	Option 2	Option 3b	Option 3	Option 7	Option 10	Option 11	Option 14	Option 16	Option 19	Option 21
Kyogle supplied	324	324	324	324	324	324	324	324	324	324	324	324	324
Kyogle ordered	324	324	324	324	324	324	324	324	324	324	324	324	324
Kyogle shortfall	0	0	0	0	0	0	0	0	0	0	0	0	0
Rous supplied	12,671	12,671	12,671	12,663	12,671	12,671	3,085	12,671	12,671	12,671	12,671	12,671	12,671
Rous ordered	12,671	12,671	12,671	12,671	12,671	12,671	3,085	12,671	12,671	12,671	12,671	12,671	12,671
Rous shortfall	0	0	0	9	0	0	0	0	0	0	0	0	0
Casino supplied	2,107	2,107	2,107	2,107	2,107	2,107	2,107	2,107	2,107	2,107	2,107	2107	2,107
Casino ordered	2,107	2,107	2,107	2,107	2,107	2,107	2,107	2,107	2,107	2,107	2,107	2107	2,107
Casino shortfall	0	0	0	0	0	0	0	0	0	0	0	0	0
Nimbin supplied	180	180	180	180	180	180	180	180	180	180	180	180	180
Nimbin ordered	180	180	180	180	180	180	180	180	180	180	180	180	180
Nimbin shortfall	0	0	0	0	0	0	0	0	0	0	0	0	0
Mullumbimby supplied	387	387	387	387	387	387	387	387	387	387	387	387	387
Mullumbimby ordered	387	387	387	387	387	387	387	387	387	387	387	387	387
Mullumbimby shortfall	0	0	0	0	0	0	0	0	0	0	0	0	0
Unregulated supplied	10,085	10,085	10,085	10,085	9,863	10,085	10,085	10,085	10,085	10085	10,085	10,086	10,137
Unregulated rainfall volume	19,091	19,091	19,091	19,091	19,092	19,091	19,091	19,091	19,091	19,091	19,149	19,090	19,098
Unregulated idealised crop required	31,814	31,814	31,814	31,814	31,814	31,814	31,814	31,814	31,814	31,814	31,814	31,814	31,814