Mullumbimby Water Supply Strategy

Final Draft Report

December 2021

Disclaimer:

This report has been prepared on behalf of and for the exclusive use of Byron Shire Council and is subject to and issued in accordance with the agreement between Byron Shire Council and Hydrosphere Consulting. Hydrosphere Consulting accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party.

Copying this report without the permission of Byron Shire Council or Hydrosphere Consulting is not permitted.

Acknowledgement of Country

Hydrosphere Consulting recognises the traditional owners of the land discussed in this report, the Bundjalung of Byron Bay, Arakwal people, the Widjabal people, the Minjungbul people and the wider Bundjalung Nation.

Cover photo: Lavertys Gap weir, September 2018

Hydrosphere Consulting Pty Ltd
Suite 6, 26-54 River Street
PO Box 7059, BALLINA NSW 2478
hydrosphere.com.au

20-020 MULLUMBIMBY WATER SUPPLY STRATEGY

REV	DESCRIPTION	AUTHORS	REVIEW	APPROVAL	DATE
0	Draft for Council review	R. Campbell, J. Fullerton, K. Menzies	K. Pratt, M. Howland	M. Howland	17 June 2021
1	Final draft	R. Campbell	M. Howland	M. Howland	17 Dec 2021

Hydrosphere Consulting

EXECUTIVE SUMMARY

Introduction

Mullumbimby's drinking water supply is sourced from the upper reaches of Wilsons Creek. Water is extracted from Lavertys Gap Weir on Wilsons Creek where it flows by gravity through an open channel, via a tunnel to the Mullumbimby water treatment plant (WTP) as shown on Figure 1. The channel and tunnel were the original raw water transfer system to the Mullumbimby Hydroelectric Power Station (now decommissioned). There is an emergency supply pipeline from the Rous County Council (RCC) bulk supply system with agreement to supply up to 0.5 ML/d to the lower areas of the Mullumbimby distribution system. The Mullumbimby water supply currently services approximately 1,620 residential properties (3,600 people) and 270 non-residential properties. Approximately 13 customers along Wilsons Creek Road are connected to the trunk main from the WTP.

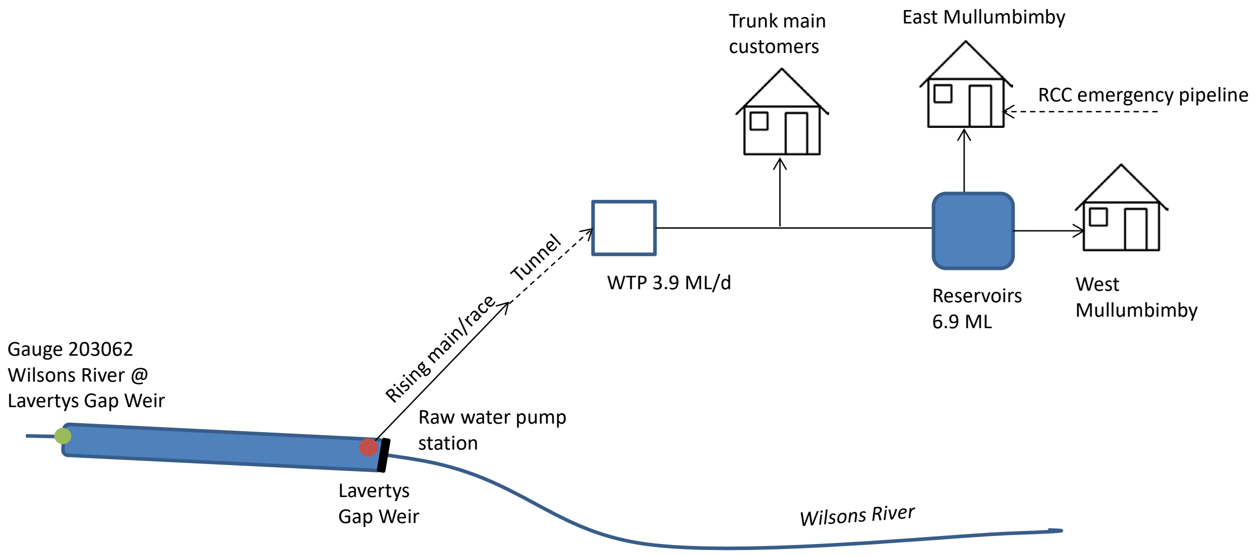


Figure 1: Mullumbimby water supply schematic diagram

Byron Shire Council (BSC) has engaged Hydrosphere Consulting to prepare a long-term strategy for Mullumbimby water supply. The key issue to be addressed is water supply security (servicing existing customers and future development over the long-term). The current demand for water is similar to the secure yield at Lavertys Gap Weir and if the worst drought on record were to repeat, the current supply would not meet demand. BSC has prepared growth management strategies for urban land, rural areas and business/industrial land which include future development that will increase the demand for potable water. The strategy also considers the following issues:

- Asset condition and performance - the raw water channel (constructed in the 1920s) has exceeded its useful life. The likelihood of failure is considered very high and on the basis that structural failure of the channel would cause extended interruption to the water supply, upgrading the raw water transfer system is a high priority while the weir supply continues to be used. In addition, due to the age of the Mullumbimby WTP (originally constructed in 1940), the WTP requires replacement in the next five to ten years. In addition, WTP upgrades are required to ensure removal of pathogens in the short-term.

- Drought management and emergency response - restrictions are currently introduced based on the water level and inflows in Lavertys Gap weir. Restrictions were imposed in Mullumbimby during the droughts of 2002/03, 2006/07 and 2019/20. An emergency supply from the Rous County Council (RCC) regional supply can supply water to lower elevation areas (East Mullumbimby) and was used for 30 days during summer 2019/20.
- Heritage considerations and management obligations - Lavertys Gap Weir and the channel (as part of the Mullumbimby hydro-electric power complex) are listed on the NSW State Heritage Register. In addition, the WTP has heritage significance at a local level.

This report assesses the security of the existing water supply system based on its secure yield and current demand. Options to increase the supply and reduce potable water demand have been identified and analysed and scenarios have been developed using combinations of the options to achieve the required secure yield in 2050. An integrated water cycle management (IWCM) approach has been used to compare options and scenarios and identify the preferred supply augmentation scenario to meet the predicted 2050 demand.

Security of Current Water Supply

'Secure yield' is defined as the highest annual water demand that can be supplied from a water supply headworks system whilst water restrictions are not too severe, not too frequent, nor of excessive duration. A model has been developed using GoldSim 12.1 (Monte Carlo simulation software) to simulate the Mullumbimby water supply and assess the secure yield for various Global Climate Models using the methodology prescribed by the draft *Guidelines on Assuring Future Urban Water Security* (NSW Office of Water, 2013). Water security is achieved if the secure yield of a water supply is at least equal to the unrestricted dry year annual demand.

The historical demand for potable water in a 'dry year' (a year with low rainfall) and an 'average year' (a year with average rainfall) were calculated using the data on existing customers and demand. The predicted residential, business and industrial development was used to estimate the additional number of future connected properties in Mullumbimby and the total demand over the next 30 years. Reduced water losses are predicted as a result of pressure reduction measures to be implemented as part of Council's water loss management program.

Mullumbimby's demand for water is increasing with development and population growth. The current (2020) and 2050 dry year unrestricted demand are compared to the secure yield in Table 1. The RCC emergency supply pipeline improves the water supply security although it is not intended to operate any more than an emergency supply. Assuming that water loss reduction measures are implemented and the emergency supply is available, the supply will be secure until 2027 (Figure 2). After this time, the existing system cannot meet forecast demand without the potential for more frequent, longer and severe water restrictions. The supply deficit at 2050 (excluding the emergency supply) will be 377 ML/a.

Table 1: Comparison of demand and secure yield

Component (ML/a)	2020	2050
Dry year unrestricted demand (including water loss reduction)	483	754
Secure yield - weir supply	440	377
RCC emergency supply	183	183
Total system yield	623	560
Supply deficit (excluding emergency supply)	+43	377

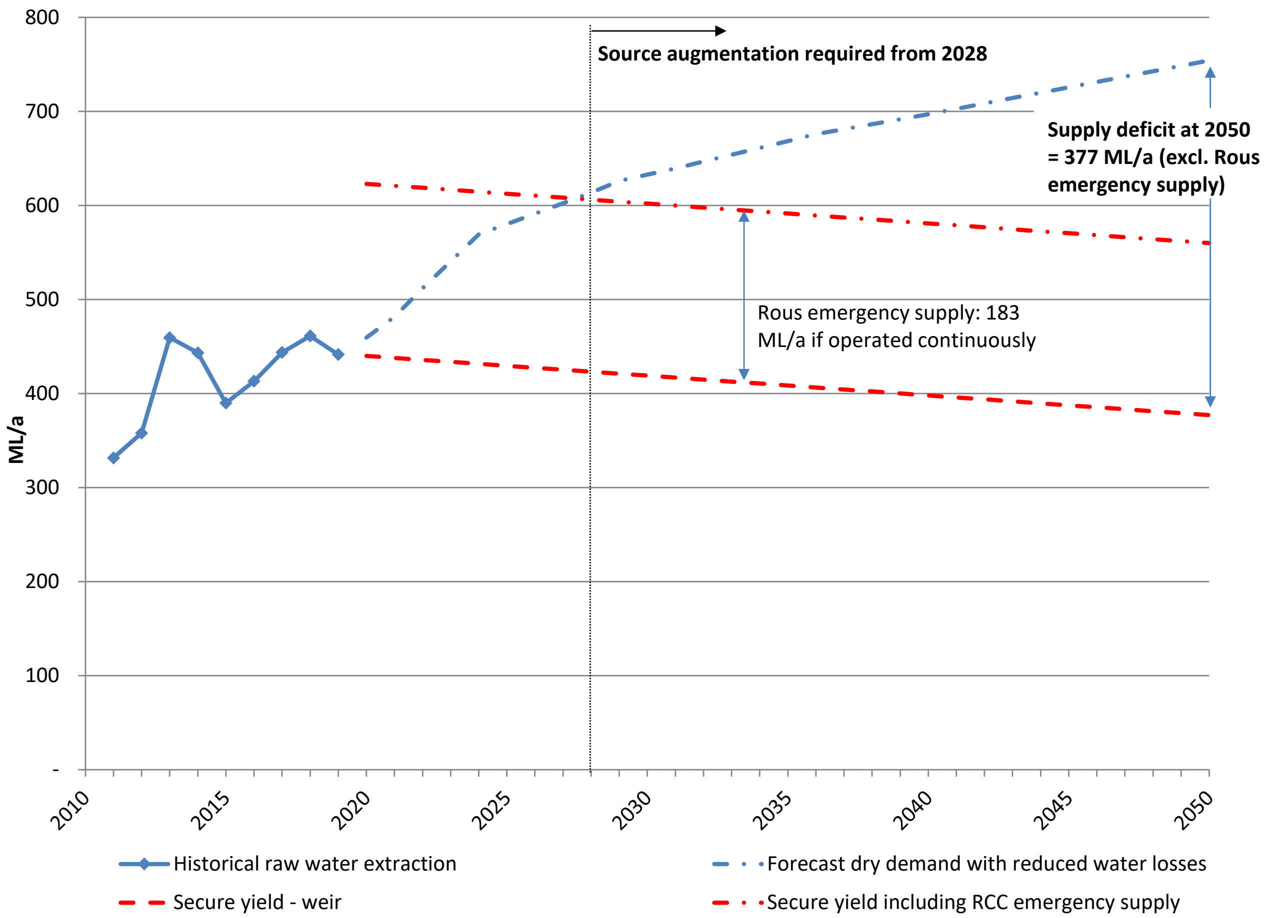


Figure 2: Comparison of forecast raw water demand and secure yield

Demand-Side Options

Implementation of demand-side options (demand management, urban effluent reuse and private supplies) will form part of the long-term strategy through the implementation of parallel initiatives including the NSW government BASIX program, BSC's recycled water strategy (currently being reviewed and updated), the Regional Demand Management Plan (RDMP, including rainwater tank rebates, the Sustainable Water Partner Program, smart metering and community engagement and education) and Council's water loss reduction measures. Increased drought restrictions are not proposed as part of the long-term strategy but may be required until water security is resolved.

Water Supply Options and Supply Scenarios

A coarse screening assessment considered a range of new as well as previously identified supply options. The following options passed the coarse assessment and are further assessed and discussed in detail in this report:

Option 1. Do nothing (for comparison with augmentation options).

Option 2. Raising Lavertys Gap weir.

Option 3. Off-stream storage.

Option 4. A: Permanent connection to the RCC bulk water supply.

B: Emergency connection to regional supply

Option 5. Groundwater.

Following a detailed assessment of these options, Option 2 (raising Lavertys Gap weir) was not recommended for further consideration due to the minimal yield benefit, high costs and significant impacts on terrestrial biodiversity as well as downstream users and the environment.

Four scenarios have been developed from combinations of the remaining options that would achieve the required secure yield over the long term (754 ML/a, an increase of 377 ML/a at 2050). All scenarios include the following common components:

- Continued use of the weir supply and Mullumbimby WTP.
- Short- term WTP upgrades to ensure consistent supply of microbially safe water.
- Extension of the RCC emergency bulk water supply connection to service all Mullumbimby water supply customers to be used as a secure emergency response measure when required to supplement the weir supply (Option 4B).
- An increase in the Lavertys gap weir licence extraction limit (likely to be required from 2023 unless an alternative source is implemented).
- Review and update of the drought management plan based on the performance of the supply and drought management regime during the recent drought.
- Implementation of the demand management measures in the RDMP.
- Water loss reduction measures.
- Continued investigation of the long-term impacts of climate change on the secure yield of the weir supply.
- Resolution of the heritage management requirements for the weir, channel and WTP.
- Development of alternative supply options for the trunk main customers.
- Continued identification and implementation of urban effluent reuse opportunities (future demand will be reduced with potable water savings and yield deficit will be reduced accordingly).

The potentially feasible water supply augmentation scenarios are (Table 2):

- Scenario S1: Base case: Improvements to the existing raw water transfer system, a new WTP and full emergency connection to the regional supply. This scenario would provide secure yield until 2025. Beyond 2025, restrictions may become more frequent and/or more severe.
- Scenario S2: Off-stream storage: Improvements to the existing raw water transfer system, full emergency connection to the regional supply, construction of a 200 ML off-stream storage and new WTP. High stream flows would be transferred to fill the off-stream storage. Water from the storage will be treated at the new WTP and transferred to the township.
- Scenario S3: Permanent connection to RCC regional supply: In this scenario, Mullumbimby would form part of the RCC regional supply network with bulk treated water transferred to the Azalea Street reservoirs.
- Scenario S4: Supplementary groundwater: Improvements to the existing raw water transfer system, a new WTP, full emergency connection to the regional supply, construction of new bores to the south-west of Mullumbimby with raw water transferred either to the weir or the new WTP for treatment and distribution to the township.

Table 2: Water supply scenarios

Scenario	S1	S2	S3	S4
Upgrade raw water transfer system from weir[1]	✓	✓		✓
WTP replacement	✓	✓		✓
Option 1 - Do Nothing	✓			
Option 3 - Off-stream Storage		✓		
Option 4A - RCC (permanent)			✓	
Option 4B - RCC (emergency extension)	✓	✓	✓	✓
Option 5 - Groundwater				✓

1. The preferred option to upgrade the raw water transfer system from the weir (for S1, S2 and S4) is a new pumped pressure pipeline following an alternative alignment that is independent of the channel.

Environmental Impacts

All surface water options considered for Mullumbimby (Wilsons Creek extraction for S1 and S2 and Rocky Creek extraction for S3) rely on existing infrastructure and extraction from the Richmond River system. Although there are significant initial impacts associated with dam construction, the ecology within the storage area and downstream eventually adapts to the changed flow regime with subsequent loss of habitat for many native species. The terrestrial environments impacted by the existing surface water supplies have been modified through increased water level in the storages and land clearing to varying extents. All proposed supply augmentations for each scenario will require infrastructure development that is not expected to significantly impact on the terrestrial environment. Scenarios relying on groundwater supplies (S4 – potentially a local fractured rock groundwater supply and S3 – proposed future coastal sand aquifer supply at Tyagarah) have the potential to impact on groundwater dependent ecosystems. However, these impacts are expected to be adequately managed through site selection and extraction regimes. Similarly, any impacts on the terrestrial environment are expected to be adequately managed through site selection.

The predicted impacts on the aquatic and terrestrial environment for all four scenarios are similar. The dominant impacts are largely related to the existing water supply arrangements and are not expected to be altered with ongoing use of these supplies. The impacts of proposed system augmentation to achieve secure yield requirements (off-stream storage in S2 and groundwater in S3 and S4) are also expected to be adequately managed.

As the environmental impacts of each scenario are similar, selection of the preferred scenario has focused on social and economic considerations.

Preferred Scenario

A triple-bottom-line (TBL) assessment has been used to compare the scenarios (Table 3).

Table 3: TBL assessment criteria

Criteria	Description	Information used
Environmental (ranked considering the biodiversity management hierarchy - avoid, minimise, rehabilitate, offset)		
Aquatic	Impact on groundwater and surface water quality and aquatic ecology and measures to offset those impacts.	Aquatic biodiversity impacts (e.g. high value aquatic ecosystems, threatened species, water quality, groundwater dependent ecosystems) and offsets proposed (e.g. environmental flows).
Terrestrial	Impact on terrestrial ecology and measures to offset those impacts.	Terrestrial biodiversity impacts (e.g. high value terrestrial ecosystems, threatened species) and offsets proposed (e.g. stewardship/ compensation).
Energy consumption	Energy requirements	Operational energy consumption (comparative).
Social		
Community acceptance	Predicted community acceptance	Community consultation has not yet been undertaken.
Security of supply	Year of augmentation required (following implementation of the scenario)	Secure yield assessment of each option.
Economic		
Net present value (NPV)	NPV of capital and operating costs (80 years) at 5% discount rate.	Estimated capital and operating costs.
Life-cycle cost	Total cost over 30 years	Estimated capital and operating costs.

A weighted score (higher is better) has been calculated for each scenario. Ranking has been calculated as follows:

$$\text{(Environmental Score + Social Score)/NPV}$$

Weightings are assigned to each criterion based on relative importance so that the sensitivity of the weightings can be tested.

A summary of the TBL assessment (with equal weighting for each criteria) is provided in the following table. Changing the weightings does not change the outcomes of the multi-criteria analysis (MCA) ranking.

Table 4: Summary of MCA outcomes

Scenario	Weighted environmental score (/5)	Weighted social score (/5)	NPV ($ million, 30 years @ 5%)	Total score (per $ NPV)	Rank (based on MCA)
S1: Base Case	4.50	1.00	13.41	205	3
S2: Off-stream Storage	3.67	3.50	29.54	121	4
S3: Permanent connection to RCC regional supply	4.67	4.00	13.75	315	1
S4: Groundwater	3.67	3.25	15.78	219	2

Based on the TBL assessment, the most favourable scenario is S3: Permanent connection to the RCC regional supply (Figure 3). This scenario would have minimal environmental impact and the security of supply is only limited by the security of the RCC regional supply. Social acceptance of this scenario has not yet been determined but when other factors such as energy consumption, infrastructure modifications and required investment are considered, the regional supply has significant benefit over the local scenarios. The NPV of the regional scenario is the lowest of all scenarios. There are significant capital cost savings in avoiding the need to replace the Mullumbimby WTP and upgrade the weir supply in addition to constructing new infrastructure, however, the ongoing costs of a regional supply are higher than local scenarios.

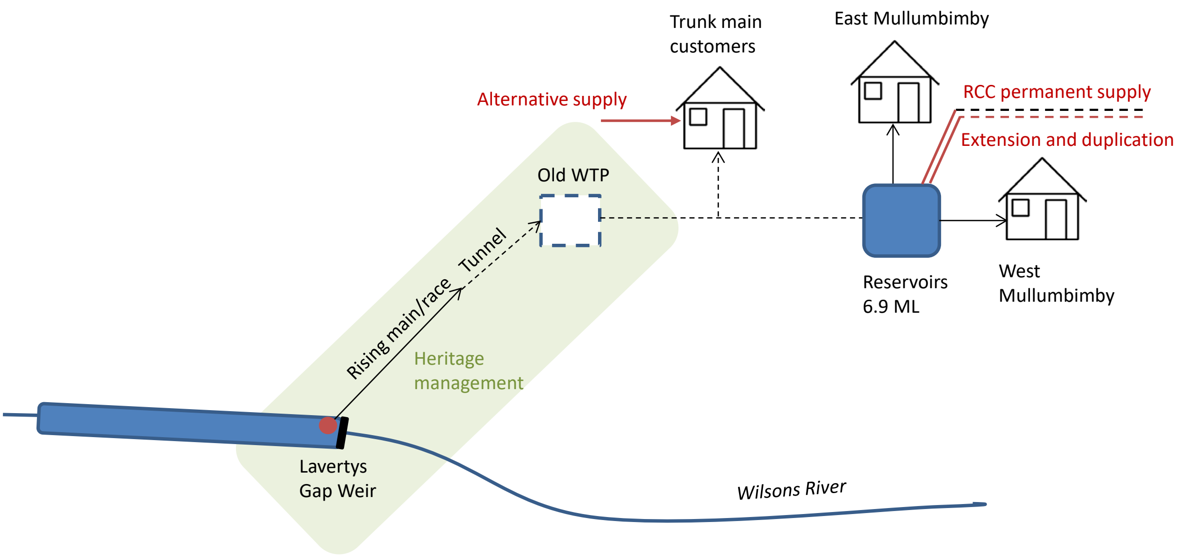


Figure 3: Preferred scenario S3: Permanent connection to RCC regional supply

The benefits of centralisation of water supplies and regional interconnection have been recognised in a previous study undertaken by the Northern Rivers Regional Organisation of Councils (now Joint Organisation) including improved financial outcomes through economies of scale, access to a wider range of options to improve efficiency, system resilience and operational flexibility. Financial benefits would result from regional opportunities for staging of water source development, increased flexibility in scheme development, reduced duplication of infrastructure and sharing of costs over a larger customer base. There is also the potential to reduce the risk of supply shortage in the region through supply diversity, supply redundancy, climate resilience and system flexibility. A regional scheme also allows access to a wider range of options to improve environmental and social outcomes than a local scheme.

Implementation Plan

A secure water supply is critical to ensure the Mullumbimby community's health and quality of life as well as a sustainable environment and continued economic prosperity. Council has a duty to ensure that there is enough water available to meet the long-term needs of Mullumbimby. Based on the current demand and secure yield forecasts, investment in new water sources cannot be continuously deferred and by 2025 new sources of water will be required to meet the town's long-term water needs.

The Mullumbimby Water Supply Strategy includes a diversified portfolio of actions to meet the community's water needs based on connection to the RCC regional supply:

- Priority actions: improved drought resilience and treatment performance:
  - Emergency pipeline extension to service the whole town.
  - Duplication of RCC regional supply pipeline to provide supply redundancy.
  - WTP upgrades to ensure consistent supply of microbially safe water in the short-term.
  - Asset management planning for existing water supply assets that are not required as part of the regional scheme.
  - Drought management and emergency response planning.
  - Consultation with RCC, the community, trunk main customers, Essential Energy and government agencies regarding the preferred strategy and implementation requirements.
  - Heritage investigations to provide guidance on long-term maintenance and management of the weir, channel and WTP.
  - Financial planning to develop funding strategies and ensure affordability of the preferred scenario.
- Ongoing actions: reducing potable water demand including water loss management and the increased use of recycled water.

The expected delivery of the preferred scenario (capital and operating cost estimates and timing) is shown in Table 5. The cost estimates do not include staff time or existing strategic planning or operational expenditure which are not influenced by the preferred water supply strategy for Mullumbimby. The implementation plan assumes that the permanent connection to the regional supply will be available from 2025.

Strategic planning actions such as financial planning and demand management would be undertaken for all BSC water supplies as part of existing budgets and have not been included here. Effluent reuse opportunities are currently unknown and costs have not yet been estimated. These actions are part of Council's shire-wide water supply strategic planning and delivery and would be included in all future water supply scenarios.

On-going monitoring and review are required to ensure the strategy actions effectively resolve the identified issues. The Council-wide *Water Supply and Sewerage Strategic Plan* (draft, 2017) and financial plan should be reviewed to incorporate the adopted strategy for Mullumbimby water supply. Annual reviews of capital and operating expenditure and financial planning should also be undertaken.

Table 5: Mullumbimby water supply strategy implementation - cost estimates

Delivery Program year		Year 5	Year 1	Year 2	Year 3	Year 4	Year 1	Year 2	Year 3	Year 4	Year 1
Year		1	2	3	4	5	6	7	8	9	10
Action/cost estimate (2021 $'000)	Ten-year cost	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Emergency pipeline extension - planning, design and approval	*100*	100									
Emergency pipeline extension - construction	*1,182*		1,182								
Pipeline duplication - planning, design and approval	*100*		150								
Pipeline duplication - construction	*1,182*			2,500							
Emergency water supply - purchase of water (allowance)	*170*	50	60	60							
WTP upgrades	*330*	106	112	112							
Regional water supply - purchase of water	*4,800*				650	660	670	690	700	710	720
Asset management planning	*200*		100	100							
Drought management plan review	*50*	50									
Consultation	*170*	50	50	50	20						
Heritage management	*100*		50	50							
Totals	***9,751***	**356**	**1,704**	**2,872**	**670**	**660**	**670**	**690**	**700**	**710**	**720**

Planning and approvals	Construction	Operation

CONTENTS

FIGURES

PLATES

TABLES

1. INTRODUCTION

Council has engaged Hydrosphere Consulting to prepare a long-term strategy for Mullumbimby water supply to ensure that it can meet future water demand. Previous investigations have included:

- *Mullumbimby Long Term Water Supply Scheme Strategy* (JWP, 2005).
- *Mullumbimby Water Treatment Plant Refurbishment* (HydroScience Consulting, 2008).
- *Mullumbimby Water Treatment Plan Concept Design Report* (HydroScience Consulting, 2009).
- *Mullumbimby Drought Management Plan* (HydroScience Consulting, 2016).
- *Byron Shire Council Water Supply and Sewerage Strategic Plan: 2017 Review* (Hydrosphere Consulting, 2017).
- *Mullumbimby Water Supply, Lavertys Gap Weir - Secure Yield Assessment* (Hydrosphere Consulting, 2019).

Detailed investigations into the WTP upgrade requirements (CWT, 2020) and heritage management requirements (Hill *et al*., 2021) have been undertaken as part of the development of this strategy. Council has also commissioned Willow + Sparrow to investigate the condition and performance of the raw water supply channel and develop hydraulic options for transfer of raw water to the WTP. Concurrently, Council is investigating the potential for effluent reuse options to supplement the Mullumbimby water supply (open space irrigation and urban dual reticulation). The outcomes of these investigations to date have also been incorporated into this Strategy.

The need for a long-term water supply strategy for Mullumbimby is based on the following findings from previous studies:

- The current demand for water is similar to the secure yield at Lavertys Gap Weir and if the worst drought on record were to repeat, the current supply would not meet demand.
- Mullumbimby's demand for water is increasing with development and population growth.
- The Mullumbimby WTP requires upgrades to ensure consistent supply of microbially safe water in the short-term and is ageing and requires replacement.
- The raw water supply channel is in poor condition and is at risk of failure.

In addition, the prolonged drought conditions experienced during summer 2019/20 resulted in a significant draw-down of the weir and the need to impose high level restrictions in Mullumbimby. Drawdown of the weir also occurred between November and December 2020 although restrictions were not required due to high rainfall in mid-December 2020.

The scope of this Water Supply Strategy includes:

- Review of existing raw water supply and WTP performance and asset condition.
- Demand analysis and forecast to 2050.
- Assessment of the security of the current supply.

- Investigation of water supply augmentation options:
    - Raising Lavertys Gap weir.
    - Off-stream storage.
    - Permanent connection to Rous regional supply.
    - Stormwater reuse.
    - Desalination.
    - Groundwater.
    - Indirect potable reuse of treated wastewater.
- Consideration of potable water demand reduction options:
    - Regional demand management actions (monitoring, reporting, water loss reduction, non-residential customer programs, smart metering, rainwater tank rebates and education).
    - Increased drought restrictions.
    - Urban effluent reuse.
    - Private water supplies (rainwater tanks, bore water etc.).
    - Rous regional emergency bulk water supply.
- Coarse assessment of long-term supply options.
- Detailed assessment (social, environmental and financial) of short-listed supply options.
- Development, assessment and comparison of long-term water supply scenarios.
- Selection of a preferred scenario and development of an implementation plan.

2. EXISTING WATER SUPPLY SYSTEM

Mullumbimby's drinking water supply is sourced from the upper reaches of Wilsons Creek, a tributary of the Richmond River. Water is extracted from Lavertys Gap Weir on Wilsons Creek where it flows by gravity through a 'race' (open channel), via a tunnel (583 m) to the WTP as shown on Figure 4. The channel and tunnel were the original raw water transfer system to the WTP and the Mullumbimby Hydroelectric Power Station (now decommissioned). The main features of the Mullumbimby water supply system are shown on Figure 4 and Figure 5.

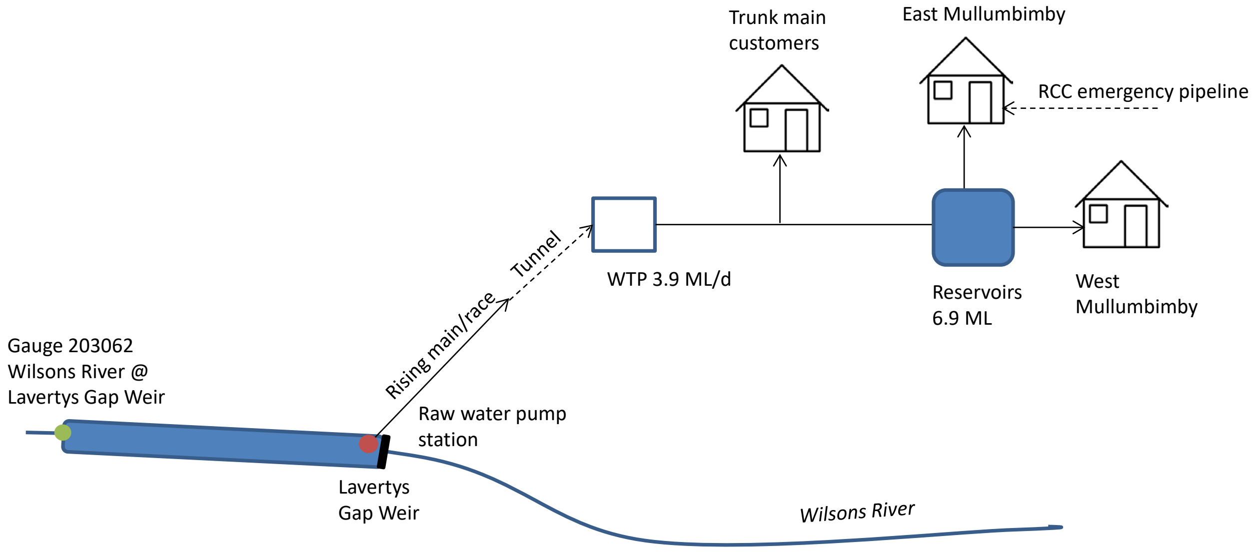


Figure 4: Mullumbimby water supply schematic diagram

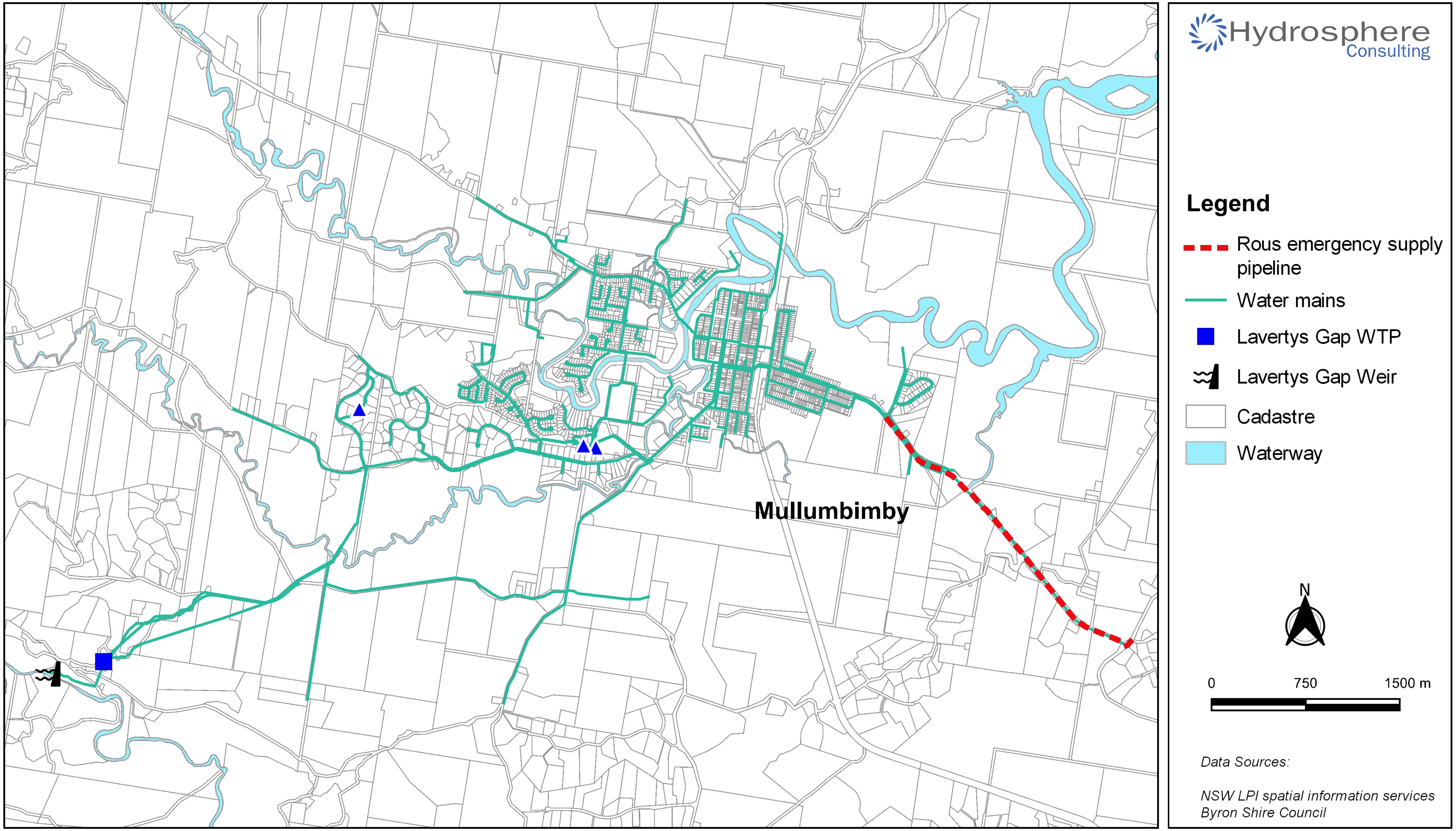


Figure 5: Mullumbimby water supply

2.1 Raw Water Supply

The Lavertys gap weir catchment and storage are shown on Figure 7. Council has a works approval (30CA304433) and water access licences (23085 and 22968, Table 6) for extraction of water from the Bangalow Area water source (Lavertys Gap weir) in accordance with the *Water Sharing Plan for the Richmond River Area Unregulated, Regulated and Alluvial Water Sources, 2010*.

Table 6: Water access licences

Water Access Licence	Purpose	Category	Water Sharing Plan	Licence entitlement p.a.	Additional requirements/comments
23085	Town water supply	Local Water Utility	*Richmond River Area Unregulated, Regulated and Alluvial Water Sources 2010*	535 ML	Restrictions on taking water do not apply to water taken under this access licence if the water is taken while the Alstonville Sewage Treatment Plant is discharging water on a daily basis.[1]
22968	Industrial	Unregulated river		10 ML	

1. The Alstonville sewage treatment plant discharges to Maguires Creek (outside the Wilsons River catchment).

A stream flow gauge was installed at the head of the weir pool (203062 Wilsons River @ Lavertys Gap weir) in March 2016 and is used to monitor flow and water level upstream of the weir. BSC also monitors the depth of water within the storage (at the weir) with SCADA.

Inflow to the weir storage is generally high and the weir frequently overflows to Wilsons Creek. Daily data recorded at the upstream (203062) gauge are shown in Figure 6 and a summary of inflow to the weir is provided in Table 7. During spring/summer 2019/20, inflows to the weir were significantly reduced due to drought conditions (shaded in Table 7). The weir has a full supply volume (FSV) of 72.663 ML at a full supply level (FSL) of 116.16 mAHD. The water level in the weir reduced to approximately 1.4 m below the FSL in December 2019 with a volume of 36.6 ML (50% capacity). The storage response during summer 2019/20 is discussed further in Section 7.3.3.

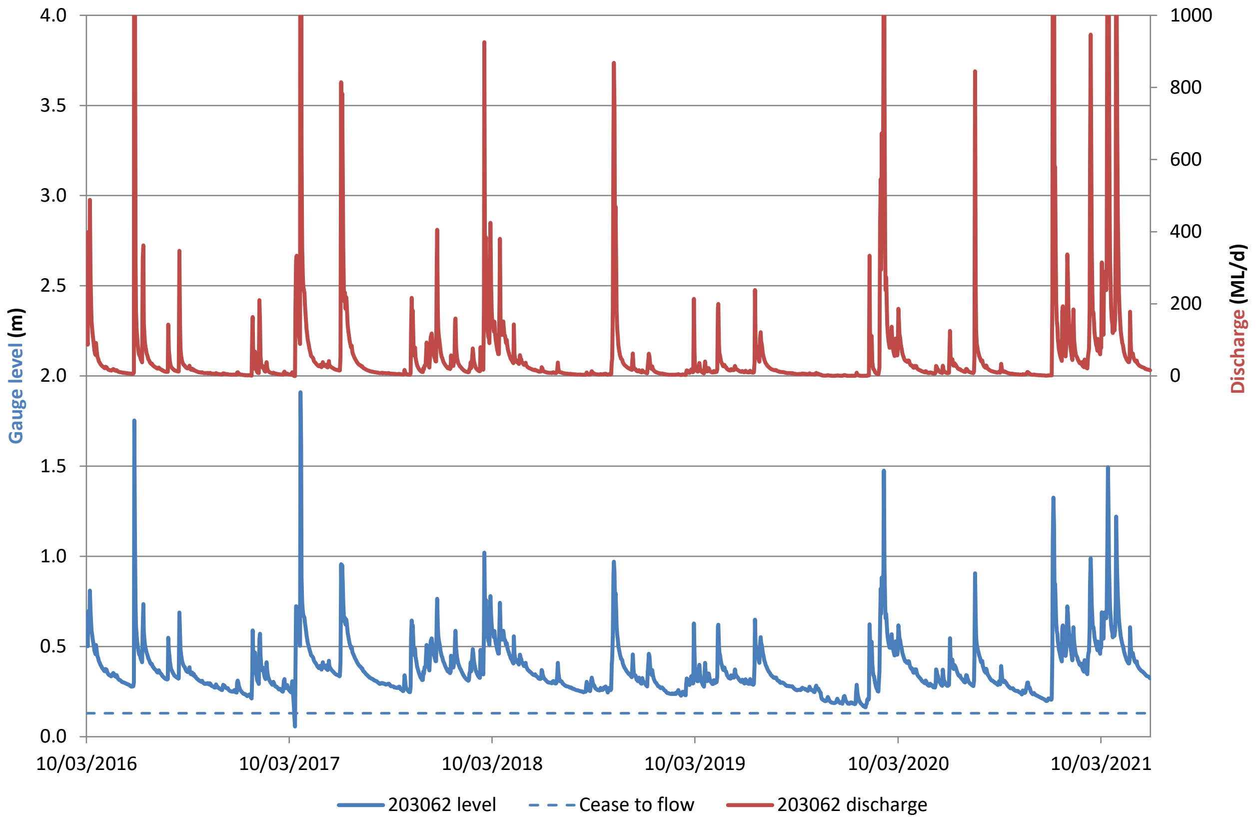


Figure 6: Stream gauge 203062 (Wilsons River @ Lavertys Gap Weir) discharge and level

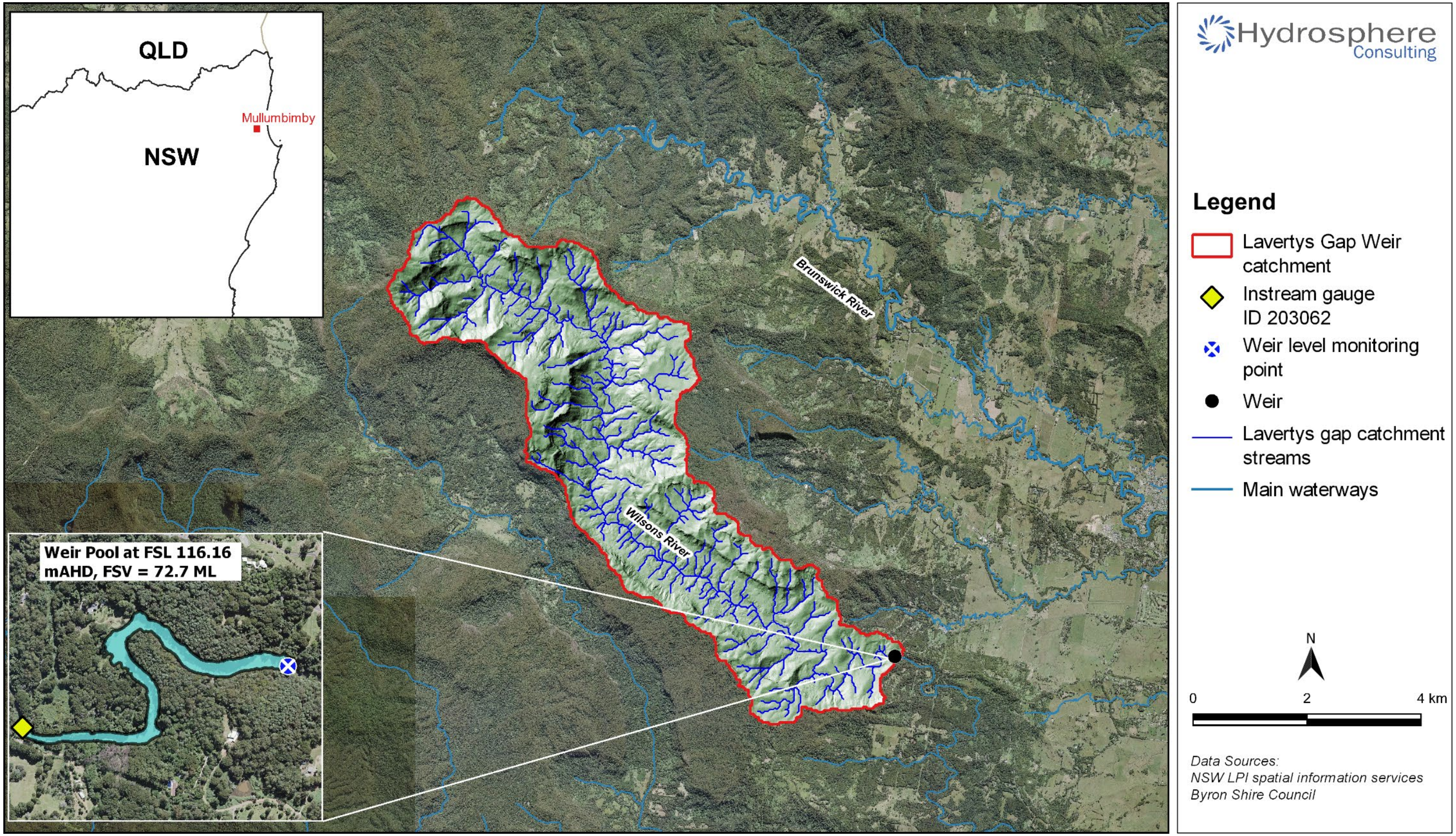


Figure 7: Lavertys Gap Weir storage and catchment

Table 7: Weir inflow data (March 2016 - May 2021)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum daily inflow (ML/d)												
2016			48.4	15.2	6.1	6.3	12.2	11.7	10.5	5.6	3.5	1.3
2017	1.1	3.5	0.0	29.7	18.9	15.3	14.8	7.6	3.8	3.3	11.2	19.4
2018	10.6	13.4	62.0	34.2	14.0	8.5	5.4	3.3	3.8	3.2	12.8	7.8
2019	3.3	2.7	7.6	9.8	12.4	9.3	16.2	7.7	4.9	1.0	0.6	0.5
2020	0.4	4.6	34.0	10.6	7.1	8.4	8.3	11.3	6.4	3.2	1.2	1.1
2021	37.1	21.2	61.3	39.2	19.0							
Minimum recorded	0.4	2.7	0.0	9.8	7.1	8.4	5.4	3.3	3.8	1.0	0.6	0.5
Mean daily inflow (ML/d)												
2016			149.4	23.5	9.8	232.4	23.6	46.7	19.1	7.8	4.9	3.7
2017	42.4	6.8	269.8	129.2	27.7	183.5	33.2	9.9	6.2	43.8	58.2	62.1
2018	34.5	110.1	151.4	63.0	25.1	11.8	9.6	4.4	5.9	154.8	23.9	19.0
2019	5.3	5.8	25.8	36.2	19.4	28.9	43.3	10.9	5.9	4.5	1.0	1.5
2020	29.3	312.9	68.9	19.5	12.3	28.4	60.0	27.6	11.4	5.4	2.9	248.3
2021	99.6	161.4	357.8	228.0	42.5							
Average recorded	42.2	119.4	174.7	95.2	25.4	63.2	36.5	13.2	7.3	52.1	21.5	82.7
Max daily inflow (ML/d)												
2016			501	42	17	3,035	43	356	32	11	8	11
2017	216	12	3,523	648	42	836	70	14	8	223	326	416
2018	164	950	436	147	48	25	38	10	14	892	64	64
2019	9	16	219	205	32	245	124	17	8	9	2	9
2020	343	2,240	191	31	29	128	867	66	35	11	7	1,847
2021	346	972	2,289	1,564	183							
Maximum recorded	346	2,240	3,523	1,564	183	3,035	867	356	35	892	326	1,847

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total daily inflow (ML)												
2016			3,286	704	302	6973	731	1,446	573	243	148	114
2017	1,314	191	8,364	3,876	859	5,506	1,028	308	185	1,357	1,745	1,924
2018	1,068	3,083	4,694	1,891	777	354	299	136	176	4,798	717	590
2019	163	161	799	1,085	601	866	1,344	338	178	138	30	48
2020	909	9,075	2,135	584	381	852	1,860	857	341	169	86	7,696
2021	3,087	4,520	11,091	6,841	1,318							
Total inflow (ML)												
2017	26,658											
2018	18,583											
2019	5,750											
2020	24,945											

During spring/summer 2019/20, inflows to the weir were significantly reduced due to drought conditions (shaded red)

Photos of the weir, catchment and storage at various water levels are provided in Plate 1.

The raw water supply arrangement is shown on Figure 8. Water flowing through the channel to the WTP can also leak from the channel and flow back into Wilsons Creek downstream of the weir. Council switches to pump feed (via pump and rising main installed in the channel /tunnel) generally when the water level falls below the FSL to minimise the loss of water and ensure continued supply.

1. Upstream catchment

2. Weir storage at FSV (18 September 2018)

3. Weir at FSV and spilling (18 September 2018)

4. Wilsons Creek downstream of weir (18 September 2018)

5. Weir level (19 December 2019) approximately 115 m AHD (1.2 m below FSV). Photo - N. Ulrick

6. Weir overtopping following heavy rainfall (7 February 2020)

Plate 1: Lavertys Gap Weir storage levels

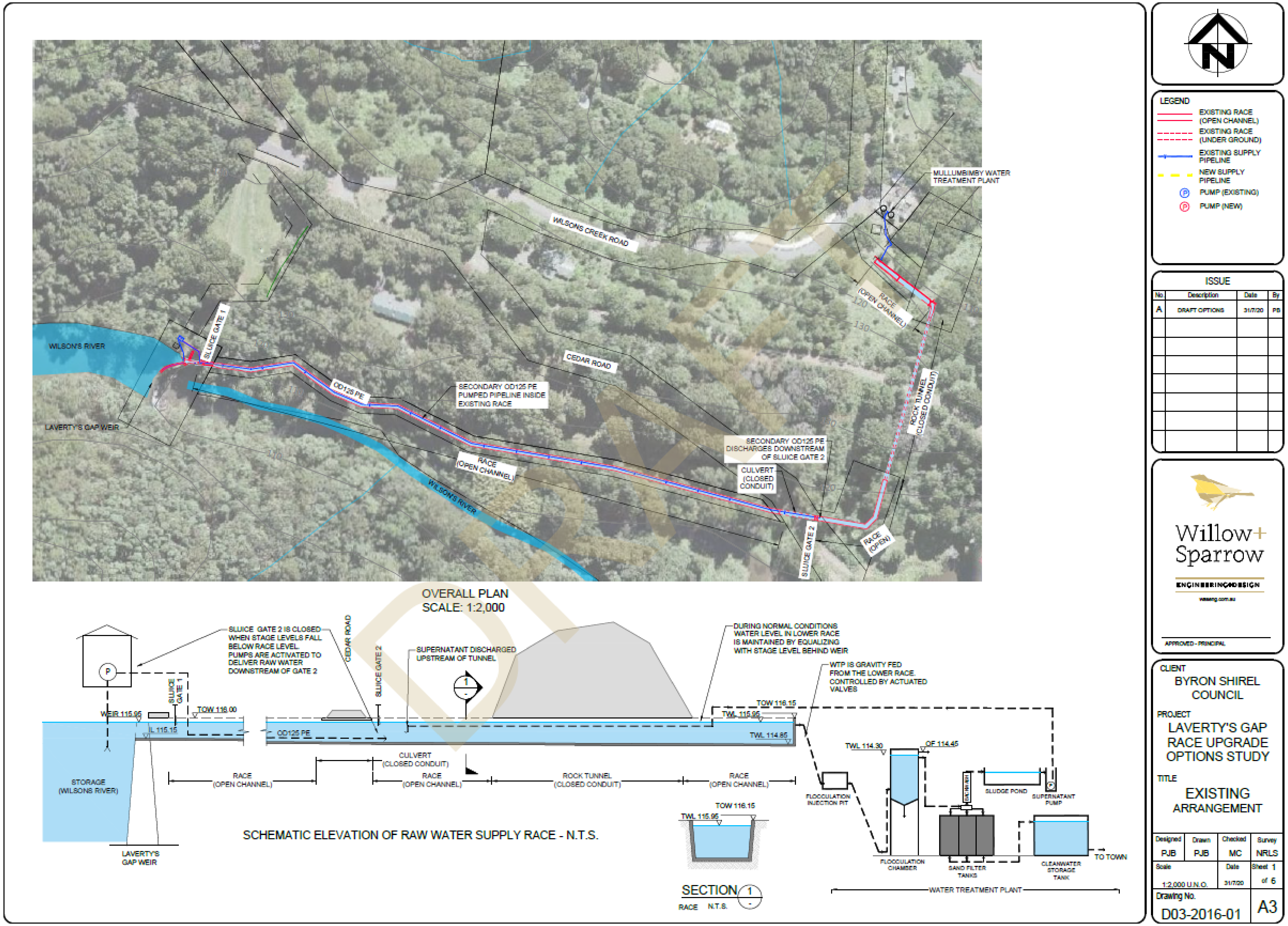


Figure 8: Existing raw water supply arrangement

Source: Willow + Sparrow (2020b)

2.2 Treatment

The Mullumbimby WTP is a conventional sand filtration plant with coagulation and flocculation (Figure 9). The original WTP was constructed in 1939 and augmented in 1962 and 1966. A backwash recovery system was completed in 2002 to stop the previous practise of disposing of the filter backwash water to Yankee Creek, a tributary of the Brunswick River. This backwash recovery system now collects all filter backwash water in a holding tank to allow the settlement of solids. The supernatant is returned to the inlet of the WTP via the raw water channel and the settled solids are removed weekly and sent to one of Council's sewage treatment plants (HydroScience Consulting, 2008).

The capacity of the plant is 3.9 ML/d. Raw water gravitates to the WTP (45 L/s) where the flow is split between two filtration units. Filtered water from either unit flows to the clear water tanks. Sodium fluoride and chlorine are dosed into the common filter outlet pipework upstream of the clear water tanks. Filtered water gravitates from the clear water tanks to the town storage reservoirs at Left Bank Road and Azalea Street then reticulated to consumers. Approximately 13 customers along Wilsons Creek Road are connected to the trunk main from the WTP (Figure 10).

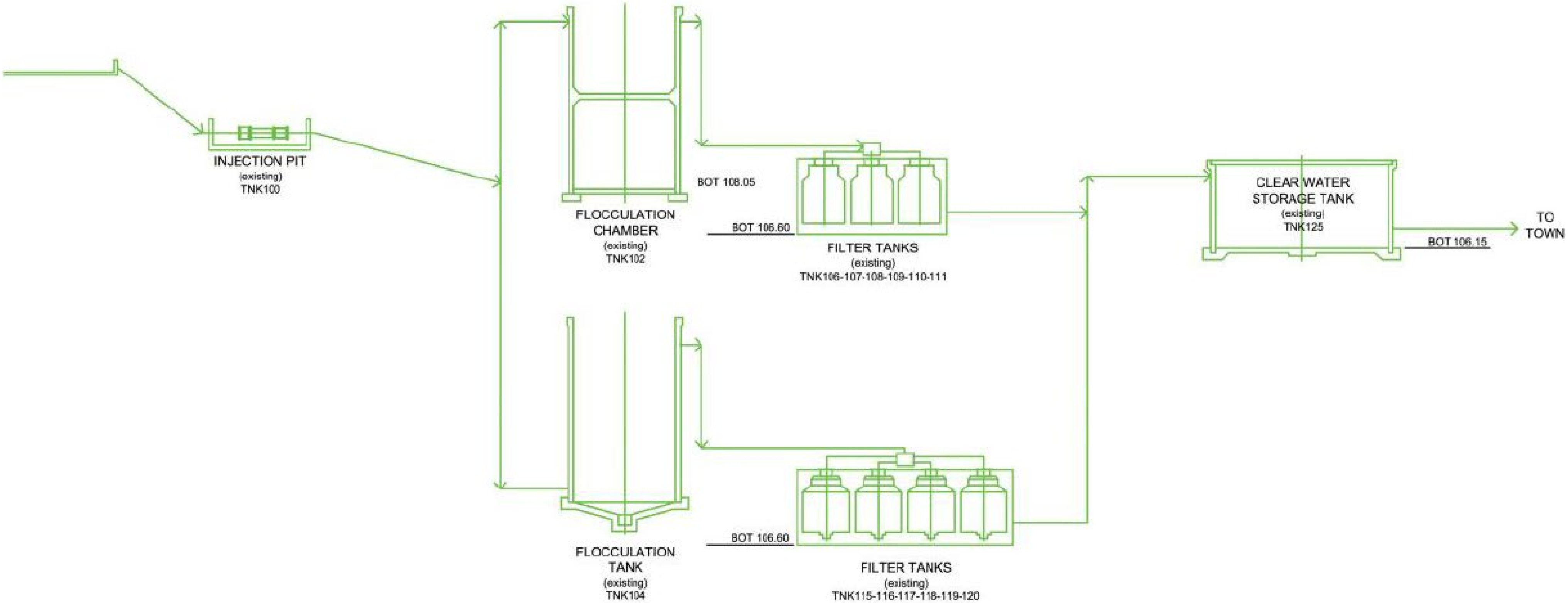


Figure 9: Mullumbimby WTP process diagram

Source: HydroScience (2012)

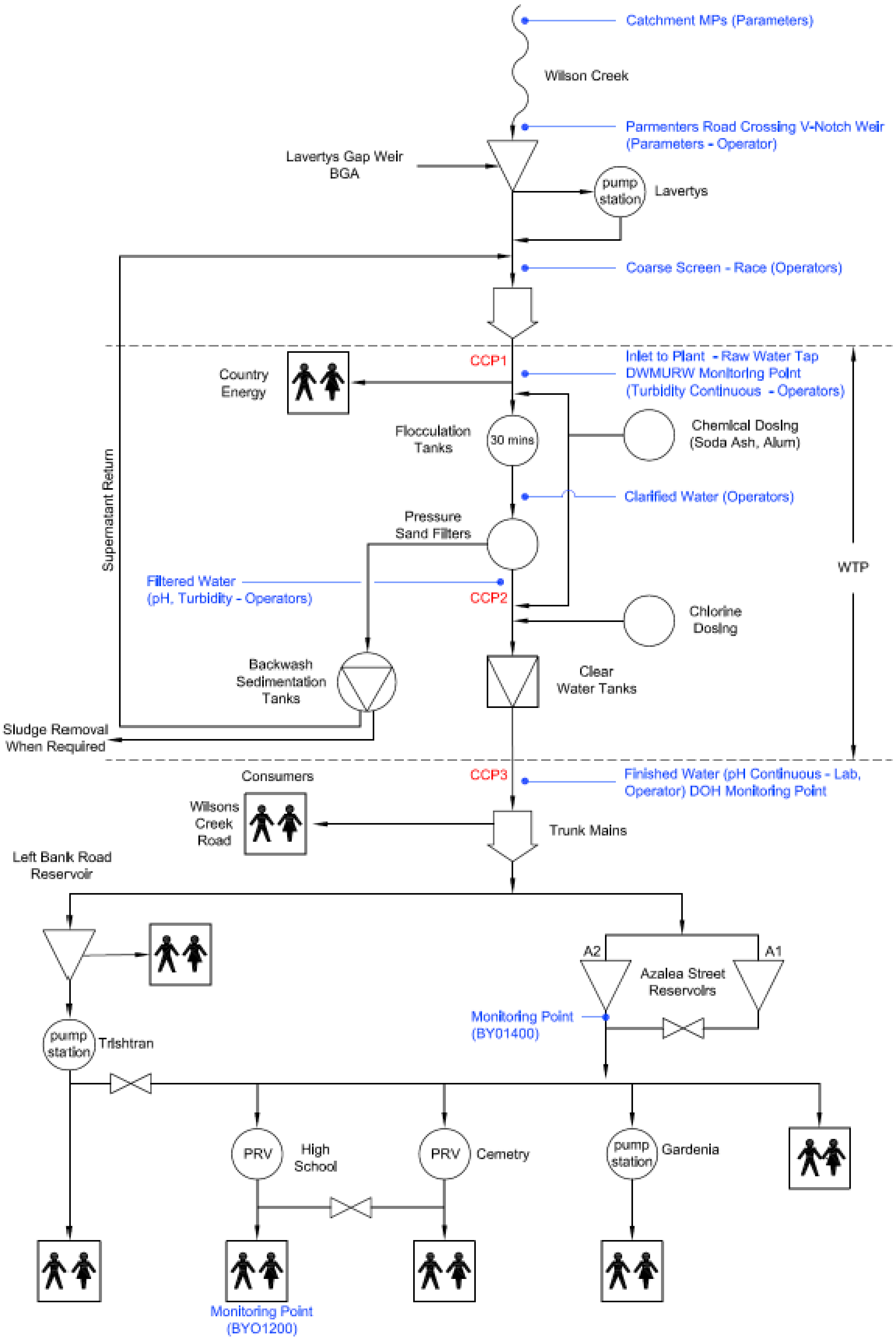


Figure 10: Mullumbimby water supply schematic

Source: HydroScience (2012)

3. DROUGHT MANAGEMENT

In accordance with the *Mullumbimby Drought Management Plan* (HydroScience, 2014), Mullumbimby residents have restrictions (7 levels) introduced based on the water level and inflows in Lavertys Gap Weir (refer Table 15, Section 7.3.2). Supply-side actions include investigation of emergency supplies including the Rous County Council (RCC) regional supply and potential alternative sources such as groundwater, effluent reuse, desalination, other surface water options.

Restrictions were imposed in Mullumbimby during the droughts of 2002/03, 2006/07 and 2019/20 (level 1 from 7/11/19 - 10/11/19 (4 days), level 3 from 11/11/19 - 23/12/19 (42 days), level 4 from 24/12/19 to 22/1/20 (30 days), level 2 from 22/1/20 to 13/2/20 (22 days)).

RCC is the regional bulk supplier for the Lismore, Ballina, Richmond Valley and Byron Local Government Areas (excluding Mullumbimby). An emergency supply pipeline (3.2 km, DN250 PVC) from the RCC bulk supply at St Helena reservoir (at the intersection of Tandys Lane and Gulgan Road to the intersection of James Street and Mullumbimby Road, Mullumbimby) was constructed in 2002/03. The emergency pipeline can only supply water to lower elevation areas (East Mullumbimby). The Service Level Agreement between BSC and RCC allows for a maximum rate of 0.5 ML/d through this main. The cost of water supplied (Special Approved Connection) is currently $4.78 per kL (Rous County Council, 2020).

During summer 2019/20, the emergency supply was used to supplement town water supply from the Mullumbimby WTP for the first time (average 0.43 ML/d for 30 days). RCC is currently augmenting the St Helena supply main to the northern areas of Byron Shire (600/375 mm) and RCC expects this to increase the available supply capacity to Mullumbimby to 3.2 ML/d subject to detailed modelling and amendment to the Service Level Agreement.

RCC imposes restrictions for all customers in Byron Shire supplied with bulk water by RCC in accordance with the *Rous Regional Drought Management Strategy* (Hydrosphere Consulting, 2016) which documents a regional restriction regime that applies to all customers served by the RCC regional water supply. The local water supplies managed by councils in the region (including Mullumbimby) may adopt triggers for the introduction of water restrictions developed for their specific water sources/storages.

4. DEMAND MANAGEMENT

Demand management initiatives have been successful in the region at reducing water demand. The 2018 *Regional Demand Management Plan* (RDMP) (Hydrosphere, 2018) provides details on demand management strategies to be adopted over the next four years (2019 - 2022) within the Ballina, Byron, Lismore and Richmond Valley Council areas. The initiatives in the RDMP target all potable water supply customers in the region. Table 8 outlines demand management actions to be implemented across the region and the tasks that BSC is responsible for where relevant to Mullumbimby.

Table 8: Demand management actions and tasks

Action	Tasks to be undertaken by Byron Shire Council relevant to Mullumbimby	Current status
Monitoring, Evaluation and Reporting: Timely, accurate and consistent reporting to assist with ongoing RDMP development and evaluation. Consumption information reported to customers.	Reporting of RDMP action status and key performance indicator (KPI) to Regional Water Supply Agreement Liaison Committee. Implement agreed definitions of connection types and modify/develop customer management systems as required. Annual reporting of water supply, customer data and consumption Confirm population served through detailed analysis. Data collection in Customer Relationship Management system (or equivalent).	BSC is progressing these tasks in accordance with the RDMP.
Water Loss Management: Quantify quarterly losses. Detect and repair leaks. Reduce losses to sustainable levels.	Develop and implement Water Loss Management Plans. Develop local non-revenue water targets for each service area to support regional targets. Monitor and report water losses quarterly.	A Water Loss Management Plan was prepared in 2019 (Detection Services, 2019) including flow metering, pressure management recommendations, active leak detection and repair. Pressure management areas were original implemented in 2007 and have recently been improved in the Cemetery PRV area (low lying areas) and parts of northern Mullumbimby. Total daily flow was reduced by 10% with background leakage reduced by an estimated 60 kL/d (i20water, 2019).
Sustainable Water Partner Program: This program offers assistance to non-residential high-water users to reduce consumption.	Byron Shire Council in Mullumbimby is a high non-residential user and therefore may take part in the program.	The program has not been actively implemented in Mullumbimby.

Action	Tasks to be undertaken by Byron Shire Council relevant to Mullumbimby	Current status
Smart Metering: Investigate the implementation of new technology for identifying leaks and monitoring consumption.	Provide input to RCC to assist with the development of a smart metering program. Roll-out program. Provide input to RCC to assist with the development of a communication and engagement strategy.	Smart water meters are being trialled in the Byron Shire from November 2020 as part of a 12-month pilot project. Approximately 400 smart water metering devices have been installed on residential and commercial properties in East Mullumbimby and selected bulk recycled water clients in Byron Bay. BSC is considering the smart water meter technology for a potential Shire-wide rollout in the future and the pilot project will help assess its viability.
Recycled Water: Develop opportunities to replace potable water with treated sewage effluent and encourage the use of recycled water.	Develop a strategy for expansion of existing systems.	Mullumbimby reuse opportunities are being investigated by Council and are incorporated in this strategy (refer Section 12.7.1).
Rainwater Tank Rebates: Encourage customers to supplement potable water supply with rainwater by offering a rebate for rainwater tanks.	Implement rebate program within supply area.	Rebates are available in Mullumbimby.
Community Engagement and Education: Promote water efficiency.	Develop local residential consumption targets to support achievement of regional targets.	Water education information is available on Council's website.

5. BACKGROUND TO THIS STRATEGY

The scope and relevant key findings of past studies are summarised in Table 9, providing background information on the Mullumbimby water supply.

Table 9: Background information

Title	Author	Date	Scope	Outcomes/findings
Richmond-Brunswick Regional Water Supply Study Discussion Paper	Public Works Department	December 1984	Prior to the connection of the Ballina Shire to the regional water supply, this investigation was undertaken to determine whether an integrated Richmond - Brunswick regional water supply scheme offers advantages over independent development by RCC and Ballina Shire Council.	The options considered for RCC proceeding alone included a scheme involving raising of Rocky Creek Dam by 4 m and construction of a 37,200 ML dam on Wilsons Creek near Goonengerry Road (downstream of Lavertys Gap Weir and including the weir inundation area). The options for a combined regional scheme (which were preferred on a cost basis) did not include a new dam on Wilsons Creek. This report assumed that the regional scheme would eventually be extended to supply bulk water to augment (but not replace) the supply to Mullumbimby from Lavertys Gap weir. At the time it was recognised that the maintenance of the weir supply relies heavily on streamflow persistence and the demands were approaching the available yield (assessed as 400 ML/a). It was assumed that the Lavertys Gap system would eventually be supplemented by a regional bulk supply point at Brunswick Heads. The report also considered surface water sources and dam sites in the Brunswick River Basin. The streams in the Brunswick River basin have small catchments and are tidal over much of their length and were not considered as potential storage sites. The Brunswick River above the tidal limit at Mullumbimby is wide with extensive Quaternary alluvial deposits and potential dam sites were only identified upstream of Main Arm but not considered in detail in the report due to the large distance to population centres.

Title	Author	Date	Scope	Outcomes/findings
Mullumbimby Long-Term Water Supply Strategy	JWP	March 2005	Presents demand forecasts and examines possible water supply options for Mullumbimby.	In 2001, the NSW Department of Land and Water Conservation (now DPIE - Water) foreshadowed that if Mullumbimby water supply was to remain independent of the regional supply, the introduction of environmental flows will be required at the time of augmentation, or in 10 years i.e. by 2011. JWP (2005) reported that Lavertys Gap Weir may be a low priority weir for requiring environmental flows due to the age of the weir, where the environment may have adjusted to the post-weir flow conditions and the large quantities of water that overflow the weir most of the time. There has been no other discussion of environmental flow requirements with regulatory agencies since then. JWP (2005) determined that the total storage required to maintain a typical environmental flow condition and supply an average demand of 450 ML/a (reduced to 80% when the storage is below 55%) and with 10% inactive storage is 432 ML. The "typical" environmental flow condition assessed was: • When inflow is < Q_{95} all inflow is passed (Q_{95} is a flow condition which occurs 5% of the time (i.e. 95% of the time the river flows exceed this condition). • When inflow is between Q_{95} and Q_{80}, 80% of the flow is passed. • When inflow is > Q_{80} at least the Q80 is passed. A more stringent condition of not abstracting any water when inflow is below Q_{80} was also considered. The strategy recommended maintaining Mullumbimby's current water supply (Lavertys Gap weir) and supplementing the supply with the regional supply requiring a permanent connection to the regional supply network.
Mullumbimby Water Treatment Plant Refurbishment	HydroScience	March 2008	Investigation of WTP and refurbishment and/or upgrade requirements.	While the plant generally meets water quality criteria, there are operational and safety issues that require upgrade. While the plant can be refurbished to overcome the current deficiencies, the age of the plant and the outdated technology mean that the plant is not likely to have a 30-year life. Money spent on refurbishment is a short-term investment, as a new plant will be required in the medium term. Membranes are a modern technology that provide added benefits, and the preferred treatment technology despite the higher cost. The preferred location of the new plant was considered to be the existing site. Other locations were investigated, including near the weir, but the existing location was considered the most advantageous. A 5.0 ML/d membrane filtration plant was estimated to cost $2.3 million (2008$).

Title	Author	Date	Scope	Outcomes/findings
Byron Shire Council Integrated Water Cycle Management (IWCM) Plan	MWH	June 2009	Provides actions to provide a secure water supply to Mullumbimby to meet future water demand. This plan was reviewed in 2017.	The Integrated Water Cycle Management (IWCM) Plan recommended: • The installation of a dual reticulation system for new residential developments in Mullumbimby. • Harvesting stormwater flows to satisfy any environmental flow requirements that may be introduced for Lavertys Gap weir. • Implement further demand management initiatives. • Implement the Mullumbimby Long-Term Water Supply Strategy (JWP, 2005).
Mullumbimby Water Treatment Plant Concept Design Report	HydroScience	December 2009	Confirmation of the required design criteria and development of a concept design for the Mullumbimby WTP.	Structural analysis identified that with proper treatment the existing structures will remain serviceable into the future. The existing plant performs well and in terms of process and structural condition it can remain serviceable for some time. Consequently, the conclusion of the concept design report is that the construction of a new plant may be deferred by approximately ten years (to 2019). Continuing to operate the existing plant poses higher risk than construction of a new plant. In order to reduce the risk, the report recommended that some immediate works be implemented in order to prolong the plant's life to 2020.
Northern Rivers Region Organisation of Councils (NOROC) Bulk Water Supply Study	Hydrosphere Consulting	October 2013	An investigation into interconnected water supply options for the local government areas within the Northern Rivers region.	The interconnection of major water supplies in the region could improve water supply security on a local and regional scale. This study considered large-scale decentralised desalination and increased surface water storage as potential water source options. The scenarios assessed in the study considered abandoning Lavertys Gap Weir with connection of Mullumbimby to the regional supply.

Title	Author	Date	Scope	Outcomes/findings
Mullumbimby Drought Management Plan	HydroScience Consulting	July 2014	Drought restriction policy for Lavertys Gap Weir water supply.	The report presents a drought restriction policy for Mullumbimby and recommends considering the following alternate supply options during emergency situations: • Connecting the emergency pipeline and developing an operational agreement. • Extracting water from the Brunswick River. • New groundwater sources. • Effluent reuse. • A temporary mobile desalination plant. • Water carting.
Byron Shire Council Water Supply and Sewerage Strategic Plan (2017 Review)	Hydrosphere Consulting	September 2017	Analysis of Mullumbimby's water supply and water supply demand forecasts.	The report predicted annual growth in water demand to be higher than previously estimated in the 2009 IWCM Plan. The review identifies a need for augmenting the Mullumbimby water supply following a detailed analysis to confirm demand forecast, a secure yield assessment and a revised drought management plan.
Mullumbimby Mini-Hydro Prefeasibility Assessment	Entura	July 2018	A prefeasibility study which considers the reinstatement of a hydro-electric power plant at the Lavertys Gap weir.	The study concludes that there is potential to reinstate the mini-hydro scheme subject to obtaining a suitable water licence to allow water to be transferred from the Wilson's Creek catchment to the Yankee Creek catchment. The operation of the plant would increase the amount of water being extracted from the weir.
Lavertys Gap Weir secure yield assessment	Hydrosphere Consulting	May 2019	Secure yield estimates of Lavertys Gap Weir based on hydrographic survey considering historic climate and climate change scenarios with and without upstream irrigation.	The report recommends Council investigate options for augmenting Mullumbimby's water supply as secure yield may not be sufficient to meet current demand and future demand with reduced stream flows due to climate change.

Title	Author	Date	Scope	Outcomes/findings
Mullumbimby WTP Assessment and Options Investigation	CWT	October 2020	Process audit and assessment of options to upgrade the WTP.	The Mullumbimby WTP is maintained and operated well, however due to its age it requires replacement in the next 5-10 years (2025-2030). The preferred approach for this is to construct a new WTP. Further investigations should be carried out to determine the requirements, treatment process and site of the new WTP. Whilst a new WTP is being designed and constructed, Mullumbimby WTP should be maintained and operated to consistently deliver microbially safe water. The report includes recommendations for improvements to general operation, flocculation, filtration, supernatant return, chemical dosing, chlorine dosing, clear water storage and chlorine contact time, treated water distribution and information management.
Hydraulic Options Study - Mullumbimby Raw Water Supply Race, Lavertys Gap NSW	Willow + Sparrow	October 2020	Hydraulic study to investigate options for the upgrade of the water supply channel.	The study recommends the channel is retained and a secondary pumped main is installed along a new alignment and operated in conjunction with the channel.
Mullumbimby raw water supply race structural & heritage assessment	Bill Jordan and Associates	October 2020	Preliminary heritage study of the raw water supply channel.	The study concludes that the channel should be conserved by keeping it in use to the maximum extent possible. The work required should be achievable by staging it in accordance with a schedule of priorities prepared in accordance with the extent of damage. The recommended sequence of work is to remove damaging vegetation, identify leaks and their size and prepare a priority schedule of rock filling and grouting and contract in stages as required.
Mullumbimby Water Supply Race, Mullumbimby NSW: Statement of Heritage Impact	Hill, T. and M. Finlayson	May 2021	Statement of heritage impact for raw water supply upgrade options.	The options (Willow + Sparrow, 2020b) for an alternate pipeline which either substantially or completely removes the water supply from the water channel have the least physical impact on the channel. An additional option should be considered which involves sole use of the alternate pipeline for the supply of water to the treatment plant. The removal of the water supply infrastructure would have a positive benefit on the heritage values of the site and would provide an opportunity for a holistic planning process for the weir, water channel, treatment plant and generator sheds.

6. ASSET CONDITION AND PERFORMANCE

Information on the condition of the raw water supply and treatment assets is provided in the following sections.

6.1 Lavertys Gap Weir

A geotechnical assessment undertaken as part of the 2005 strategy (SMEC, 2003) identified some weak founding conditions at the right abutment and some potential leakage from the weir. A visual inspection of the weir was also undertaken in May 2007 (HydroScience Consulting, 2008). No visual structural defects were identified, although the channel wall was damaged in a several places, resulting in water spills.

6.2 Raw Water Channel

The raw water supply channel is a gravity feed system that is an open channel and tunnel constructed in the 1920s to supply town water to Mullumbimby and supply water to the Mullumbimby hydro-electric scheme. The hydro-power station was decommissioned in 1990 and the weir and channel have been retained and currently operate only for town water supply.

Various studies have discussed the condition of the channel (JWP, 2005; HydroScience Consulting, 2008; Entura, 2018). Most recently, the condition of the channel was inspected on 5 February 2020 (Willow + Sparrow, 2020a). Findings of the condition assessment were:

- The existing structural condition is very poor and considered inadequate for current demand. There is extensive cracking in containment walls. Scouring around walls and subsidence was observed in numerous locations where there is no buttress or cantilever support against bending moments.
- Water loss is very high and leaking is prevalent. It is unlikely the volume of loss would significantly impact on yield when the weir is overtopping, because the water leaking from the channel which would ordinarily flow across the weir and generally drain back into the creek. However, during periods of low flows in the creek and when the water level in the weir is below the weir crest, the leaking would reduce yield and the water loss would be proportionally high. The channel invert level is 860 mm below the weir crest so that water enters the channel from the weir pool when the water level in the weir pool is above this invert level.
- Slips and geotechnical failures were observed. There are numerous slips where earth supporting the channel wall has slipped/subsided and compromised the structural integrity of the channel wall. Extensive sinkhole formations were observed behind the channel wall which is most likely caused by leaking water scouring behind the wall, creating cavities behind the wall.

Photographs from the condition assessment are included in Plate 2.

1. Subsidence and scour has exposed edges of buttress support.

2. Scouring has removed buttressing.

3. Major cracking.

4. Structure has crumbled.

5. Localised slip/subsidence resulting in movement of channel wall.

6. Sinkhole formation behind channel wall.

Plate 2: Condition of raw water channel - February 2020

Source: Willow + Sparrow (2020a)

The asset in its current condition has exceeded its useful life. The likelihood of failure is considered very high, and on the basis that structural failure of the channel would cause extended interruption to water supply, Willow + Sparrow (2020a) recommended that upgrading the channel be a high priority.

6.3 Water Treatment Plant

The Mullumbimby WTP is a sand filtration plant constructed in 1940 with major augmentation in 1962. It is situated on a steep site in the hills south-west of Mullumbimby.

HydroScience Consulting (2008) identified occupational health and safety hazards at the WTP as well as required upgrades to the existing WTP structure, mechanical and electrical systems. In 2008, the plant generally met the requirements of the ADWG but major upgrades to the plant were expected to be required due to its age. Subsequent investigations by HydroScience (2009) concluded that the structures have the potential to remain serviceable with rehabilitation and ongoing maintenance until a new plant is constructed (by approximately 2020). Regular (5-10 years) inspections and reviews to confirm ongoing serviceability and the need for any additional work would be required.

CWT (2020) provided a review of WTP condition and performance. The review found that:

- Treated water quality generally meets the ADWG limits however, there are several parameters with recorded deviations (turbidity, pH and total aluminium).

- Reticulated water is typically within ADWG values, however free and total chlorine are generally lower during warmer months with very low chlorine residual in summer 2019/20 coinciding with water restrictions and drought conditions.
- The existing treatment processes at Mullumbimby WTP are insufficient to achieve the required log credits for all pathogen groups (bacteria, viruses and protozoa).
- Upgrades to the filtration system and optimisation of the whole of WTP operation will be required to achieve the maximum log credits available for treatment processes. Additional process(es) such as ultraviolet disinfection (UV) or clarification will be required to address shortfalls for all pathogen groups and provide a treatment buffer.

6.4 Heritage Considerations

The hydro-electric power complex, including the weir and channel is listed on the NSW State Heritage Register (listing number 01926). The *Heritage Act 1977* refers to regulations for setting out the requirements for maintenance and the *Heritage Regulation 2012* details “Minimum standards of maintenance and repair”. Bill Jordan and Associates (2020) documented the work required to conserve the heritage status of the channel (removal of damaging vegetation, identification of leaks and their size and preparation of a priority schedule of rock filling and grouting). Some repairs are exempt from approval under the *Heritage Act 1977.*

An investigation of heritage significance (Ellsmore, D., 2007 *in* HydroScience Consulting, 2008) found that the WTP has heritage significance at a local level. The original plant that was built in 1940, consisting of one flocculation tank, one filter tank, plant room and clear water storage tank is the part of highest significance at the site. The heritage advice suggests that the original components constructed in the 1940s must be conserved to retain heritage value. Based on this advice, any new plant constructed on the existing site or refurbishment of the existing plant will need to retain the original plant components.

A Statement of Heritage Impact (‘SoHI’) was prepared for the proposed options for upgrade of the raw water supply to the Mullumbimby WTP which form part of the Mullumbimby Hydro-Electric Power Station heritage site and are listed on the NSW State Heritage Register (Hill *et al.*, 2021). This is discussed further in Section 12.7.2.

7. SECURE YIELD

7.1 Secure Yield Methodology

The current NSW Security of Supply Methodology in NSW has been in use for over 25 years and modelling approaches have been developed to determine the secure yield based on this methodology. The security of supply basis has been designed to cost-effectively provide sufficient storage capacity to allow a water utility to effectively manage its water supply in future droughts of greater severity than experienced over the past 100 or more years. 'Secure yield' is now defined as the highest annual water demand that can be supplied from a water supply headworks system while meeting the '5/10/10 design rule'. This rule dictates that water restrictions must not be too severe, not too frequent, nor of excessive duration, hence under the NSW Security of Supply requirement, water supply headworks systems are normally sized so that:

a) Duration of restrictions does not exceed 5% of the time; and

b) Frequency of restrictions does not exceed 10% of years (i.e. 1 year in 10 on average); and

c) Severity of restrictions does not exceed 10%. Systems must be able to meet 90% of the unrestricted dry year water demand (i.e. 10% average reduction in consumption due to water restrictions) through simulation of the worst recorded drought, commencing at the time restrictions are introduced.

This enables water utilities to operate their systems without restrictions until the volume of stored water approaches the restriction volume. If at this trigger volume, the utility imposes drought water restrictions which reduce demand by an average of 10%, the system would be able to cope with a repeat of the worst recorded drought, commencing at that time, without emptying the storage. Water security is achieved if the secure yield of a water supply is at least equal to the unrestricted dry year annual demand (NSW Office of Water, 2013).

Estimating the yield of a headworks system involves two stages:

- Stream flow estimation: Developing an appropriate sequence of stream flows for the water sources.
- System behaviour modelling: Modelling the behaviour of the headworks system subject to operating constraints using the stream flows to assess what demand subject to reliability or security criteria can be satisfied.

Consideration also needs to be given to possible impacts of climate change. Draft *Guidelines on Assuring Future Urban Water Security* (NSW Office of Water, 2013) provide guidance to NSW local water utilities on assessing and adapting to the impact of variable climatic patterns on the secure yield of urban water supplies. The methodology in these guidelines enables local water utilities to estimate their future secure yield taking into account the expected impact of future climatic patterns.

Determining the impact of climate change on the secure yield of a water supply system involves two modelling steps:

- Modification of daily rainfall and evapotranspiration data and calibrated rainfall-runoff models to produce climate changed daily stream flows.

- The daily climate changed streamflow, rainfall and evapotranspiration are input into the water supply system simulation models to determine climate changed secure yields.

The methodology has been developed from a pilot study (Samra and Cloke, 2010) which involved undertaking hydrological and system modelling to determine the impact of climate change on secure yield. The pilot study incorporates the scientific logic of the CSIRO's Murray Darling Basin Sustainable Yields Project which used daily historical data from 1895 to 2006 and applied the relevant global climate models (GCMs) to provide projected climate changed data for each GCM for this period. The 15 GCMs are listed in Table 10.

Table 10: GCMs used in the secure yield assessment

GCM No.	GCM	Modelling Group	Country
1	CCCMA T47	Canadian Climate Centre	Canada
2	CCCMA T63	Canadian Climate Centre	Canada
3	CNRM	Meteo-France	France
4	CSIRO-MK3.0	CSIRO	Australia
5	GFDL 2.0	Geophysical Fluid Dynamics Lab	USA
6	GISS-AOM	NASA/Goddard Institute for Space Studies	USA
7	IAP	LASG/Institute of Atmospheric Physics	China
8	INMCM	Institute of Numerical Mathematics	Russia
9	IPSL	Institute Pierre Simon Laplace	France
10	MIROC-M	Centre for Climate Research	Japan
11	MIUB	Meteorological Institute of the University of Bonn,	Germany
		Meteorological Institute of KMA	Korea
12	MPI-ECHAMS	Max Planck Institute for Meteorology, DKRZ	Japan
13	MRI	Meteorological Research Institute	Japan
14	NCAR-CCSM	National Center for Atmospheric Research	USA
15	NCAR-PCMI	National Center for Atmospheric Research	USA

The rainfall-runoff model is used to estimate daily stream flows for each GCM and for the historical data provided with the GCM data. The current system simulation model is used to determine the secure yield for each of the 15 GCMs, as well as for the above historical data with the 5/10/10 design rule.

Whilst the 15 GCMs represent a range of plausible climate futures for a 1ºC warming scenario, there is some uncertainty which needs to be acknowledged when considering the full range of possible outcomes. The secure yield is determined for all 15 GCMs under the 5/10/10 design rule as well as the secure yield for the

GCM with the lowest yield for a more severe restriction regime (10/15/25). The guidelines (NSW Office of Water, 2013) require consideration of:

- GCM with the median secure yield under the 5/10/10 design rule.
- GCM with the lowest secure yield under the 5/10/10 design rule.
- GCM with the lowest secure yield under the 10/15/25 design rule.

7.2 Previous Secure Yield Studies

JWP (2005) reported the secure yield of the Mullumbimby water supply based on previous surveys of the storage, available streamflow data and various assumptions regarding environmental flow requirements. The report also assesses various options for increasing the secure yield of the water supply while considering environmental flow requirements.

A revised secure yield assessment (Hydrosphere Consulting, 2019; NSW Urban Water Services, 2018) provides secure yield estimates for the climate experienced over the last 120 years and with projected 1°C climate warming. The purpose-built system behaviour model developed by NSW Urban Water Services assesses the secure yield of the Mullumbimby water supply headworks system for the period January 1890 to October 2018 (129 years). Due to the limited amount of recorded streamflow data and the lack of upstream irrigation data, a range of secure yield estimates were obtained.

Inflow to the WTP from the weir has ranged from 332 ML/a to 461 ML/a between 2006 and 2018 with the highest demand in that period experienced in 2017/18. The secure yield assessment results suggest that the weir could supply the average demand (approximately 430 ML/a) during a repeat of the worst drought on record. However, with the predicted reduction in streamflow due to climate change and the predicted increase in demand due to population growth, the secure yield assessment suggests the weir supply would not meet future demand.

7.3 Updated Secure Yield Assessment

The secure yield estimates have been updated as part of the development of this strategy. A model has been developed using GoldSim 12.1 (Monte Carlo simulation software) to simulate the Mullumbimby water supply (streamflow, weir characteristics, WTP extraction/demand etc.) to assess current performance (such as secure yield and weir water level) and evaluate the effectiveness of augmentation options.

7.3.1 Model development

The model simulates the water balance within Lavertys Gap Weir (Figure 11).

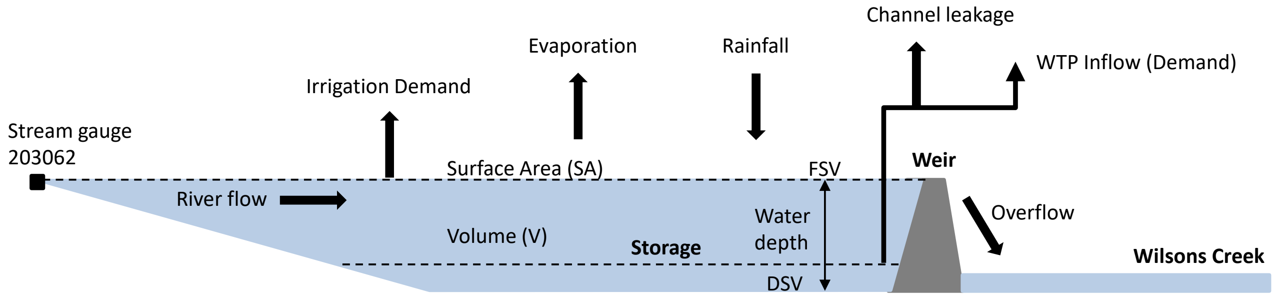


Figure 11: Weir water balance model

The water depth at the weir (and hence storage volume) is a function of:

- Weir inputs:
  - River flow (modelled or measured at stream gauge 203062).
  - Rainfall over weir surface.
- Weir outputs:
  - Evaporation.
  - Irrigation demand.
  - WTP inflow (demand).
  - Channel leakage.
  - Weir overflow.

The storage response can be modelled as two different simulation types (Table 11). A third simulation type (response of the storage to a future drought) can be built into the model but is not included in this assessment.

Table 11: Simulation settings

Simulation type	Aim	Demand	Simulation duration	Realisations (model runs)
Secure yield	Determine the highest annual demand than can be supplied from the water supply sources based on the system operating rules.	The total annual demand is held constant throughout the simulation period to assess whether the water supply security rules can be met for that demand.	Available duration of climate sequences (refer Section 7.3.2).	1
Validation	Confirm that the model replicates actual recorded behaviour of the storage.	Actual daily demand.	Available duration of recorded weir level data for validation.	1

7.3.2 Initial model inputs

Existing weir characteristics

Recent hydrographic survey of the weir (Hydrosphere Consulting, 2019) provided data on the water surface area, volume and height relationship for the existing weir (Table 12, Figure 12 and Figure 13).

Table 12: Weir storage details

Full Supply Volume (FSV)	72.663 ML
Surface Area (SA) at FSV	27,085 m^2
Weir height at FSV (crest)	116.16 m AHD
Seepage	Assumed none
Environmental release	None required
Licence entitlement	545 ML/a
Channel invert	115.3 m AHD
Dead storage volume (DSV)	10.455 ML

Source: Hydrosphere Consulting (2019)

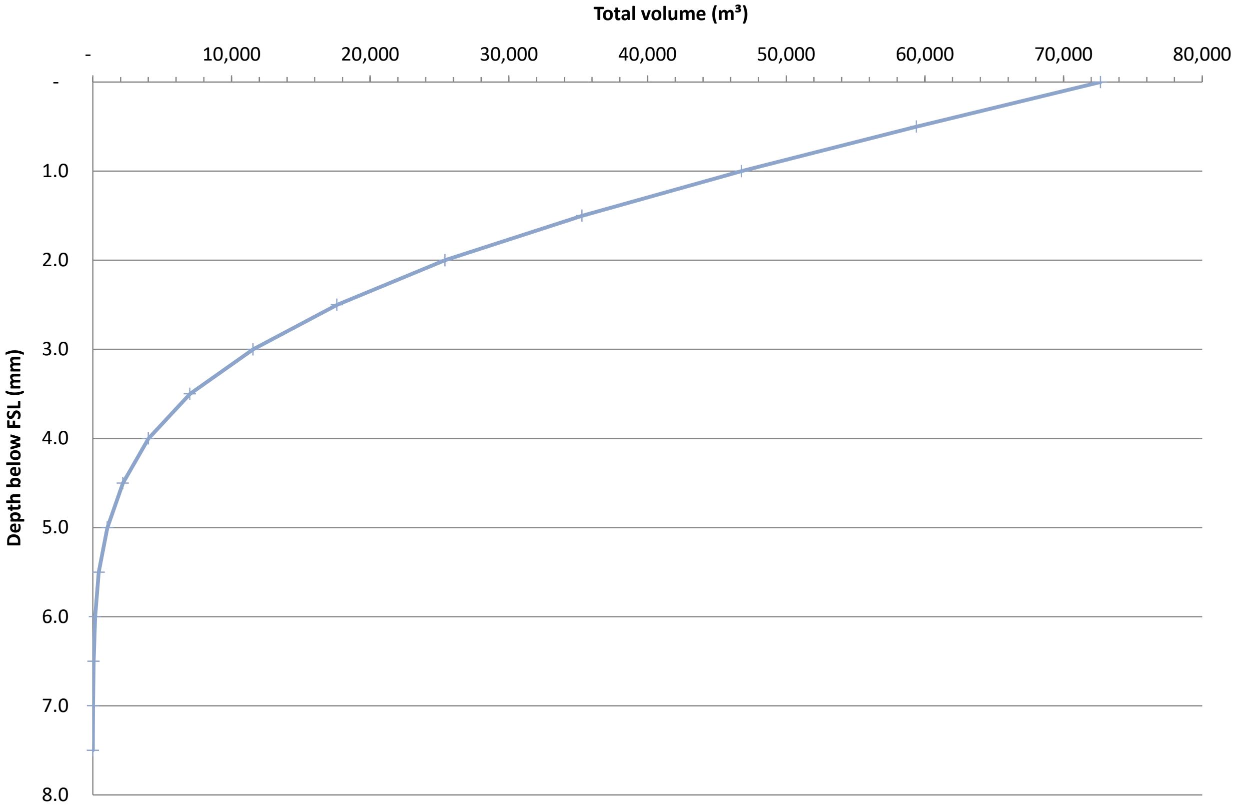


Figure 12: Volume of weir storage

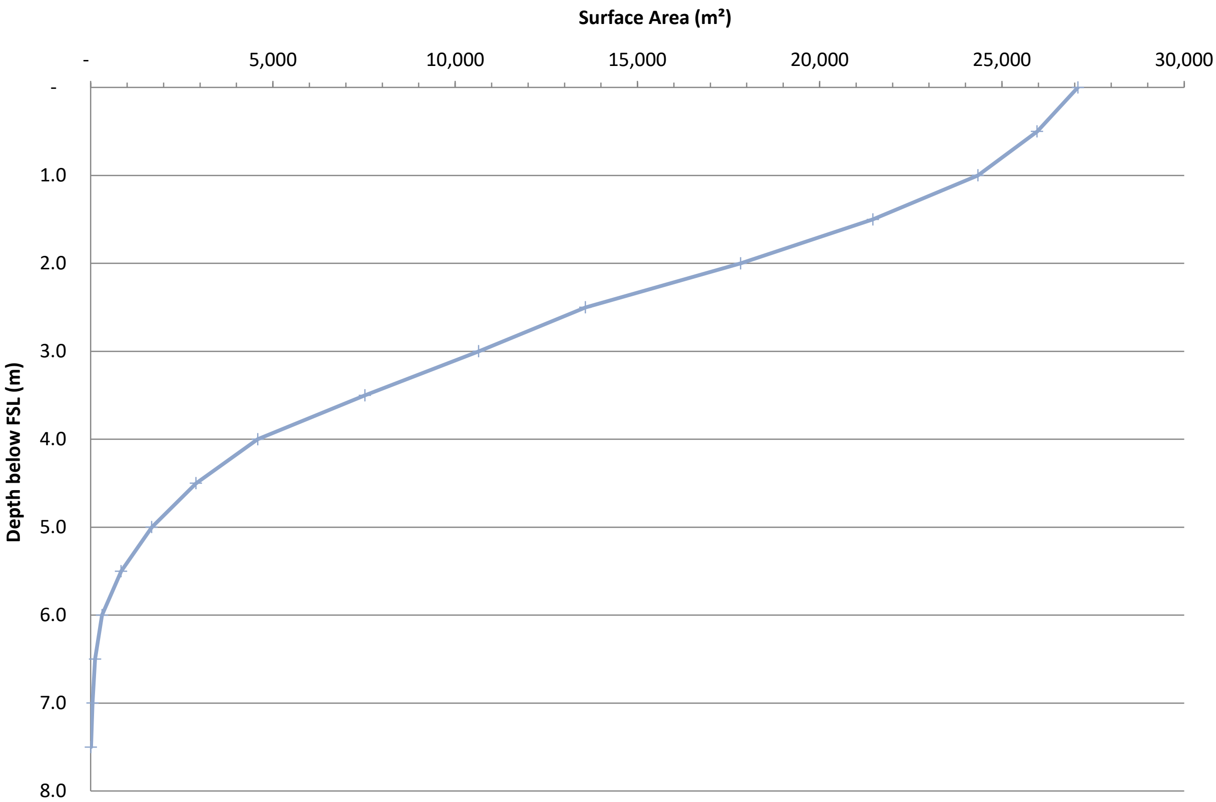


Figure 13: Surface area of weir

Meteorological data

Daily rainfall and daily evapotranspiration data were obtained from the SILO Data Drill for three grid points as given in Table 13 to represent the weir catchment (Figure 14).

Table 13: SILO grid points

Point	Latitude	Longitude
1	-28.60	153.40
2	-28.55	153.45
3	-28.60	153.45

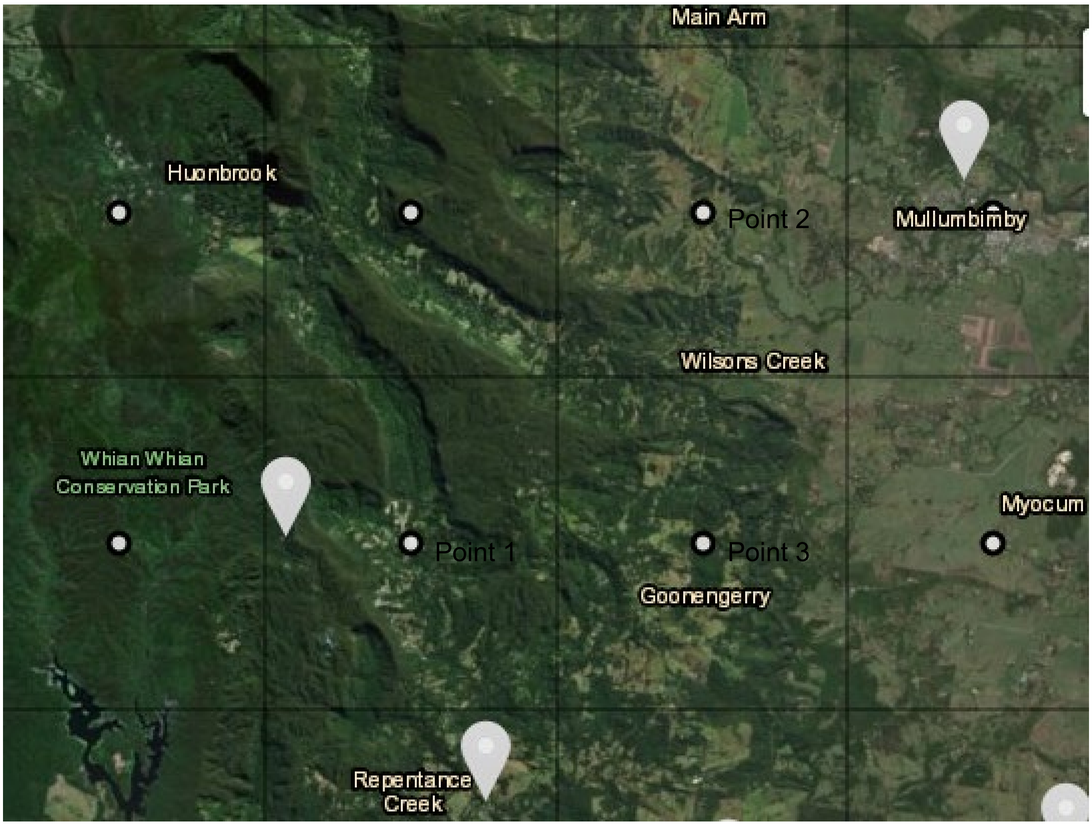


Figure 14: SILO point data grid points

Source: Queensland Government (2019)

Hydrological sequences

Daily streamflow data has been provided by NSW Urban Water Services from the yield modelling undertaken in 2018 (NSW Urban Water Services, 2018) for 1/1/1890 to 9/3/2016. Two sets of data were used in the modelling:

- Set 1 - based on gauging station 203062 (upstream of weir) and Sacramento model - rainfall runoff model.
- Set 2 - based on gauging station 203062 (upstream of weir) and Australian Water Balance Model (AWBM) - rainfall runoff model.

Flow data from gauging station 203062 (Wilsons River at Lavertys Gap weir) has been recorded since 9/3/2016. The gauging station has a catchment area of 26 km^2. Flow recorded at the gauging station has been adjusted by the ratio of weir to gauge catchment areas to estimate the total weir inflow.

Water supply demand

The model applies a daily demand based on a monthly demand factor (reflecting seasonal variation) and the annual demand (Table 14).

Table 14: Monthly demand factors

Month	Factor
January	1.042
February	0.985
March	0.971
April	0.918
May	0.936
June	0.914
July	0.935
August	0.997
September	1.038
October	1.080
November	1.082
December	1.103
Average	1.000

Restriction regime

The model simulates restrictions implemented based on both the level of water in the storage (below full supply level, FSL) and inflows to the weir. The restriction regime is based on the Mullumbimby Drought Management Plan (HydroScience, 2014). A trigger to lift restrictions based on water level has also been included (Table 15).

Table 15: Restriction regime

Restriction level	Water level trigger (m AHD)	Depth below FSL (m)	Inflow trigger (ML/d)	Volume (ML)	% Volume introduced	% Volume lifted	Target demand (ML/d)	% reduction in demand
0	116.16	-	-	72.663	100%	-	1.18	-
1	115.86	0.3	1.0	64.696	89%	94%	1.12	-5%
2	115.56	0.6	1.0	56.862	78%	83%	1.00	-15%

Restriction level	Water level trigger (m AHD)	Depth below FSL (m)	Inflow trigger (ML/d)	Volume (ML)	% Volume introduced	% Volume lifted	Target demand (ML/d)	% reduction in demand
3	115.26	0.9	1.0	49.293	68%	73%	0.889	-25%
4	114.96	1.2	0.5	42.172	58%	63%	0.83	-30%
5	114.66	1.5	0.5	35.275	49%	54%	0.79	-33%
6	114.36	1.8	0.5	29.345	40%	45%	0.76	-36%
7	113.96	2.2	0	22.276	31%	36%	0.52	-56%

Channel leakage

In normal operation, water flows into the channel from the weir storage and flows by gravity to the WTP. When the water level in the storage is above the channel invert, water from the weir flows into the channel (Plate 3). Due to the condition of the channel, water leaks from the channel walls at various locations and flows into Wilsons Creek downstream of the weir. The volume of water leakage from the channel is unknown but due to the poor condition of the channel and the extent of leakage, Council believes that the leakage can be significant.

A raw water pump and pipeline within the channel are generally used when the water level at the weir is below the level of the weir crest. The old penstock at the inlet of the channel was not effective at preventing inflow to the channel and while the pump was in operation and water still flowed by gravity through the channel resulting in continued leakage. From mid-November to the end of December 2019, the water level dropped below the invert of the channel (Plate 4) and hence there was no loss to the channel.

Council replaced the penstock on 14 January 2020 (Plate 5) and no leakage into the channel would have occurred after that time.

1. Channel inlet (submerged)

2. Water in channel

3. Water in channel and leakage from bend

Plate 3: Channel inlet and leakage (September 2018)

1. Channel inlet (exposed at low weir level)

2. Old penstock

3. Dry channel at weir

4. Dry channel looking downstream

Plate 4: Exposed channel inlet (December 2019)

Photos - N. Ulrick

1. New penstock (old penstock in background)

2. New penstock and realigned pump pipework

Plate 5: New penstock (January 2020)

Photos - N. Ulrick

Irrigation demand

Land owners adjacent to the weir storage can potentially extract water from the weir (Plate 6) although there are no data available on extraction volumes. The 2018 yield study (NSW Urban Water Services, 2018) assumed allowances for irrigation from the assumptions used in a previous (1998) yield study (Table 16). The model initially applies these allowances as daily equivalent demand in the respective month.

Table 16: Irrigation allowance (ML)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
3.4	1.5	0.9	1.1	1.0	1.1	0.9	1.5	2.4	2.9	3.0	3.1	22.8

Source: NSW Urban Water Services (2018)

1. Riparian landowner

2. Landowner irrigation pump

3. Landowner irrigation pump

Plate 6: Potential upstream irrigation from weir storage (September 2018)

7.3.3 Storage Response in Summer 2019/20

BSC has monitored the water level (SCADA) in the weir since February 2014 although data are incomplete and considered erroneous prior to December 2016 (Figure 15). Rainfall, weir inflow and weir level since 2017 are shown in Figure 16.

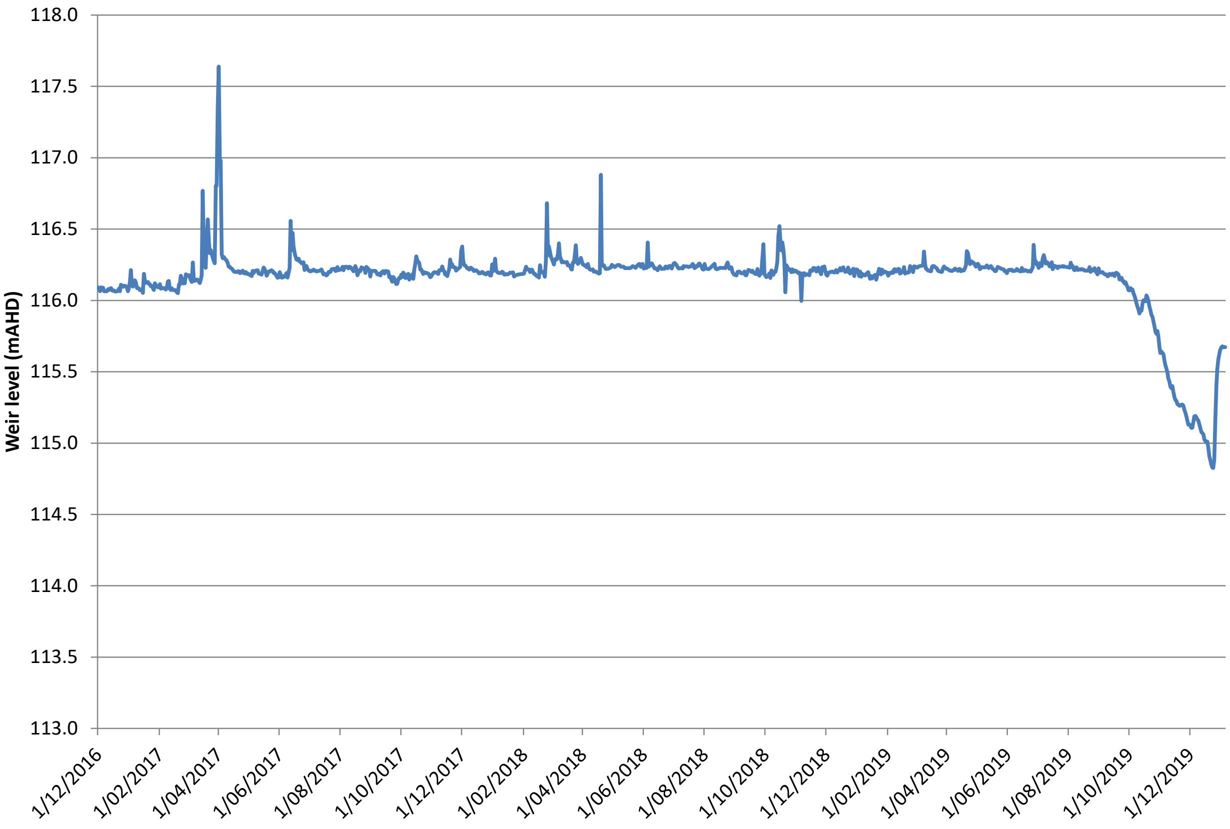


Figure 15: Weir level monitored by Council SCADA system (December 2016 - January 2020)

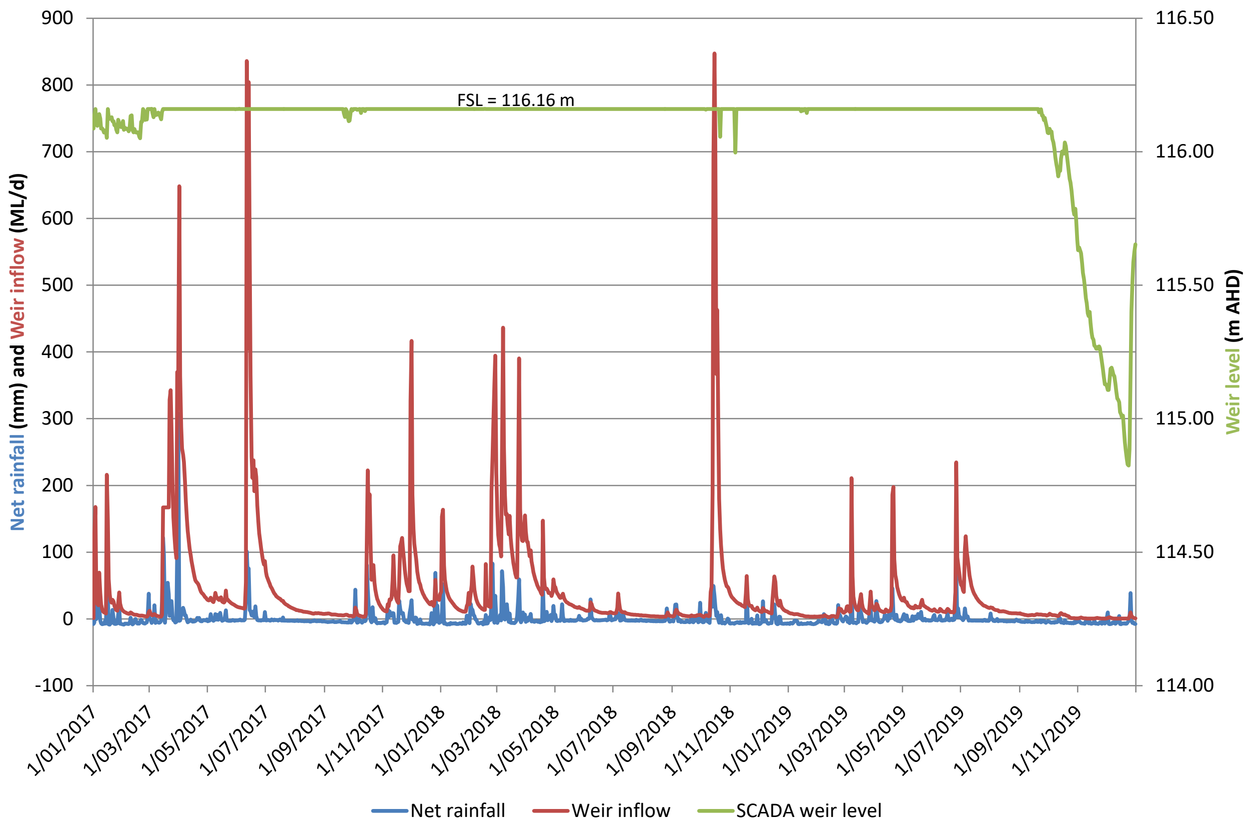


Figure 16: Rainfall, weir inflow and weir level: 2017 - 2019

During 2019 there were sustained periods of low rainfall, particularly in the spring and summer periods (with the lowest level experienced prior to Christmas 2019. During that time, the weir level dropped to approximately 1.4 m below the FSL (Figure 17 and Figure 18).

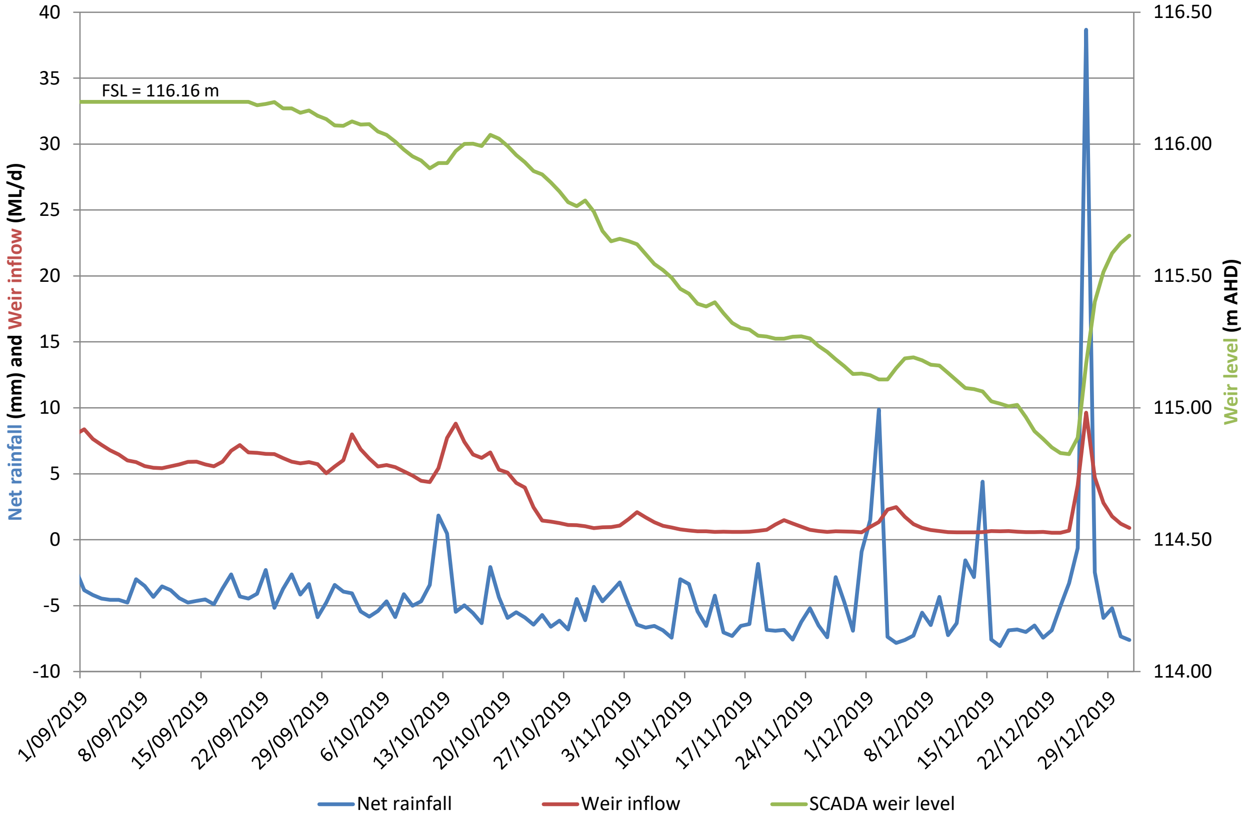


Figure 17: Rainfall, weir inflow and weir level: spring and summer 2019/20

Figure 18: Weir level (19 December 2019)

Photo - N. Ulrick

The weir level data suggests the water level dropped below FSL from 20/9/19 even though the weir inflow was above 5 ML/d for the following month. With daily demand approximately 1 ML/d and losses (channel and irrigation demand) of 0.29 kL/d, this is expected to be due to losses in the channel which become significant when the inflow reduces and the water level falls below the weir crest.

The pump supply was in operation from the end of October 2019 to mid-January 2020. During October 2019, Council also attempted to repair the major leaks in the channel although this was considered to be only partially effective at these locations. During December 2019, Council manually checked the SCADA level data to ensure accuracy. The WTP inflow meter was also checked and found to be accurate.

7.3.4 Model Validation

Validation of the model has been undertaken using recorded weir level between 1 January 2017 and 31 December 2019 (Figure 19) and actual demand experienced during that time. During summer 2019/20, the water sourced from the RCC emergency pipeline was 12,840 kL over 30 days from 23/12/19, compared to the total demand of 28,700 kL (45% of total demand).

As discussed in Section 7.3.3, a significant proportion of water from the weir is lost through channel leakage. The amount of channel leakage at various water levels was adjusted in the model until the storage level was replicated. Results are shown in Figure 19 and Figure 20. The model outputs align with the recorded weir level.

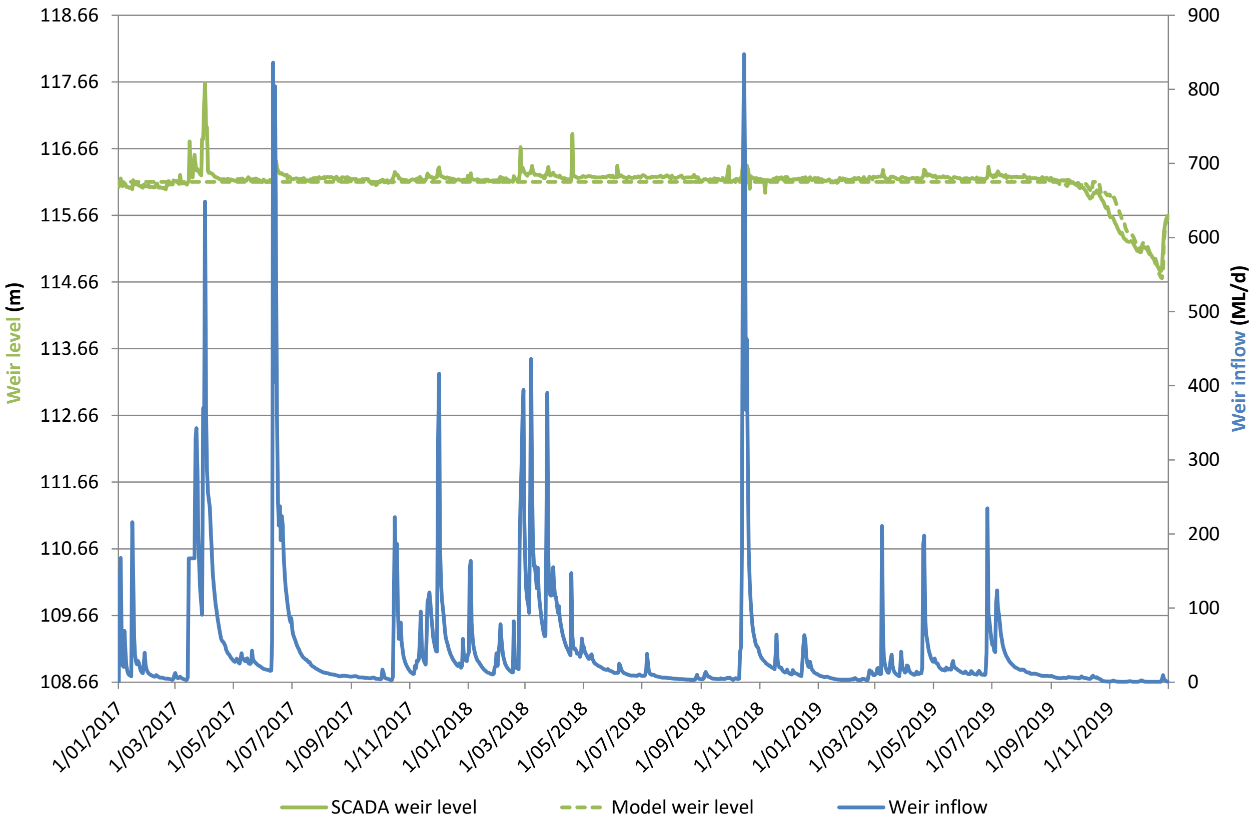


Figure 19: Model validation results: 2017 - 2019

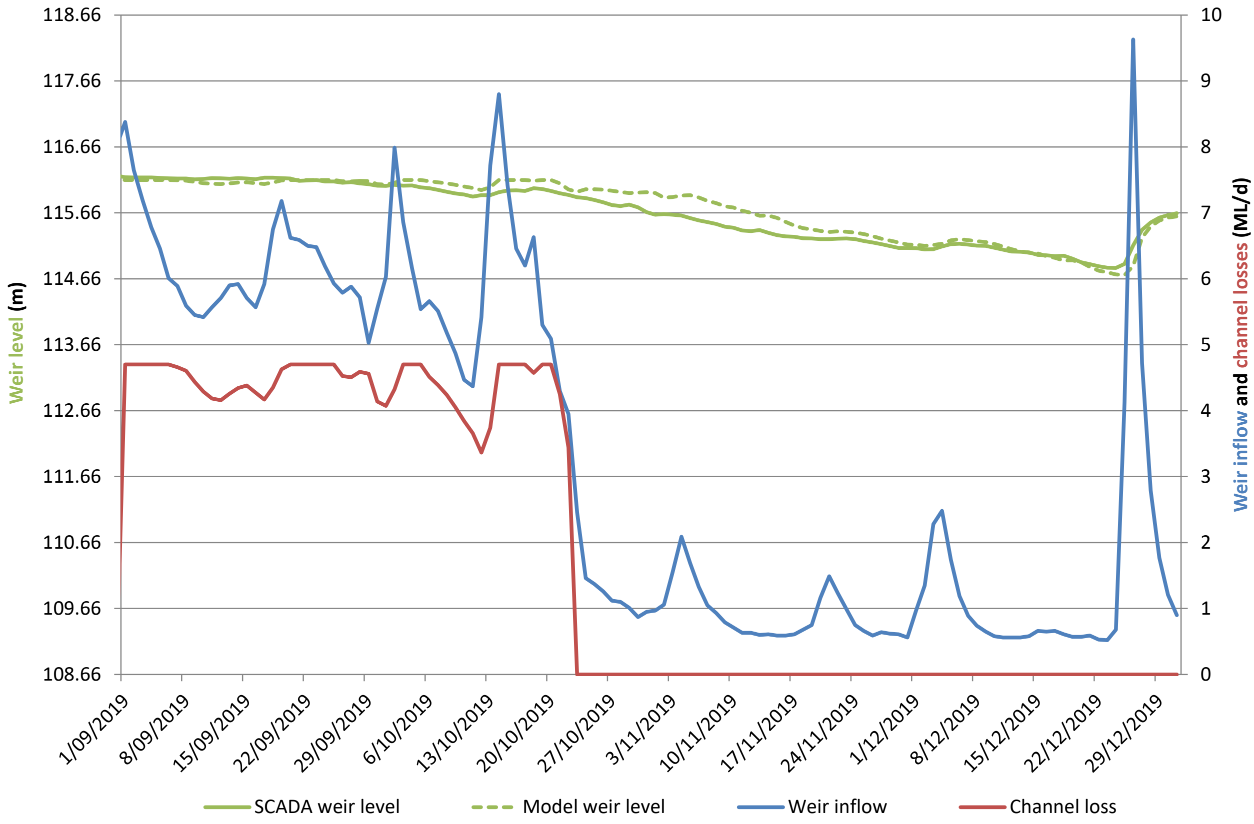


Figure 20: Model validation results: summer 2019

7.3.5 Current System Secure Yield

Current Climate

Results from the NSW Urban Water Services (2018) modelling are provided in Table 17. NSW Urban Water Services (2018) considered the results obtained from the Set 1 flows were more likely to be representative, however, to be conservative in terms of water supply security consideration may be given to adopting the lower estimates. This modelling methodology in NSW Urban Water Services (2018) does not consider the water supply operating rules for Mullumbimby but allows for demand restrictions when required to be introduced to meet the 5/10/10 rule.

Table 17: Secure yield estimates - current climate (NSW Urban Water Services, 2019)

Upstream irrigation allowance (ML/a)	Flow series[1,2]	Secure yield (ML/a) for historic climate (5/10/10)[3]	Applied at storage (% full)	Duration of restrictions (%)	% of years
None	1	430	80	0.27	5.38
	2	335	75	0.41	9.23
22.8	1	410	80	0.26	5.38
	2	305	75	0.40	9.23

Source: NSW Urban Water Services (2018)

1. Set 1 - based on gauging station 203062 (upstream of weir) and Sacramento model - rainfall runoff model.

2. Set 2 - based on gauging station 203062 (upstream of weir) and AWBM - rainfall runoff model.

3. Duration of restrictions does not exceed 5% of the time and frequency of restrictions does not exceed 10% of years (i.e. 1 year in 10 on average) and severity of restrictions does not exceed 10%. Systems must be able to meet 90% of the unrestricted water demand during water restrictions through a repetition of the worst recorded drought.

The secure yield was re-assessed using the GoldSim model for the period January 1890 to October 2018 with results shown in Table 18.

Table 18: Secure yield estimates - current climate (GoldSim model)

Upstream irrigation allowance (ML/a)	Flow series[1,2]	Secure yield (ML/a) for historic climate	Duration of restrictions (% of time)	Frequency of restrictions	Severity of restrictions
None	1	440	0.43	10%	0.061%
	2	260	0.43	10%	0.035%
22.8	1	410	0.44	10%	0.061%
	2	228	0.43	10%	0.035%

1. Set 1 - based on gauging station 203062 (upstream of weir) and Sacramento model - rainfall runoff model.

2. Set 2 - based on gauging station 203062 (upstream of weir) and Australian Water Balance Model (AWBM) - rainfall runoff model.

The model output for the storage behaviour for flow series 1, no irrigation demand and the historic climate is shown in Figure 21.

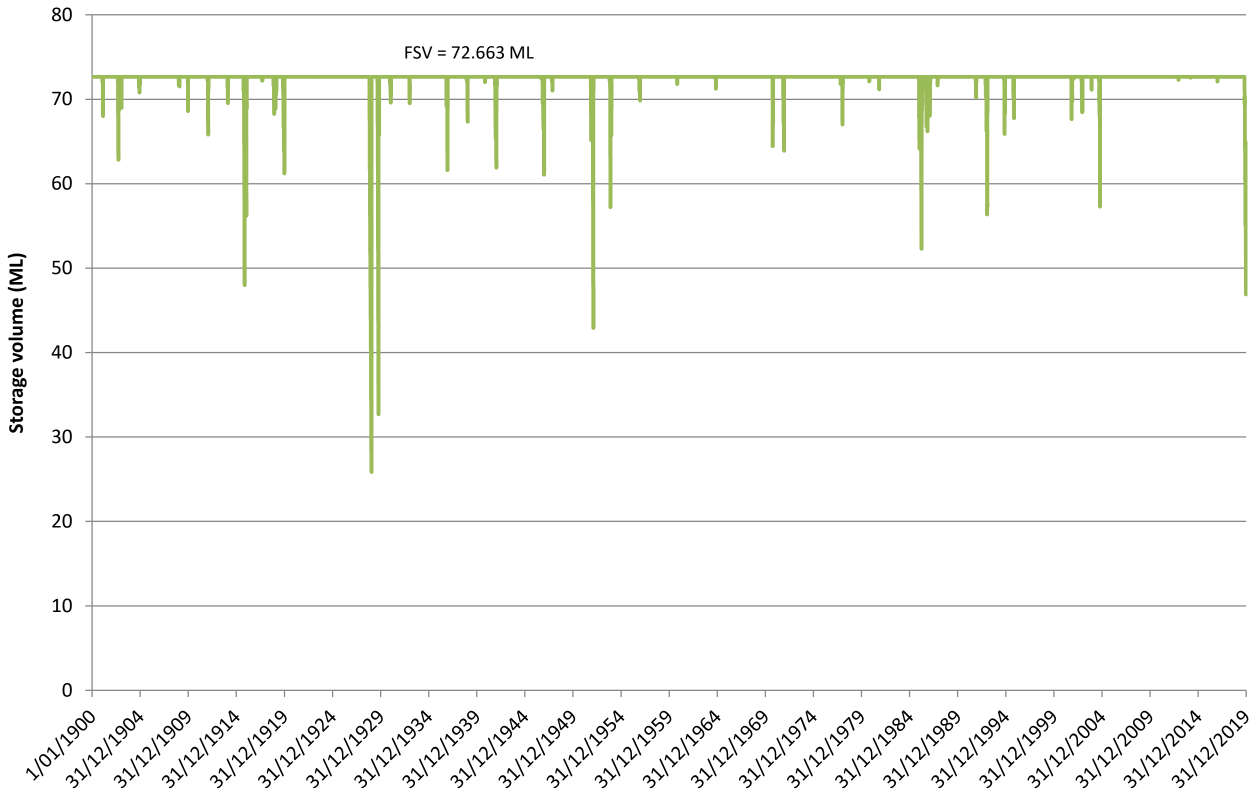


Figure 21: Secure yield modelling results - current climate

The GoldSim results obtained using Set 1 flow series are similar however the results for Set 2 are lower than obtained by NSW Urban Water Services (2018). Based on the findings of NSW Urban Water Services (2018), Set 1 flows have been used in the GoldSim model.

The secure yield assessment was repeated for the full record of hydrometeorological data (1/1/1890 - 31/12/2019, 130 years). The same yield results were obtained for the Set 1 flow series.

While irrigation demand is unknown, there are only a few properties adjacent to the weir pool and irrigation usage is predicted to be limited to stock and domestic uses. In addition, rainfall is generally high with monthly averages ranging from 53 mm in September to 247 mm in February with annual average of 1,826 mm. Therefore, in most years, irrigation demand is expected to be minimal. The GoldSim model will therefore assume no irrigation allowance but the yield analysis will consider the potential for irrigation extraction during dry periods.

Climate Change

The equivalent hydrological data with climate change based on 1°C warming and the historic data corresponding to the GCM database (1/1/1895 - 31/12/2008, 114 years) were also provided by NSW Urban Water Services for use in the model. The climate change data was generated by scaling the historical daily rainfall and evapotranspiration data for the A1B (1°C increase) warming scenarios. The secure yield assessment was repeated with hydrological and climate data for each of the GCMs in accordance with the draft *Guidelines on Assuring Future Urban Water Security* (NSW Office of Water, 2013). Results are shown in Table 19 using the methodology prescribed in the guidelines (NSW Office of Water, 2013).

Table 19: Secure yield estimates - climate change (GoldSim model)

Data Set	Secure yield (ML/a)	Duration of restrictions	Frequency of restrictions	Severity of restrictions
A: Historical data from NSW Database based on 5/10/10 design rule	340	0.166%	9.6%	0.011%
B: 15 GCMs based on 5/10/10 design rule				
GCM1	275	0.155%	8.8%	0.0096%
GCM2	304	0.17%	9.6%	0.011%
GCM3	262	0.186%	8.8%	0.016%
GCM4	222	0.211%	9.6%	0.016%
GCM5	290	0.221%	9.6%	0.019%
GCM6	273	0.202%	9.6%	0.017%
GCM7	314	0.171%	9.6%	0.012%
GCM8	263	0.182%	9.6%	0.012%
GCM9	267	0.205%	9.6%	0.017%
GCM10	355	0.137%	9.6%	0.01%
GCM11	293	0.173%	9.6%	0.012%
GCM12	266	0.178%	8.8%	0.013%
GCM13	230	0.2%	9.6%	0.015%
GCM14	327	0.17%	9.6%	0.012%
GCM15	331	0.159%	9.6%	0.011%
C: Median of 15 GCMs based on 5/10/10 design rule	275 (GCM1)			
D: Lowest of 15 GCM based on 5/10/10 design rule	222 (GCM4)			
E: Lowest GCM rerun for 10/15/25 design rule	322 (GCM4)			
Lesser of C and E	275			
Adopted % change in secure yield - based on median GCM (5/10/10)	[(275 - 340)/340] x 100 = -19.1%			
Secure yield using observed historical data based on 5/10/10 design rule (Table 18)	440			
Best estimate of future secure yield	356			

The secure yield with 1ºC climate warming calculated using the GoldSim model (356 ML/a) is similar to the result provided in NSW Urban Water Services (2018) (345 ML/a).

8. DEMAND ANALYSIS

8.1 Water Supply Customers

Council has supplied data on the annual number of properties connected to the Mullumbimby water supply since 2011 (Figure 22). Since 2017, Council has categorised the customers into multi- and single residential customers and non-residential types (commercial, industrial, institutional). The ratio of multi-residential customers from 2017 - 2019 (average 5%) has been used to estimate multi-residential customers between 2011 and 2016. Growth in connections averaged 2.3% p.a. over the last 3 years. It is unclear why the reported number of connected properties decreased between 2011 and 2012, although this is assumed to be a correction in reporting methodology.

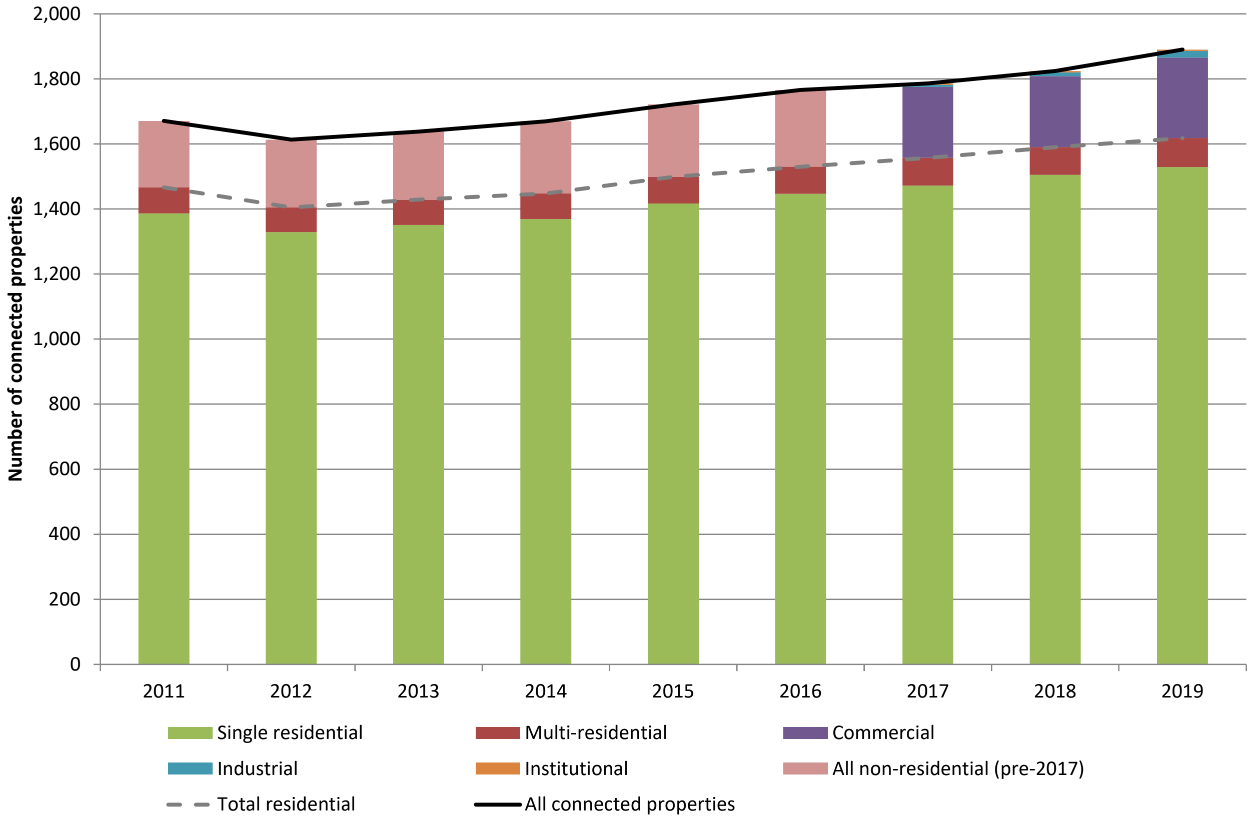


Figure 22: Water supply connected properties - 2011 - 2019

BASIX is the NSW Government's online sustainability tool that has a mandated water and energy savings for residential development in NSW. BASIX has mandated energy and water savings in regional NSW since July 2005. BASIX certificate information is available from the NSW Department of Planning and Infrastructure for 2011/12 to 2017/18. The certificates database provides information on building location and estimated water consumption.

The BASIX certificates have been analysed to determine the number of certificates in the Mullumbimby water supply area. The total number of certificates for each year in Mullumbimby is shown in Table 20. This includes BASIX certificates that specified that the property was using the town water supply. Certificates for developments in Mullumbimby and Mullumbimby Creek that specified use of tank water are assumed to be rural properties and were not included.

Table 20: BASIX certificate data - total number of certificates in Mullumbimby water supply area

Type	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	Total (2011-2018)
Single residential	26	22	38	55	53	43	57	294
Multi-residential	0	2	1	9	10	5	14	41

A BASIX compliant property is considered to represent a “water efficient” connection due to the installation of water saving measures such as efficient appliances and alternative water sources (rainwater tanks). The number of new BASIX houses has been assumed to be equivalent to the total number of new connections in the supply area. The number of renovated BASIX houses has been assumed to be the remainder of the BASIX certificates in each year. This may be an over-estimate as there may be some BASIX certificates that are not converted to BASIX connections. Similarly, a non-BASIX property is assumed to be non-efficient and a higher average consumption has been applied to account for the variation in household characteristics and water uses.

In addition to the new development, it has been assumed that some existing connections will be converted from non-BASIX to BASIX connections as they are developed or renovated. The rate of conversion is assumed to be 0.5% p.a. prior to 2015, 1.0% p.a. until 2040 and 0.5% p.a. beyond 2040.

The current number of connected properties is given in Table 21 and the historical data is shown in Figure 23.

Table 21: Connected properties - 2018/19

Property type	Number
Single residential	1,132
Multi-residential	38
BASIX single residential	397
BASIX multi-residential	51
Total residential	1,618
Commercial	247
Industrial	21
Institutional	4
Total non-residential	272
All connected properties	1,890

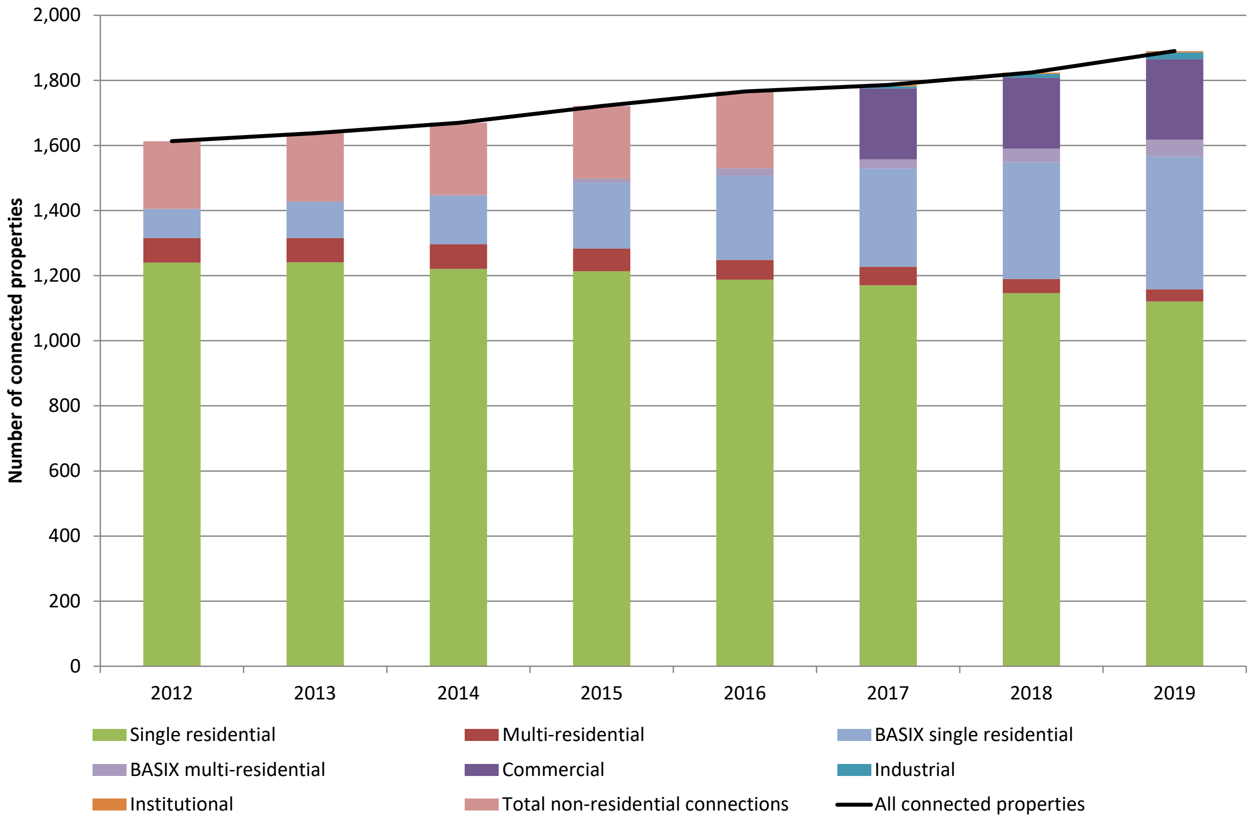


Figure 23: Historical connections profile

8.2 Historical Demand

8.2.1 WTP Inflow and Treated Water Production

BSC has supplied data on daily WTP inflow, treated water production for Mullumbimby water supply (July 2006 - May 2020) as shown on Figure 25 and Figure 26. Prior to 2013, the amount of WTP inflow was estimated from the treated water production data with an allowance for backwash volumes and these older data may be inaccurate.

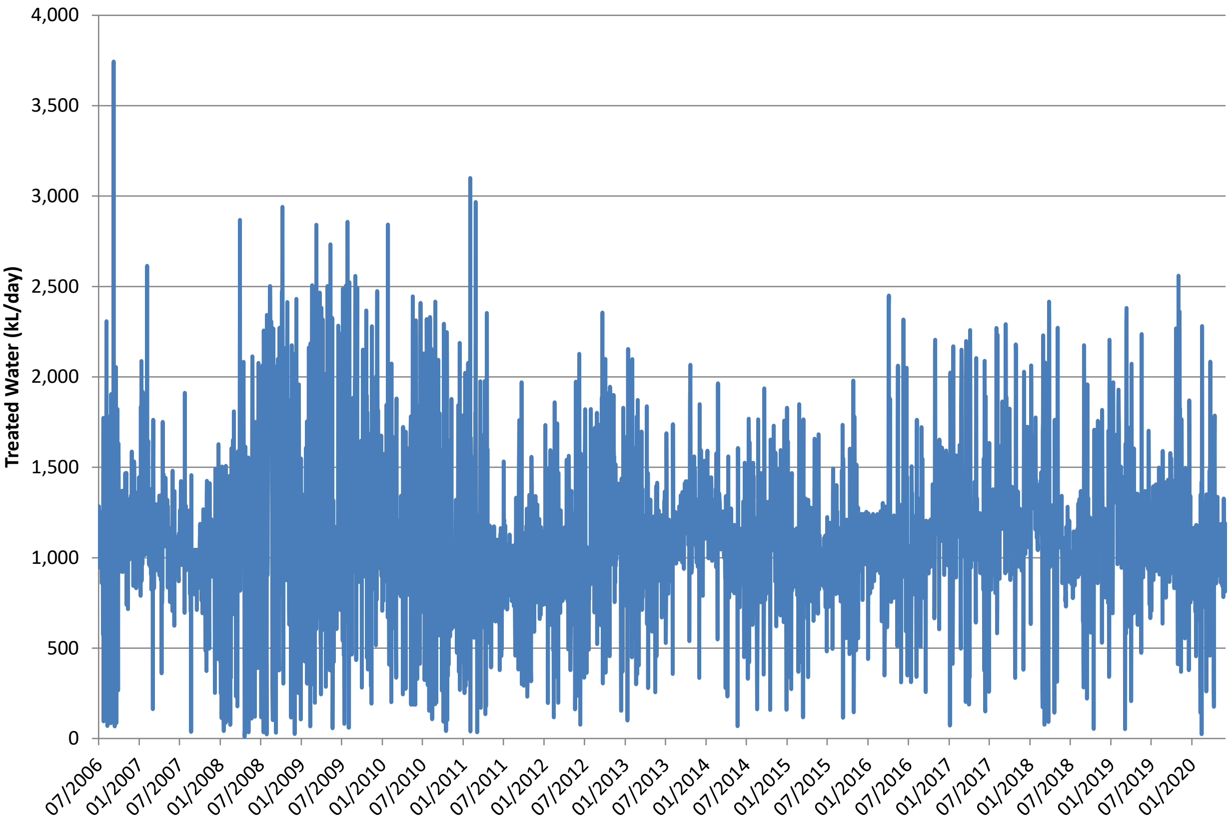


Figure 24: Daily treated water production

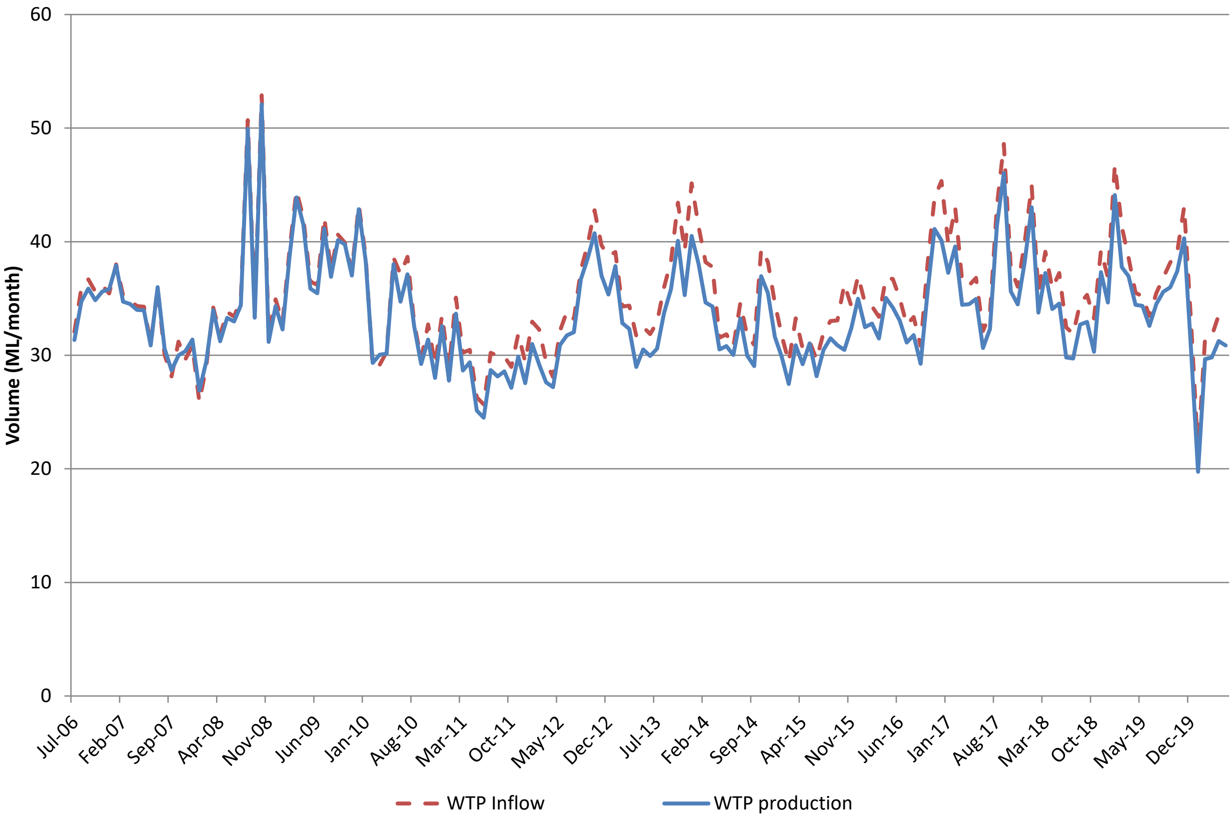


Figure 25: Monthly WTP inflow and treated water production

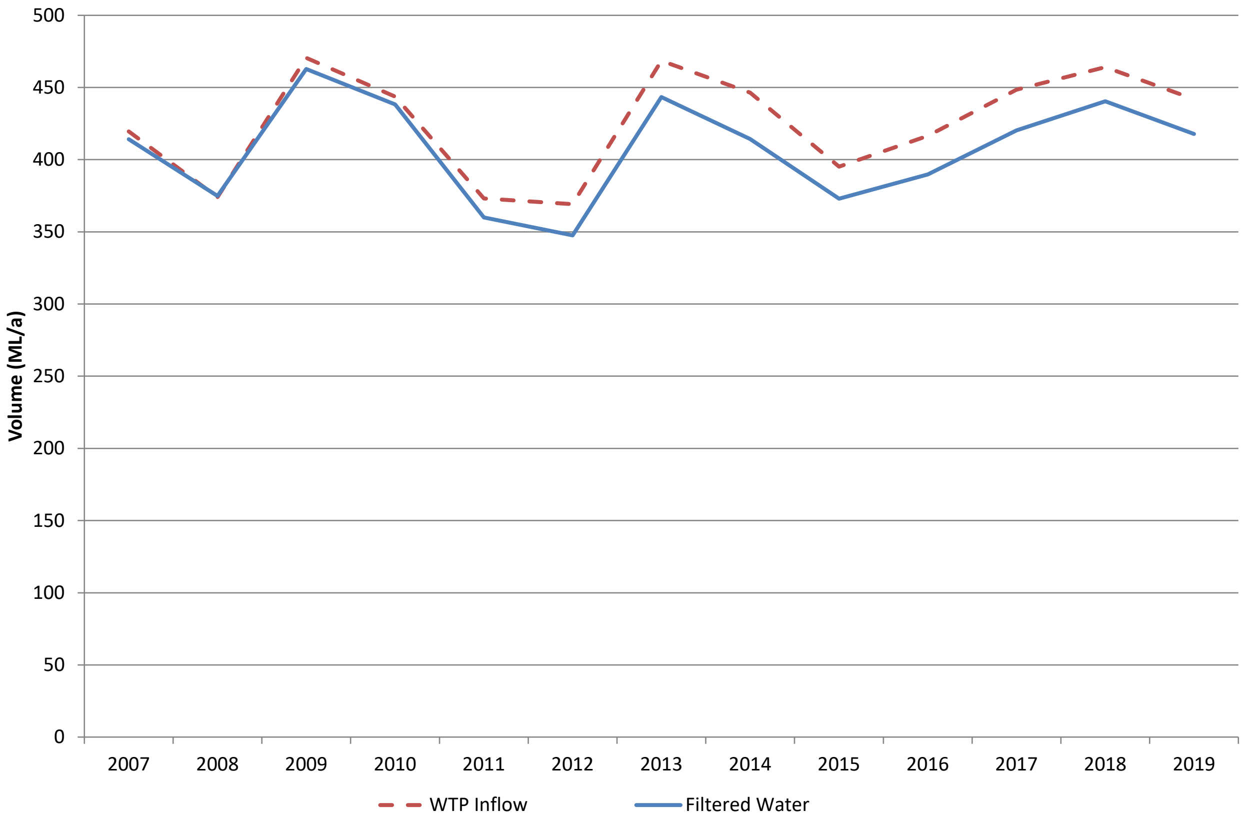


Figure 26: Annual WTP inflow and treated water production (2007 - 2019)

Data from the summer of 2019/20 during the drought and restriction periods are shown on Figure 27. The restrictions imposed have reduced total demand. During this period, the WTP production was supplemented with supply from the Rous regional supply as discussed in Section 12.1.1 and shown on Figure 28.

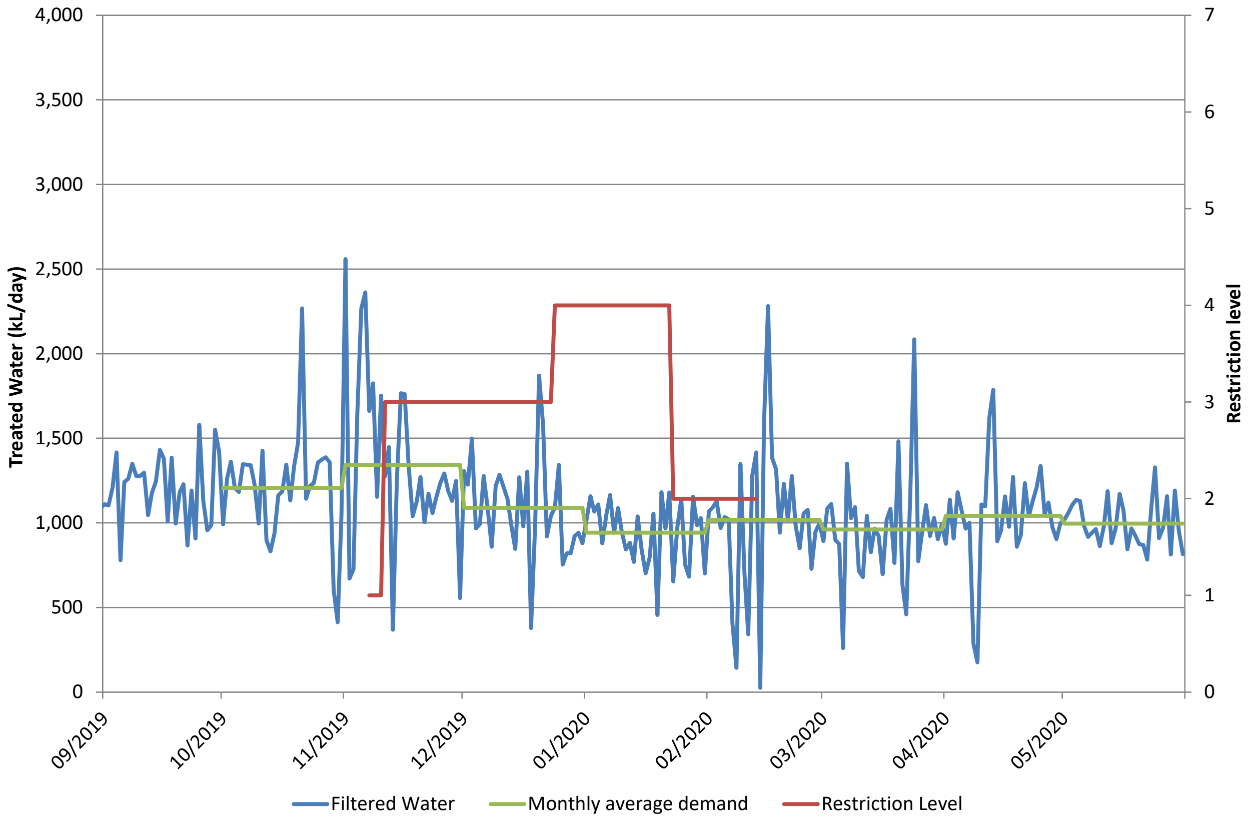


Figure 27: Daily treated water production and restrictions imposed (October 2019 - May 2020)

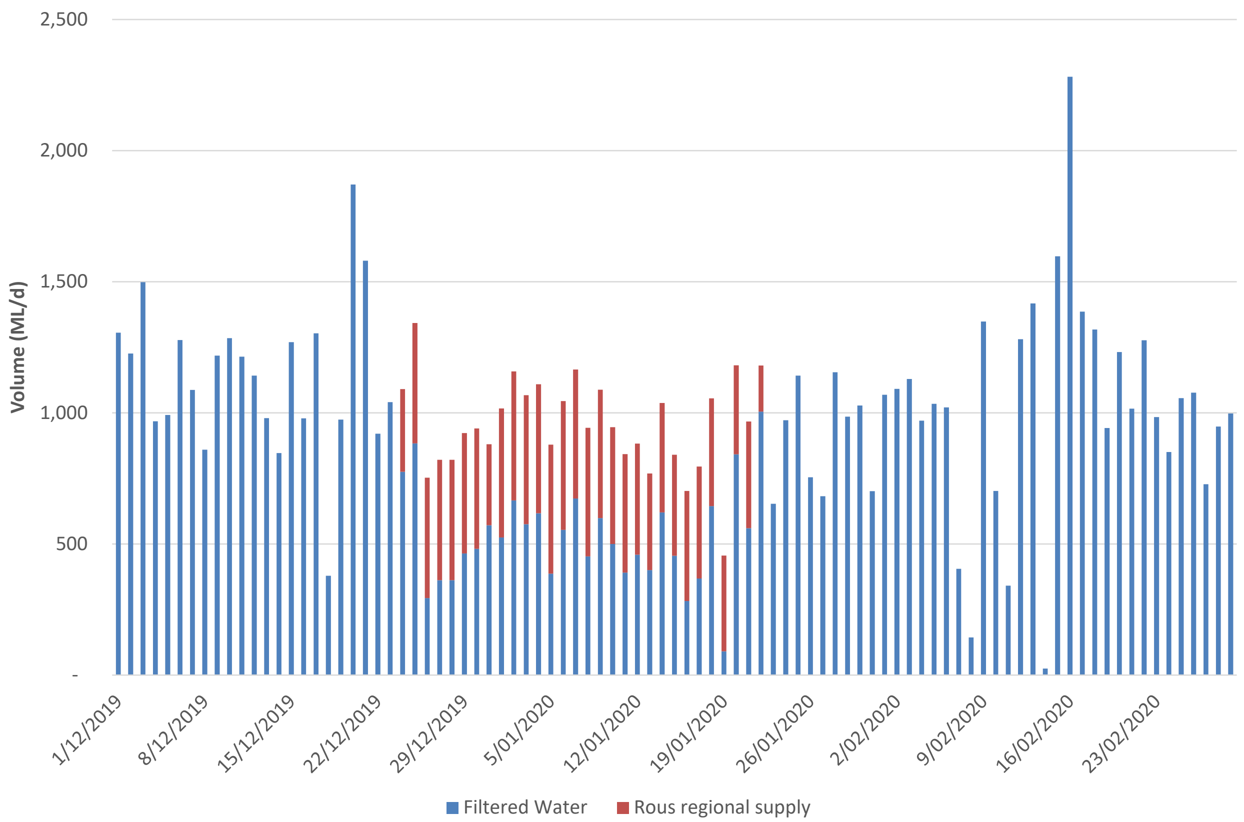


Figure 28: Supply from the WTP and Rous regional supply during summer 2019/20

8.2.2 Metered Consumption

BSC has supplied data on quarterly metered customer consumption between 2011 and 2016 and annual totals between 2017 and 2019 (Figure 29). Since 2017, data are reported for the non-residential customer categories (institutional, commercial, industrial).

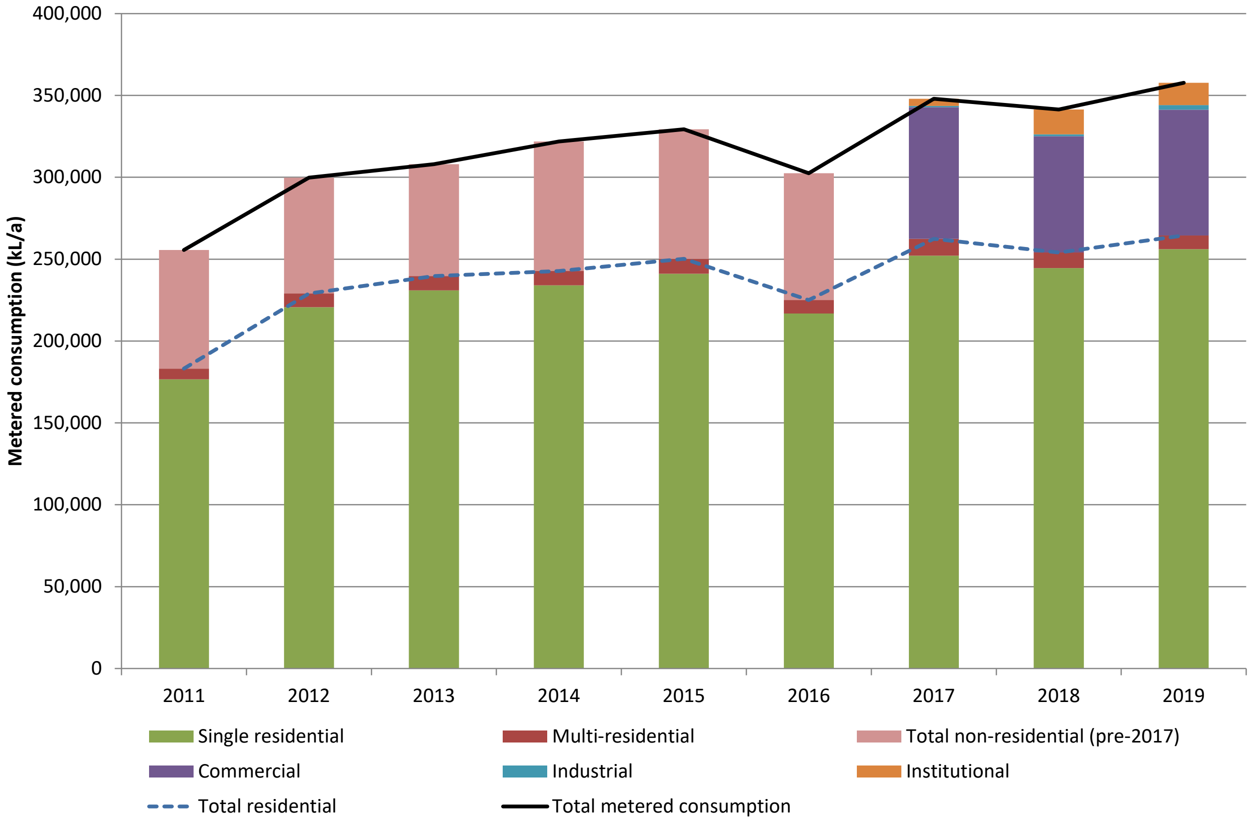


Figure 29: Metered customer consumption

The BASIX certificate data was also used to estimate the per connection consumption for BASIX compliant connected properties using the estimated water consumption reported on each certificate. The estimated water consumption for BASIX compliant buildings is the average water consumption on the BASIX certificates in the Mullumbimby water supply area at the time of their development application (Table 22).

Table 22: Estimated consumption for BASIX compliant connections

Connection Type	Estimated water consumption (L/conn/day)	Estimated water consumption (kL/conn/year)
Single Residential	316	116
Multi-residential	264	97

Data on the average consumption per connection type are shown in Table 23 and the historic consumption profile is shown on Figure 30.

Table 23: Consumption per connection type (2012 - 2019)

Customer Type	Average consumption per connected property (kL/a)
Single residential	176
Multi-residential	112
BASIX single residential	116
BASIX multi-residential	97
Commercial (2017 - 2019)	335
Industrial (2017 - 2019)	121
Institutional (2017 - 2019)	2,746

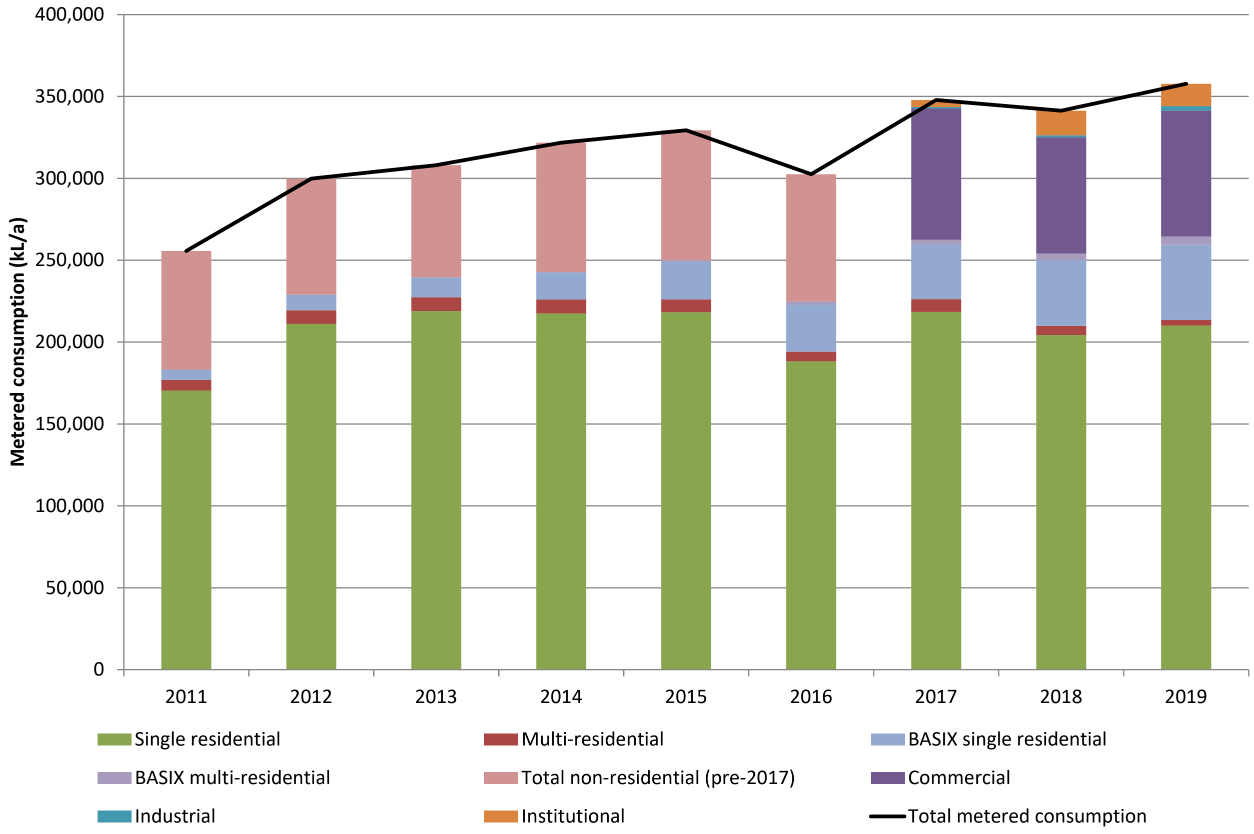


Figure 30: Historic consumption profile

8.2.3 Factors Influencing Demand

Annual consumption appears to be increasing between 2012 and 2019 (refer Figure 29). The impact of the following factors on metered customer demand has been assessed:

- Consumption per connected property (refer Figure 31). Residential and non-residential consumption per connected property has fluctuated each year with no noticeable increase or decrease over time.
- Climate (average maximum temperature and annual rainfall at Mullumbimby, refer Figure 32 and Figure 33). There is no obvious relationship between consumption and rainfall or temperature.

- Water pricing (usage charge, refer Figure 34). Despite the increasing price of water since 2007, there is no obvious impact on residential or non-residential consumption per connected property.

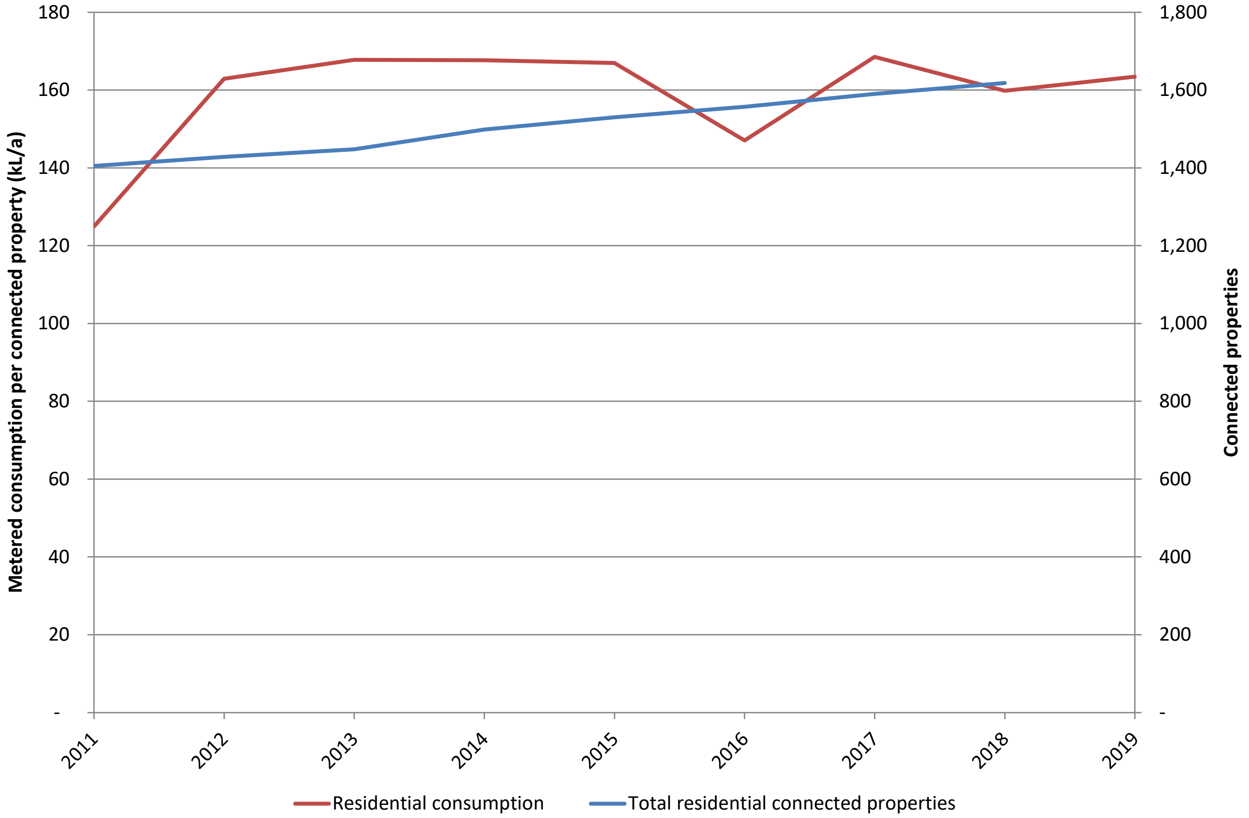


Figure 31: Comparison between connected properties and metered demand per property

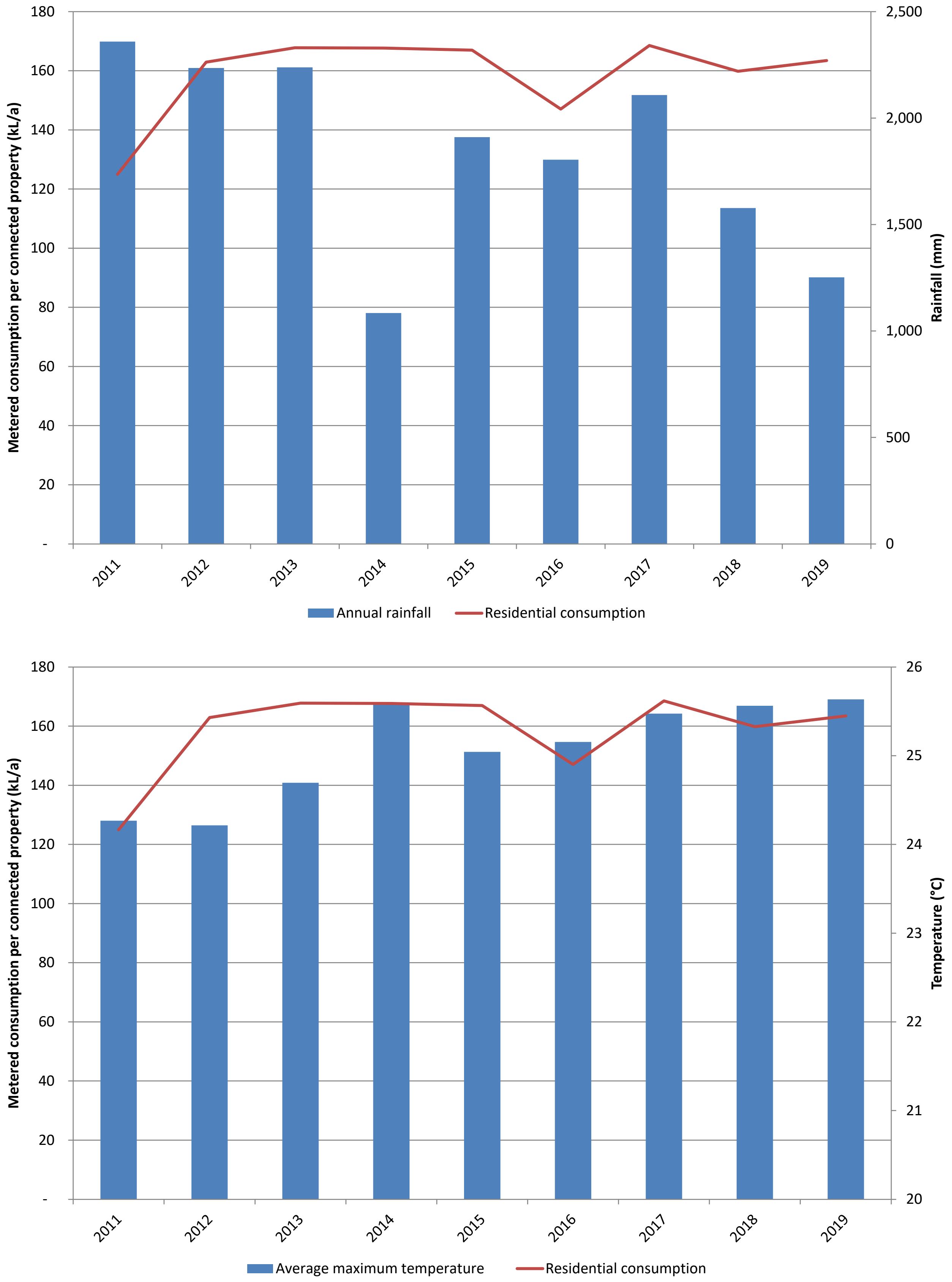
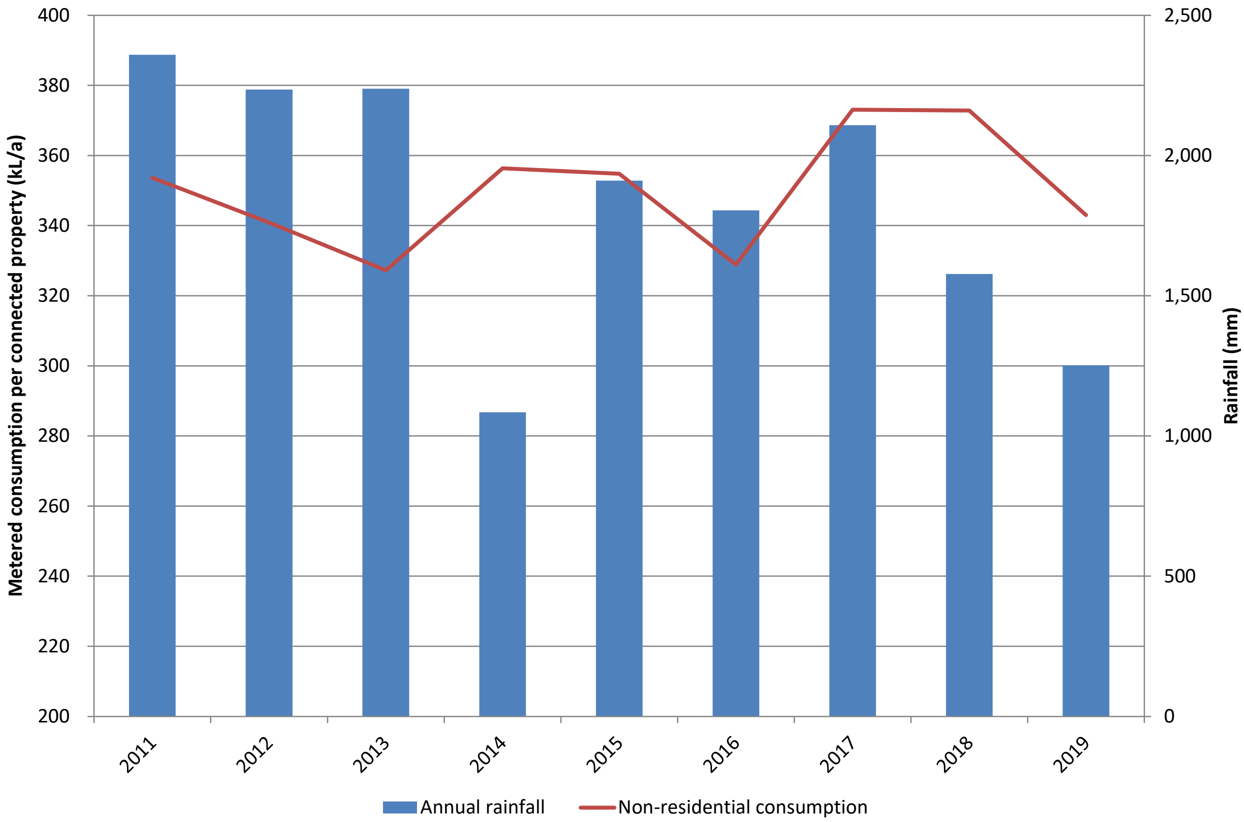


Figure 32: Comparison between climate and metered demand per residential property



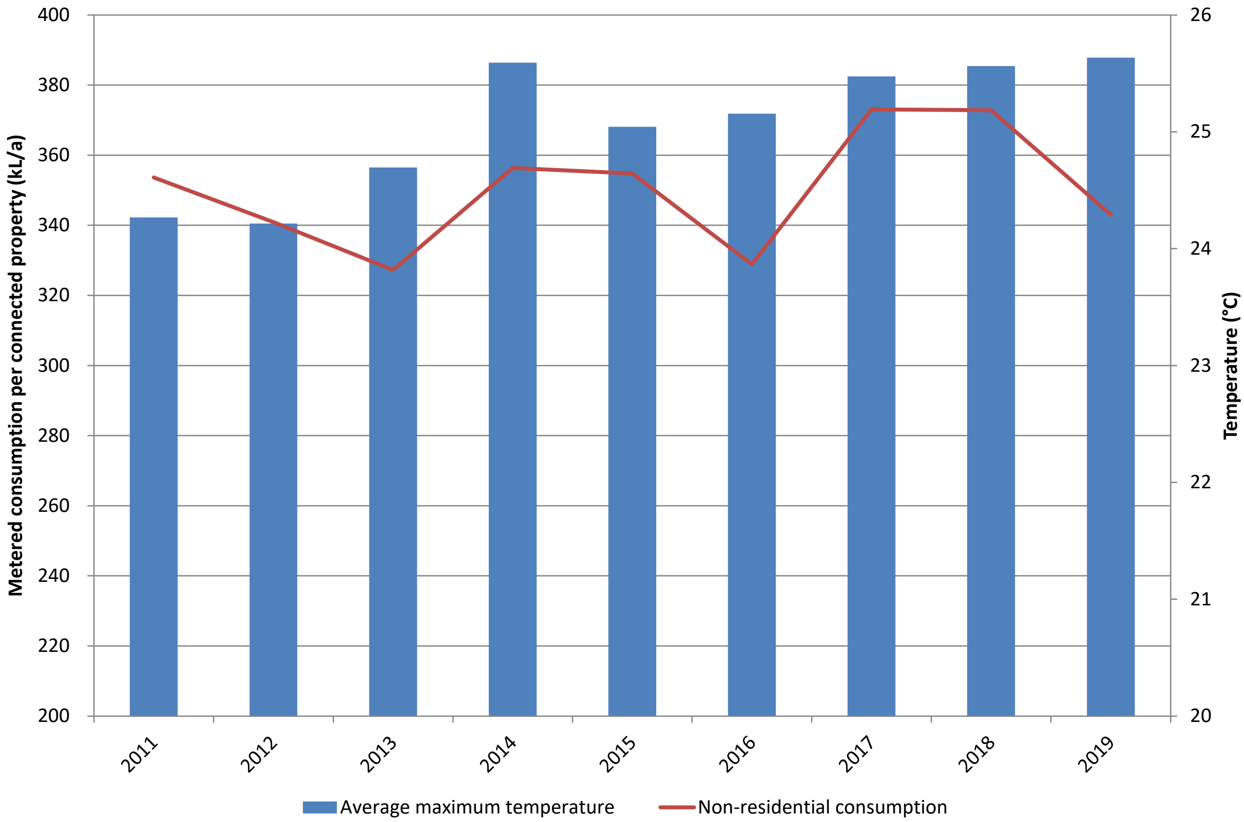
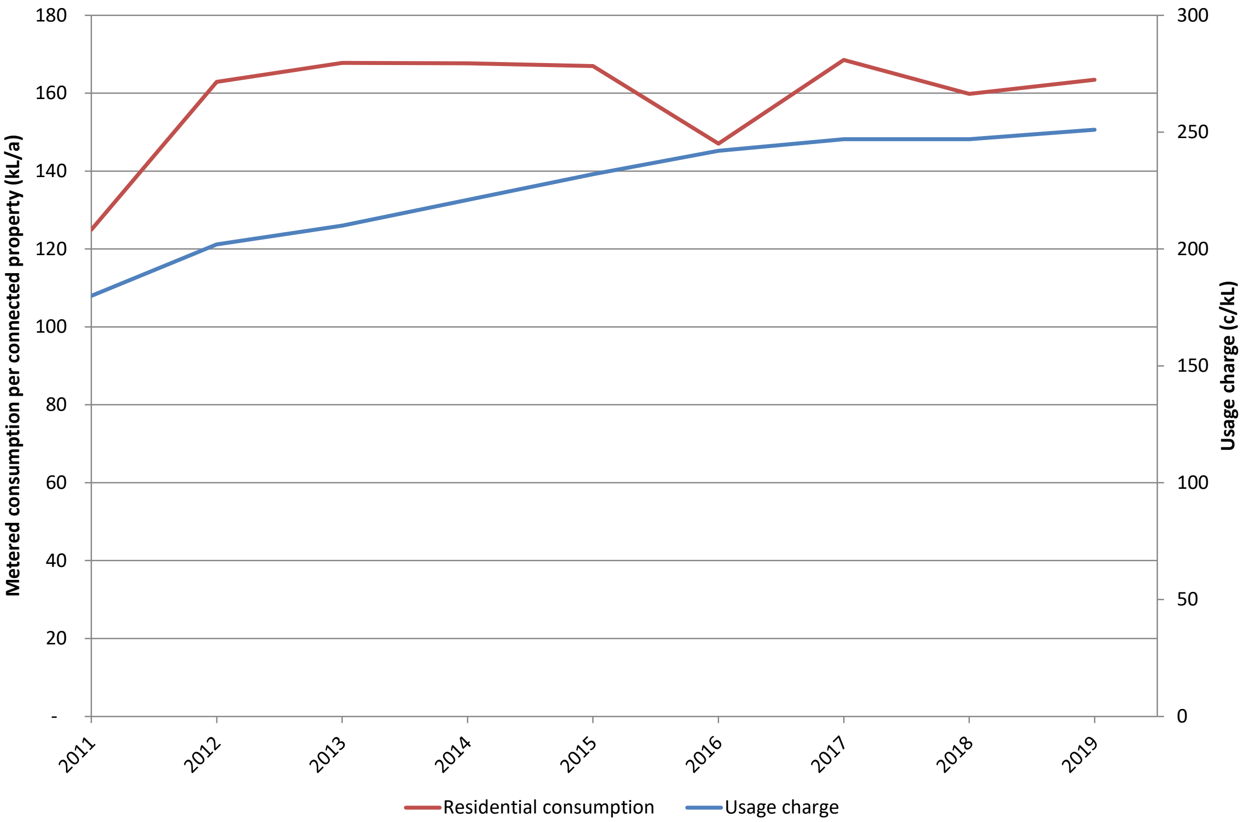


Figure 33: Comparison between climate and metered demand per non-residential property



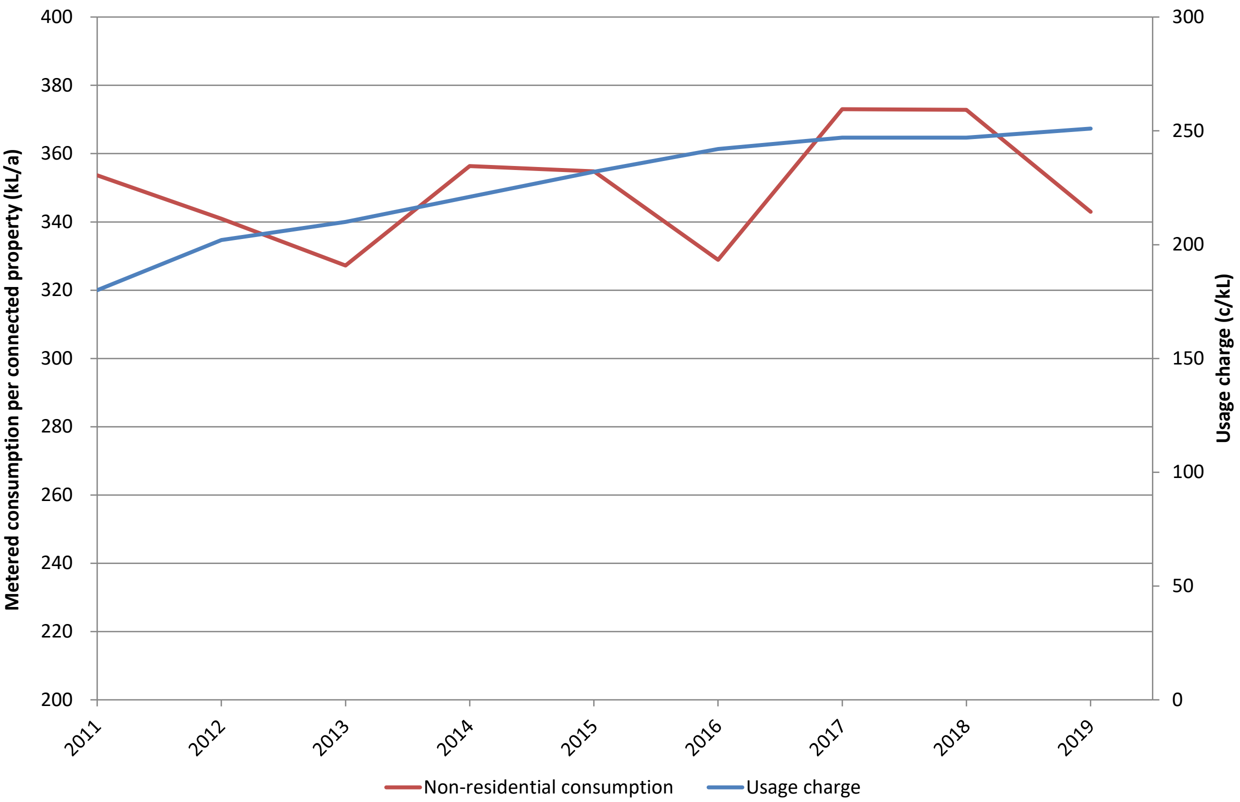


Figure 34: Comparison between usage charge and metered demand

8.2.4 Water Losses

Annual WTP inflow, filtered water, customer demand and water losses (WTP losses and non-revenue water, NRW, the difference between total water production and total metered consumption) are summarised in Table 24 and Figure 35. Since 2015, the calculated WTP losses have been 5.6% of raw water extraction and NRW has fluctuated between 10% and 22% of treated water production. Total losses have fluctuated between 16% and 27% of raw water extraction. This analysis does not consider losses in the rising main/ channel from the weir and tunnel into the WTP (Section 6.2).

Table 24: Water supply demand and losses (2007-2019)

Year	Raw water extraction (ML/a)	Treated water production (ML/a)	WTP losses (ML/a, % of raw water extraction)	Customer consumption (ML/a)	NRW (ML/a, % of treated water production)
2007	420	414	5 (1.3%)	307	107 (25.8%)
2008	370	371	N/A	296	74 (20.1%)
2009	407	402	5 (1.3%)	337	65 (16.2%)
2010	404	399	6 (1.4%)	347	52 (13.0%)
2011	332	321	10 (3.1%)	256	66 (20.4%)
2012	358	337	21 (5.8%)	300	37 (11.1%)
2013	459	435	24 (5.3%)	308	127 (29.2%)
2014	443	413	31 (6.9%)	322	91 (22.0%)
2015	390	367	23 (5.8%)	329	38 (10.3%)
2016	413	387	26 (6.3%)	303	84 (21.8%)
2017	444	419	25 (5.6%)	348	71 (16.9%)
2018	461	439	22 (4.8%)	341	98 (22.3%)
2019	442	418	24 (5.6%)	315	60 (14.4%)
Average (5 years)	430	406	24 (5.6%)	336	70 (17.3%)

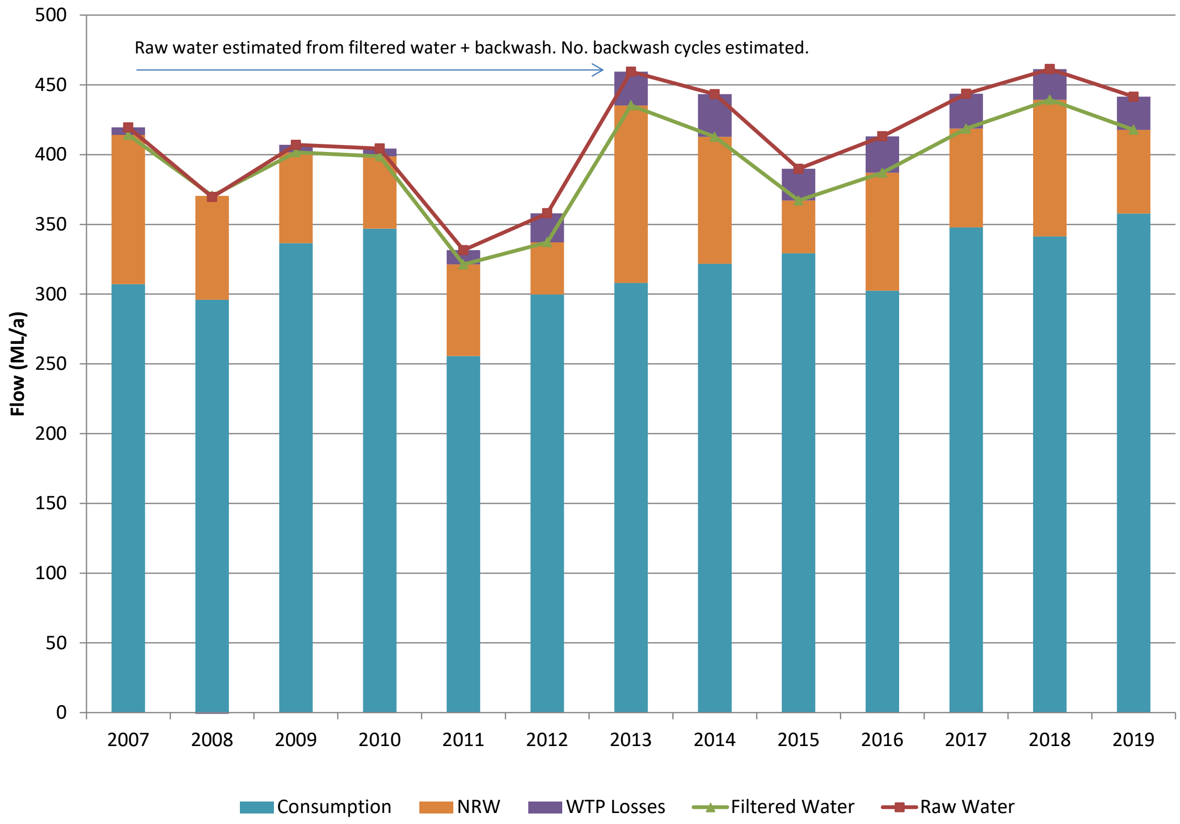


Figure 35: Historical water supply demand - Mullumbimby: 2007 - 2019

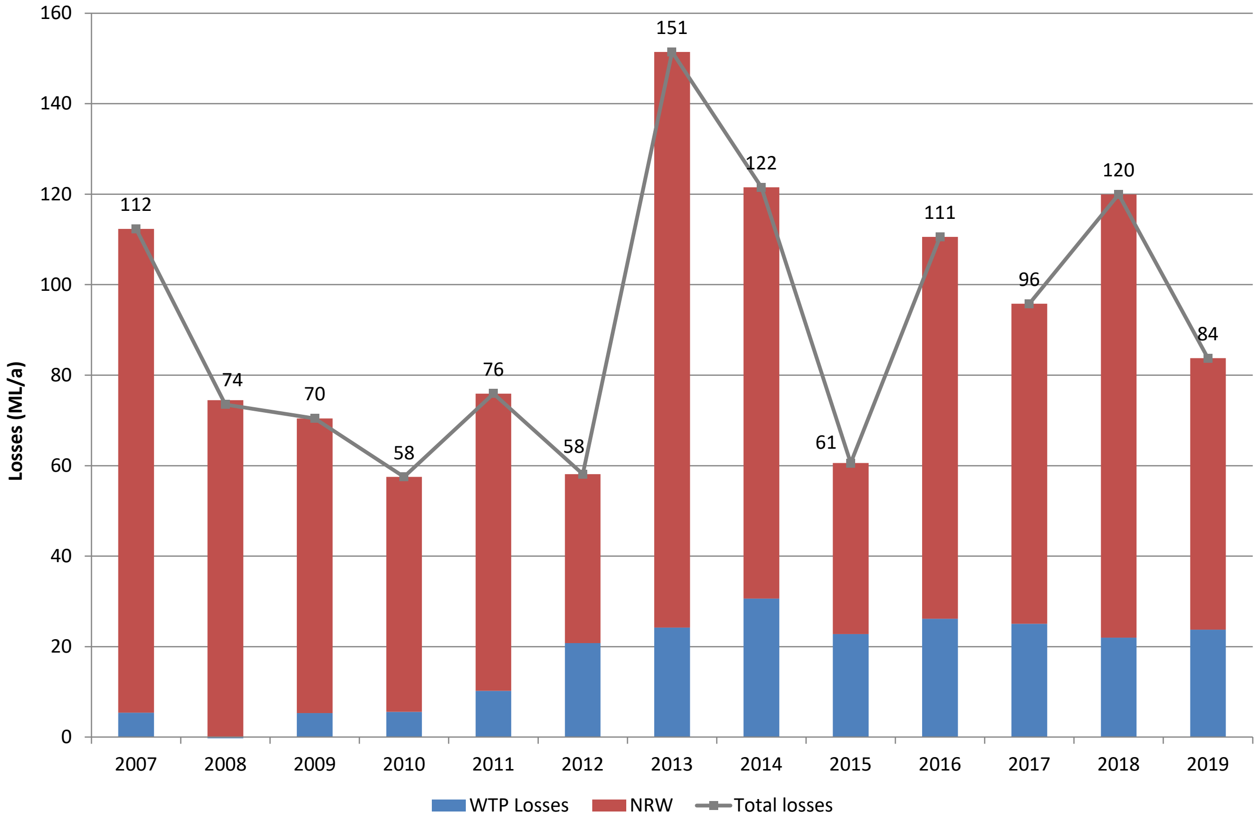


Figure 36: WTP losses and NRW - Mullumbimby

8.3 Average and Dry Year Demand

Daily water demand patterns are highly variable and are likely to be influenced by a broad range of factors. The council data provides an estimate of the consumption per connection type. This varies over the available time period which is due to the influences of short-term climate variations or other non-climate variables. Despite variability in the data there is an intuitive connection between climate and water demand which has been considered in this demand analysis.

The demand of non-residential connections may be less influenced by climate variables than residential connections. The demand patterns of some of the larger non-residential connections in the bulk supply area are likely to be influenced by factors other than climate. Conversely, water usage for non-residential connections such as sporting grounds and nurseries are more likely to be influenced by climate. No data on the consumption patterns of individual non-residential connections were available for analysis for this report.

The water losses vary from year to year. The reasons for these variations are not yet known, however it should be noted that as this estimate is derived from the difference between bulk and customer supply meters, metering errors are also incorporated into this statistic, as well as actual losses and real unmetered water.

Using the current NSW Security of Supply Methodology, water security is achieved if the secure yield of a water supply is at least equal to the unrestricted dry year annual demand (NSW Office of Water, 2013). Analysis has been undertaken to identify key climate-influencing factors such rainfall, temperature and evaporation and evaluate changes in demand due to periods of dry/hot climate. This has been used to estimate the unrestricted dry year annual demand. The climate correction analysis undertaken for Mullumbimby water supply suggests that the dry year demand is 3.24% higher than the average demand (Appendix 3). The historical metered consumption per connected property for each customer type and the average, maximum and dry year consumption per connected property are shown in Table 25.

Table 25: Consumption per connected property (kL/a)

Connection type	2012	2013	2014	2015	2016	2017	2018	2019	Average since 2012	Maximum since 2012	Dry year
Single residential	170	176	178	179	157	186	177	186	176	186	182
Multi-residential	109	112	112	114	98	134	127	91	112	116	116
BASIX single residential	116	116	116	116	116	116	116	116	116	116	120
BASIX multi-residential	97	97	97	97	97	97	97	97	97	97	100
Total residential	163	168	168	167	147	169	160	163	163	169	168

Connection type	2012	2013	2014	2015	2016	2017	2018	2019	Average since 2012	Maximum since 2012	Dry year
Commercial	No data					368	325	311	335	368	346
Industrial	No data					120	104	138	121	138	124
Institutional	No data					1,069	3,765	3,405	2,746	3,765	2,835
Total non-residential	No data					373	373	343	363	373	375

8.4 Predicted Growth

BSC has prepared growth management strategies for urban land, rural areas and business/industrial land. Anticipated residential development from 2020 to 2036 is summarised in Table 26 and shown on Figure 38. Residential development is expected to be a mix of single and multi-residential properties (5.5%) that are BASIX compliant. The urban development is likely to be a mix of dwelling yield for the available lots with allowance for affordable housing (micro lots). The data in Table 26 is expected to be the most likely mix of dwelling yield (a combination of traditional and affordable housing) based on Council's urban land use strategy. Beyond 2036, the number of new residential connections each year is assumed to be the same as between 2032 and 2036.

Table 26: Anticipated residential development (new houses) to 2036

Stage	Vacant	Infill	New release areas	Total additional dwellings
Short-term	90	20	105	215
2 - 5 years	50	50	455	555
5 - 10 years	50	50	240	340
10 + years	43	40	125	208
Total	233	160	925	1,318

Source: BSC (2020a)

Anticipated business and industrial development from 2020 to 2041 is summarised in Table 27. Business tenancies are assumed to generate demand equivalent to a commercial property.

Table 27: Anticipated business and industrial development

Stage	Large footprint tenancies	Smaller tenancies	Industrial expansion
By 2022	-	20	20
By 2028	1	20	-
By 2031	-	20	-
By 2041	-	40	-

Source: BSC (2019b), BSC (2019c)

The resulting number of connected properties in each 10-year period is given in Table 28. Although the mix of future dwelling types is unknown, the application of the different consumption rates for BASIX single and multi-residential properties will allow for the variation in consumption based on dwelling size.

Table 28: Future connected properties

Connection Type	2020	2030	2040	2050
Single residential	1,109	1,003	907	863
Multi-residential	37	34	30	29
BASIX single residential	521	1,619	1,995	2,321
BASIX multi-residential	58	117	137	154
Total residential connected properties	1,726	2,773	3,070	3,367
Commercial	254	301	362	397
Industrial	31	41	41	41
Institutional	4	4	4	4
Non-residential connected properties	289	346	407	442
All connected properties	2,0214	3,119	3,477	3,809
Growth (total connections) % p.a.	6.6%	1.2%	1.0%	0.9%

The predicted growth in connected properties is shown on Figure 37.

The *Byron Shire Residential Strategy* (BSC, 2020b) predicts the population of Mullumbimby will be approximately 6,645 in 2036, an increase of 2,864 people since the 2016 Census (3,781 people) or 3.8 % p.a. increase in population over the 20-year period although all residents will not be served by the town water supply. Mullumbimby is expected to accommodate the largest number and percentage of additional dwellings and potential residents by 2036 (39% of the total urban population growth).

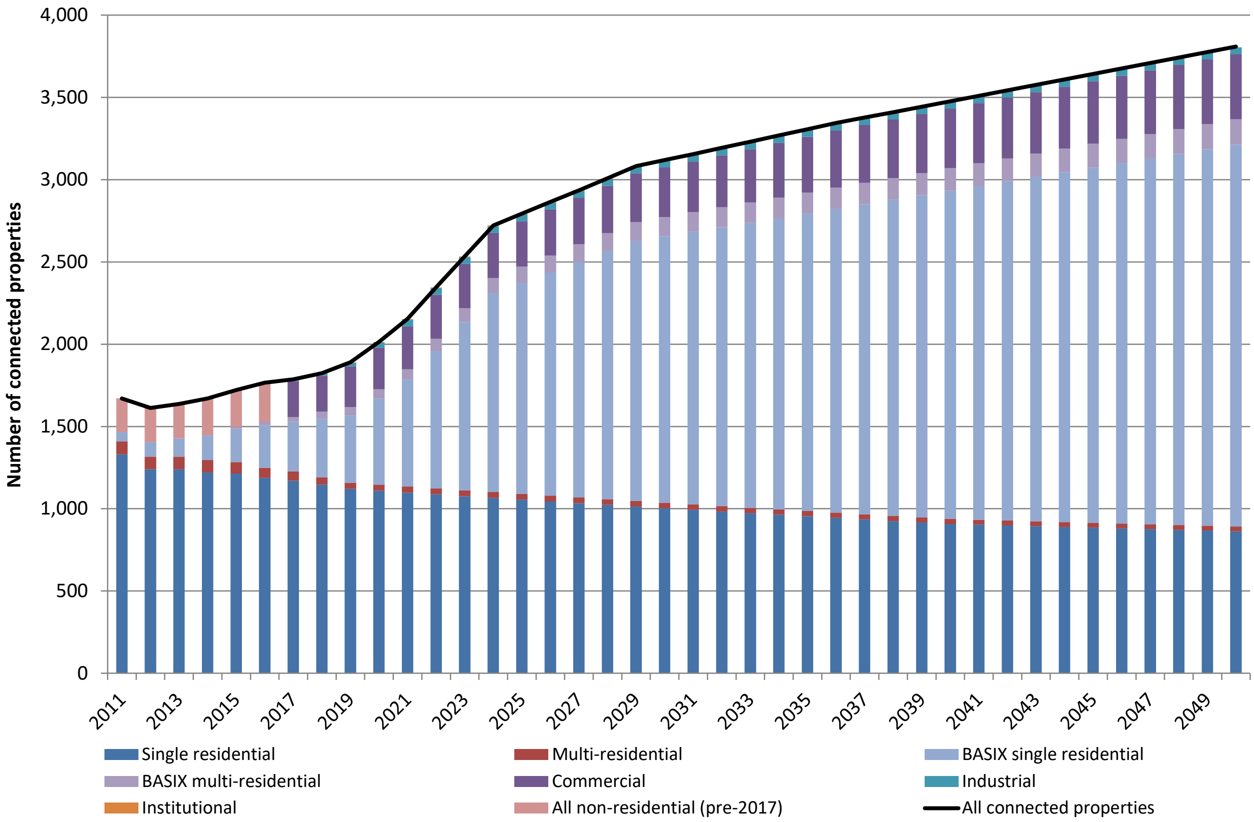


Figure 37: Forecast connected properties

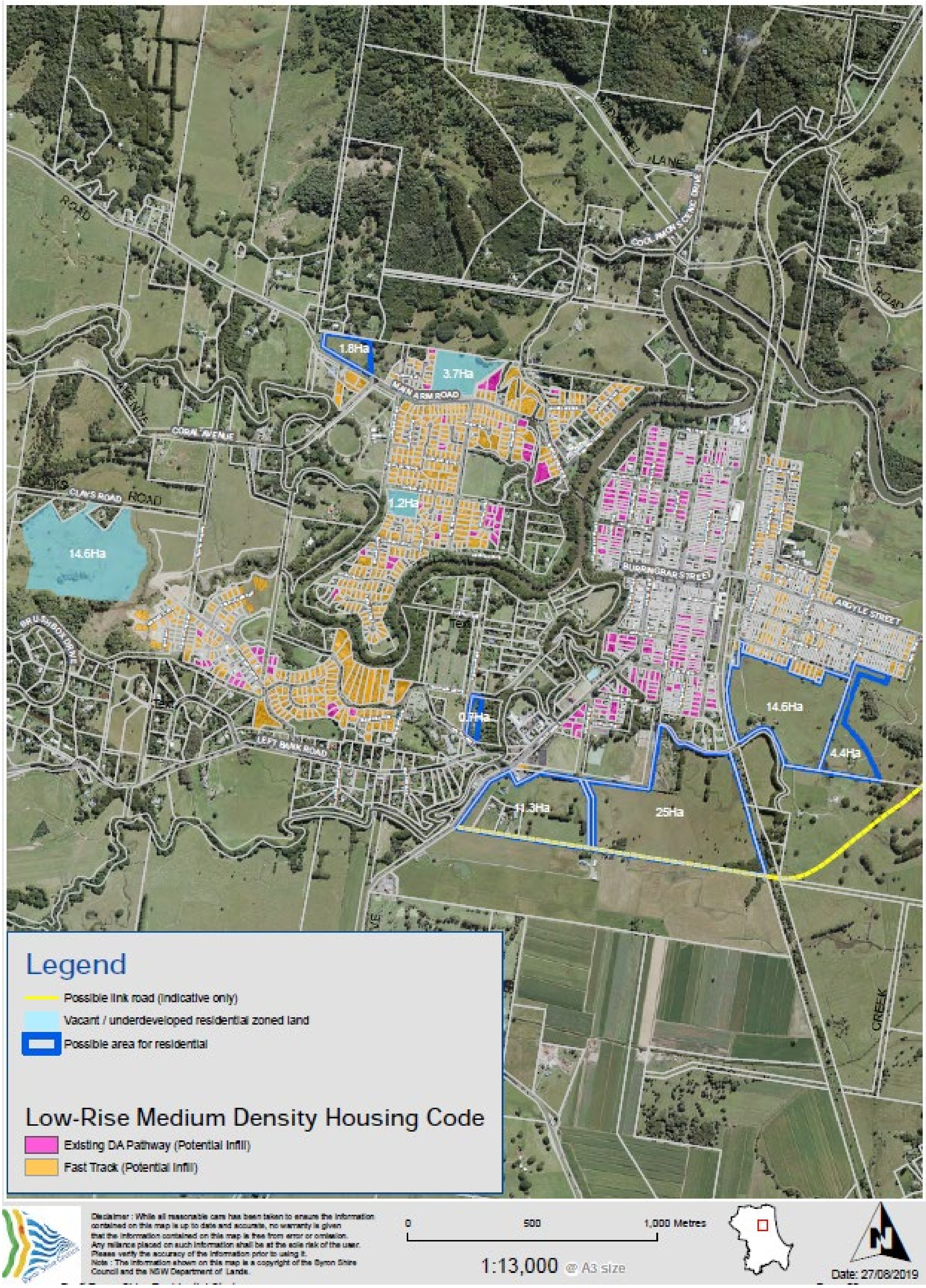


Figure 38: Potential urban housing supply - Mullumbimby

Source: BSC (2019a)

8.5 Predicted Future Demand

8.5.1 Consumption

The forecast average and dry year customer demand is shown on Figure 39.

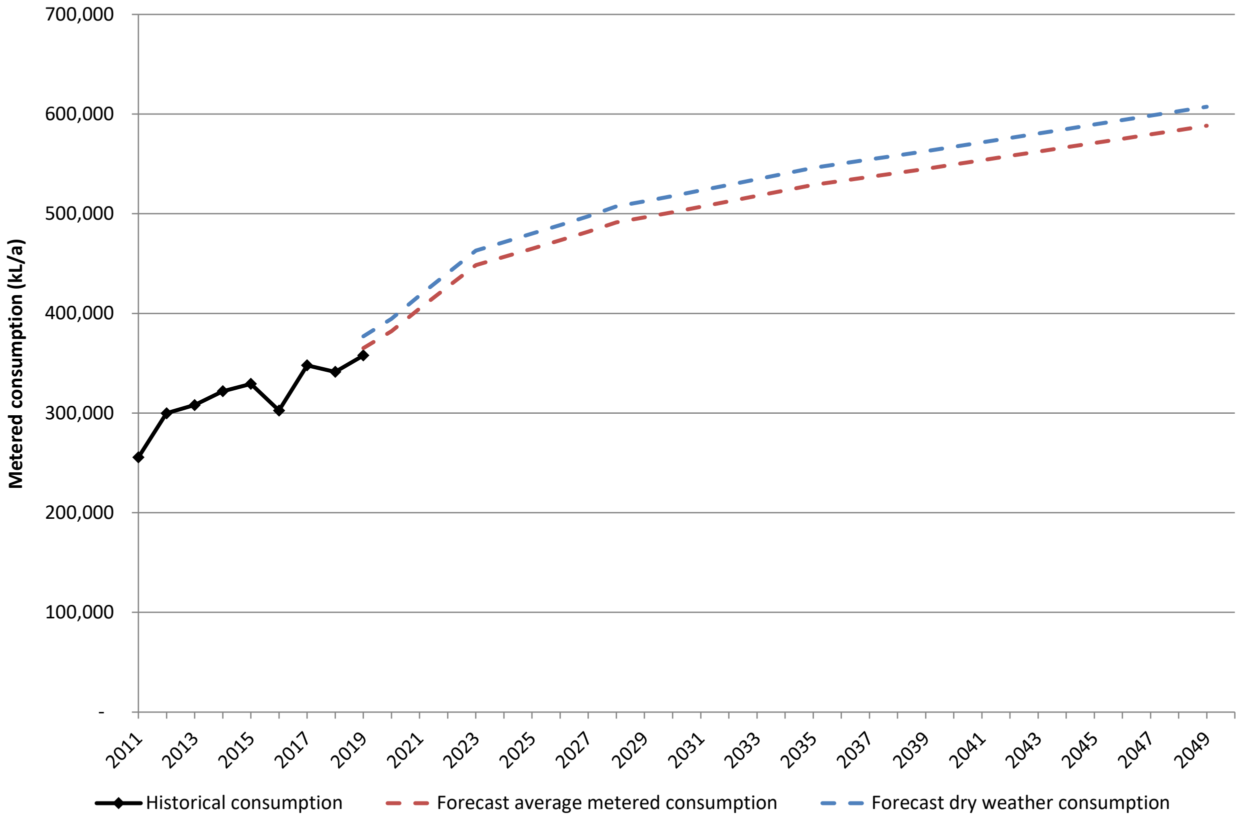


Figure 39: Forecast metered consumption - average and dry year

8.5.2 Water loss management measures

Two scenarios have been developed for water savings due to demand management:

1. No water loss management - using current average NRW = 17.3 % of raw water supply.
2. Predicted NRW with water loss savings due to pressure reduction measures implemented - NRW savings of 22 ML/a (Table 8).

The forecast dry year demand with scenarios 1 and 2 is shown on Figure 40. Forecast raw water extraction is summarised in Table 29.

Table 29: Annual demand forecast scenarios

Scenario		Demand (ML/a)			
		2020	2030	2040	2050
A1	Average demand with no water loss management	468	636	698	753
A2	Average demand with water loss savings	444	612	675	730
D1	Dry year demand with no water loss management	483	656	720	778
D2	Dry year demand with water loss savings	459	633	697	754

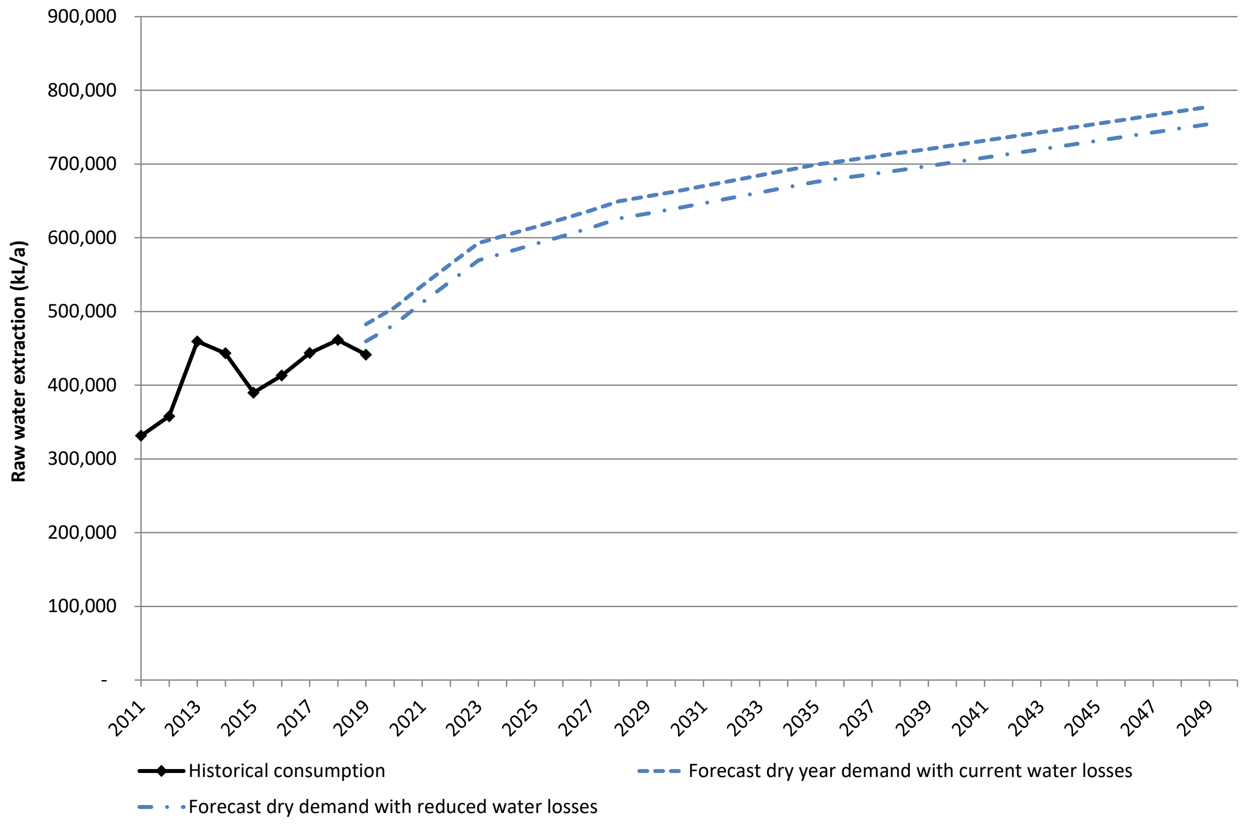


Figure 40: Dry year unrestricted demand forecast: water loss management scenario 1 and 2

8.6 Peak Day Demand

A peak day demand (PDD, WTP output and emergency supply) of 2.56 ML/d was experienced in November 2019 (Figure 24, since 2012). Average daily treated water demand (ADD) since 2012 is 1.1 ML/d. Table 30 lists the highest production days from June 2012 - May 2020 (i.e. production > 2.3 ML/day). Some days of peak demand were preceded by hot, dry conditions and in most cases, there was an obvious ramping up of water production prior to the peak and a ramping down following the peak. The data suggests that a real PDD of 2.56 ML/day (1,350 kL/d/connected property) was experienced in November 2019, following a sustained period of dry, hot weather with a peak demand ratio (PDD:ADD) of 2.3.

Data on connection types is not available to analyse the proportion of peak demand attributable to various uses. However, it is expected that increased water usage during hot, dry conditions would be primarily due to increased outdoor use such as watering gardens.

Table 30: Peak day production including emergency supply (2012 - 2020)

Date	Peak day Production (ML)	Discussion of climatic and other factors
20/9/12	2.36	Production levels ramping up on days before peak, then a low demand recorded the following day (0.305 ML) and then returning to average demand in the following days. Dry and hot month leading up to peak.
3/4/16	2.39	Production levels were average prior to the peak and remained high for 2 days then above average for the following week. High rainfall in month prior (250 mm) and high temperatures in week before and day of peak (maximum temp 29.5°C).
4/4/16	2.45	
8/6/16	2.32	Production levels were average prior to and after the peak. Very high rainfall in week prior (430 mm). Moderate temperatures in week before peak (max temp 22°C).
27/3/18	2.42	Production levels were low prior to the peak and high demand persisted for 2 days before returning to average in the week after the peak. High rainfall in week prior (120 mm). High temperatures in week before peak (max temp 30°C).
12/3/19	2.38	Production levels ramping up in the 2 days prior to the peak and high demand persisted for 2.5 weeks after the peak. Low rainfall in month prior (92 mm) and 17 mm rain in 5 days before peak. High temperatures (max temp 33°C).
1/11/19	**2.56**	Production levels were low prior to and 2 days after the peak but high demand persisted until December 2019. Very low rainfall (61 mm) in 4 months prior to the peak. High temperatures in week before peak (max temp 29.5°C).
6/11/19	2.36	

9. SECURITY OF CURRENT WATER SUPPLY

The secure yield results from Section 7.3.5 for the current and future climate are shown in Table 31. The secure yield estimates for Lavertys Gap Weir do not include the RCC emergency supply (0.5 ML/d, 183 ML/a) which is shown separately.

Table 31: Updated secure yield estimates - Mullumbimby water supply

Secure Yield (ML/a)	Historic climate (5/10/10)	1°C climate warming
Lavertys Gap Weir [1]	440	356
RCC emergency supply [2]	183	183
System security	623	539

1. Set 1 flow series - based on gauging station 203062 (upstream of weir) and Sacramento model - rainfall runoff model. Irrigation demand was assumed to be nil.

2. Intended to operate as an emergency supply only.

A comparison between historic demand and dry year demand (Scenario D2 with water loss savings) and the secure yield (Section 8.6) is provided in Figure 41. The guidelines (NSW Office of Water, 2013) do not specify the year to apply the yield with the climate experienced over the last 120 years (historic climate), the decline in yield to the projected 1°C climate warming and the decline in yield beyond that time. In the guidelines (NSW Office of Water, 2013), the 1ºC warming (assumed to occur at 2030) relates to changes from 1990 climate (i.e. 40 years of climate warming). The following assumptions have been made for this report:

- The secure yield with the current climate is assumed to represent the available supply in 2020 (as secure yield modelling includes consideration of the 2019/20 drought although this was not necessarily the worst drought on record).
- The secure yield with projected 1°C climate warming is assumed to represent the available supply in 2060 (as the climate warming data has been imposed on the 2019/20 drought in the secure yield modelling and 1°C climate warming is expected to occur in 40 years).
- Between 2020 and 2060, there is assumed to be a linear reduction in secure yield.
- Beyond 2060, the secure yield is unknown. Previous secure yield modelling methods have considered a 2°C climate warming scenario although this is not currently endorsed by the NSW Government and has not been applied here.

These assumptions are critical in assessing the target secure yield of the water supply and should be checked as new information becomes available.

Mullumbimby's demand for water is increasing with development and population growth. The current (2020) and 2050 dry year unrestricted demand are compared to the secure yield in Table 32. The RCC emergency supply pipeline improves the water supply security although it is not intended to operate any more than an emergency supply. Assuming that water loss reduction measures are implemented and the emergency supply is available, the supply will be secure until 2027 (Figure 41). After this time, the existing system cannot meet forecast demand without the potential for more frequent, longer and severe water restrictions.

The supply deficit at 2050 (excluding the emergency supply) will be 377 ML/a. This will be the target increase in yield with source augmentation for this strategy.

Table 32: Comparison of demand and secure yield

Component (ML/a)	2020	2050
Dry year unrestricted demand (including water loss reduction)	483	754
Secure yield - weir supply	440	377
RCC emergency supply	183	183
Total system yield	623	560
Supply deficit (excluding emergency supply)	+43	377

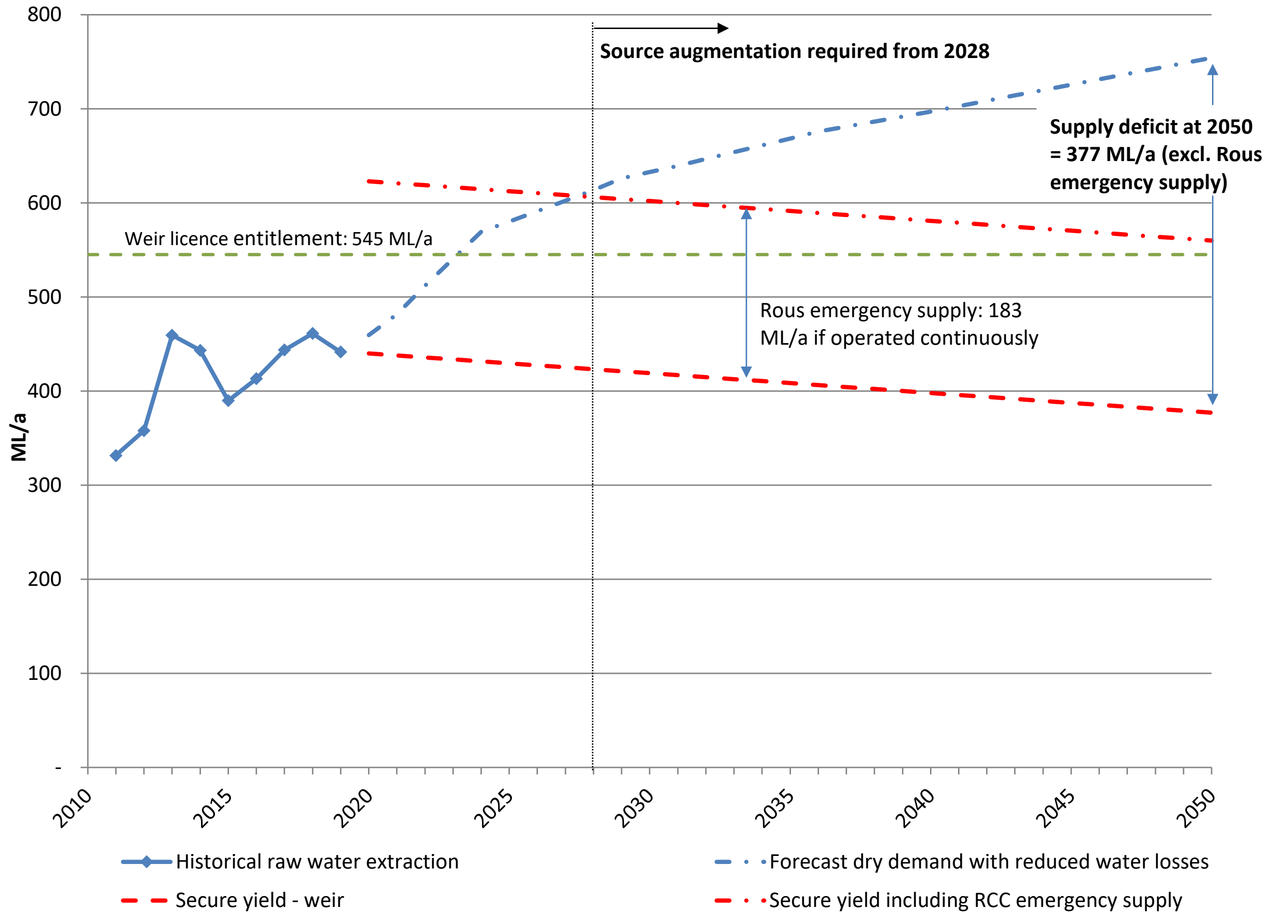


Figure 41: Comparison of forecast raw water demand, licence entitlement and secure yield

An increase in the weir licence extraction limit will be required from 2023 depending on the reliance on the supply from the weir.

10. WATER SUPPLY OPTIONS

10.1 Supply-Side Options

Supply options have been identified through previous studies (JWP, 2005) as well as new options identified. The following options have been identified to potentially increase the water supply.

10.1.1 Raising Lavertys Gap weir

JWP (2005) determined that the total weir storage required to maintain a typical environmental flow condition (Section 6) and supply an average demand of 450 ML/a was 432 ML (an increase of 359 ML). Preliminary analysis undertaken by JWP (2005) indicated that this storage would be achieved with a FSL of 120 m AHD (3.84 m raising of the weir). The area inundated at this height was expected to be approximately 17.77 ha (an increase of 14.67 ha). Separate geotechnical, ecological and structural inspections were undertaken at the Lavertys Gap Weir site (September 2003). Preliminary conclusions of JWP (2005) indicate that this option is feasible and that there are a number of engineering possibilities to achieve the result.

It is noted that water supply works approvals are not permitted to be granted or amended for in-river dams on third order or higher streams (including the Wilsons River at Lavertys Gap) in the Bangalow Area water source under the *Water Sharing Plan for the Richmond River Unregulated, Regulated and Alluvial Water Sources 2010*. The Bangalow Area water source has been classified as high instream values and high hydrological stress of hydrologic risk (NSW DPI Water, 2016d). The Water Sharing Plan is to be reviewed by June 2021.

10.1.2 Off-stream storage

Two sites were identified in JWP (2005) as possible locations to provide the additional storage required (assumed to be 430 ML). JWP (2005) assumed that the raw water from the weir would be transferred to the storage prior to treatment. Initial environmental and geotechnical assessment did not identify any problems with the identified sites. Other sites have been considered in this report (Section 12.3)

Under the *Water Sharing Plan for the Richmond River Unregulated, Regulated and Alluvial Water Sources 2010*, applications for conversion of licences to a high flow access licence entitlement (commencing at the 30th percentile flow) for up to five times the existing entitlement would be considered in the Bangalow Area water source (NSW DPI Water, 2016d).

10.1.3 Regional Interconnection

RCC bulk water supply

BSC currently distributes water purchased from the RCC regional supply to Bangalow, Brunswick Heads, Byron Bay, Suffolk Park, Ocean Shores, New Brighton, South Golden Beach and Billinudgel (all areas except Mullumbimby). The RCC emergency supply to Mullumbimby is available during drought (Section 3). In 2019, RCC supplied approximately 2,700 ML to Byron Shire Council for distribution to its customers and this demand is predicted to increase to 3,500 ML/a by 2050 (Hydrosphere Consulting, 2020). Full connection of the Mullumbimby supply area to the Rous regional supply would require an additional 730 ML/a by 2050 (Section 8.5).

JWP (2005) assessed the option of abandoning Lavertys Gap Weir and connection of Mullumbimby to the RCC regional bulk water supply. The study found that the weir could be retained if required for heritage reasons and may be used to supply water to the hydro-electric power station if it was reinstated. The existing emergency supply pipeline would need to be assessed for suitability as a permanent supply and would need to be extended to service the whole of Mullumbimby.

The total dry year demand for water at 2060 for the RCC regional water supply area is predicted to be between 16,000 ML/a and 16,700 ML/a, an increase of approximately 5,000 ML/a over current (2020) dry year demand. RCC has compared the water supply demand to the secure yield of the system (13,350 ML/a) and determined that a new regional water source will be required from 2024 (Hydrosphere Consulting, 2021a). The *Future Water Project 2060 Integrated Water Cycle Management Strategy* (Rous Future Water Project 2060, Hydrosphere Consulting, 2021a) outlines RCC's preferred strategy for augmentation of water supply sources. This project builds on extensive investigations undertaken by RCC over the last few decades to identify potential source augmentation options and enable selection of a preferred long-term strategy. The Future Water Project 2060 documents the outcomes of detailed investigations undertaken regarding potential source augmentation options and implementation scenarios for the regional water supply. The scenarios were compared using a multi-criteria analysis (MCA) considering environmental, social and financial outcomes.

Following consultation on the potential options and scenarios in 2020, and a resolution of RCC [61/20], the long-term strategy was developed to include a diversified portfolio of actions to meet the region's water security needs. Stage 1 (2021 - 2025) of the preferred scenario includes Marom Creek WTP treating groundwater from Alstonville in addition to existing surface water supplies from Marom Creek weir. Stage 2 (2026 -2029) of the preferred scenario will include the implementation of the Tyagarah groundwater source as a primary supply and maintaining Woodburn groundwater as a dry period supply. Source augmentation options beyond Stage 2 will require further investigation but will include additional groundwater schemes, desalination or water recycling (Figure 42).

The Rous Future Water Project 2060 will also include:

- Ongoing implementation of the *Regional Demand Management Plan 2019-2022* and regular review and update of the plan.
- Water loss management.
- Smart metering.
- Ongoing review and update of drought management requirements.
- Development and implementation of a direct potable reuse pilot scheme.
- Additional investigations into the feasibility of indirect potable reuse as part of the regional water supply.
- Ongoing investigations into the preferred long-term source augmentation strategy.
- Stakeholder engagement through a number of methods.

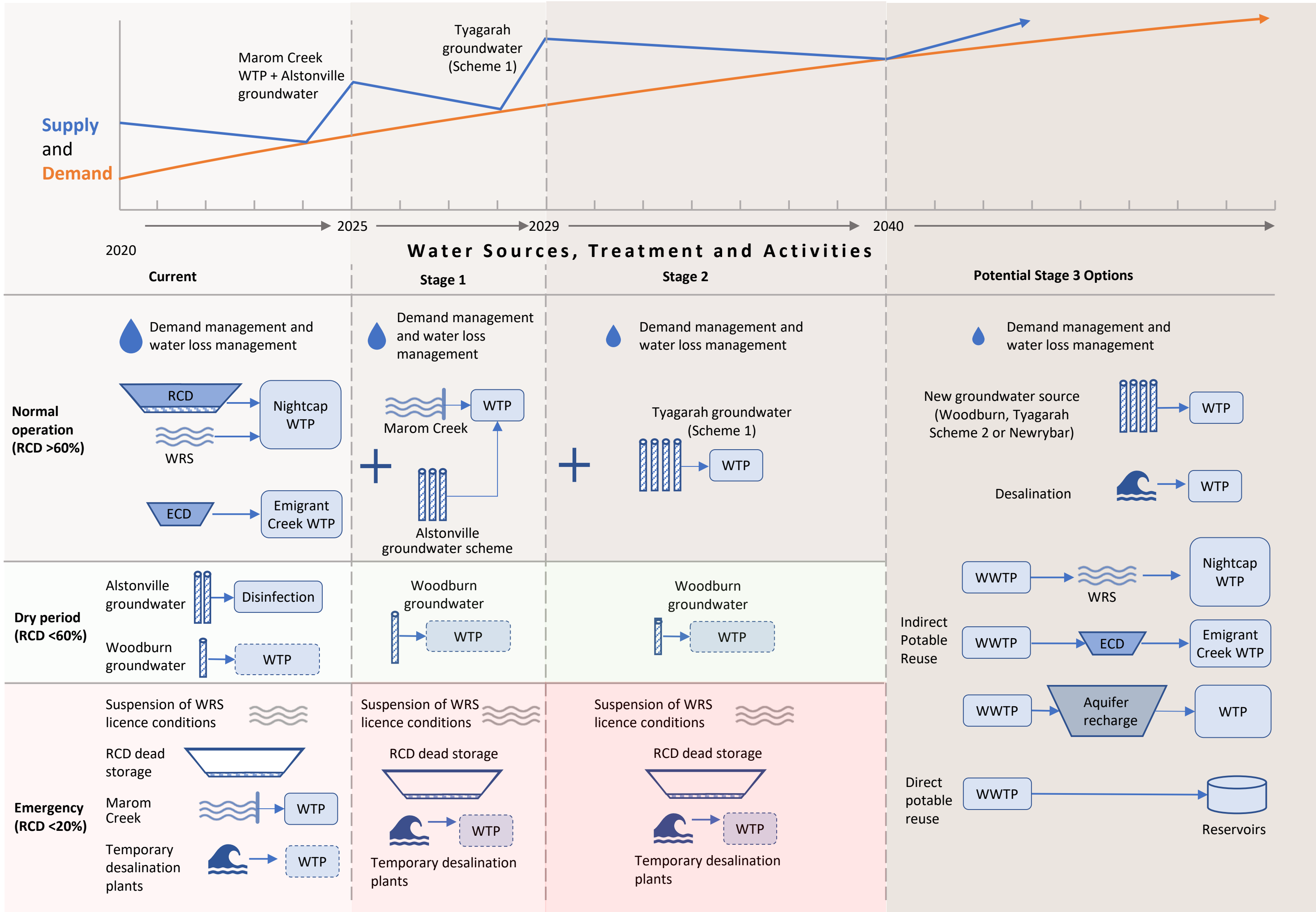


Figure 42: Staging of water source augmentation - RCC Future Water Project 2060

Source: Hydrosphere (2021)

Wider Northern Rivers region

The *Northern Rivers Regional Bulk Water Supply Study* (Hydrosphere Consulting, 2013) examined potential scenarios for interconnecting the region's water supplies to address water security issues. The study assesses five scenarios which each involve integrating Mullumbimby into the RCC regional supply scheme. The five scenarios are summarised in Table 33.

Table 33: Interconnected regional water supply scenarios

<table>
<tr><th></th><th>Means of supply augmentation</th><th>Means of interconnection</th></tr>
<tr><td>Scenario 1</td><td>Desalination</td><td rowspan="3">Connect Nimbin, the Channon, Mullumbimby and Casino to the RCC supply and connect the RCC supply area to the Tweed supply area via a pipeline between Ocean Shores and Pottsville.</td></tr>
<tr><td>Scenario 2</td><td>Construct 50,000ML Dunoon Dam and Raise Clarrie Hall Dam</td></tr>
<tr><td>Scenario 3</td><td>Construct 85,000ML Dunoon Dam</td></tr>
<tr><td>Scenario 4</td><td>Raise the Toonumbar Dam by 20m</td><td rowspan="2">Connect Nimbin, the Channon, Mullumbimby, Casino and Kyogle to the RCC water supply and connect the RCC supply area to the Tweed supply area via a pipeline between Ocean Shores and Pottsville.</td></tr>
<tr><td>Scenario 5</td><td>Raise the Toonumbar Dam by 10m and raise Clarrie hall dam</td></tr>
</table>

The study concluded that significant financial, social and environmental benefits are expected to be gained from interconnecting the regions water supply as well as improving the resilience and flexibility of the system. These options would require the cooperation of the Northern Rivers Joint Organisation of Councils, RCC, Tweed Shire Council and individual LWUs including Byron Shire Council. These options are also included in the long list of options in the Draft *Regional Water Strategy for the Far North Coast* (DPIE, 2020). The long-term strategy for Mullumbimby considers interconnection with the RCC regional supply in the short-term. In the longer term, RCC and other regional water supply authorities may consider additional interconnection options.

10.1.4 Stormwater reuse

The *Northern Rivers Regional Bulk Water Supply Study* (Hydrosphere Consulting, 2013) considered large-scale urban stormwater reuse as a future water source. Urban areas generate large amounts of stormwater due to impervious surfaces such as roads, pavements, car parks and buildings. Stormwater can be an alternative to mains water supply use, particularly for non-potable uses. However, there are health and environmental risks associated with the use of stormwater due to its associated pollutants. Unlike recycled water, stormwater supplies are very sporadic, especially in a sub-tropical climate of high rainfall during summer and low rainfall during winter such as the Northern Rivers. As a result, stormwater is very climate dependent with supply in dry times being unreliable. Any stormwater storage would need to be large enough to capture large rainfall events during the wet season and supply it throughout the low rainfall times of the dry season. The regional study found that the large-scale reuse of stormwater often contributes very little to the reduction in potable water demand.

Stormwater as a substitute for environmental flows was not considered in detail in JWP (2005) due to the low quantity of stormwater during dry weather (and low stream flow) when environmental flows would be required. In addition, additional treatment will be required to bring the water to an acceptable quality, the distance and elevation of the town and the treatment plant would require significant investment in a transfer system and there would be high ongoing operation costs.

Improving stormwater management is included in the long list of options in the *Draft Regional Water Strategy for the Far North Coast* (DPIE, 2020).

10.1.5 Desalination

The source of water for desalination can include seawater, brackish estuarine water, brackish groundwater and sewage effluent. There are currently no desalination plants in the Northern Rivers region. The *Northern Rivers Regional Bulk Water Supply Study* (Hydrosphere Consulting, 2013) found that desalination presents an attractive option for future water supply for the Northern Rivers region due to its potential to supply a virtually unlimited amount of water that is independent from climate impacts such as drought. Desalination is approaching a level of technological maturity where it can underpin future urban water needs at a reasonable cost if water efficiency, water recycling, return flow and river source options are fully utilised. There are many issues to consider including the source of water (either seawater, estuarine or brackish groundwater), brine disposal, energy consumption and costs. The Northern Rivers study included a supply scenario with a new 70 ML/d marine desalination facility, potentially located between Ocean Shores and Pottsville to supply the whole region (Tweed Shire, RCC bulk supply, Casino, Nimbin and Mullumbimby).

The RCC Future Water Strategy (MWH, 2014) considered desalination plant(s) that could be staged with smaller modules and augmented as required. Ballina Shire Council also considered a 20 ML/d desalination plant to supplement the regional RCC bulk supply. The Mullumbimby Drought Management Plan (HydroScience, 2014) suggests that a temporary mobile desalination plant could be considered as an option to provide a flexible water supply solution during an emergency situation. It proposes that a 0.5 ML/d mobile desalination plant could be installed at Brunswick Heads with water transferred through the emergency pipeline which was built to connect Mullumbimby to the RCC water supply network.

Decentralised desalination and regional desalination are included in the long list of options in the Draft Regional Water Strategy for the Far North Coast (DPIE, 2020).

10.1.6 Groundwater

A new groundwater source could be developed to supplement the supply from Lavertys Gap weir. Groundwater supplies in Woodburn and the Alstonville area have been used by RCC and Ballina Shire Council to supplement surface water sources. The current level of groundwater use for urban water supply in the region is low with groundwater used infrequently to augment water supply during drought periods. Groundwater has also been considered as a new supply source by LCC for Nimbin, RVC for Casino and Tweed Shire and RCC to augment their major supplies. The *Northern Rivers Regional Bulk Water Supply Study* (Hydrosphere Consulting, 2013) considered small-scale localised supplies in the regional supply scenarios.

Characterising coastal groundwater resources is included in the long list of options in the *Draft Regional Water Strategy for the Far North Coast* (DPIE, 2020).

10.1.7 Indirect potable reuse of treated wastewater

Indirect potable reuse (IPR) involves delivery of highly treated reclaimed water directly into an existing major storage dam or possibly a groundwater source, for subsequent extraction, treatment and transfer using existing distribution infrastructure. Through the use of reclaimed water from an urban wastewater treatment plant, this option can provide a new water source that is always available even in drought conditions. The yield of the supply is only limited by the effluent flows and the capacity of the reclaimed water treatment facilities. The process already occurs unintentionally in a number of locations within Australia e.g. the RCC Wilson River Source intake is downstream of Bangalow STP. IPR has also been considered by RCC as part of its Future Water Project 2060 to augment existing supplies. The water supply augmentation options assessment for the Tweed District considered advanced treatment of 75% of the available effluent from the Banora Point WWTP and Kingscliff WWTP and pumping of the water through a 50 km pipeline to Clarrie Hall Dam but concluded that the option is expensive and not socially acceptable. Richmond Valley Council also considered IPR from Casino STP to the river 2 km upstream of Jabour weir to augment its water supply.

Indirect potable reuse of purified recycled water is included in the long list of options in the *Draft Regional Water Strategy for the Far North Coast* (DPIE, 2020).

10.1.8 Upgrade the raw water supply from the weir

In normal operation, water flows into the channel from the weir storage and flows by gravity to the WTP. A significant quantity of water leaks from the channel through cracks in the channel walls. This flow re-enters Wilsons Creek downstream of the weir and is not of concern when the weir is overtopping as it provides additional environmental flows and the water is not required as raw water supply. When the water level drops below the weir crest, this volume of leakage can be significant, and the water level can drop quickly. Council has attempted to repair sections of the channel but this is considered to be ineffective due to the large extent of structure defects.

The raw water pump (15 L/s) and pipeline within the channel are generally used when the water level at the weir is below the level of the weir crest. Until recently, the channel stop board leaked and a significant amount of water was still able to enter the channel. The stop board was replaced in January 2020 and this has now been resolved. As the WTP operates at 45 L/s and there is no raw water storage at the WTP, the pump is only used as a temporary measure.

Council has investigated options for the transfer of raw water to the WTP as discussed in Section 12.6. Once implemented, the preferred option will minimise the leakage in the raw water supply.

10.1.9 Brunswick River surface water sources

Surface water sources in the Brunswick River have previously been considered for augmentation of the Rous regional water supply (Public Works Department, 1984) but not considered in detail due to the limited opportunities for instream dams. The tidal limit of the Brunswick River estuary extends to Mullumbimby and the estuary is a Habitat Protection Zone within the Cape Byron Marine Park. Estuarine surface waters would require desalination as discussed in Section 10.1.5. The construction of instream dams is prohibited in the lower catchment water sources (including in the Lower Brunswick River water source, Figure 43) under the *Water Sharing Plan for the Brunswick Unregulated and Alluvial Water Sources 2016.*

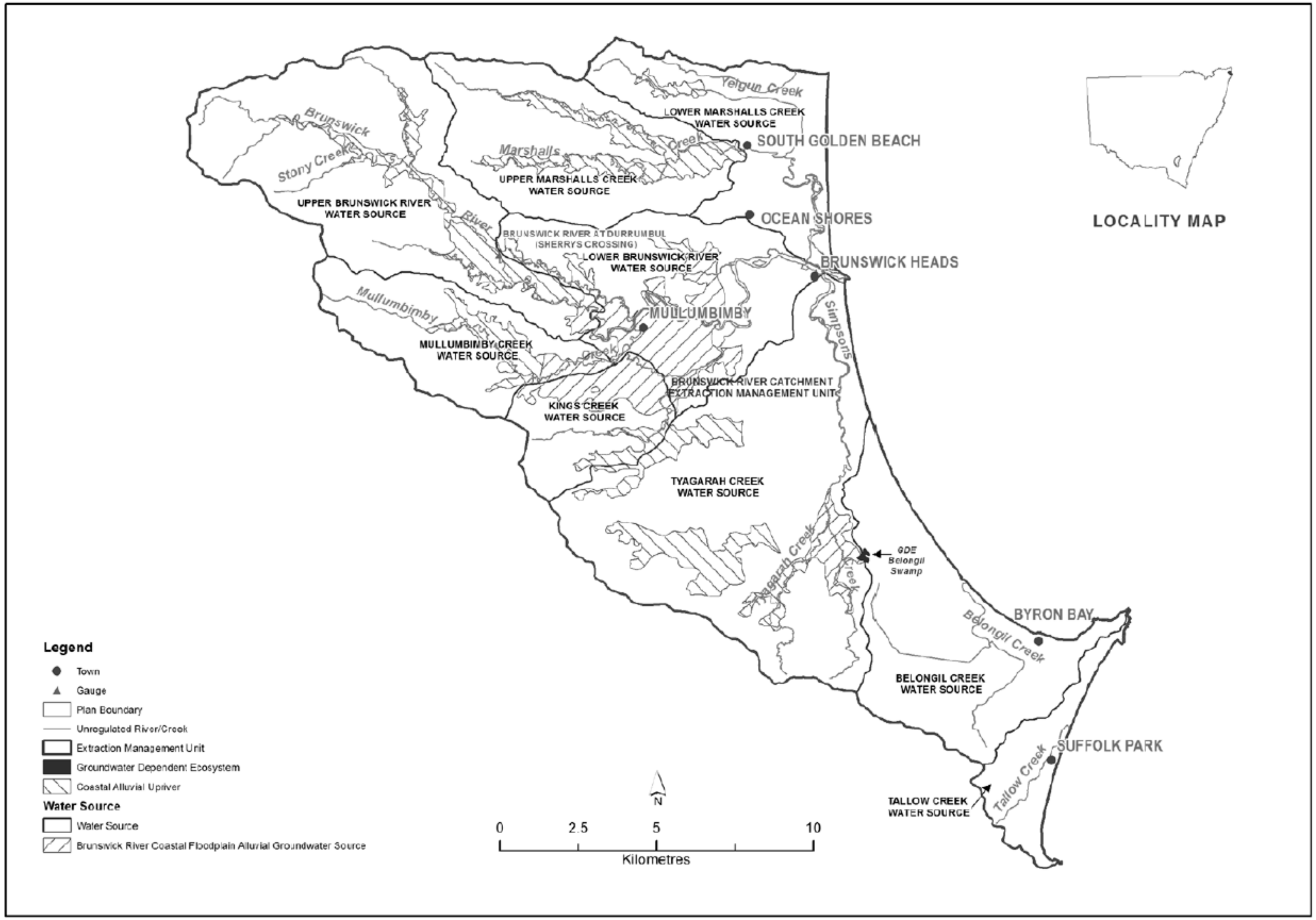


Figure 43: Water Sharing Plan map - *Water Sharing Plan for the Brunswick Unregulated and Alluvial Water Sources 2016*

Source: NSW DPI Water (2016b)

The *Water Sharing Plan for the Brunswick Unregulated and Alluvial Water Sources 2016* does not permit the granting of new unregulated river access licences. Entitlements can be purchased from existing licences consistent with the dealing rules and can also be converted to high flow access licences (commencing at the 30^{th} percentile flow) for up to 5 times the existing entitlement. However, the high flow entitlements are capped at 187 ML/a, 297 ML/a and 440 ML/a for the Kings Creek, Mullumbimby Creek and Upper Brunswick River water sources respectively (Figure 43). The construction of instream dams is not prohibited in these upper catchment water sources (NSW DPI Water, 2016b).

The social, environmental and economic impacts of establishing a surface water source in the freshwater reaches of the Brunswick River have not been considered in detail. The Background Document for the *Water Sharing Plan for the Brunswick Unregulated and Alluvial Water Sources 2016* (NSW DPI Water, 2016b) identifies threatened species known or modelled to be present in the upper catchment water sources, medium-high hydrologic stress or hydrologic risk and medium instream values. Due to the Water Sharing Plan constraints, legislative risks with this option are considered to be significant. In addition, either an instream dam and potentially an off-stream storage is assumed to be required to provide the required yield. Environmental flows and fish passage requirements will affect the yield.

1.1 Demand-Side Options

The following options have been identified to reduce the demand for raw water from Lavertys Gap weir.

10.1.10 Demand management

The RDMP includes actions for BSC to reduce demand (Section 4). Most of these options are still under-development and the full cost and demand reduction are unknown. Water loss reduction measures have been assumed to be successful (Section 8.5.2) and are ongoing. While additional demand management measures may be introduced, these have been discounted through the development of the RDMP and will not be considered further in this report. BSC will continue to incorporate demand management measures in water supply planning and will collaborate with RCC on ongoing review of the RDMP which may identify additional demand management measures.

10.1.11 Increased drought restrictions

The water supply is required to meet the NSW Government's security of supply rule (5/10/10) where the duration of restrictions does not exceed 5% of the time and frequency of restrictions does not exceed 10% of years (i.e. 1 year in 10 on average) and severity of restrictions does not exceed 10%. Systems must be able to meet 90% of the unrestricted water demand during water restrictions through a repetition of the worst recorded drought. BSC has developed a drought restriction policy for Mullumbimby and a set of triggers (Section 3) for introduction of restrictions. A more stringent set of triggers may be introduced to reduce demand earlier and prolong the supply available from the weir (i.e. a lower level of service may be acceptable to the community). However, a secure supply would minimise the financial implications of emergency responses including use of the RCC emergency supply. The social implications of a more stringent restriction regime have not been assessed. Community consultation is required to test the willingness to accept more frequent or more severe water restrictions.

10.1.12 Rural effluent reuse

JWP (2005) considered that any treated effluent available for reuse from the Brunswick Valley STP is likely to be used for agricultural reuse. The recycled water from Brunswick Valley STP is delivered to the Main Arm Recycled Water Scheme and used on two local farms. The draft Byron Shire Effluent Management Strategy 2017-2027 (BSC, 2017) has been prepared to establish the path for effluent management in the Byron Shire over the next ten years. The Main Arm Recycled Water Scheme has been the least successful effluent management application in Byron Shire with the scheme failing to meet community aspirations. In theory, rural reuse projects are able to utilise high volumes of effluent, however the uncertainty with the operation of rural schemes due to external limitations such as high rainfall (low demand for alternative water sources) and the business decisions of private landowners increases the risks associated with the development of rural schemes. The effluent management strategy proposes expansion of the existing rural scheme, a new wetland regeneration and biomass cropping scheme (Sustainability Reserve) and wetlands at Ocean Shores. The benefit of rural reuse depends on the demand for potable water substitution (which is minimal for agricultural applications) and water quality requirements.

Providing purified recycled wastewater for industry and rural users is included in the long list of options in the *Draft Regional Water Strategy for the Far North Coast* (DPIE, 2020).

10.1.13 Urban effluent reuse

Recycled water for non-potable supply to households and businesses is available in some parts of the region including Ballina Shire and Byron Bay. Rebates are available for non-residential customers through the Sustainable Water Partner Program (in the RDMP) where the property is not required to connect to an approved recycled water scheme as part of BASIX. Council also provides customers with the opportunity of funding the portion of the connection to the recycled water scheme that is not eligible for a rebate through increased future recycled water bills (rather than up-front payments). The RDMP includes an action for Council to document a strategy for implementation of the recycled water schemes in their LGAs including areas to be serviced now and in the future, connection types, customers eligible for the rebate, funding, administrative requirements and marketing/promotional activities.

10.1.14 Private supplies

Properties not connected to the town water supply rely on household rainwater tanks, bore water or direct river extraction. In times of prolonged drought, rainwater tanks may be depleted or groundwater/surface water extraction may be restricted and these private water supplies will purchase potable water from town water supplies via water carters. While BASIX mandates the inclusion of rainwater tanks in new developments, additional incentives are required for existing customers to install a rainwater tank or for new developments to install a larger tank. The RDMP includes rainwater tank rebates for customers in the RCC bulk supply area and equivalent rebates to customers of the local water supply schemes (including Mullumbimby). This is complementary to the BASIX scheme which requires rainwater tanks to be installed for all new developments in NSW. Council also provides guidance to customers for tank selection by roof catchment and usage. Rainwater tanks provide opportunities for reduction in demand during normal climatic conditions (i.e. when tanks are refilled by rain). During droughts, the effectiveness of rainwater tanks diminishes with larger tanks able to store more water for dry periods.

The BASIX requirements will address any demand reduction opportunities from rainwater tanks in new developments and rebates can assist with encouraging water efficiency in pre-BASIX houses (although all rainwater tanks supplying internal uses are required to have potable water top-up from the mains supply). Rainwater tanks in existing water supply areas are likely to fail in severe drought and customers will rely on town water supplies. This was experienced in recent (2019/20) droughts with significant demand for water carting to properties serviced by rainwater tanks across the region (from town water supplies).

10.1.15 RCC emergency bulk water supply

The emergency supply pipeline from the RCC bulk supply at St Helena is the current back-up supply for Mullumbimby (Section 3).

1.2 Other Infrastructure Requirements

Some of the options will require relocation or replacement of existing infrastructure or new infrastructure for raw water transfer or treatment. The WTP is more than 80 years old and despite some upgrades, it is likely that the plant will require major refurbishment or replacement in the near future (Sections 6.3 and 12.6). In addition, the location of the WTP will not be suitable for all options. For the options relying on raw water supply from the weir, secure operation of the raw water channel is required (Section 12.7).

11. COARSE ASSESSMENT OF OPTIONS

A preliminary assessment of the supply-side and demand-side options was undertaken to document the attractiveness and issues related to each option and develop a short-list for further consideration. The preliminary assessment criteria are given in the following table. Economic criteria were not assessed in the coarse assessment but will be considered as part of detailed option and scenario assessment.

Table 34: Coarse assessment criteria - supply-side and demand-side options

Criteria	Measure
Beneficial	The option is expected to result in a measurable improvement in water security through a reduction in water demand, an increased water supply or both.
Safe/ fit for purpose	The option meets water quality and/or health legislation and guidelines relevant to its intended use.
Availability/ reliability	The option can supply water when most needed (i.e. drought).
Compatibility	Compatibility of the option with existing infrastructure or operations - additional infrastructure required to enable combination with existing systems is feasible.
Acceptability	Social (prevailing community opinion), political, heritage and legal (current regulatory environment).
Timeliness	Potential to be implemented efficiently (lead time including studies required, approval requirements, and construction timeframe).
Technical feasibility	Proven and reliable technology that can be applied with certainty.
Environmental sustainability	Ecological impact and resource use - known issues and potential footprint.

The coarse screening assessment was undertaken using the currently available information as reported in previous studies. The assessment outcomes are (Table 35):

Good the option is expected to fully achieve the assessment criteria objectives

Partial the option is expected to partially achieve the assessment criteria objectives

Poor the option is not expected to achieve the assessment criteria objectives

The following options will be considered further including detailed assessment of social, environmental and financial implications:

- Do nothing (for comparison with augmentation options).
- Raising Lavertys Gap weir.
- Off-stream storage.
- Permanent connection to the RCC bulk water supply.
- Groundwater.
- Upgrade the raw water supply from the weir.
- Urban effluent reuse.

Table 35: Preliminary assessment of options

No.	Option	Beneficial	Safe/ fit for purpose	Availability/ reliability	Compatibility	Acceptability	Timeliness	Technical feasibility	Environmental sustainability	Conclusion
1	Raising Lavertys Gap weir	Storage will increase but the expected need for environmental flows and fish passage will affect the yield.	Raw water quality will be affected but WTP processes are expected to be adequate.	The expected need for environmental flows will affect the supply yield, particularly at low flows.	Relocation of some raw water transfer infrastructure will be required. Land acquisition will be required.	Does not comply with current legislation but may be considered as part of Water Sharing Plan review. Some community opposition is expected.	Will require significant lead time for approvals.	Technically feasible.	Loss of biodiversity will result but could be offset.	Further consideration is recommended.
2	Off-stream storage	Storage will increase but the expected need for environmental flows and fish passage will affect the yield.	Raw water quality can be managed.	Storage of high flows will provide security during drought.	New raw water transfer infrastructure and relocation of WTP will be required depending on location of storage. Land acquisition will be required.	Likely to be considered acceptable for the majority of the community.	Will require significant lead time for approvals.	Technically feasible.	Minimal impact depending on location.	Further consideration is recommended.

No.	Option	Beneficial	Safe/ fit for purpose	Availability/ reliability	Compatibility	Acceptability	Timeliness	Technical feasibility	Environmental sustainability	Conclusion
3	Permanent connection to the RCC bulk water supply	Secure long-term supply assuming RCC Future Water Strategy is implemented.	High quality	Reliable assuming RCC Future Water Strategy is implemented.	Extension of water transfer system required.	Likely to be considered acceptable	Minimal lead-time	Technically feasible.	Minimal impact.	Further consideration is recommended.
4	Stormwater reuse	Not likely to significantly contribute to reduced demand or increased supply.	Treatment will be required depending on end use.	Climate dependent with supply in dry times unreliable.	Additional storage, transfer, treatment and distribution infrastructure required.	Likely to be considered acceptable	Will require significant lead time for approvals.	Technically feasible.	Minimal impact.	Not recommended.
5	Desalination	Unlimited increase in supply.	Treatment required.	Climate independent.	Estuarine and ocean water sources are a significant distance from Mullumbimby. Significant transfer, treatment, distribution and waste disposal infrastructure required.	Likely to be considered acceptable if energy use can be offset.	Will require significant lead time for approvals.	Technically feasible.	High energy use but can be offset.	Not recommended as a local supply option for Mullumbimby but potentially advantageous as a larger regional supply option.

No.	Option	Beneficial	Safe/ fit for purpose	Availability/ reliability	Compatibility	Acceptability	Timeliness	Technical feasibility	Environmental sustainability	Conclusion
6	Groundwater	Assumes adequate supply can be found.	Treatment will be required depending on source water quality.	Will be impacted during drought.	Additional treatment and transfer infrastructure required.	Likely to be considered acceptable.	Potentially significant lead time.	Technically feasible.	Minimal impact.	Further consideration is recommended.
7	Indirect potable reuse	Constant source of water.	Treatment required.	Climate independent.	Transfer system (pumping and pipeline) from Brunswick Valley STP will be significant.	Community opposition is expected. Regulatory requirements are unknown but there is a risk that approval would be refused on health grounds.	Potentially significant lead time. NSW government policy has not been developed for planned indirect potable reuse.	Technically feasible.	Minimal impact if appropriately treated.	Not recommended.
8	Upgrade the raw water supply from the weir	Increased supply during low flows through reduced wastage.	No change from current.	Source augmentation will still be required.	Transfer system modifications and raw water storage will be required.	Likely to be considered acceptable.	Minimal lead-time.	Technically feasible.	Minimal impact.	Further consideration is recommended.

No.	Option	Beneficial	Safe/ fit for purpose	Availability/ reliability	Compatibility	Acceptability	Timeliness	Technical feasibility	Environmental sustainability	Conclusion
9	Northern Rivers regional interconnection	Secure long-term supply assuming RCC Future Water Strategy and Tweed Shire Council source augmentation are implemented.	Existing treatment facilities are acceptable.	Reliable assuming RCC Future Water Strategy and Tweed Shire Council source augmentation are implemented.	Transfer system will be required.	Likely to be considered acceptable.	Potentially significant lead time. RCC and Tweed Shire Council are implementing the next stage of their water strategies independent of a regional approach.	Technically feasible.	Minimal impact.	Not recommended as a local supply option for Mullumbimby but potentially advantageous as a long-term regional supply option.
10	Brunswick River surface water source (freshwater)	Yield has not been assessed but either instream or off-stream storage is assumed to be required to provide the required yield. The need for environmental flows and fish passage will affect the yield.	Treatment will be required depending on source water quality.	Will be impacted during drought.	Transfer system may be significant depending on source location. Treatment facility required.	Does not comply with current legislation but may be considered as part of Water Sharing Plan review. Some community opposition is expected.	Potentially significant lead time.	Assumed to be technically feasible.	Potentially high energy use and impact on biodiversity but could be offset.	Not recommended as a local supply option for Mullumbimby

No.	Option	Beneficial	Safe/ fit for purpose	Availability/ reliability	Compatibility	Acceptability	Timeliness	Technical feasibility	Environmental sustainability	Conclusion
11	Demand management (RDMP)	Demand reduction expected.	No change from current.	Source augmentation will still be required.	No change from current	Likely to be considered acceptable	Minimal lead-time	Technically feasible.	Minimal impact.	Implementation of RDMP actions will form part of the long-term strategy.
12	Increased drought restrictions	Demand reduction expected during drought conditions.	No change from current.	Source augmentation will still be required.	No change from current	Community consultation has not been undertaken but the community may be prepared to forgo water security to reduce augmentation costs.	Minimal lead-time	Technically feasible.	Minimal impact.	Not recommended as part of the long-term strategy but may be required until water security is resolved.
13	Rural effluent reuse	No change to potable water use.	Existing wastewater treatment is appropriate for end uses.	Source augmentation will still be required.	No change from current.	Likely to be considered acceptable.	Minimal lead-time.	Technically feasible.	Minimal impact.	Implementation of Effluent Management Strategy actions will form part of the long-term strategy.

No.	Option	Beneficial	Safe/ fit for purpose	Availability/ reliability	Compatibility	Acceptability	Timeliness	Technical feasibility	Environmental sustainability	Conclusion
14	Urban effluent reuse	Demand reduction expected.	Treatment will be required.	Source augmentation will still be required.	Additional treatment and distribution infrastructure required.	Likely to be considered acceptable	Potentially significant lead time.	Technically feasible.	Minimal impact.	Further consideration is recommended.
15	Private supplies	Demand reduction expected.	No change from current	Source augmentation will still be required.	Rainwater tanks and/or private bores required.	Likely to be considered acceptable	Minimal lead-time	Technically feasible.	Minimal impact.	Implementation of RDMP actions (rainwater tank rebates) will form part of the long-term strategy.
16	RCC emergency bulk water supply	Demand reduction expected.	No change from current	Source augmentation will still be required.	No change from current	Likely to be considered acceptable	Minimal lead-time	Technically feasible.	Minimal impact.	Current emergency source will form part of the long-term strategy.

12. DETAILED ASSESSMENT OF SHORT-LISTED OPTIONS

Detailed information on the short-listed options from Section 11 is provided below. Legislative requirements are summarised in Appendix 1.

12.1 Option 1 - Do Nothing

As discussed in Section 9, the current supply is expected to be secure until 2027 assuming the emergency supply is available (earlier if water loss management measures are not implemented). If the raw water supply is not augmented, it is likely that restrictions will be imposed more frequently and the weir supply will be depleted in a prolonged drought. The RCC emergency supply pipeline can only service part of the town and other emergency response options would be required for the north-western areas if the weir supply was unable to supply the demand. There is a significant amount of growth predicted for Mullumbimby and this new development would be compromised without augmentation of the supply. Tourism may also be affected if restrictions are required more frequently. The emergency response options are discussed in the following sections.

12.1.1 Emergency response

In the event that the Lavertys Gap Weir is unable to provide the town with sufficient water supply, emergency response options include the existing RCC supply, water carting, accessing the water in dead storage and a new emergency source.

RCC emergency supply

As discussed in Section 3, there is an emergency supply pipeline with agreement with RCC to supply 0.5 ML/d from the RCC bulk supply to the lower areas of the Mullumbimby distribution system (Figure 44). This pipeline is estimated to supply water to 45% of properties in Mullumbimby.

The drought management plan (HydroScience, 2014) indicates that the emergency supply would be utilised during level 7 restrictions. During summer 2019/20, the water sourced from the emergency pipeline was 12,840 kL over 30 days from 23/12/19 (during level 4 restrictions), compared to the total demand of 28,700 kL (45% of total demand).

During level 4 restrictions, the target demand is 0.83 ML/d (Table 15, based on current demand) and the volume of water remaining in the weir storage is 42.2 ML (31.7 ML active storage). If the emergency pipeline can supply 45% of the Mullumbimby demand (0.37 ML/d), there would be 69 days of supply left in the storage until another emergency response option is required. This timeframe could be increased with higher level restrictions to a maximum of 111 days.

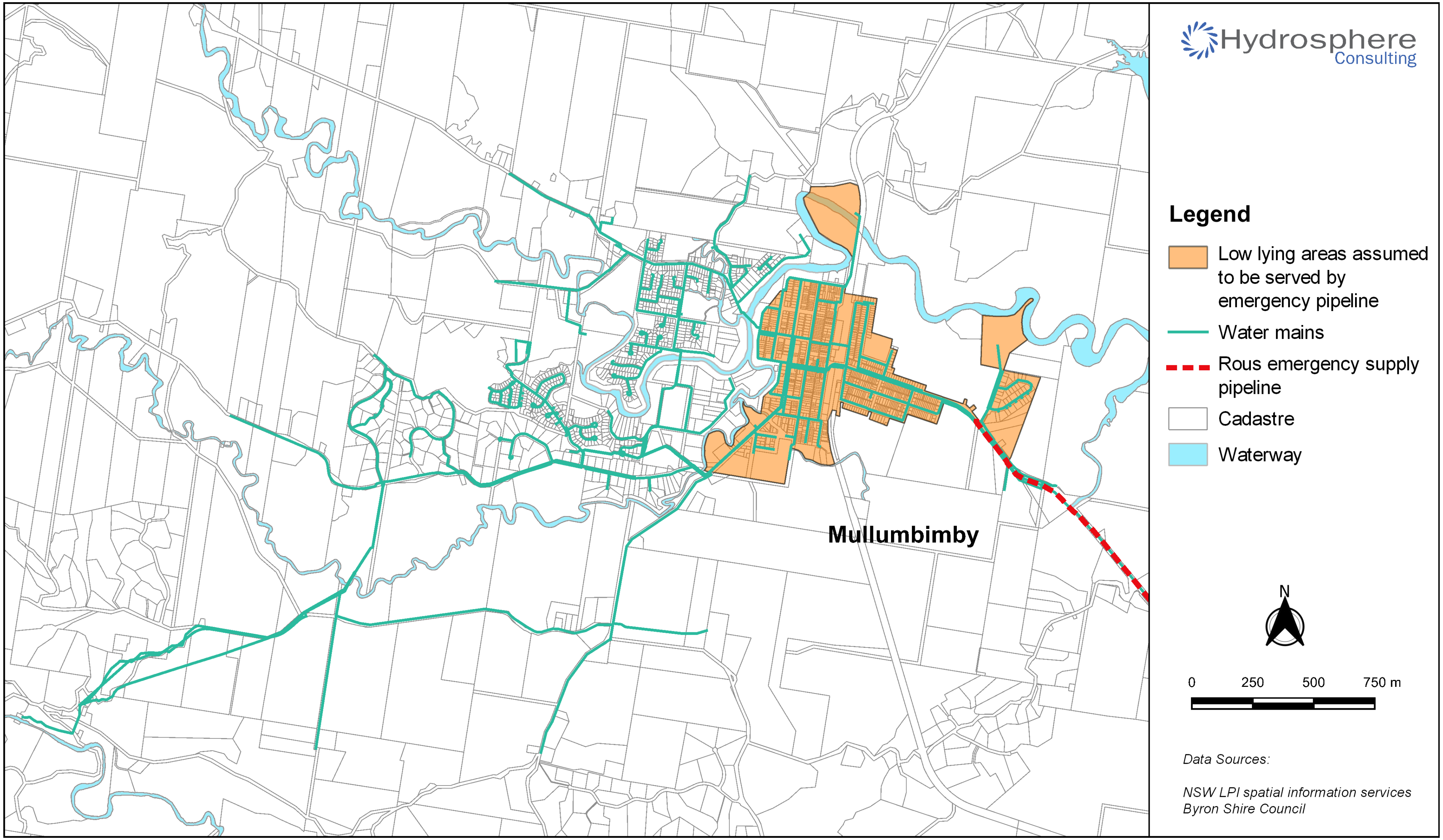


Figure 44: Emergency supply service area

Water carting

During a drought or emergency situation, if local sources of water or assets have failed, Council will be required to cart water from a different Council water supply or neighbouring Council area. Water carting is a temporary measure, for a limited time, until other solutions can be found due to the volume, time, cost and logistical requirements of transporting water. The economic feasibility of carting also depends on the distance from potential water supplies and infrastructure requirements.

Emergency water requirements for Mullumbimby have been calculated in accordance with the NSW Government publication “*Drought and Emergency Relief for Regional Town Water Supplies*” (NSW Government, 2018) as shown in Table 36. The resident population of Mullumbimby is estimated to be 3,900 (.id, 2020).

If the Lavertys Gap water source is exhausted, water would also need to be carted to the two reservoirs in order to service the higher areas of the town. The predicted water carting demand is 267 kL/d.

Table 36: Estimated emergency water demand for Mullumbimby

Component	Allowance (L/p/d)	Demand (kL/d)	Assumptions
Residential	95	370.5	Sewered system, reticulated water supply
Schools	37	18.5	Estimated 500 non-resident (rural) population
Health facilities		40.0	Aged care, medical centres, estimate
Hotels		20.0	Various, estimate
Cafés/restaurants		20.0	Various, estimate
Public toilets		5.0	Estimate
Tourists	95	1.9	Estimate 20 per day
Other		10.0	Estimate
Total emergency water demand		485.9	
RCC emergency supply		500.0	Estimated maximum supply to low-lying areas served by emergency supply
Water carting demand		267.2	Areas not currently served by emergency supply (55% of total demand)
Level 7 demand target		520.0	Whole town

The closest bulk water filling station is at Tyagarah. Using bulk water carters, 22 x 12 kL tanker loads or 11 x 25 tanker loads would be required each day. The total cost would be $7,150 - $14,300 per day (based on 2020 market rates). NSW government subsidy may be available (for freight costs in excess of the NSW median usage charge, approximately $1.90 per kL).

Access dead storage

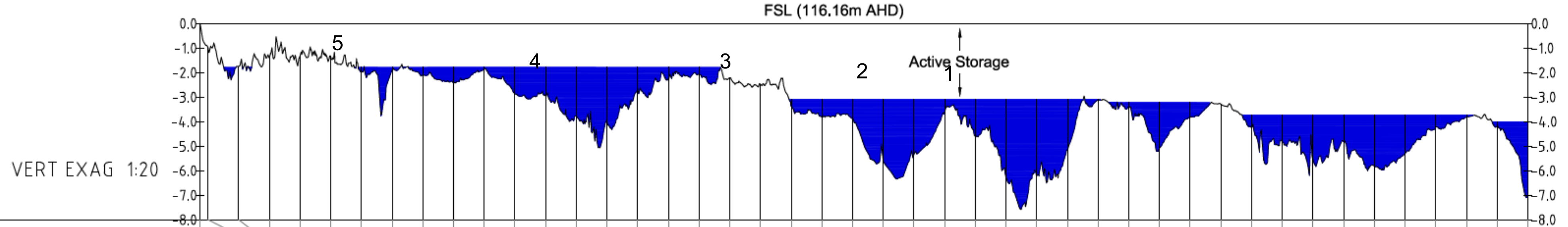
The 2018 survey of the weir storage identified 5 compartments of dead storage that are not currently accessible by the raw water intake (Figure 45). The volume of the dead storage compartments is shown in Table 37. This volume of water is only sufficient to supply 20 days at emergency restriction level 7 (assuming water is accessible and of suitable quality).

Table 37: Dead storage volumes

Compartment	Approximate distance from weir (m)	Dead storage level (m below FSL)	Dead storage volume (kL)
1	0 - 30	4.0	324
2	40 - 230	3.7	1,731
3	260 - 340	3.2	512
4	350 - 600	3.1	4,900
5	660 - 950	1.8	2,988
Total		-	10,455

Groundwater source

A groundwater bore may be established as an emergency source. The groundwater resources in the area are discussed in Section 12.5.



CHAINAGE	BED DEPTH (m)	DEAD STORAGE (m)	DEPTH
1081		-1.780	
1075	-0.975	-1.780	0.805
1050	-1.756	-1.780	0.024
1025	-1.405	-1.780	0.375
1000	-1.322	-1.780	0.458
975	-1.349	-1.780	0.431
950	-1.965	-1.780	-0.185
925	-1.884	-1.780	-0.104
900	-2.105	-1.780	-0.325
875	-2.403	-1.780	-0.623
850	-1.844	-1.780	-0.064
825	-2.857	-1.780	-1.077
800	-2.948	-1.780	-1.168
775	-3.767	-1.780	-1.987
750	-4.002	-1.780	-2.222
725	-2.664	-1.780	-0.884
700	-2.220	-1.780	-0.440
675	-2.079	-1.780	-0.299
650	-2.217	-3.090	0.873
625	-2.484	-3.090	0.606
600	-3.365	-3.090	-0.275
575	-3.804	-3.090	-0.714
550	-3.884	-3.090	-0.794
525	-5.611	-3.090	-2.521
500	-5.334	-3.090	-2.244
475	-3.591	-3.090	-0.501
450	-4.607	-3.090	-1.517
425	-6.277	-3.090	-3.187
400	-6.204	-3.090	-3.114
375	-5.131	-3.090	-2.041
350	-3.107	-3.090	-0.017
325	-3.364	-3.210	-0.154
300	-5.077	-3.210	-1.867
275	-3.820	-3.210	-0.610
250	-3.300	-3.740	0.440
225	-4.219	-3.740	-0.479
200	-4.852	-3.740	-1.112
175	-5.553	-3.740	-1.813
150	-4.804	-3.740	-1.064
125	-5.809	-3.740	-2.069
100	-5.290	-3.740	-1.550
75	-4.232	-3.740	-0.492
50	-3.816	-3.740	-0.076
25	-4.185	-4.000	-0.185
0		-4.000	

Figure 45: Lavertys Gap Weir dead storage

Source: Hydrosphere Consulting (2019)

Depths based on hydrographic survey undertaken by Hydrosphere Consulting 12, 13 & 14 November 2018. Depths relative to the weir crest at 116.16m AHD. Chainage starting at weir crest following deepest river sections. Dead storage is shown as blue hatching.

12.2 Option 2 - Raising Lavertys Gap weir

This option involves raising the height of the weir to provide additional storage. Currently the weir is a 7 m high concrete arch dam with FSL of RL 116.16 mAHD (Hydrosphere Consulting, 2019). The arch dam wall has a crest length of 46 m and is designed to be overtopped at the crest. This option considers scenarios in which the FSL is increased by various heights.

12.2.1 Weir Height

The estimated volume and inundation area impacted by raising Lavertys gap weir was calculated from a combination of existing LiDAR data and data collected during the previous hydrographic survey (reported in Hydrosphere Consulting, 2019). Weir height increases to 5.5 mAHD were modelled as this is the height required to achieve 450 ML of storage, similar to the amount determined in JWP (2005) to provide the required secure yield. However, JWP (2005) estimated that an increase in storage of 450 ML would be achieved with a weir raising of 3.84 m to 120 mAHD.

Volumes and surface areas for weir height increases (0.5 m intervals) are summarised in Table 38. The projected inundation areas do not include flood surcharge inundation. All volume calculations include previously identified ‘dead storage’.

Table 38: Weir raising options

Increase in weir height (mAHD)	New weir crest (mAHD)	Storage capacity (ML)	Increase in storage capacity ML (%)	Surface area (m^2)	Additional inundated area (m^2)
-	116.16	72.7	0	27,104	0
0.5	116.66	87.6	14.9 (20%)	32,280	5,176
1.0	117.16	106.8	34.1 (47%)	40,714	13,610
1.5	117.66	128.8	56.1 (77%)	47,315	20,211
2.0	118.16	154.4	81.7 (112%)	55,085	27,981
2.5	118.66	184.0	111.3 (153%)	63,004	35,900
3.0	119.16	217.4	144.7 (199%)	69,432	42,328
3.5	119.66	254.6	181.9 (250%)	78,622	51,518
4.0	120.16	280.0	207.0 (285%)	87,549	60,454
4.5	120.66	343.0	270.3 (371%)	97,463	70,359
5.0	121.16	394.3	321.6 (442%)	106,911	79,807
5.3	121.46	430.1	357.4 (492%)	113,374	86,270
5.5	121.66	450.2	377.5 (519%)	116,816	89,712

12.2.2 Construction

The structural report (SMEC, 2003) included in the 2005 strategy (JWP, 2005) considered three options for raising the weir wall by 3.84 m to a height of 120 mAHD (the height required to provide the additional storage considered necessary to provide the required yield):

- Raise the wall as an arch dam - addition of a concrete arch to the top of the dam, retaining the type and general appearance of the dam.
- Construct a gravity dam immediately downstream of the existing weir.
- Stabilise the weir wall using grouted anchors and raise as a cantilever dam.

The option recommended by SMEC (2003) for raising the weir based on assessed risks relating to foundations, constructability, flooding, heritage and costs was to construct a gravity dam downstream of the existing weir wall. This would entail constructing a new gravity dam wall from roller compacted concrete immediately downstream of the existing arch dam wall. The existing arch wall would form the upstream face of the dam but would be effectively abandoned. This would involve cleaning the foundation downstream of the existing weir as well as considerable excavation on the left side (southern side) to construct the new wall. Detailed site survey, geotechnical and flooding investigations would be required to confirm the suitability of any weir raising option.

12.2.3 Environmental flows

In the context of dams and weirs constructed on rivers, "environmental flows" refers to the flows in the river required to maintain the aquatic environment in a condition similar to its natural state. Environmental flows are typically achieved by releasing low flows from the weir however they may also be achieved by discharging stormwater or treated wastewater into the weir storage.

JWP (2005) discussed the implications of environmental flow requirements planned to be introduced at that time and found that this would have a significant impact on storage behaviour and secure yield during dry periods and may negate any increases in yield achieved by raising the weir. The following environmental flow requirements were assumed in JWP (2005):

"All flows are passed below Q_{95}, 80% of the flows are passed between Q_{95} and Q_{80}, and at least Q_{80} flows are passed when the flow in the river is above Q_{80}. Q_{95} is a flow condition which occurs 5% of the time (i.e. 95% of the time the river flows exceed this condition)."

This was the less conservative assumption of the two environmental flow scenarios considered in the 2005 strategy (refer Section 6).

The current water access licence includes no restrictions on extraction for town water supply. The water sharing rules for the Bangalow Area water source (under the *Water Sharing Plan for the Richmond River Area Unregulated, Regulated and Alluvial Water Sources, 2010*) include pumping restrictions as follows (NSW Office of Water, 2014):

"… water cannot be taken for more than 6 hours per day when the flow in the Wilsons River at the Eltham gauge is greater than 24 ML/d and less than or equal to 31 ML/d."

Amendment provisions indicate that environmental flow rules may be implemented within the life of the Plan for the purposes of providing habitat flows for the Eastern Freshwater Cod. The Water Sharing Plan is due for amendment in July 2021. Any requirements for environmental flow releases would need to be determined in consultation with DPIE - Water and the Natural Resources Access Regulator (NRAR).

The flow duration curve for inflow to the weir is shown in Figure 46. The environmental flow releases resulting from the environmental flow rule used in JWP (2005) at various inflows are shown in Figure 47. This does not consider flow releases due to weir overtopping.

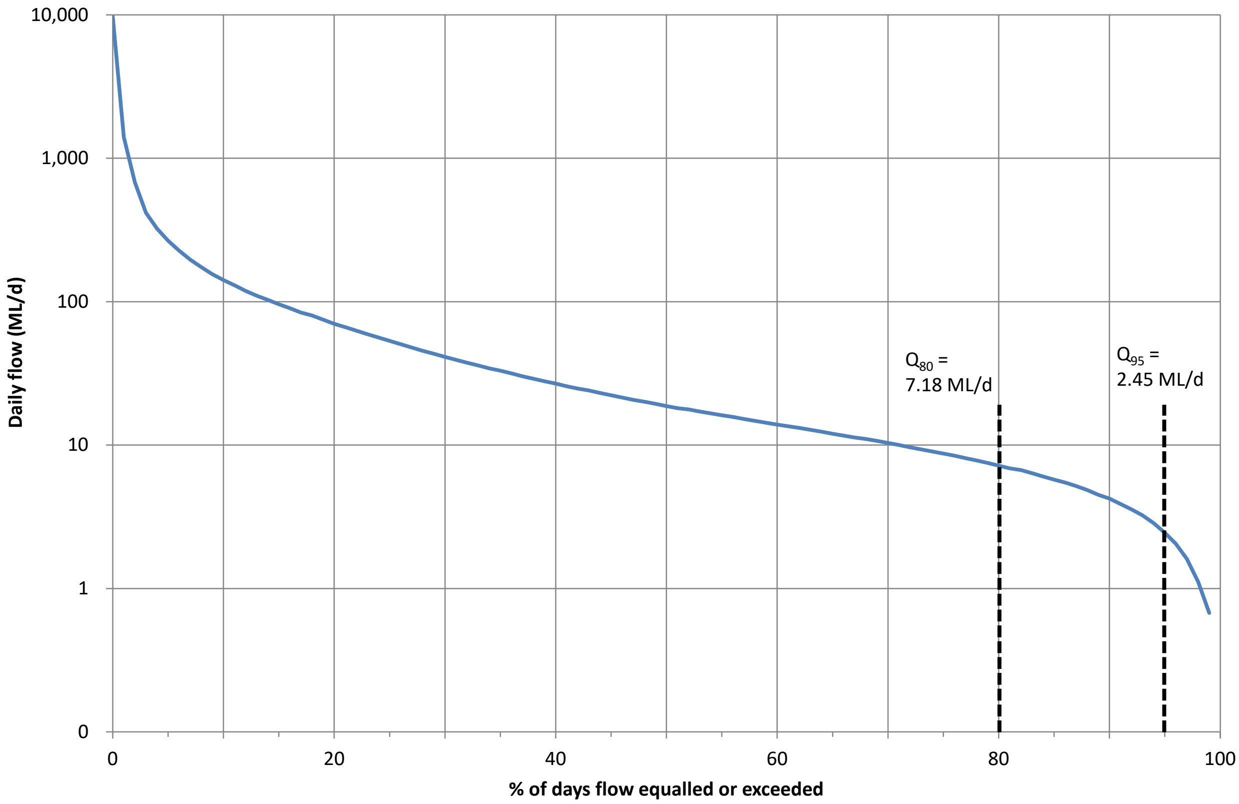


Figure 46: Flow duration curve - inflow to the weir

Source: Modelled flows using Set 1 - based on gauging station 203062 (upstream of weir) and Sacramento model - rainfall runoff model and gauge flows (203062) 10/3/2016 - 5/1/2020

As shown in Figure 47, all inflows below 2.45 ML/d are released with this environmental flow rule. Based on the historic inflow series (Set 1), there were 2,373 days when the inflow was less than Q_{95} (5% of time in 130 years of data). The modelled storage response with the 5 m weir raising and environmental flow releases is shown in Figure 48. Between November 1985 and January 1987 (when the storage would have been drawn down the most), the inflow was below Q_{95} for 66% of the time. On these days, the storage would be drawn down as no inflows would be available to meet demand. With the 5 m weir raising option, the dead storage level would be reached if this environmental flow regime was imposed with a demand of 440 ML/a (equivalent to the current secure yield). Hence security of supply is not achieved. Level 3 restrictions would be imposed but the inflow trigger for higher restrictions (0.5 ML/d) is not reached. Environmental flow releases for this scenario are shown in Figure 49. The weir is not overflowing during this period. With this environmental flow rule, environmental flow releases are substantially less than the overflows that occur at present (with the lower weir).

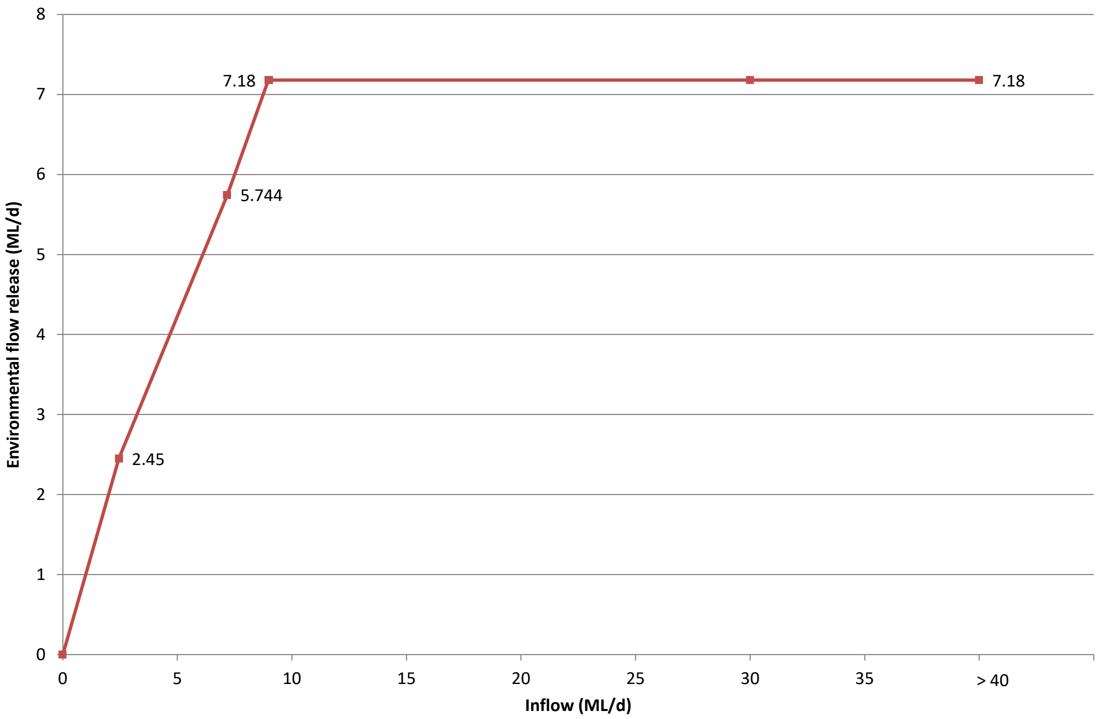


Figure 47: Environmental flow releases with assumed environmental flow rule

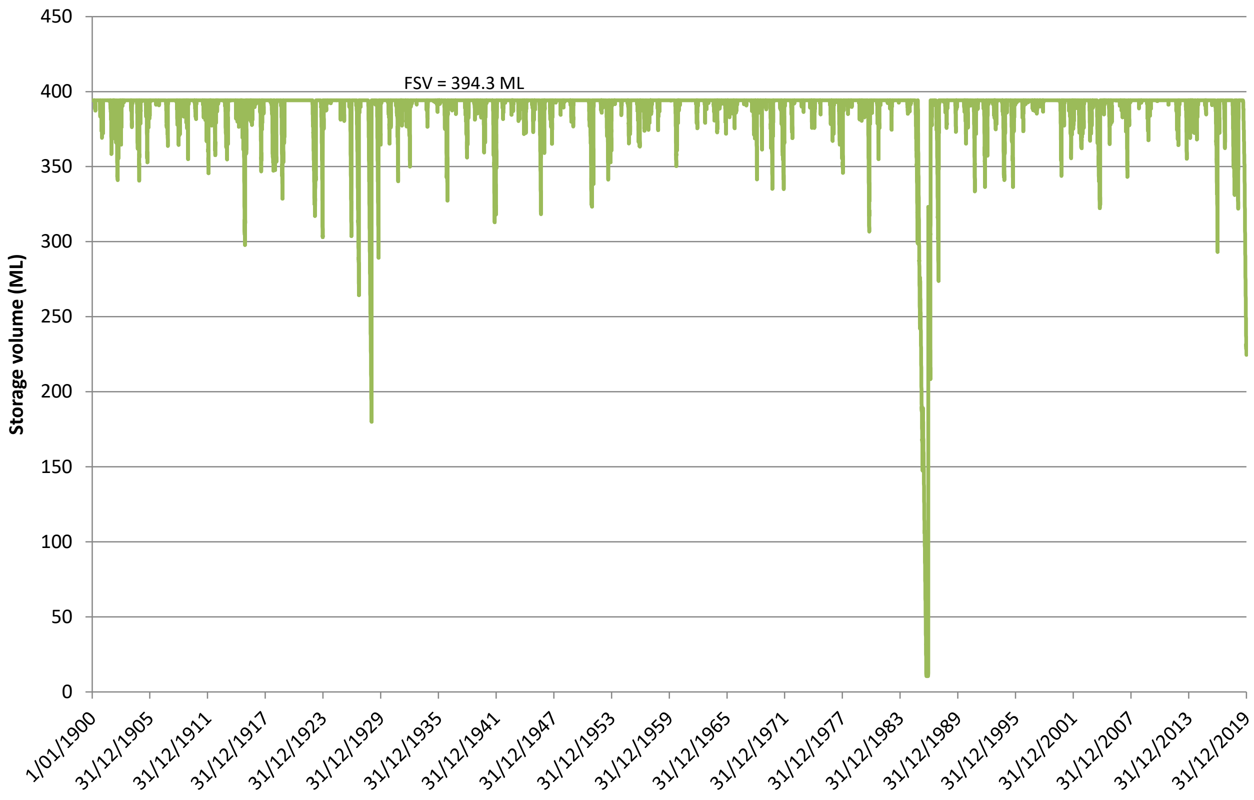


Figure 48: Storage response with 5 m raising and environmental flow releases (demand = 440 ML/a)

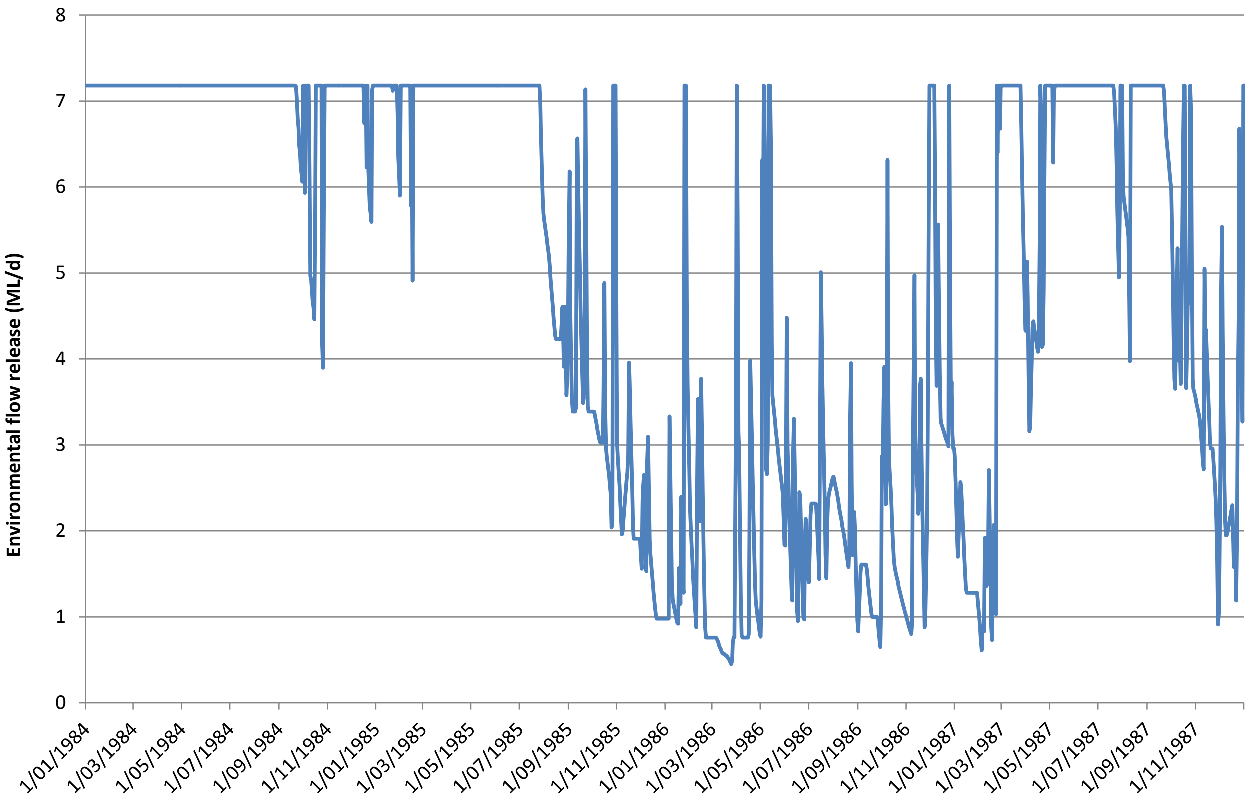


Figure 49: Environmental flow releases with 5 m raising (demand = 440 ML/a)

A revised flow regime has also been considered to mimic emergency provisions with nil environmental flow releases below the level 7 restriction level (31% storage or 122 ML which is higher than the current weir level). Figure 50 shows that the weir would have been drawn down to the level 7 restriction level for 3 months during 1986. Environmental flow releases would have been 0.65 ML/d on average during that time.

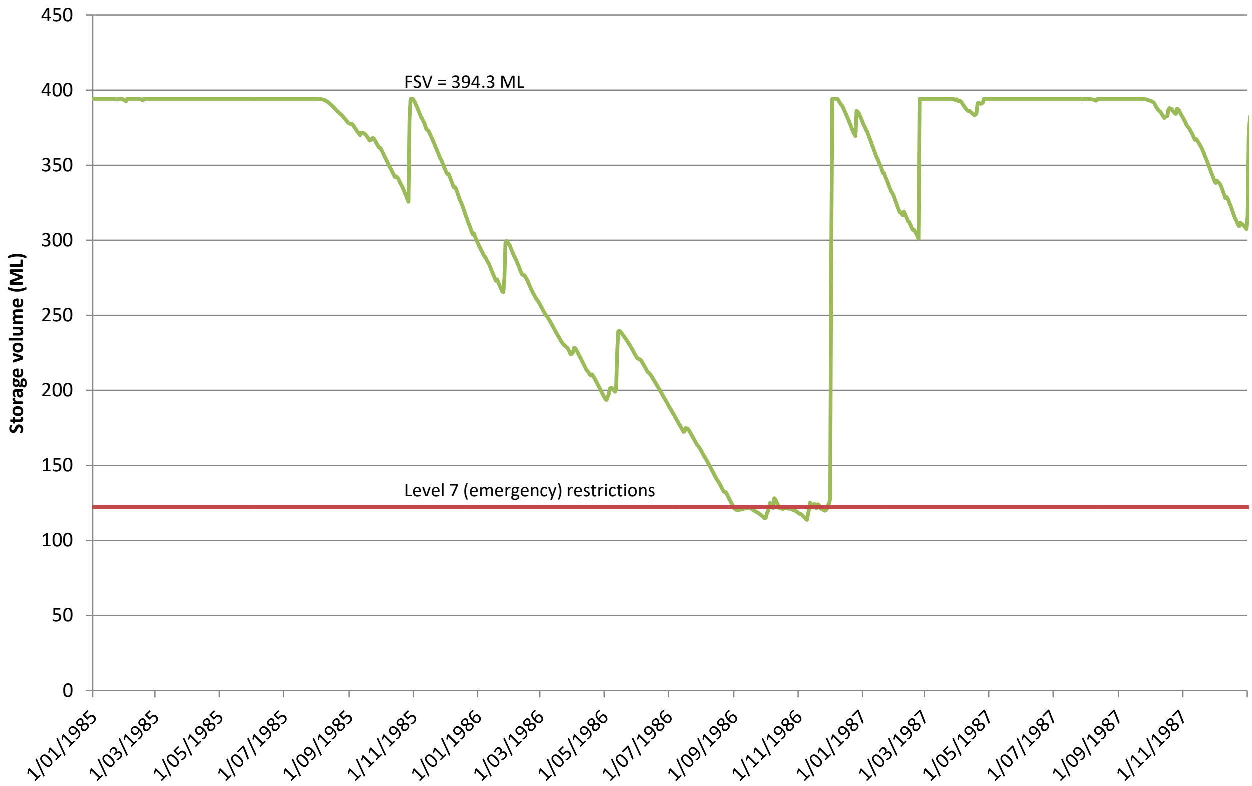


Figure 50: Storage response with 5 m raising and modified environmental flow releases (demand = 440 ML/a)

12.2.4 Inundation area and land acquisition

The current inundation area and potentially inundated areas and infrastructure impacted by raising the weir by 2.0 m, 4.0 m and 5.5 m AHD intervals are presented in Figure 51.

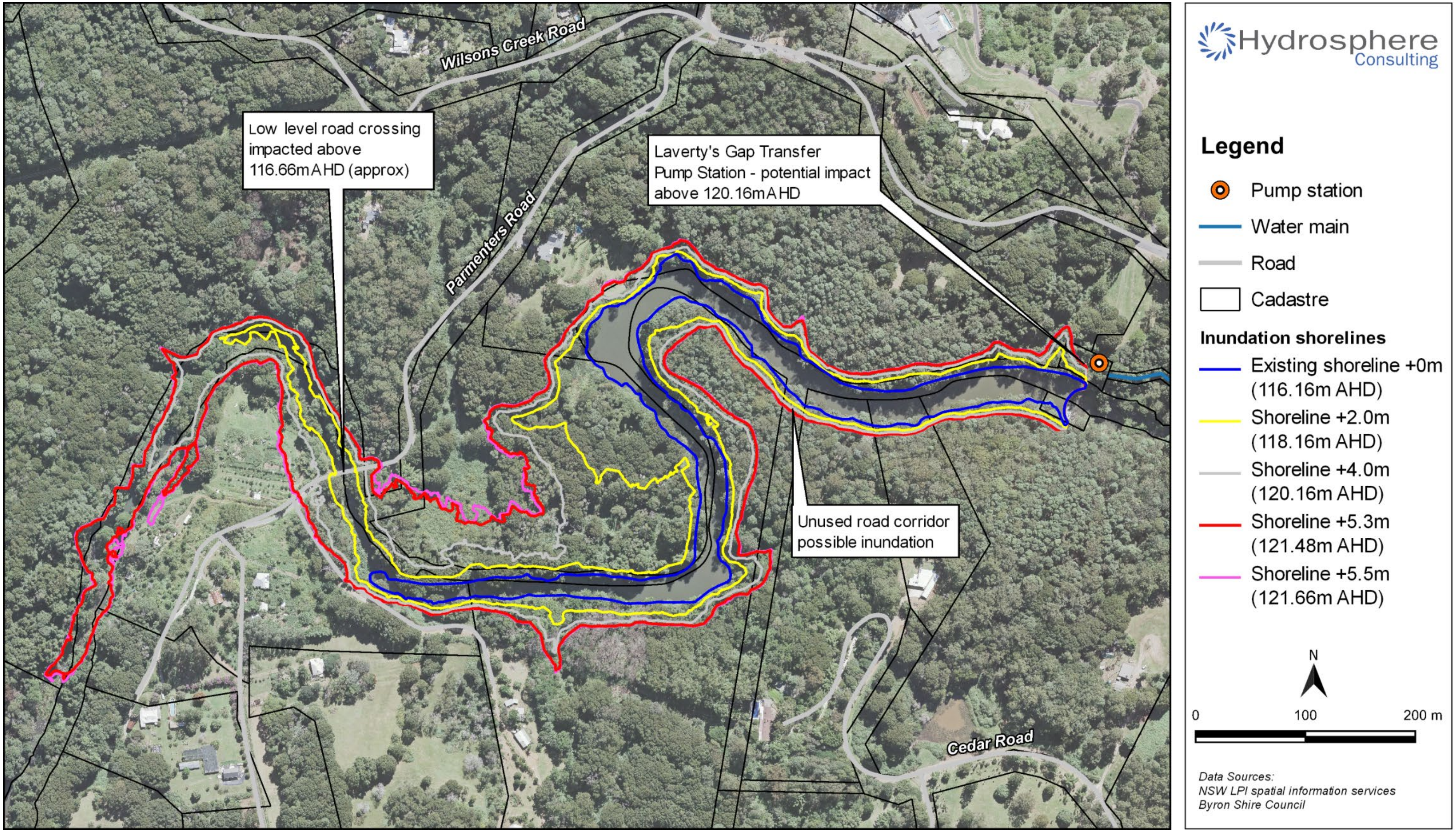


Figure 51: Potential inundation scenarios

Any increase in weir height will likely impact eight private lots upstream of the weir and the weir site (Council owned) to varying degrees relative to topography. Any change in weir height will also increase inundation of road corridors as well as the low-level river crossing on Parmenters Road which will be impacted from an increase above 116.66 mAHD (0.5 m raising). Further consideration would have to be given to rebuilding this crossing as the access road to the adjacent properties would become impassable. Additionally, above approximately 120.16 mAHD (4.0m raising), Lavertys Gap transfer pump station would likely be impacted (refer Table 39).

Table 39: Summary of potential inundation impacts

Increase in weir height (m AHD)	Potential inundation impacts
≥1.0	Eight private lots and weir site partially inundated. Parmenters Road inundated. Seven properties use the road for access to town. Private pump infrastructure likely to require relocation.
≥2.5	Lavertys Gap raw water transfer pump station potentially inundated.
≥4.0	Neighbouring property partially inundated.
≥5.5	Additional neighbouring property and access road partially inundated.

The establishment of vegetated buffer zones around water supply reservoirs is a recognised catchment management strategy which helps to protect the water quality and reduce risks to water supply. Vegetated buffer zones are used to:

- Exclude incompatible land use (e.g. stock access).
- Provide “filtering” capability to remove contaminants and reduce turbidity of runoff and reduce reliance on water treatment processes.
- Offset the effects of remote contaminant sources.
- Reduce erosion and sedimentation (hence improve storage longevity).
- Improve storage water quality through reduced ‘dead’ storage, environmental incidents and operational requirements.
- Allow long-term land management planning (revegetation, bush fire access, provision for future dam raising inundation areas).
- Create additional environmental value (e.g. biodiversity, habitat offset, fauna movement corridors).

There is no standard size for buffer zone widths which range from less than 20m in width to several kilometres depending on site specific factors such as catchment land-use, land tenure, slope, vegetation type and cover as well as project specific factors such as costs, operational requirements and land acquisition arrangements. At this stage, the need for a buffer zone has not been assessed. If a vegetated buffer zone is required further land acquisition would be required.

12.2.5 Potential environmental impacts

A preliminary assessment of environmental impacts associated with weir raising options is provided in the following sections.

Terrestrial flora and fauna

A detailed flora and fauna assessment has not been undertaken for the areas potentially impacted by the construction works and land inundation. A preliminary ecological assessment (FRC Environmental, 2003) undertaken as part of JWP (2005) found that the project area is within an area of high natural biodiversity, as it is in an area of overlap between biogeographic zones (the McPherson-Macleay Overlap). A combination of climatic and geographic conditions has produced an area that has both temperate and tropical species as well as having a significant number of species that are endemic to the region. Most of the vegetation surrounding the weir pool formed by Lavertys Gap Weir is dominated by camphor laurel with other weed species and rainforest remnants. Near Lavertys Gap Weir the riparian forest is dominated by brush box and white mahogany with many other native species such as forest sheoak and hovea. Given the extent of clearing in the area, any remnant native forests are considered to be of conservation significance and will provide habitat for threatened flora and fauna species (FRC Environmental, 2003).

Figure 52 shows the vegetation mapped by BSC within the inundation area (by plant community type). Vegetation mapped as subtropical rainforest and north coast wet sclerophyll forest will become permanently inundated and require removal as a result of raising the weir by the different heights.

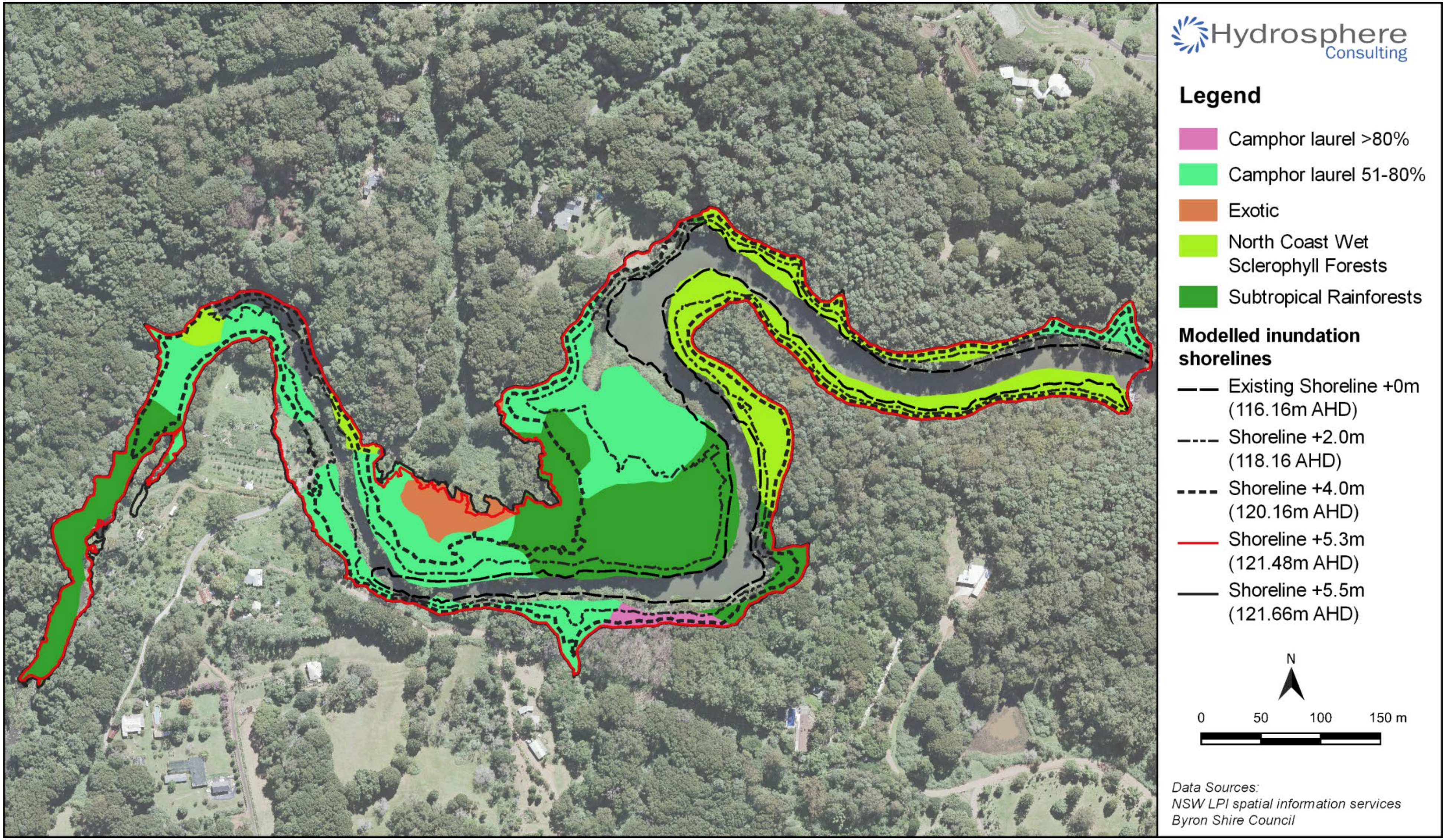


Figure 52: Vegetation within shorelines

Aquatic habitat

The weir pool upstream of Lavertys Gap Weir is relatively broad and deep near the weir, but shallows to less than 0.5 m deep in the upstream area. Upstream areas of the dam are characterised by a boulder, rubble and very coarse sand bottom, with plants such as *Lomandra longifolia* (spiny headed mat rush) colonising the bank and small islands (FRC Environmental, 2003).

Wilson’s Creek is likely to support a diverse assemblage of both native and introduced fish species. Many of the freshwater fish found in the Richmond River system (and likely to be found in Wilson’s Creek) will migrate, moving both laterally and longitudinally at some stage of their lifecycle. However, upstream migration is now blocked by the weir and hence it is expected that diadromous species would no longer be expected upstream of the weir given the age of the structure.

Platypus (*Ornithorhynchus anatinus*) have been sighted within the vicinity of the weir. The status of the platypus is described as common but vulnerable. Platypus require access to pool and riffle habitat as the major source of food and to firm banks for the construction of burrows and the nest used for rearing young. Two species of turtle have also been recorded in the Byron Shire - *Chelodina longicollis* (long-necked tortoise) and *Elseya latisternum* (saw shelled turtle) (FRC Environmental, 2003).

The waterway makes up part of the indicative distribution (high probability of the species occurring) of two freshwater threatened species - Eastern Freshwater Cod (*Maccullochella ikei*) and southern purple spotted gudgeon (*Mogurnda adspersa*). This section of the Wilsons River is also included in the Byron Bay LGA ‘Key Fish Habitat’ map published by NSW Department of Primary Industries (DPI - Fisheries). Key Fish Habitat are those aquatic habitats that are important to the sustainability of the recreational and commercial fishing industries, the maintenance of fish populations generally and the survival and recovery of threatened aquatic species. Raising the weir is likely to impact any species present by altering flows and potentially altering habitats. Impacts on individual species would need to be fully considered and fish passage structure options identified. A fish passage structure may be required in accordance with the *Fisheries Management Act 1994* to offset these impacts (refer Section 12.2.5).

FRC Environmental (2003) found that inundation of land upstream of the existing weir pool will change the nature of the aquatic habitat from a diverse, highly productive riverine community to a lentic one characterised by deeper, still waters. Overall species diversity is likely to decrease and the changed conditions are likely to favour introduced species at the expense of native ones.

Threatened Species

Searches of the following information and databases were conducted to obtain an updated list of threatened species potentially occurring within the study area:

- Richmond River Water Sharing Plan.
- NSW BioNet database.
- *Environmental Protection Biodiversity Conservation Act 1999* (EPBC) Protected Matters Search Tool.

The *Water Sharing Plan Background Document* (NSW DPI Water, 2016d) identifies threatened species occurring in each water source that are likely to be sensitive to extraction and have been considered when assessing the water source values. Some threatened species such as the Eastern Freshwater Cod are highly sensitive to low flow extraction and is now locally extinct in the Richmond River system (DPI, 2012). Purple spotted gudgeon were not identified in the *Water Sharing Plan Background Document* (NSW DPI Water, 2016d).

Table 40: Threatened species in the Wilsons Creek/Bangalow area identified in the Water Sharing Plan

Species Name	Bangalow Area (includes Wilson's Creek)
Fish	
Eastern Freshwater Cod	Known to occur
Frogs	
Fleay's Barred Frog	Expected to occur
Giant Barred Frog	Expected to occur
Green-thighed Frog	Expected to occur
Loveridge's Frog	Expected to occur
Pouched Frog	Known to occur
Stuttering Frog	Known to occur
Wallum Froglet	Expected to occur
Birds	
Black Bittern	Known to occur
Black-necked Stork	Known to occur
Osprey	Expected to occur
Other Fauna	
Large Footed Myotis	Known to occur
Wet Flora Species	
Ball nut	Known to occur
Phyllanthus microcladus	Known to occur
Thorny Pea	Known to occur

Source: NSW DPI Water (2016d)

A search of the NSW BioNet database revealed records of four different threatened flora and fauna species within the potentially inundated footprint plus a 50m buffer as shown in Figure 53. The search revealed sightings of the following threatened species within the inundation area:

- Red boppel nut (*Hicksbeachia pinnatifolia*) - Vulnerable (*Biodiversity Conservation Act 2016* (BC Act)).
- Red lilly pilly (*Syzygium hodgkinsoniae*) - Vulnerable (BC Act; *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act)).
- Rough-shelled bush nut (*Macadamia tetraphylla*) - Vulnerable (BC Act; EPBC Act).

- Thorny pea (*Desmodium acanthocladum*) - Vulnerable (BC Act; EPBC Act).

The search report identified two listed ecological communities, 60 threatened species and 15 migratory species that are known to occur, likely to occur or that may occur within the study area which includes the potentially inundated areas plus a 50m buffer (Table 41).

A search of the EPBC Protected Matters Search Tool returned two listed threatened ecological communities, 60 listed threatened species and 15 listed migratory species protected by the EPBC Act as either likely or known to occur in the area. Of these, the following species are most likely to be affected by the change in flows resulting from raising the weir:

- Fleay's Frog (*Mixophyes fleayi*) - Endangered (BC Act, EPBC Act).
- Giant Barred Frog - Endangered (BC Act, EPBC Act).
- Wallum Sedge Frog - Vulnerable (BC Act, EPBC Act).

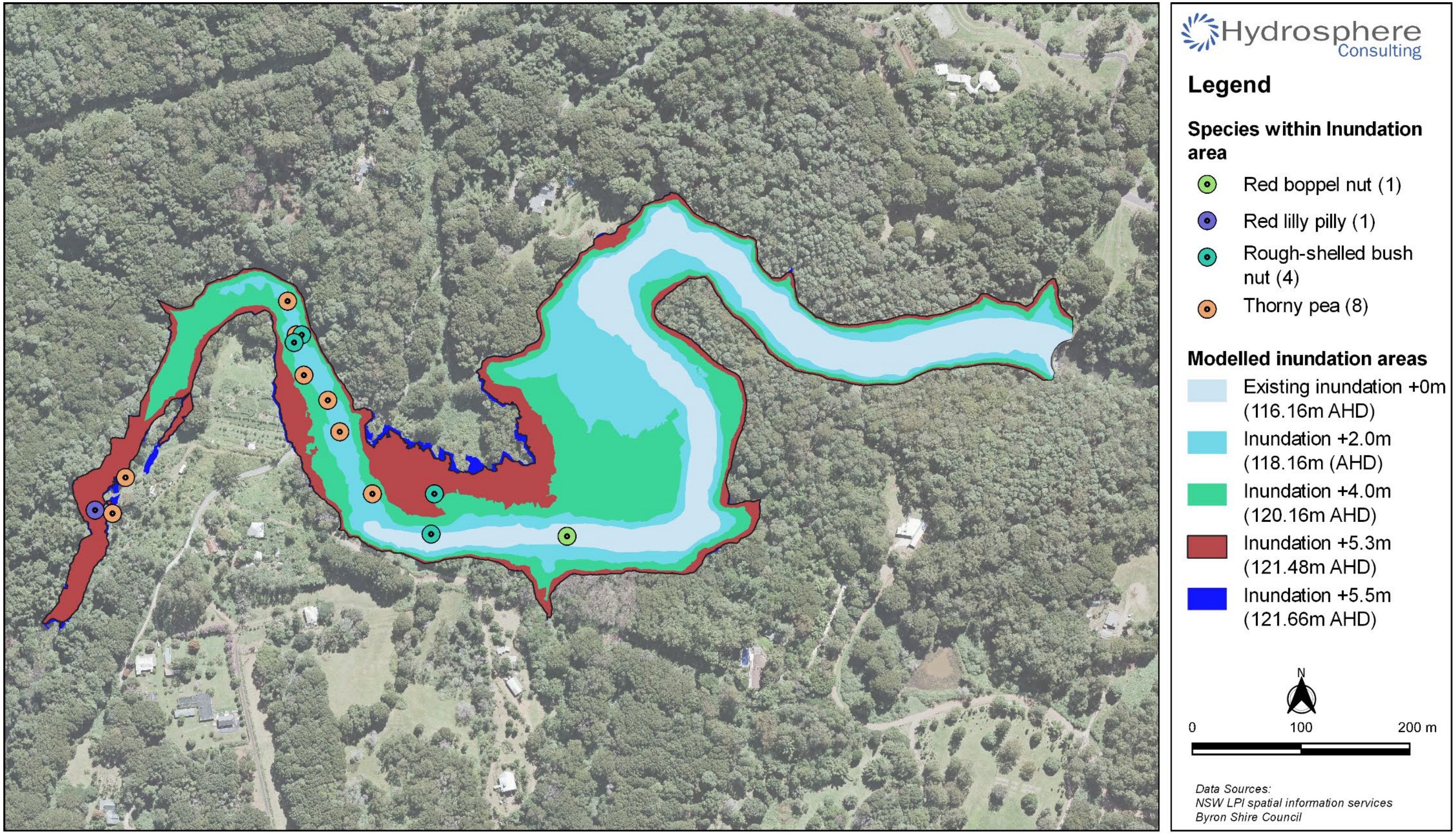


Figure 53: Threatened species recorded in BioNet NSW Atlas search at Lavertys Gap weir

Table 41: BioNet Atlas search results

Species or species habitat known to occur within area	Conservation Status	
	BC Act	EPBC Act
Australasian Bittern	Endangered	Endangered
Red Goshawk	Critically Endangered	Vulnerable
Australian Painted Snipe	Endangered	Endangered
Eastern Freshwater Cod	FM Act: Endangered	
Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll	Vulnerable	Endangered
Koala	Vulnerable	Vulnerable
Smooth Davidson's Plum	Endangered	Endangered
Thorny Pea	Vulnerable	Vulnerable
Small-leaved Tamarind	Endangered	Endangered
Floyd's Walnut	Endangered	Endangered
Red Boppel Nut	Vulnerable	-
Rough-shelled Bush Nut	Vulnerable	Vulnerable
Durobby	Vulnerable	Vulnerable
White-throated Needletail	-	Migratory Species
Black-faced Monarch	-	Migratory Species
Spectacled Monarch	-	Migratory Species
Satin Flycatcher	-	Migratory Species
Painted Snipe	Endangered	Endangered
Critically endangered species or species habitat likely to occur within area		
Lowland Rainforest of Subtropical Australia	-	Critically Endangered
Regent Honeyeater	Critically Endangered	Critically Endangered
Swift Parrot	Endangered	Critically Endangered
Critically endangered species or species habitat that may occur within area		
Australian Fritillary	Endangered	Critically Endangered
Curlew Sandpiper	Endangered	Critically Endangered Migratory Species
Eastern Curlew	-	Critically Endangered, Migratory
Coxen's fig-parrot	Critically Endangered	Endangered
Black-breasted Button-quail	Critically Endangered	Vulnerable
Hooded Plover	Critically Endangered	Vulnerable

Flooding

Raising the weir will result in flooding impacts upstream during flood flows and also has the potential to alter flood behaviour downstream. The extent of flooding impacts is unknown and has not been assessed in this study.

Water quality

The construction phase of the gravity dam wall is likely to negatively affect the water quality downstream with higher turbidity levels and suspended solids concentrations due to runoff from disturbed soils downstream of the weir. There is also potential for unintended contaminants to spill into the water from construction activities. These impacts can be managed through standard control measures.

Raising the weir will have temporary impacts on the in-storage water quality during the first inundation after the raising through mobilisation of sediments and decomposing vegetation from the newly inundated areas. The inundation area would be cleared of most vegetation and fauna relocated prior to inundation.

Any long-term downstream water quality impacts will need to be considered and assessed in the development of the environmental flow regime.

European heritage

The Mullumbimby hydro-electric power station (including the weir and channel) is listed under the *NSW Heritage Act*. An assessment of heritage significance would be required to determine impacts on heritage values.

Aboriginal cultural heritage

A search of the Office of the Environment and Heritage Aboriginal Heritage Information Management System (AHIMS) has identified no Aboriginal sites nor any Aboriginal places declared near the project location. An Aboriginal heritage assessment would be required to determine any impacts on cultural heritage.

Fish passage

All proposals for the construction of, or modification to dams, weirs or similar structures are required to be referred to DPI - Fisheries for assessment. For the construction or the major modification or alteration of dams, weirs and regulators the construction of a fishway will generally be required. Under Section 218 of the *Fisheries Management Act*, a public authority that proposes to construct, alter or modify a dam, weir or reservoir on a waterway (or to approve of any such construction, alteration or modification) must notify the Minister of the proposal, and must, if the Minister so requests, include as part of the works for the dam, weir or reservoir, or for its alteration or modification, a suitable fishway or fish by-pass.

The appropriateness of a particular fishway and its design specifications are usually dealt with on a case-by-case basis. Where the nature of the structure or other factors mean that it is not cost-effective or practical to install a fish passage structure or restore fish passage and greater ecological outcomes can be achieved elsewhere, fish passage trade-offs may be considered. A trade-off involves ensuring equal or more cost-effective fish passage outcomes through transferral of fish passage works from the proposed works site to an alternative site or sites. Generally, trade-off sites must:

- Occur within the same catchment as the compliance site.

- Be identified by DPI - Fisheries as a high priority for rehabilitation of a fish passage barrier.
- Not be a site where planned upgrade works are proposed in the next 10 years.
- Derive equal to or greater ecological benefit than providing fish passage at the original compliance site.
- Be discussed and agreed upon by DPI - Fisheries.

The existing weir structure does not include a fishway or fish passage. The requirement for a fishway, fish passage offset or permit to obstruct free passage of fish would need to be negotiated with DPIE - Fisheries. Increasing the height of the weir will make it more difficult to install an effective fishway. Fishways under 6 m high are very successful in transferring fish in this region of Australia. Fishways over a greater height are typically more complicated and expensive to design. FRC Environmental (2003) concluded that developing and maintaining an effective fishway may be a major constraint to the development of this option.

In eastern Australia, rock-ramp fishways, vertical slot fishways, bypass channel fishways and fishlocks have been successfully used to circumvent instream obstructions. Rock ramp fishways are generally used for low barriers (up to two metres high), vertical slot fishways for medium sized barriers (up to six metres high), bypass channels for dams and weirs up to eight metres high and fish locks for high barriers (typically over eight to ten metres high).

12.2.6 Secure yield

Secure yield estimates for the historical and changed climate patterns and Set 1 inflows for the weir raising scenarios including the modified environmental flow regime are shown in Table 42. The secure yield for the historic climate would be below the secure yield of the current weir with raising less than 5 m. The secure yield estimates do not include the RCC emergency supply.

Table 42: Secure yield estimates - weir raising

Raising scenario	Increased storage volume (ML)	Environmental flows[1]	Secure yield (ML/a) for historic climate	Secure yield (ML/a) for 1°C warming[2]
0 m	-	No	440	356
2 m	82	No	672	Not estimated
2 m	82	Yes	252	Not estimated
3 m	145	Yes	332	Not estimated
4 m	207	Yes	393	Not estimated
5 m	322	Yes	525	423

1. There is currently no requirement for environmental flows and no infrastructure available to allow for environmental flows apart from weir overtopping. Weir raising scenarios would include facilities to release flows.

2. The climate change factor calculated for 5 m raising scenario with climate change is 0.772 (1/1/1895 - 31/12/2008).

A raising of 5 m only provides a modelled yield benefit of 65 ML/a for the current climate. The model output for the storage behaviour with 5 m raising and historic climate and modified environmental flow regime is shown in Figure 54. The modelling shows that the storage with a 5m raising (including environmental flow provision) would still be drawn down to the level 7 (emergency) level when exposed to similar climatic conditions.

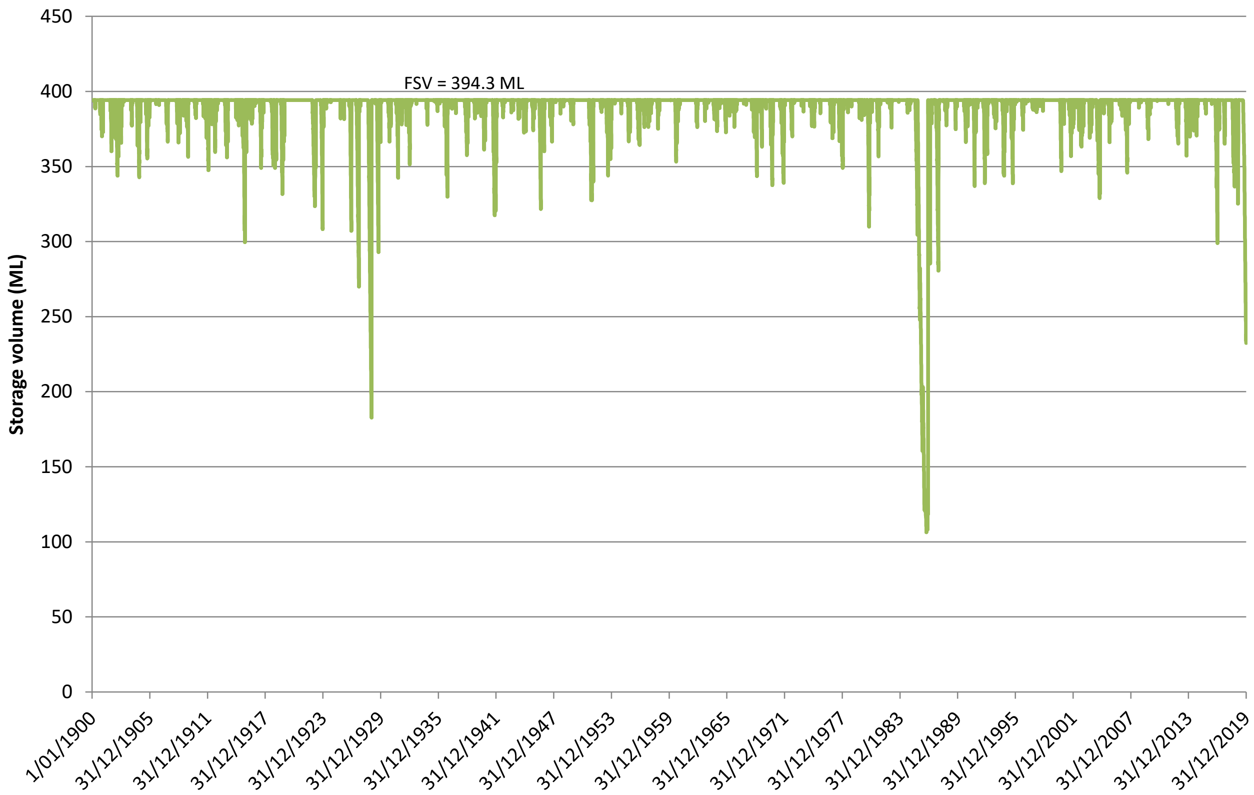


Figure 54: Secure yield modelling results - 5 m weir raising with historic climate and modified environmental flow regime (525 ML/a)

If environmental flows were not imposed with the weir raising, security of supply is likely to be achieved (with increased secure yield) however, the overflow from the weir would be substantially reduced and downstream aquatic environments would be negatively impacted.

A 5 m weir raising is expected to provide the required secure yield until approximately 2035 (including the RCC emergency supply). The secure yield of the water supply system with the weir raising constructed by 2028 is shown in Figure 55.

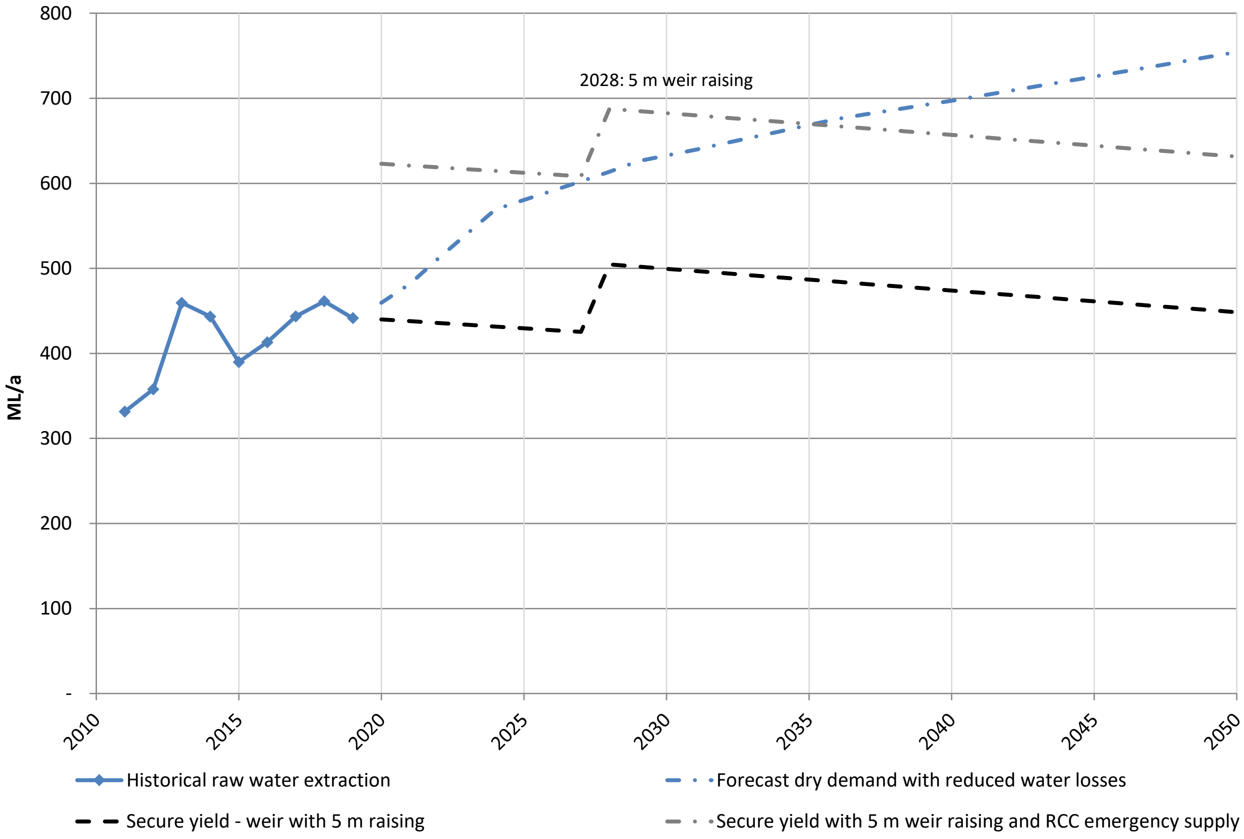


Figure 55: Secure yield with 5 m weir raising

12.2.7 Cost estimates

JWP (2005) estimated the total capital to raise the weir by 4m with a concrete mass gravity dam constructed on the downstream side of the existing arch as $7.78 million (escalated to 2020$) including $1.44 million for a fishway. The 2005 report quotes an accuracy level in the order of 20% and does not include land acquisition costs, any required environmental offset costs or the costs of rebuilding inundated assets.

Walgett Shire Council (2014) reported a cost estimate of $10.2 million (2020$) to raise the Walgett weir by 1 m. The cost estimation included $5.3 million for the constuction of a vertical slot fishway fishway.

Raising Jabour weir at Casino from a height of 3.8 m by 0.5 m - 3.0 m was estimated to cost between $3.9 million and $13.0 million exluding land acquisition costs or containment (e.g. levees) for breakout areas (2020$, Hydrosphere Consulting, 2008). A fishway at Jabour weir with the weir raised by 2 m was estimated to cost $8.29 million (2020$) by NSW Public Works (2012).

A revised indicative cost estimate for raising the weir by 5 m with a fishway is shown in Table 43 (excluding land acquisition and auxilliary construction costs). Costs associated with the raw water supply upgrade or WTP are not included but will be addressed in scenarios where this would be required (Section 13). Cost estimates are included in Appendix 2.

Table 43: Cost estimate - raising weir by 5m

Item	Cost estimate (2021 $)
Capital cost	$16,677,000
Operation and maintenance	$150,000 p.a.

12.3 Option 3 - Off-Stream Storage

This option involves the construction of a new, off-stream reservoir between Lavertys Gap Weir and Mullumbimby township. The existing weir will remain in use and high flows (i.e. above those flows that overtop the weir with allowance for environmental flows) will be transferred from the weir to fill the new off-stream storage. The stored water will either be used as an emergency supply for when water level in the weir level begins to drop or as the main raw water feed into the WTP. Aeration of the water in the new storage is likely to be required to maintain water quality.

12.3.1 Potential storage sites

Four locations have been identified as indicative off-stream storage sites (Figure 56). Sites were chosen based on topography, slope/elevation, vegetation cover and proximity to existing infrastructure. All sites require a dam wall to retain water along with varying degrees of excavation, depending on the topography and volume of storage required.

The off-stream storage would be constructed as a “turkey’s nest” dam where the material excavated within the reservoir would be used to construct the peripheral embankment, bunding the reservoir on several sides with clay lining. The construction would utilise the existing topography, locating the reservoir at the foot of hills, hence reducing construction costs where possible. Areas with steep relief would require more extensive excavation into the hill. Sites were chosen to make use of the natural topography to minimise excavation whilst balancing the water drainage into the dam. There was no land holder consultation or on-ground site assessment undertaken. Sites chosen are indicative to allow the potential feasibility of this broad strategy to be assessed.

All four sites are on cleared land on private property and are accessible from Wilsons Creek Road:

- Site 1: adjacent to Robinsons Lane at the foot of the Koonyum Range - this site was identified as the southern storage option in JWP (2005). The site is on land zoned RU1 primary production in Byron Local Environmental Plan (BLEP) 2014. It collects natural run-off from the surrounding hills and the topography shows a suitable area where the land is gently sloping between the 17.5 and 12.5 mAHD contours.
- Site 2: adjacent to Yankee Creek Road and Wilsons Creek Road - the site is on land zoned RU1 primary production. Similar to site 1 the site collects natural run-off from the surrounding area and topography shows a suitably large area between the 17.5 and 12.5 mAHD contours.
- Site 3: the eastern side of Coolamon Scenic Drive and to the north of Lagoon Drive - site 3 is on land zoned RU5 Large Lot Residential and RU1 Primary Production. The site is on cleared farmland with significant relief. The location provides for the possibility of a smaller, deeper dam with relief between the 3.5 and 12.5 mAHD contours.

- Site 4: adjacent to Robinsons Lane on the eastern side - the site is on land zoned RU1 Primary production and provides a suitable area between the 16.5m and 25m AHD contours.

Due to the topography, raw water stored in the off-stream storage would need to be pumped back to the WTP if it is retained in its current position. If an off-stream storage option is pursued, relocation of the WTP to the off-stream storage site should be considered (refer Section 12.6). The proposed raw water transfer system upgrade (Section 12.6) would also need to be extended to the off-stream storage site.

Estimated dam wall earth volume, excavation requirements and water storage volumes are shown in Table 44.

Table 44: Off stream storage characteristics

Site	Dam earth volume (m^3) [1]	Excavation (m^3) [2]	Water surface area (m^2)	Water storage volume (m^3) [3]	Water storage volume (ML)
1	34,326	75,987	51,155	208,818	209
2	52,349	43,0760	67,251	689,157	689
3	93,982	50,549	48,257	471,187	471
4	98,288	155,633	64,206	465,149	465

1. Dam earth volume is the quantity of earth required to build the dam wall to a given AHD contour.

2. Excavation cut is the quantity of earth excavated to the new ground level/dam base and could be used to build the dam wall if the material is suitable.

3. Water storage volume is an approximation of the volume of water that the storage dam could hold.

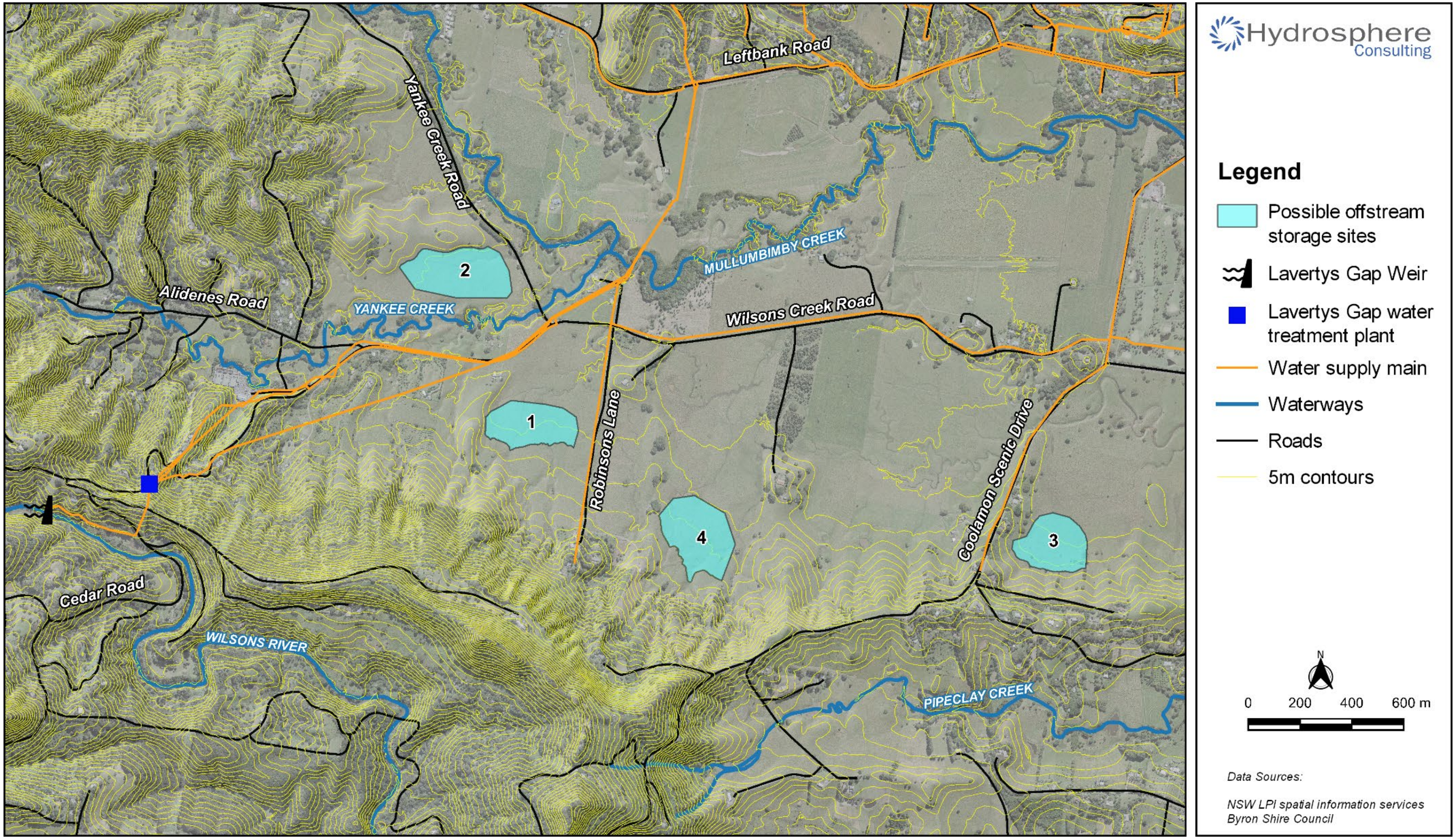


Figure 56: Potential off-stream storage sites

12.3.2 Potential environmental impacts

The locations proposed for the off-stream storage reservoir are predominantly cleared grazing land. As such the construction of the dam is expected to have minimal ecological impact.

A fishway or suitable offset is expected to be required similar to the weir raising options as discussed in Section 12.2.5.

Hydrological, flooding and drainage impacts (including impacts on downstream flows) have not been assessed. Catchment impacts would need to be assessed in terms of storage water quality, spillway requirements and any diversion of creek flows around the storage.

The storage and new WTP would be visible from surrounding higher elevation areas.

12.3.3 Secure yield

The surface area of the off-stream storage is similar to the increase in surface area for the weir raising scenarios (and hence the effect of evaporation would be similar). As environmental flows would be achieved through overflows from the current weir, additional environmental flow releases have not been included although further consultation with regulatory stakeholders is required to confirm this. While the operational philosophy is yet to be developed, the yield increase resulting from the off-stream storage scenarios has been assessed through increasing the storage available (similar to the effect of weir raising).

Secure yield estimates for the historical and changed climate patterns and Set 1 inflows for various off-stream storage volumes are shown in Table 45. A 200 ML storage is expected to provide the required secure yield until approximately 2060 (including the RCC emergency supply). The secure yield of the water supply system with an 80 ML and 200 ML off-stream storage constructed by 2028 is shown in Figure 57. An additional source would be required from 2045 if the 80 ML storage was constructed.

Table 45: Secure yield estimates - including off-stream storage

Off-stream storage volume (ML)	Secure yield (ML/a) for historic climate	Secure yield (ML/a) for 1°C warming[1]
-	440	356
80	670	479
200	885	633

1. The climate change factor calculated for the 200 ML storage with climate change is 0.715 (1/1/1895 - 31/12/2008).

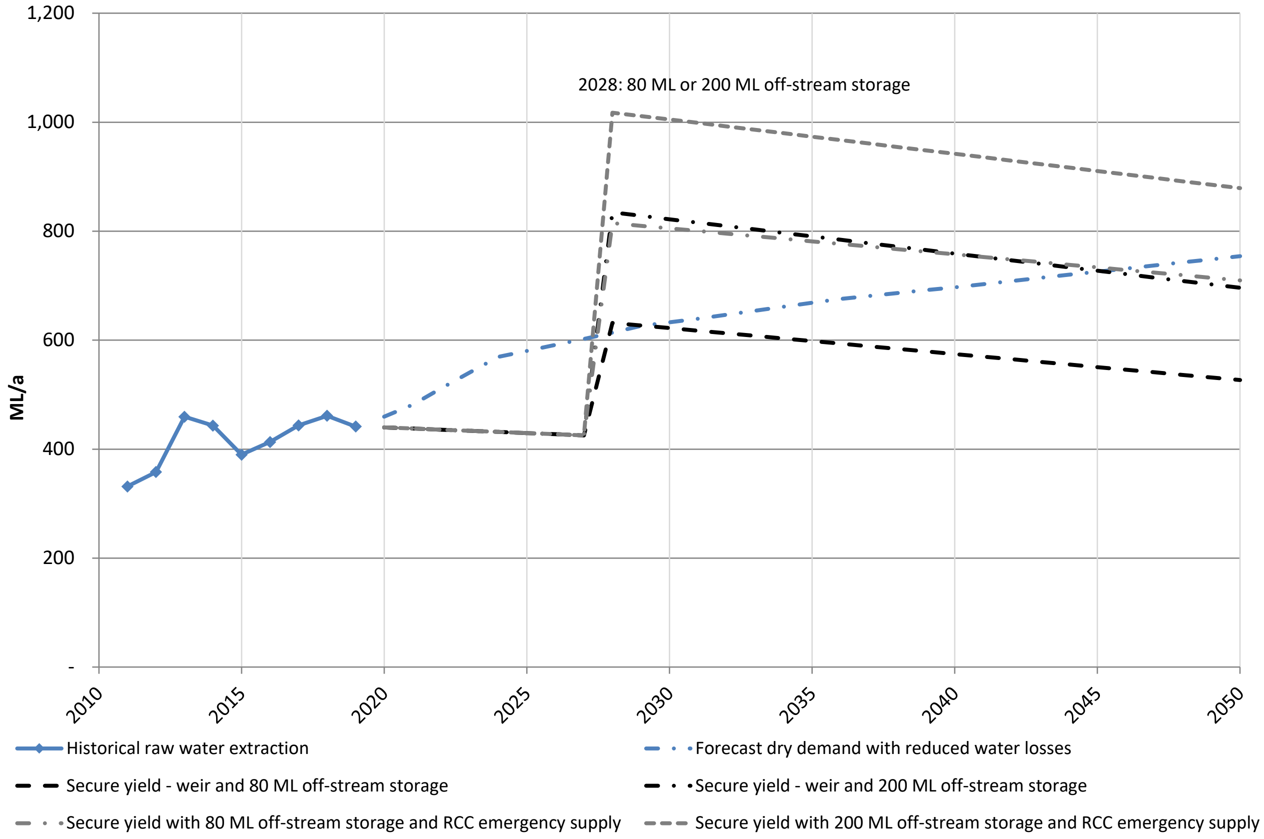


Figure 57: Secure yield with off-stream storage

12.3.4 Cost estimates

JWP (2005) estimated the total capital cost of a 450 ML off-stream storage at site 1 to be $9.01 million (2020$) including land acquisition, fishway or suitable alternative offset and transfer system but not including a new WTP.

A revised indicative cost estimate for a 200 ML off-stream storage with a fishway is shown in Table 46 (excluding land acquisition). Costs associated with the raw water supply upgrade or WTP are not included but will be addressed in scenarios where this would be required (Section 13). Cost estimates are included in Appendix 2.

Table 46: Cost estimate - 200 ML off-stream storage

Item	Cost estimate (2021 $)
Capital cost	$20,680,000
Operation and maintenance	$200,000 p.a.

This cost estimate assumes the excavated material is suitable for use in construction of the storage walls and that pipework to transfer the raw water from the weir to the storage and from the storage to the WTP is in place. Geotechnical investigations would be required to confirm site suitability and cost estimates. Costs associated with the WTP are not included.

12.4 Option 4 - Full Connection to RCC Regional Supply

12.4.1 Pipeline extension

JWP (2005) considered a permanent connection to the RCC bulk supply (the regional water supply) which would replace the current water supply from Lavertys Gap weir. In future, the pipeline from St Helena reservoir is expected to be able to supply 3.2 ML/d as discussed in Section 3 which would be sufficient to supply the Mullumbimby demand beyond 2050 (average demand at 2050 is predicted to be 2.1 ML/d). The pipeline would be extended to the Azalea Street reservoirs (3 km) as shown indicatively on Figure 58. The Left Bank Road and Azalea Street reservoirs are interconnected and this arrangement would service the whole urban area of Mullumbimby. The customers along the Wilsons Creek Road trunk main would not be serviced with this arrangement.

12.4.2 Option 4A - permanent connection to regional supply

A permanent connection to the RCC regional supply would mean that Mullumbimby would be supplied with bulk water from RCC bulk supply to the inlet of Azalea Street reservoir. The extension of the emergency supply pipeline to Azalea Street reservoir (4B) would be required as an interim measure. BSC would be responsible for distribution to customers in Mullumbimby which is the same arrangement as the remainder of Byron Shire urban areas. There has been no assessment of the hydraulic capacity or condition of the existing pipeline. It has been assumed that dual pipelines will be required as a contingency measure.

This option would negate the need for the weir supply as a raw water source for Mullumbimby.

12.4.3 Option 4B - emergency connection to regional supply

As an alternative, the existing RCC emergency supply pipeline could be extended to service the remaining areas of Mullumbimby as an emergency supply only. BSC would then retain Lavertys Gap Weir and WTP as the normal supply regime with future augmentation with another raw water supply source. The customers along the Wilsons Creek Road trunk main would still be serviced by the weir supply and WTP if there was sufficient water in the weir storage.

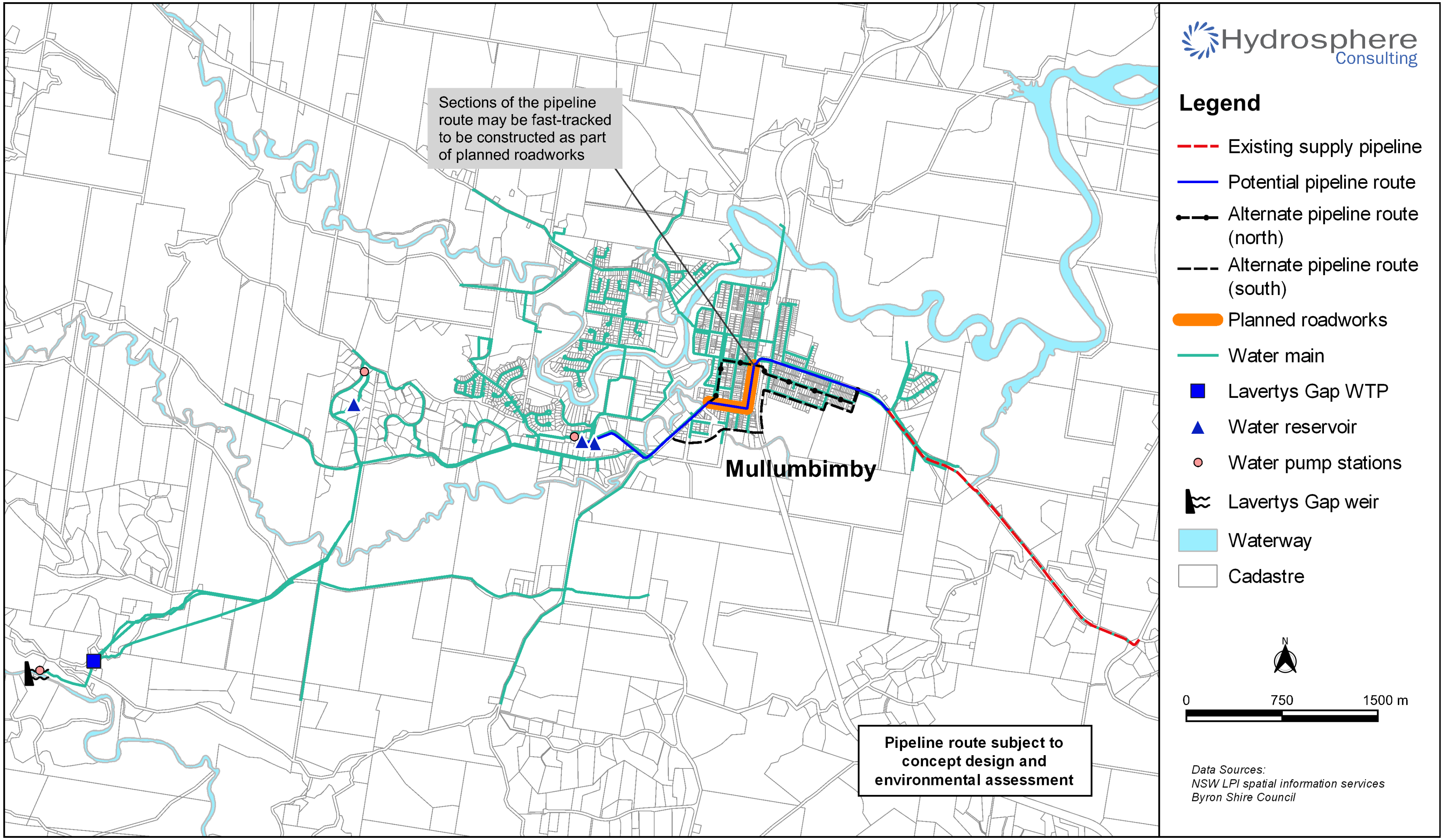


Figure 58: Proposed connection from main to reservoir

12.4.4 Potential environmental impacts

The pipeline route is expected to follow existing roads within urban areas of Mullumbimby and environmental impacts are expected to be minimal.

The RCC Future Water Project 2060 included a MCA to select the preferred long-term strategy of a diversified portfolio of actions including groundwater supplies, recycle water, demand management and water loss management (Hydrosphere Consulting, 2021a). The MCA methodology built on previous studies undertaken by RCC in 2014 and a detailed assessment of options and supply scenarios. The environmental assessment criteria used in the RCC Future Water Project 2060 included:

- Aquatic: Impact on groundwater and surface water quality and aquatic ecology and measures to offset those impacts (aquatic biodiversity impacts (e.g. high value aquatic ecosystems, threatened species, water quality, groundwater dependent ecosystems, GDEs) and offsets proposed (e.g. environmental flows).
- Terrestrial: Impact on terrestrial ecology and measures to offset those impacts (terrestrial biodiversity impacts (e.g. high value terrestrial ecosystems, threatened species) and offsets proposed (e.g. stewardship/ compensation)).
- Energy consumption: Operational energy consumption per kL of water produced (over 80 years).

Based on the MCA, the most favourable regional supply scenario is groundwater which scored higher on environmental and social criteria than scenarios including a new dam. While limited environmental investigations have been undertaken by RCC for groundwater options (potential impacts on GDEs require further assessment), RCC considers that the impacts are manageable. RCC considers that suitable measures can be put in place to obtain planning approval and ensure stakeholder acceptance of the groundwater scenarios (Hydrosphere Consulting, 2021a).

12.4.5 Secure yield

If Mullumbimby became part of the RCC regional supply, the secure yield would be determined by the RCC bulk supply system. RCC is currently investigating options to ensure long-term security. As such, this option is considered to provide long-term security for Mullumbimby (either as a permanent or emergency supply).

The unrestricted dry year demand of Mullumbimby customers is expected to be 633 ML/a in 2030 or 4.7 % of the Rous demand forecast at 2030 (13,480 ML/a). In preparing its demand forecast, RCC considered the additional demand that will result from connection of local supplies (including Mullumbimby, Casino, Wardell and Nimbin). RCC is already committed to providing 183 ML/a (0.5 ML/d) as an emergency supply to Mullumbimby. No detailed consultation has been undertaken with RCC but it is assumed that this minor increase in demand will not alter the preferred strategy for the regional water supply.

12.4.6 Cost Estimates

The extension of the pipeline to Azalea Street reservoir is estimated to cost $1,282,300 (refer Appendix 2). This assumes that the existing pipeline is adequate as an emergency supply. Hydraulic modelling would be required to confirm this.

For the permanent connection option (Option 5A), JWP (2005) included a connection fee equivalent to headworks contributions (in accordance with the RCC Development Servicing Plan, DSP) but considered options where lower headworks contributions would apply. Connection and supply costs would be negotiated with RCC. Considerations for a permanent connection (Option 5A) include:

- Headworks contributions calculated in accordance with the 2020/21 developer charge would be $17.7 million (based on 2,000 ET at $8,872 per equivalent tenement (ET), Rous County Council, 2020).
- Mullumbimby township may be considered as a backlog area, which does not normally attract developer contributions.
- The 2020/21 notional price of water charged to regional councils is $1.72 per kL (2019/20, Rous County Council, 2019). BSC would save costs associated with Mullumbimby raw water supply and treatment, estimated as $0.60 per kL.
- Future developer contributions would be payable to RCC for headworks contributions and to BSC for distribution system contributions.

It is assumed that the emergency supply pipeline is operated when level 4 restrictions are in place. The frequency is expected to increase with the impacts of climate change over the long-term. The cost of the water as an emergency supply for Option 5B is $4.78 per kL in 2020/21 (Special Approved Connection).

Cost estimates for the permanent and emergency supply option are given in Table 47. The financial impact of the transfer of ownership or decommissioning of assets has not been estimated. Costs associated with the raw water supply upgrade or WTP are not included as they are unlikely to be required. For the purposes of this cost estimate, it is assumed that headworks contributions will not be payable by BSC. Cost estimates are included in Appendix 2.

Table 47: Cost estimate - RCC regional supply

Item	Cost estimate (2021 $)
Permanent supply	
Capital cost	$3,932,000
Purchase of water (bulk supply) - average	$784,000 p.a.
Emergency supply	
Capital cost	$1,282,000
Purchase of water (emergency supply)[1] - average	$148,000 p.a.

1. Average cost with emergency supply estimated to be required 10% of the time.

12.5 Option 5 - Groundwater

This option involves supplementing the current water supply from Lavertys Gap Weir with a new groundwater source. The groundwater supply could be either a permanent supply supplementing the weir supply or used as an emergency supply only as suggested in the 2014 drought management plan (HydroScience, 2014). This water would either be pumped directly to the WTP for treatment or to the weir storage depending on the location of the bore supply and future location of the WTP.

There are five groundwater sources within the Mullumbimby/Wilsons Creek region within 5 km of the WTP/weir. Table 48 provides a summary of the geology, water quality, yield, socio-economic and environmental risks of each source. The environmental risk rating considers the impacts of extraction on the groundwater source and any high priority GDEs and identifies risks to ecological, water quality and aquifer integrity assets. The socio-economic risk assessment considers the dependence of local communities on groundwater extraction. A detailed description of the geology and groundwater sources is provided in the following sections.

12.5.1 Geology

The geology underlying Mullumbimby and the surrounding area is comprised of the following rock types (from oldest to youngest rock) (McKibbon, 1995):

- Palaeozoic age sedimentary rocks of the Beenleigh Block (Part of the New England fold belt) form the effective geological basement of the area. The Neranleigh Fernvale Beds of this unit outcrop the areas surrounding Mullumbimby (EHA, 2008). These beds consist of strongly folded and structurally deformed greywackle, slate, phyllite and quartzite.
- Teritiary age volcanics overlay the deep bedrock formations. The key geological unit of the tertiary age volcanics within the Mullumbimby area are the Lamington volcanics comprising sub-alkali basalt with members of rhyolite, trachyte, tuff, agglomerate and conglomerate.
- To the South and west of Mullumbimby, underlying the Lamington volcanics, are the consolidated sediments of the Clarence Morton Basin.
- Quarternary age alluvial sediment associated with the low-lying coastal flats and river valley-fill.

Figure 59 shows the surface geology in the Mullumbimby area and geological cross section showing geology at depth from a location to the north-west of Mullumbimby. The mapping shows that river gravels and alluvium (labelled ‘Qa’) cover the low-lying areas immediately surrounding Mullumbimby. To the north-west is the Neranleigh-Fernvale group (labelled ‘Pzn’). The Neranleigh-Fernvale group is approximately 3,000 ft (914 m) thick. The North Coast volcanics (or Lamington volcanics) lie to the south-south-west of Mullumbimby which overlie the Clarence-Moreton Basin.

Table 48: Characteristics of groundwater sources in the area

Groundwater source	Geology	Quality	Yield	Estimated likely bore production (per bore)	Socio-economic risk	Environmental risk	Water Sharing Plan
Brunswick River Coastal Floodplain Alluvial	Floodplain alluvial	Variable Salinity: 200 - 3,500 mg/L	Typically low	NA	Medium	Medium	*Water Sharing Plan for the Brunswick Unregulated and Alluvial Water Sources, 2016*
New England Fold Belt	Fractured rock	Conductivity: 1,000 - 10,000 µS/cm	Typically: 0.5 L/s - yields of up to 16L/s obtained in gold coast area	NA	Low	Moderate	*Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources, 2016*
Clarence Moreton Basin	Porous rock	Variable, typical salinity 500 mg/L	Typically: < 1 L/s	NA	Moderate	Low	
North Coast Volcanics	Fractured rock	Typically excellent	Typically: 5-10 L/s	15-235 ML/a	Moderate	High	
Tweed-Brunswick Coastal Sands	Beach and dune sands	Typically fresh, high risk of encountering acid sulphate soil	Typically: 0.5-6 L/s	10-95 ML/a	Moderate	High Could potentially affect GDEs	*Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources, 2016*

Sources: NSW DPI (2016a), NSW DPI (2016b), NSW DPI (2016c), DLWC (1998), Parsons Brinckerhoff (2011), Jacobs (2015), DLWC (1998).

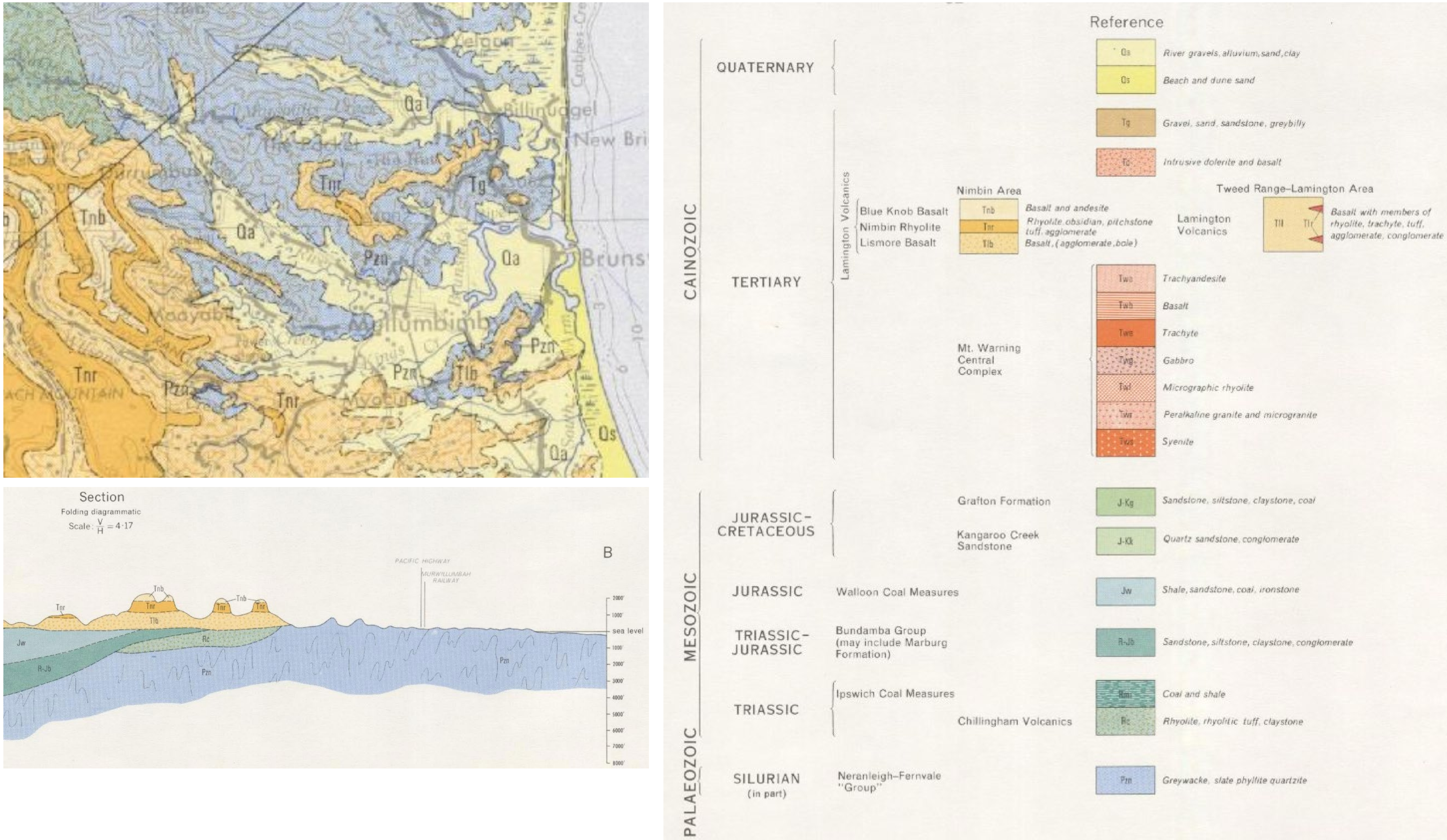


Figure 59: Mullumbimby surface geology and cross section showing geology at depth from location to the north-west of Mullumbimby

Source: Tweed Heads 1:250,000 Geological Survey of NSW (1972)

12.5.2 Potential Groundwater Sources

Figure 60 shows the location of groundwater sources in the Mullumbimby area including the aquifers of the porous rocks of the Clarence Morton Basin, fractured rock of the North Coast Volcanics and the New England Fold Belt and unconsolidated sediments of the Brunswick River alluvium and coastal sands.

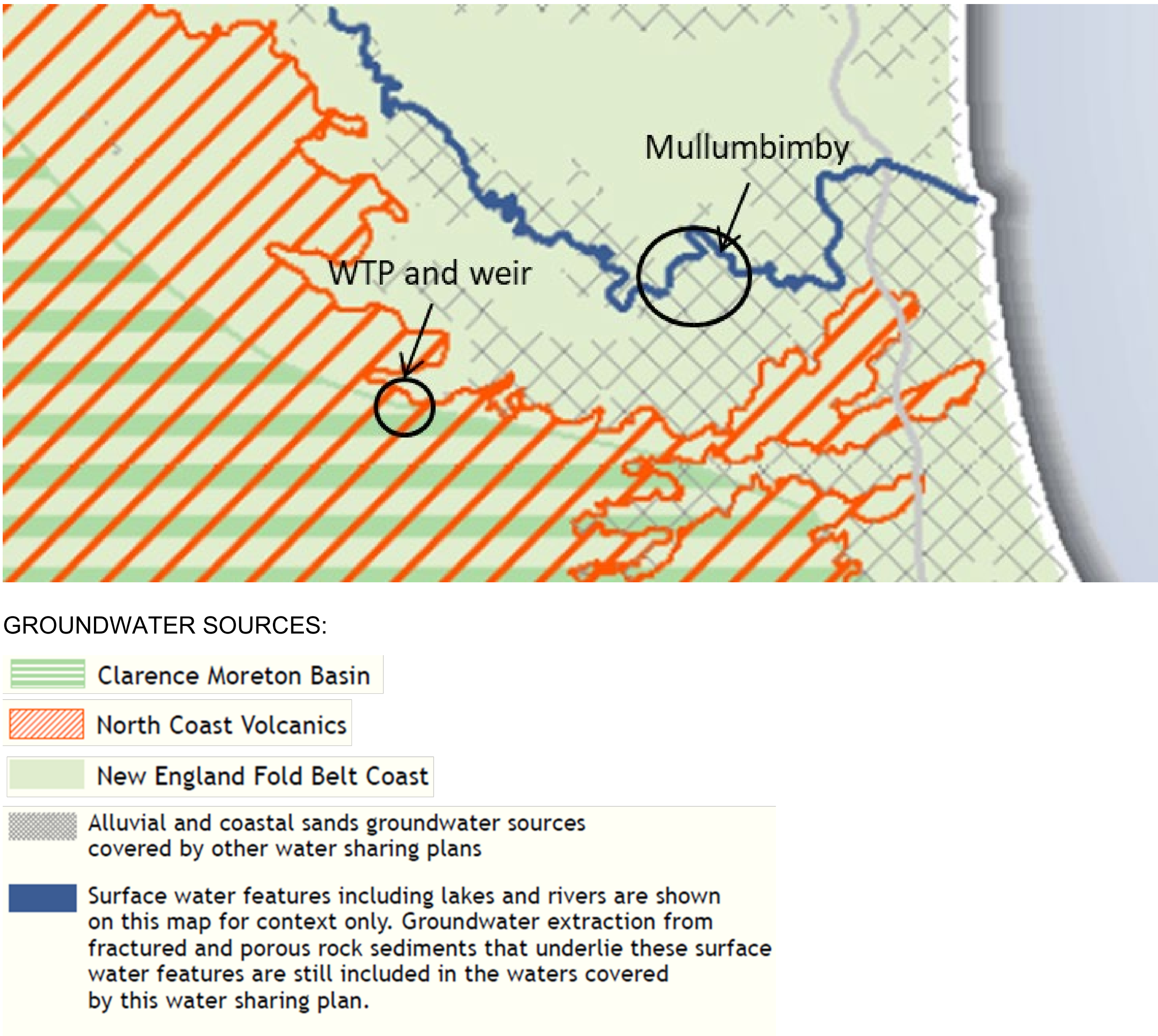


Figure 60: Groundwater sources in the Mullumbimby area

Source: NSW DPI (2016a)

Based on the information discussed below on the typical yields and water quality, the Tweed-Brunswick Coastal Sands and North Coast Volcanics (also referred to as Lamington Volcanics group or North Coast Fractured Rock) may provide adequate yield and quality. However, the yield may vary significantly between locations within the same aquifer and test bores would need to be established to confirm actual yield. Units of the Clarence Moreton basin and the Neranleigh-Fernvale group which underlie the North Coast Volcanics and Coastal Sands aquifers may also provide potential groundwater sources and should be considered if test bores are to be drilled.

Brunswick River Floodplain Alluvial

Mullumbimby is situated within the Brunswick River Coastal Floodplain Alluvial Groundwater Source which extends from approximately 2 km east of the town to approximately 2 km west of the town. It primarily consists of fine grain sands, silts and clays ranging up to 2km wide and 20m in depth.

The background document (NSW DPI Water, 2016b) discusses the development of the rules in *The Water Sharing Plan for Brunswick Unregulated and Alluvial Water Sources*. It considers the following constraints on the yield and water quality of the groundwater source:

- Groundwater yields from this source are generally low and typically only suitable for stock use.
- Water quality from this source is variable with some areas producing fresh water and others more saline water.
- These coastal alluvial floodplains are often underlain by acid sulphate soils which further restricts the suitability of pumping the groundwater and can lead to poor water quality

Due to the poor/variable water quality and low yields this groundwater source is not considered a viable option for Mullumbimby town water supply.

New England Fold Belt

The Naranleigh-Fernvale beds of the New England Fold Belt form the geological basement of the area surrounding Mullumbimby and are overlain by the Clarence Moreton Basic and North Coast Volcanics groundwater sources and by the alluvial and coastal sand deposits further east. McKibbon (1995) indicated that this unit has generally low permeability and yields of typically around 0.5 L/s, however occasional yields of up to 5 L/s are recorded. Swann (1997) indicated that in Queensland the Neranleigh Fernvale beds rarely host significant groundwater sources except in areas associated with zones of structural deformation along drainage lines.

Despite high yields being obtained by bores extracting groundwater from this source in South-East Queensland, the low permeability and limited storage potential within the aquifer limits its potential and it is unlikely that this aquifer presents as a potential source for groundwater extraction.

Clarence Moreton Basin

The Clarence Morton Basin is a more extensive aquifer also located in north-east NSW. It is overlain by the North Coast Volcanics groundwater source and in the east it is overlain by alluvial and coastal sand deposits. Yields are typically low (most commonly 0.3 L/s and up to 1.5 L/s) and quality is variable (McKibbon, 1995). The shallowest and youngest part of the unit, the Grafton formation, is more saline and only suitable for stock. Older/deeper units generally have water which is suitable for domestic purposes (NSW DPI Water, 2016a).

Due to the typically low yields extracted from this aquifer it is unlikely to be a potential source for groundwater extraction.

North Coast Volcanics

Mullumbimby and Lavertys Gap Weir are situated within the North Coast Volcanics Groundwater Source which is a fractured rock groundwater source bound by Lismore to the south, Mullumbimby to the east, Kyogle to the west and extends to the NSW-QLD border (NSW DPI Water, 2016). The geology of the North Coast Volcanics is made up of various volcanic formations with the Lismore basalts the most widespread formation of the Lamington Volcanics Group (Jacobs, 2015). The typical saturated thickness of the aquifer is 60 m (Jacobs, 2015).

The aquifer risk assessment (NSW DPI Water, 2016) for this groundwater source determined that changes in groundwater levels and the timing of fluctuations pose a high risk to GDEs such as springs, rainforests, dependant soils, seasonal drys and that extraction will reduce base flows for plateau streams. During dry periods, stream and spring flow is reliant on groundwater discharge and as a result GDEs are common within the water source. An assessment would be required to determine if there are high priority GDEs present which may be affected by extracting water from this source.

The basalt aquifers of the North Coast Volcanics have variable yields which can be attributed to the nature of the fractured rock sequence. Yields are generally moderate, up to 5 L/s and some bores may obtain yields up to 10 L/s when associated with highly fractured areas. The groundwater has excellent water quality, however deeper aquifers have better yield and quality potential than shallow aquifers (Jacobs, 2015). As such, deeper aquifers may be considered as a potentially viable option for augmenting the Mullumbimby town water supply. A structural lineament analysis may be used in prospective site selection to identify sites that are likely to be highly fractured as these areas are more likely to produce higher yields (Jacobs, 2015).

Tweed-Brunswick Coastal Sands

Northern NSW coastal sand aquifers typically consist of medium grained sands with the occasional interbedded indurated iron and clay layers. The water table is relatively close to the surface and is often connected to wetlands and swamps that sustain numerous groundwater dependant ecosystems. The water is typically fresh, however water quality issues may arise due to the high iron content and saline water from adjoining estuaries (NSW DPI Water, 2016c). Further, much of the land to the east of Mullumbimby is classified as having a high risk of containing potential acid sulphate soils which if exposed to oxygen can cause acidification events. The vast majority of coastal sand units is of “High” aquifer vulnerability due to their shallow, unconfined and highly permeable characteristics. The water tables were typically less than 5 m deep, combined with shallow soil depth, low slope and high to very high permeability, which placed them in the high risk category for contamination and variation in yield.

Jacobs (2015) considered an area along the coast between Brunswick Heads and Byron Bay as not being viable for water supply development as the area could potentially encounter saline intrusion and high iron.

12.5.3 Water Sharing Plans

The potential groundwater sources are covered by the following water sharing plans (refer Table 48):

- *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources.*
- *Water Sharing Plan for the Brunswick Unregulated and Alluvial Water Sources.*
- *Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources.*

These WSP provide the rules for extracting water from local aquifers to ensure their sustainable management.

12.5.4 Groundwater bore data

The Water NSW website provides data on groundwater bores (Figure 61). Table 49 gives a summary of groundwater works within 1.5 km of the WTP. The information was recorded by the driller at the time of drilling over a short time period and may not be an accurate representation of the sustainable yield or water quality.

Table 49: Local bores work summary

Bore ID	Year drilled	Water bearing zone (m below surface)	Yield (L/s)	Salinity (mg/L)	Rock type/ geological material
GW303878	2002	24-34	0.15	-	-
GW302784	2000	25-28	0.38	140	-
GW306146	2006	-	-	-	-
GW306234	2007	21-26	0.189	150	-
GW068295	1989	19-32	0.5	-	Fractured
GW067283	1991	53-69	0.6	“Good”	Fractured
GW0306233	2007	31-36	0.759	90	Fractured (basalt)
GW307448	2005	45-50	1.5		-
GW064558	1987	21-24	0.31		Shale/gravel/rock
GW049436	1979	7	0.38		Basalt
GW306147	2006	18-22 30-35	0.38 1.26	80 100	Basalt/red jasper Serpentine
GW303848	2002	21-39	0.45	-	Basalt
GW306483	2009	19-21 27-27.5 29-29.5	0.5 1.0 0.5	- - -	Basalt
GW058254	1982	23-27	0.52	-	Fractured (Shale)
GW052768	1980	9-11	0.39	-	Fractured (Basalt)
GW302356	-	-	-	“Good”	-

The bores near the WTP with the higher yields (> 0.6 L/s) are greater than 30 m in depth.

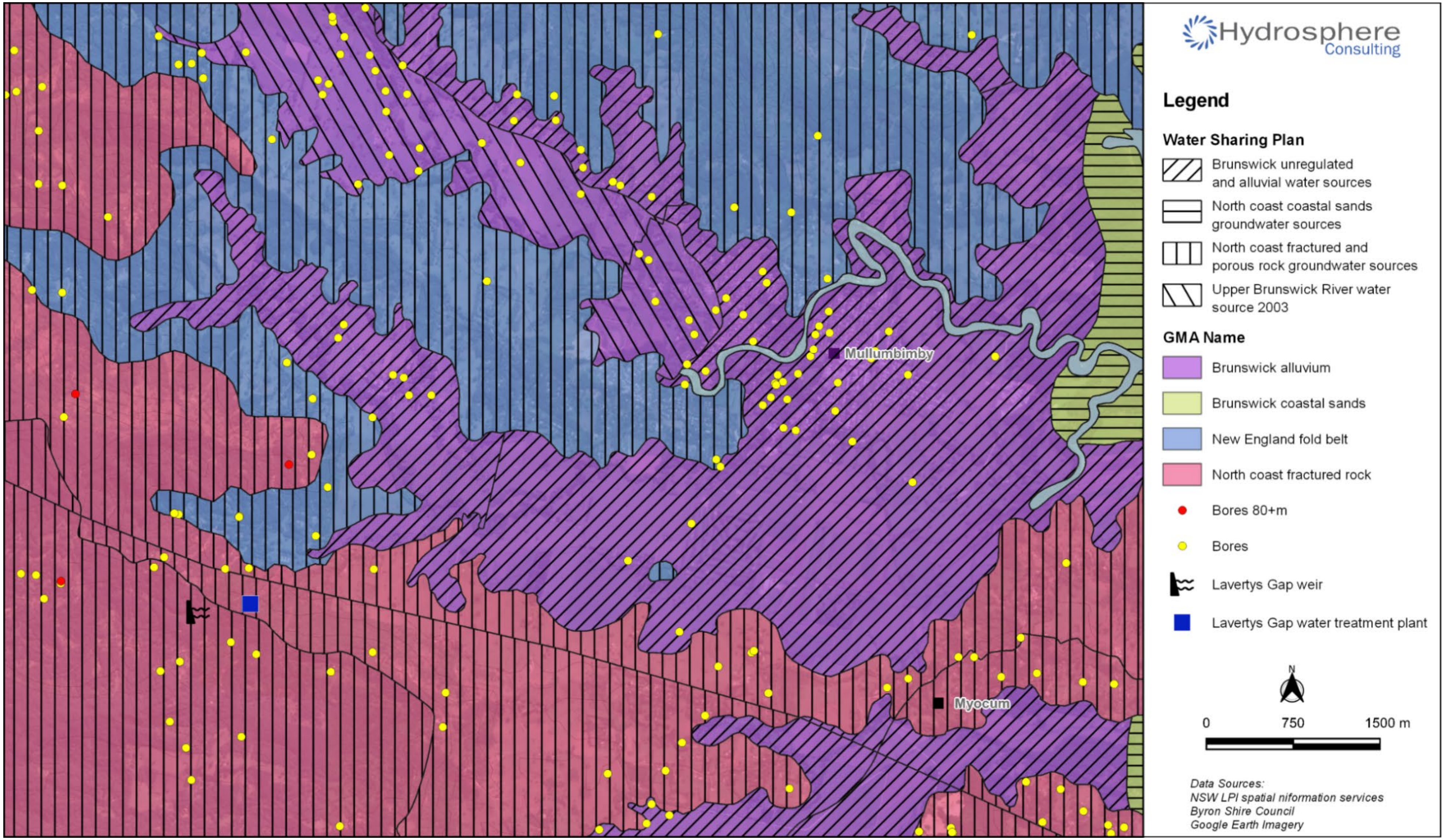


Figure 61: Water sharing plan areas and registered bores

12.5.5 Potential Environmental Impacts

The following potential environmental impacts would need to be taken into consideration for the extraction of groundwater:

- Extracting groundwater has the potential to impact GDEs such as wetlands that rely on spring or seepage water, terrestrial ecosystems that utilise water from shallow aquifers and aquatic and riparian ecosystems whose surface water supply is fed by groundwater. GDEs would be identified through a desktop exercise with all known records of GDEs from known databases, GIS records and other studies. Impacts on GDEs have not been assessed but it has been assumed that bore locations can be selected to minimise impacts.
- Acid sulphate soils are a potential concern for coastal sand aquifers.
- Contaminated lands (e.g. industrial sites, landfill, cattle dips and sewage disposal areas) have the potential to impact groundwater quality. Sites that are particularly at risk of contaminated groundwater are sites within urban areas with a shallow water table and permeable soils. Sites selected for groundwater investigation would need to be assessed for contamination.

12.5.6 Considerations for further investigation

Based on the preliminary desk-top investigations, the North Coast Volcanics (fractured rock groundwater source) is recommended for further investigation. The following factors will need to be considered if this option is considered further:

- Potential bore location - this will need to consider land ownership and acquisition, heritage constraints, local geology and environmental constraints. Once potential bore locations have been identified, test bores may be established and samples taken to determine the yield, salinity and other parameters of concern for drinking water supply.
- Licensing and legislative requirements.
- Infrastructure requirements - raw groundwater transfer, level of treatment required and distribution to the reservoirs.

12.5.7 Secure yield

There is currently no guidance on the assessment of secure yield of groundwater supplies with climate change. The yield of the bores is assumed to be influenced by rainfall. The reduction in annual rainfall with 1ºC warming indicated by the GCM data is 10% (on average) and this has been assumed to be the reduction in yield experienced at 2060. A current groundwater yield of 1.1 ML/d is required to achieve the future yield requirements (supplementing the weir supply to meet the 2050 demand). A groundwater supply with a yield less than 1.1 ML/d could be utilised if Council was to continue reliance on the RCC emergency supply. Higher groundwater yields would reduce reliance on the weir supply and increase the security of the groundwater option.

The secure yield of the water supply system with supplementary groundwater supply of 1.1 ML/d constructed by 2028 is shown in Figure 62.

Table 50: Secure yield estimates - groundwater (1.1 ML/d)

Secure yield (ML/a) for historic climate	Secure yield (ML/a) for 1°C warming[1]
408 (1.1 ML/d)	367

1. The climate change factor calculated for a groundwater supply with climate change is assumed to be 0.9 (based on a 10% reduction in rainfall).

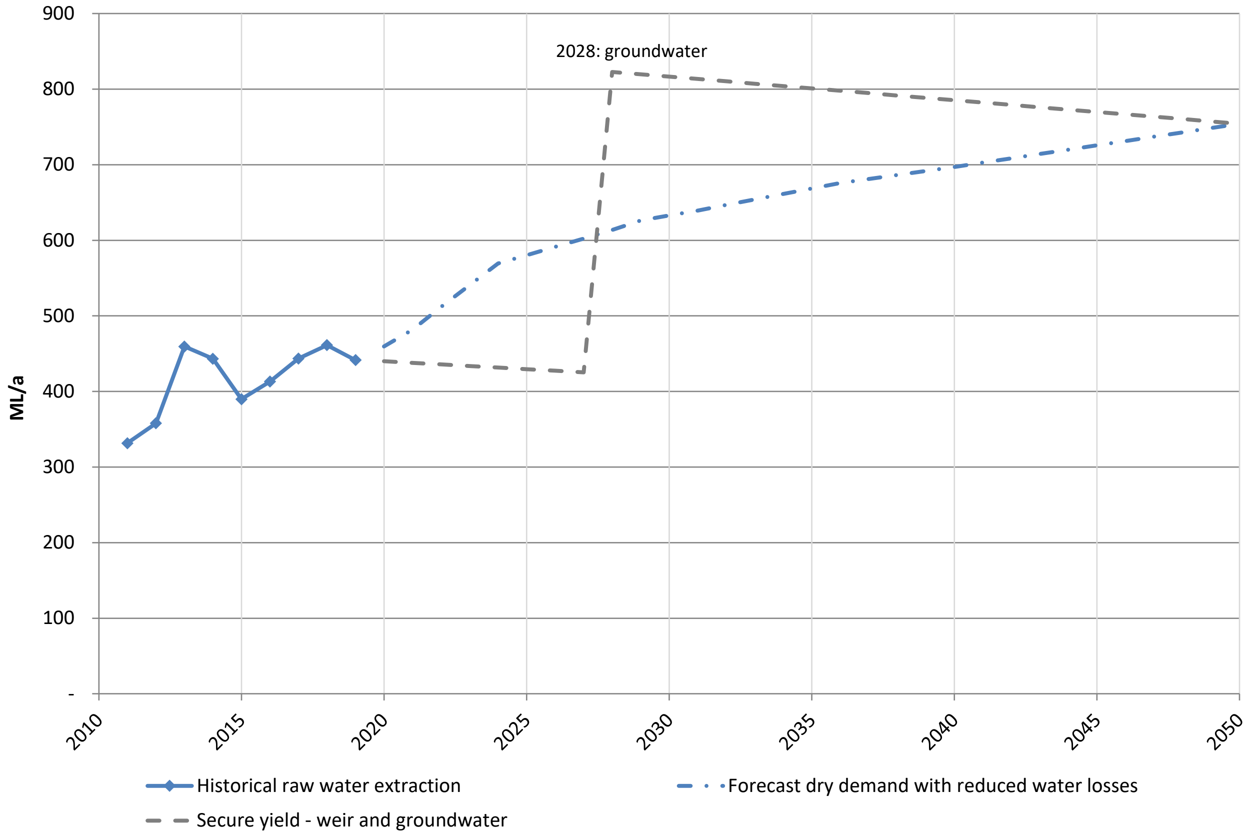


Figure 62: Secure yield with groundwater

12.5.8 Cost Estimates

The cost estimates for the groundwater supply option are shown in Table 51 based on cost estimates prepared for groundwater schemes for the RCC Future Water Project 2060 (Jacobs, 2020) for new bores in fractured basalt aquifers at Alstonville (2.5 ML/d), modified to reflect the reduced capacity (excluding land acquisition). Groundwater treatment costs or costs associated with the existing WTP have not been included as it has been assumed that high level treatment (e.g. to remove salinity) will not be required. Costs associated with the raw water supply upgrade or WTP are not included but will be addressed in scenarios where this would be required (Section 13).

Table 51: Cost estimate - groundwater supply

Item	Cost estimate (2021 $)
Capital cost	$2,855,000
Operation and maintenance	$206,000 p.a.

The cost of groundwater collection, treatment and distribution will vary depending on water quality, the yield and location of the bore/s and whether or not the water will be treated at the existing WTP or if new facilities need to be established.

12.6 Comparison of Options

The water supply options are compared below in Table 52 on the basis of yield benefit, infrastructure requirements, environmental and social outcomes. Community consultation has not been undertaken.

All options will require upgrade of the WTP (at least short-term improvements) and upgrade of the raw water supply from the weir apart from Option 4A - permanent connection to regional supply.

Table 52: Comparison of options

Option		Description	Yield at 2050 and security	Other infrastructure required (not costed)	Environmental	Social	Conclusion
1	Do nothing	No raw water supply upgrade. Emergency response actions will include water carting to service higher areas of town in addition to the Rous emergency supply.	560 ML/a (yield of weir and emergency supply). Secure until 2027.	Upgrade of raw water supply from weir. WTP upgrades (short-term) and replacement/ relocation. Heritage management requirements for current scheme.	No change	It is likely that restrictions will be imposed more frequently than at present and the weir supply will be depleted in a prolonged drought, requiring emergency measures including water carting to higher areas of Mullumbimby. Heritage management measures are required for continued use of the channel. Trunk main customers would not be served when the weir supply fails.	The supply is secure until 2025 (with additional emergency response actions potentially required). This option could be maintained for the short-term until augmentation options are implemented.

Option		Description	Yield at 2050 and security	Other infrastructure required (not costed)	Environmental	Social	Conclusion
2	Raise Lavertys Gap weir	Raise Lavertys Gap Weir by 5 m to provide additional storage of 322 ML.	632 (increase of 62 ML/a). Secure until 2035.	Upgrade of raw water supply from weir. WTP upgrades (short-term) and replacement/ relocation. Heritage management requirements for current scheme.	Environmental flow provisions are assumed to be required. With the environmental flow rule assessed, environmental flow releases are substantially lower than the overflows that occur at present (with the lower weir) although flow rules could be optimised. Loss of terrestrial biodiversity including remnant native forests, listed ecological communities and threatened species. Biodiversity offsets would be required. Decrease in diversity of aquatic species. Fishway or equivalent offsets is assumed to be required.	No identified impacts on Aboriginal cultural heritage. Heritage requirements for the weir (listed on State Heritage register) have not been considered. Heritage management measures are required for continued use of the channel. Restrictions and emergency response measures will still be required with the 5 m weir raising and environmental flow regime. Trunk main customers would not be served when the weir supply fails.	Although the environmental flow regime could be optimised to improve environmental outcomes, the yield benefit of this option is minimal (and expected to be further reduced with improved environmental flows) and costs are high. Impacts on terrestrial biodiversity are expected to be significant. Not recommended for further consideration.

Option		Description	Yield at 2050 and security	Other infrastructure required (not costed)	Environmental	Social	Conclusion
3	Off-stream storage	Nominal 200 ML off-stream storage (location to be determined).	879 (increase of 319 ML/a). Secure until 2060.	Upgrade of raw water supply from weir and extension to off-stream storage site. WTP upgrades (short-term) and replacement/ relocation. Heritage management requirements for current scheme.	Minimal impact on terrestrial ecology. A fishway at the weir or equivalent offset is expected to be required similar to the weir raising option. As environmental flows would be achieved through overflows from the current weir, additional environmental flow releases have not been assumed although further consultation with regulatory stakeholders is required to confirm requirements.	No identified impacts on Aboriginal cultural heritage associated with new infrastructure. Land would be acquired for the storage and would result in potential loss of farmland. Trunk main customers would require alternative supplies (e.g. rainwater tanks).	A 200 ML storage is expected to provide significant yield benefit but at high cost. Environmental and social impacts are expected to be manageable. Recommended for further consideration to augment the weir supply.
4A	Permanent connection to RCC regional supply	Extend RCC emergency supply main to Azalea Street reservoir and convert to a permanent supply from RCC bulk water supply (dual pipelines)	754 (equivalent to demand) (increase of 194 ML/a, limited by RCC supply). Long-term security.	WTP upgrades (short-term). Heritage management requirements for current scheme.	Minimal impact as construction would be limited to road reserves in urban areas.	Mullumbimby residents may consider that a loss of local identity would result from connection to the regional supply. Trunk main customers would not be served by the regional supply and would require alternative supplies (e.g. rainwater tanks). Community consultation has not been undertaken.	The permanent regional connection provides virtually unlimited yield benefit. Environmental and social impacts are expected to be manageable. Further consideration is recommended.

Option		Description	Yield at 2050 and security	Other infrastructure required (not costed)	Environmental	Social	Conclusion
4B	Full emergency connection to regional supply	Extend RCC emergency supply main to Azalea Street reservoir and emergency supply to all urban areas.	754 (equivalent to demand) (increase of 194 ML/a, limited by RCC supply). Long-term security.	Upgrade of raw water supply from weir WTP upgrades (short-term) and replacement/ relocation. Heritage management requirements for current scheme.	Minimal impact as construction would be limited to road reserves in urban areas.	It is likely that restrictions will be imposed more frequently than at present and the weir supply will be depleted in a prolonged drought. Trunk main customers would not be served by the regional supply and would require alternative supplies when the weir supply fails (e.g. rainwater tanks).	The supply is secure until 2027. It is recommended that this option is further considered for implementation in the short-term until other augmentation options are implemented.
5	Groundwater	Construction of new bores (one production, one standby) in fractured basalt aquifer (1.1 ML/d). Higher yields (if available) would reduce reliance on the weir supply.	754 (equivalent to demand) (increase of 194 ML/a). Secure until 2050.	Upgrade of raw water supply from weir. WTP upgrades (short-term) and replacement/ relocation. Groundwater distribution and treatment infrastructure. Heritage management requirements for current scheme.	Impacts have not been assessed but it has been assumed that bore locations can be selected to minimise environmental impacts.	Impacts have not been assessed but it has been assumed that bore locations can be selected to minimise impacts on other water users. Servicing of trunk main customers would depend on location of bores and groundwater treatment plant.	A groundwater supply can be used as an emergency supply or a permanent supplement to the weir supply. Further consideration is recommended.

12.7 Additional Upgrade Requirements

12.7.1 Effluent reuse

Currently sewage from Mullumbimby is being treated at the Brunswick Valley sewage treatment plant (STP) and some of it is reused for agricultural irrigation. There are further opportunities to reuse effluent via direct reuse by connecting properties to a dual reticulation system, allowing reused water to partially substitute the potable supply to the properties.

Brunswick Valley sewerage treatment system

The Brunswick Valley STP comprises of a 3-stage Phoredox (oxidation ditch with anaerobic pre-reactor) tertiary treatment plant. Following treatment, the effluent is delivered to the Main Arm Recycled Water Scheme via the Mullumbimby recycled water facility storage lagoon and chlorine dosing unit. Recycled water is used on two farms for pasture and fodder irrigation. The remaining treated effluent is discharged to the Brunswick River on the ebb tide. The Main Arm recycled water scheme has the capacity to recycle 100% of the effluent produced at the Brunswick Valley STP and currently recycles 80% of the STP inflows (BSC 2017). The demand for the reused water fluctuates and is dependent on factors such rainfall and soil moisture content.

The *2017-2027 Byron Shire Effluent Management Strategy* (BSC, 2017) proposes that future treated effluent is used for further rural applications and a proposed sustainability project that would involve constructed wetlands, biomass cropping and renewable energy production including solar farming and co-generation (BSC, 2017). The strategy considered that the development of an urban reuse scheme was not the most beneficial reuse option due to the low volumes of recycled water expected to be used within the town.

Council is currently planning transfer of the sewage from Ocean Shores STP to the Brunswick Valley STP to address capacity issues at Ocean Shores STP, wet weather flow issues experienced in Mullumbimby and provide flexibility to the system including enhancement of reuse capacity as well as the capture and treatment of storm flows.

Recycled water planning

Currently, the demand for the available recycled water resource in Byron Shire has not matched supply resulting in the discharge of highly treated wastewater to the environment. This is regarded as a lost opportunity to utilise this resource. Recent drought conditions in the region have highlighted the community's desire for the use of recycled water as part of a portfolio of water sources to secure the region's future water supplies and its resilience to future droughts and climate change. Council is currently reviewing its recycled water strategy (BSC, 2017), taking a more proactive approach to harness the potential of recycled water to deliver broader community outcomes, while also maintaining the original focus of protecting waterways from effluent discharge and supporting environmental flows.

Dual reticulation

Dual reticulation involves the construction of a recycled water pipeline which will supply recycled water from the Mullumbimby recycled water facility to future development areas for toilet flushing and garden use, open urban spaces such as sporting fields, parks, gardens, golf course, school ovals, public toilets, Council gardens and industrial users within the Mullumbimby township. The scheme would replace potable water sources with highly treated effluent that meets the criteria according to the *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1) 2006*, (AGWR). Council will consider the implementation of a dual-reticulation network to distribute fit-for-purpose recycled water as a focus for potable water substitution. To achieve this, the following opportunities will be pursued:

- Mandatory recycled water connections for all new residential developments (refer Section 8.4).
- Facilitation of an enabling environment for retrofitting recycled water connections into already established urban areas, with a focus on high water-using businesses on a voluntary basis.
- Maximising recycled water use for municipal purposes (including public spaces and amenities, green infrastructure, Council buildings, road works, standpipes etc.).

The current recycled water pipeline which delivers recycled water to rural customers at Main Arm could be extended and used as a recycled water reticulation system to deliver high quality treated effluent to greenfield and future development areas in the south and west of the township (Figure 63).

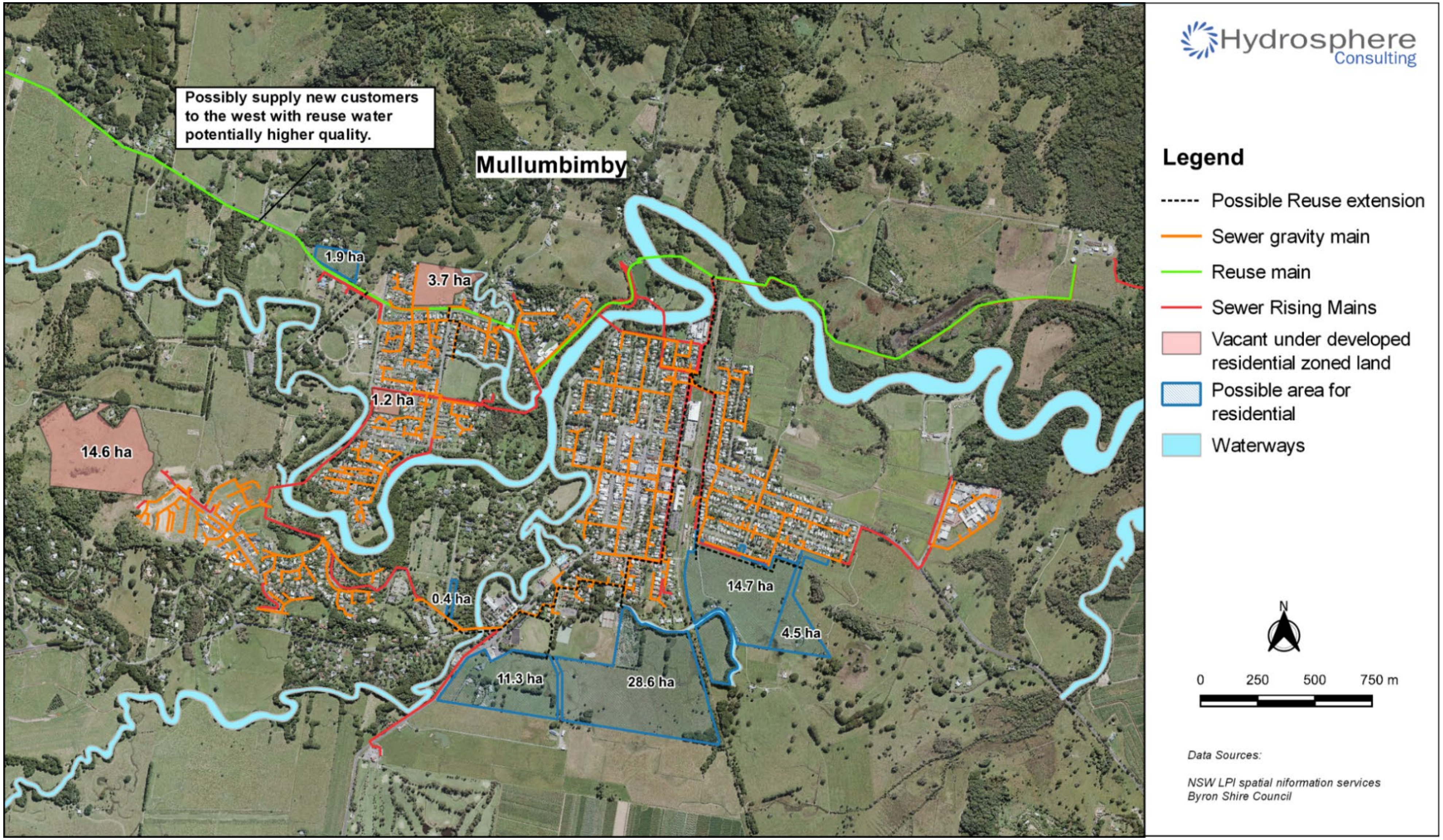


Figure 63: Mullumbimby sewerage network and possible reuse extension

12.7.2 Upgrade of raw water supply from the weir

The raw water channel is currently leaking and at risk of failure in several locations (Entura, 2018; Willow + Sparrow, 2020) as discussed in Section 6.2. Figure 17 (Section 5) shows that between 22/09/2019 and 24/12/2019 the weir level progressively dropped to a minimum level of 114.82 mAHD (1.34 m below the weir crest) despite a weir inflow of approximately 5 ML/d and an average WTP demand of 1.2 ML/d during the same period. Leakage is considered to be a significant component of this shortfall.

The GoldSim model has been used to assess the water level in the weir if channel leakage did not occur during the period September 2019 - December 2019. Figure 64 shows the modelled water level of the weir pool for this period and the theoretical water level assuming that the channel had not lost any water. This also assumes that restrictions were imposed in accordance with Section 3, the RCC emergency supply was used from 23/12/19 and the pump was used from 23/10/19 (mimicking the actual conditions). The channel would still have leaked until the stopboard was replaced in January 2020. The storage would not have been drawn down until the end of October when inflows reduced to an average of 0.93 ML/d (until the high rainfall experienced on Christmas day in 2019). Modelling suggests the water level would only have reduced to a level of 114.87 mAHD compared to 114.72 mAHD (15 cm higher). The weir level was not impacted by leakage once the water level fell below the channel invert. The volume of water lost to leakage over that time period was 301 ML or an average of 2.6 ML/d (Figure 65).

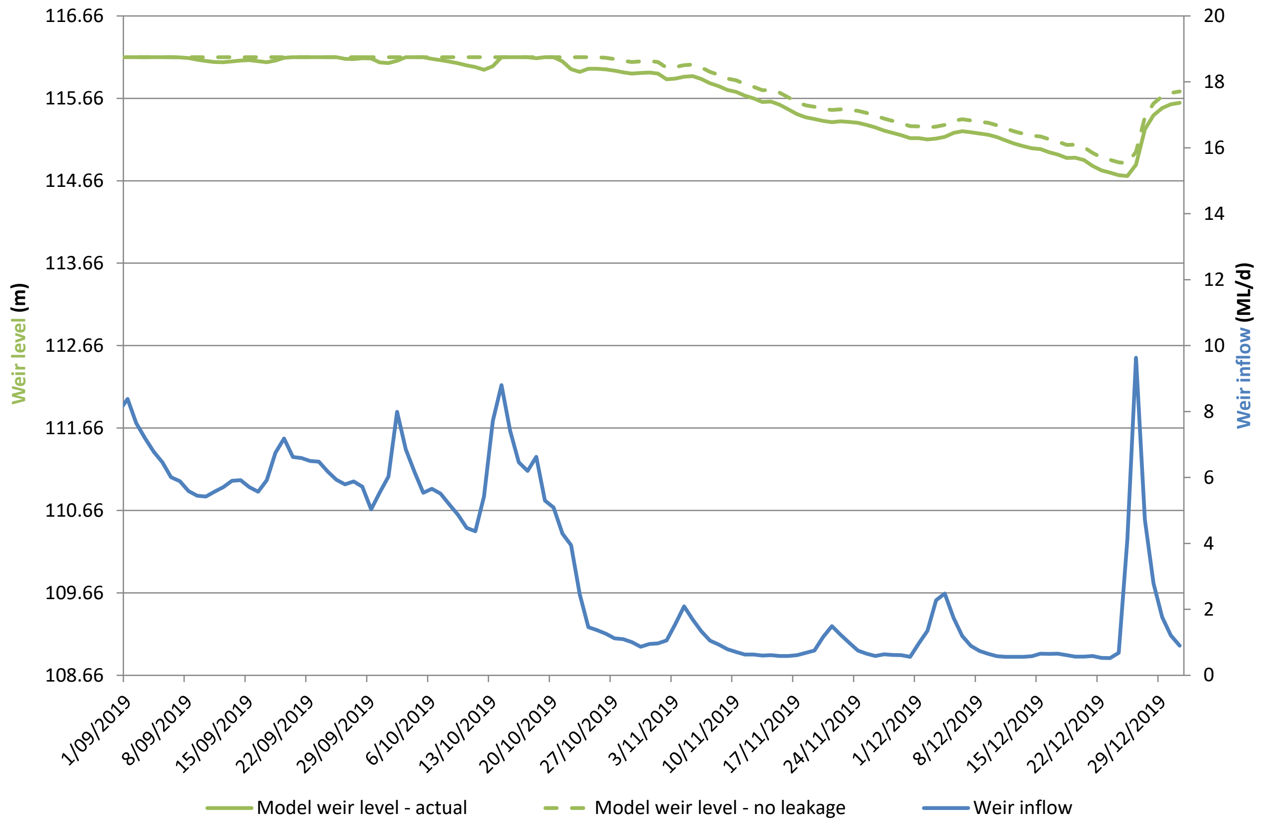


Figure 64: Weir level with no channel leakage

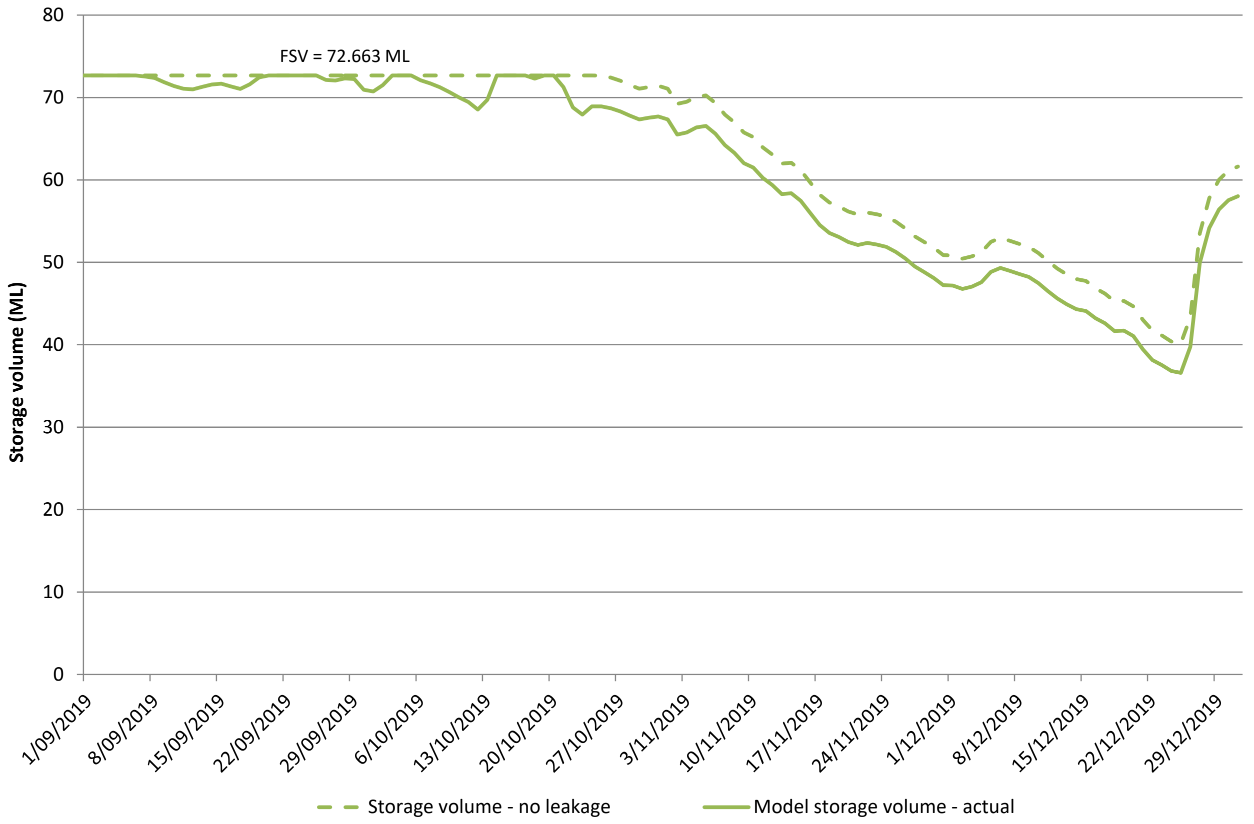


Figure 65: Storage volume with no channel leakage

Currently the downstream flow ceases when the water level falls below the level of the channel intake. Leakage from the channel acts as an environmental flow when the water level is above the channel intake. Downstream flows will be reduced when the weir is not overtopping which would occur when inflows are generally below water supply demand (currently 1.2 ML/d on average). Water available for downstream users will be reduced when the weir is not overtopping (during low inflows).

Raw water can also be pumped from the weir (at 15 L/s which is below peak demand) into the lower end of the channel with the stopboard (sluice gate) closed. A gravity pipeline delivers water from the lower end of the channel to the WTP. If the channel were to fail, raw water supply to the WTP will be compromised and the water level would fall to the channel invert level (approximately 860 mm below full supply level) which is similar to the level 3 water restrictions trigger. Given the serious consequences of channel failure and the increased extraction from the weir resulting from the current leakages, addressing this issue is recommended as a priority.

Willow + Sparrow (2020) identifies immediate works required for the raw water supply and considered the following options:

1. Refurbish and remediate the existing channel. This would require lining the channel to prevent leaking and water loss during drought seasons.
2. Replace the channel with a gravity feed pipeline along the existing channel alignment. This is a closed system that performs the same hydraulic function as the existing channel. This option is only of benefit if the existing channel is to be decommissioned.

3. New pumped pressure pipeline following the existing channel alignment. This option enables the hydraulic function of the channel to be retained, however the pipeline would need to be housed within the channel along certain sections.
4. New pumped pressure pipeline following an alternative alignment that is independent of the channel. The hydraulic function is similar to Option 3 however has additional pump pressure head demands. The channel would be retained under this option and operate in combination with the new main.
5. New pumped pressure pipeline following an alternative alignment with the inclusion of a header tank that enables gravity flow from the top of the hill to the WTP. This pipeline follows the same alternative alignment as with Option 4. Similar to Option 4, the channel would be retained under this option and operate in combination with the new main.

Options 1 and 2 are not recommended by Willow + Sparrow (2020) because of their impacts on the cultural heritage aspect of the channel and their inherent risks to Council. Heritage impacts are discussed further below. Of Options 3, 4 and 5, Option 4 (Figure 66) is recommended by Willow + Sparrow (2020) based on its balance of safe and secure supply and construction and operational cost. The capital cost of option 4 is estimated as $771,000 (Willow + Sparrow, 2020). However, the operational cost of the new transfer system is likely to be high should it be relied upon to supply the WTP in lieu of the channel. Willow + Sparrow (2020) recommend that the pipeline is operated in conjunction with the channel. The benefits of operating both supply systems include:

- Low long-term operation costs.
- A completely independent and secure supply system.
- The channel retains its functionality.
- The supply channel can be taken out of service for maintenance while not interrupting supply to the WTP.
- The pipeline and booster pump station can be taken out of service without disrupting supply to the WTP.

The following tasks are required as part of the concept design for the transfer system:

- Heritage assessment be undertaken in conjunction with the environmental assessment and regulatory approval process.
- Investigation of the current WTP sludge tank processing and water quality testing of the supernatant water. Design an alternative arrangement to discharging supernatant water.
- Confirmation of design capacity.

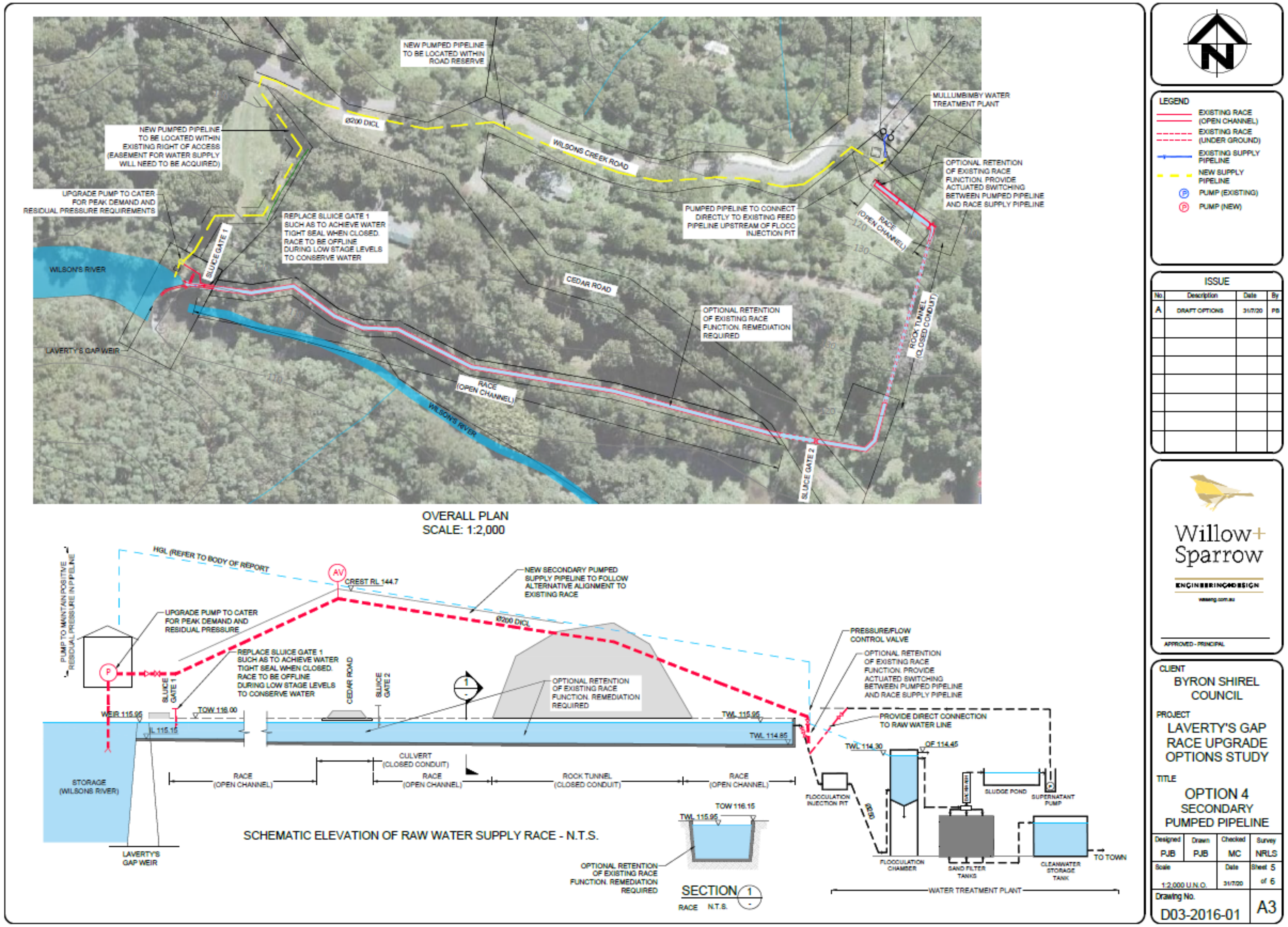


Figure 66: Preferred option for raw water transfer system upgrade

Source: Willow + Sparrow (2020)

The SOHI (Hill *et al*., 2021) assessed the impacts of the proposed options for upgrade of the raw water supply on heritage value. The options (Willow + Sparrow, 2020b) for an alternate pipeline which either substantially or completely removes the water supply from the channel (water race) have the least physical impact on the channel. Option 4 without the use of the channel (i.e. raw water always supplied via the alternate pipeline) is preferred provided the heritage value of the channel can be preserved (through adaptive reuse). The material changes on the water channel within the state significant site boundaries would be substantially avoided, however, it is anticipated that natural deterioration of weak spots in the channel would continue to breakdown and the erosion of surrounding soils will remain unmanaged and there is the potential for the channel to crack as a result. This may exacerbate further deterioration of weaker sections of the channel.

As a result of the heritage assessment, Hill *et al.* considered that an additional option should be considered which involves sole use of the alternate pipeline for the supply of water to the treatment plant. This option would reduce the load on the existing channel and reduce deterioration from water flows. The removal of the channel as a functional component of the water supply is preferred as it would allow for the removal of non-historical infrastructure associated with the water supply from the channel in the short term (crossings, fences, gates, pipes, valves etc), the requirements for maintenance and upgrades (leak sealing etc.) would be removed and this would provide opportunities for adaptive reuse in the medium to long term. The removal of the water supply infrastructure would have a positive benefit on the heritage values of the site and would provide an opportunity for a holistic planning process for the weir, water channel, treatment plant and generator sheds.

Standard Exemption clauses specified in the *Heritage Act 1977* would apply for works which do not have a significant material impact on the Heritage Item. Any form of adaptive reuse would need to be subject to an additional assessment.

12.7.3 Upgrade of water treatment plant

Several recommendations were made by CWT (2020) to upgrade the Mullumbimby WTP in the short term. The costs and priority for the short-term capital and operational upgrades are provided in Table 53 and Table 54. Other actions have also been recommended that will only require BSC labour to implement.

Table 53: Required short-term WTP capital upgrades

Upgrade	High priority (1-2 years)	Medium priority (2-5 years)	Low priority (5-10 years)
General operation	$35,000	$210,000	-
Flocculation	-	$1,000	$20,000
Filtration	-	-	-
Supernatant return	$5,000	-	-
Chemical dosing	$49,000	$8,500	-
Chlorine dosing	$17,000	$5,000	
Clear water storage and chlorine contact time	-	$1,000	-
Totals	$106,000	$225,500	$20,000

Source: CWT (2020)

Table 54: Required short-term WTP operational upgrades

Upgrade	Very high priority (< 6 months)	High priority (6-12 months)	Medium priority (1-2 years)
General operation		BSC labour	
Filtration	BSC labour	BSC labour	$19,000
Supernatant return		$12,000	
Chlorine dosing		$5,000 + BSC labour	
Clear water storage and chlorine contact time	BSC labour		$5,000
Distribution		BSC labour	BSC labour
Information management	BSC labour	$30,000	BSC labour
Totals	BSC labour	$47,000 + BSC labour	$24,000 + BSC labour

Source: CWT (2020)

The Mullumbimby WTP is regularly maintained but due to its age, it requires replacement in the next 5 - 10 years. Broad options for the future of Mullumbimby WTP were identified (CWT, 2020):

- Option 1 - Do Nothing: The 'do nothing' approach would not meet the log reduction requirements and will lead to difficulty in meeting water quality targets in the medium - long term. The main risks associated with continued operation of the WTP are:
    - Work health and safety risks to operators within the plant and in chemical deliveries.
    - Risk of turbidity breakthrough/water quality risk.
    - Risk of failure due to ageing infrastructure.
    - Risk of spillage to the environment during chemical deliveries or from WTP.
- Option 2 - Refurbish the existing WTP including:
    - Addressing very high and high priority recommendations from Table 53 and Table 54.
    - Concrete remediation of flocculation tanks, filters, buildings, filter upgrades, potential upgrade of media design to dual media, addition of UV to meet log reduction requirements based on the health-based targets and automation/SCADA upgrade.
    - Log reduction requirements may be difficult to meet with a refurbished WTP in the long term.
- Option 3 - Construct a new WTP at the existing site or on a new site.
- Option 4 - Decommission the WTP and permanently connect to the regional bulk water supply (refer discussion in Section 12.4).

The preferred option for continued operation of a WTP at Mullumbimby is Option 3 - replacement of Mullumbimby WTP. Options 1 and 2 are not recommended based on the age of the existing WTP, the condition of the process units and the need to maintain components of the WTP to retain heritage value (CWT, 2020).

Potential options for the site of the new WTP include:

- Existing WTP site.
- At Lavertys Gap weir.
- Near the weir (towards Wilsons Creek Road).
- Along the raw water channel near Cedar Road.
- At the power station.
- A site in the vicinity of Yankee Creek Road/Wilsons Creek Road.

The new WTP is assumed to have a capacity of 3.9 ML/d. Further investigations are required to determine the requirements, process and preferred site of the new WTP:

- Peak demand analysis to confirm the required capacity of the plant.
- Site investigations to determine the preferred WTP site.
- Options assessment to determine preferred treatment process for the new WTP.
- Concept design and technical specification for preferred process.

The cost for a new 3.9 ML/d WTP is estimated at $6.7 million, not including land acquisition, engineering, approvals, heritage studies, project management and contingencies (CWT, 2020). While a new WTP is being designed and constructed, Mullumbimby WTP should be maintained and operated to consistently deliver microbially safe water. This includes addressing at minimum, the short-term upgrades in Table 53. The short-term upgrades in Table 53 are required regardless of the water supply augmentation scenario adopted.

12.7.4 Trunk main customers

Approximately 13 customers along Wilsons Creek Road are connected to the trunk main and supplied with potable water from the WTP (Figure 10). All options except Option 4A involve relocation of the WTP. This relocation is considered likely due to the site constraints at the current WTP site, require consideration on long-term supply for these customers. If a new WTP was constructed, these customers may continue to be serviced by a potable supply from a new WTP, however the feasibility of this would depend on the location of the new WTP and customer preference. Trunk main customers would not be served by the regional supply (Options 4A and 4B) and would require alternative supplies (e.g. rainwater tanks).

12.7.5 Implications of the reinstatement of the Hydro-electric power station

In 2018 a prefeasibility study was conducted which considers the reinstatement of a hydro-electric power plant at the Lavertys Gap Weir (Entura, 2018). The mini-hydro-electric power station was commissioned in 1926 and was operational until 1989. The study concludes that there is potential to reinstate the mini-hydro scheme providing that a suitable water licence can be obtained to allow water to be transferred from the Wilson’s Creek catchment to the Yankee Creek catchment. According to the study, the scheme would utilise up to 44 ML/day requiring approximately 7,874 ML/a of water which would be released into the Yankee Creek. If the project were to proceed it would only be able to extract water from Lavertys Gap that is surplus to the water required for the by Mullumbimby water supply. Upgrade of the water supply channel would also need to be considered.

13. SCENARIO DEVELOPMENT AND ASSESSMENT

13.1 Supply Scenarios

No local options have been identified for Mullumbimby that do not require major infrastructure solutions. Supply scenarios have been developed from combinations of options that achieve the required secure yield over the long-term (754 ML/a, an increase of 377 ML/a at 2050). All scenarios include the following common components in the short-term:

- Continued use of the weir supply and Mullumbimby WTP.
- Short- term WTP upgrades to ensure consistent supply of microbially safe water.
- Extension of the RCC emergency bulk water supply connection to service all Mullumbimby water supply customers to be used as a secure emergency response measure when required to supplement the weir supply (Option 4B). This is the existing emergency water supply arrangement for Mullumbimby.
- An increase in the Lavertys gap weir licence extraction limit (likely to be required from 2023 unless an alternative source is implemented).
- Review and update of the drought management plan based on the performance of the supply and drought management regime during the recent drought.
- Implementation of the demand management measures in the RDMP.
- Water loss reduction measures.
- Continued investigation of the long-term impacts of climate change on the secure yield of the weir supply.
- Resolution of the heritage management requirements for the weir, channel an WTP.
- Development of alternative supply options for the trunk main customers.
- Continued identification and implementation of urban effluent reuse opportunities (future demand will be reduced with potable water savings and yield deficit will be reduced accordingly).

The weir supply is at risk of failure during prolonged drought and/or structural failure of the raw water channel to the WTP. Therefore, all options also include full emergency connection to the regional supply (extension of the pipeline to service all areas of Mullumbimby) included as an emergency response measure to provide scheme resilience. Without this, there is a risk that the higher elevation areas of Mullumbimby will not be serviced by a water supply and water would need to be carted to these areas. The predicted water carting demand would be 250 kL/d (10-20 tanker loads each day). No other suitable emergency response measures have been identified (Section 12.1.1).

Servicing of trunk main customers is yet to be resolved for all options. Council will consult with these customers as part of the assessment of supply options for the preferred scenario. These customers may be serviced from the new WTP (depending on location) or by a partially treated supply from the existing WTP.

The following scenarios have been developed:

- Scenario S1: Base case: Improvements to the existing raw water transfer system, a new WTP and full emergency connection to the regional supply. This scenario would provide secure yield until 2025. Beyond 2025, restrictions may become more frequent and/or more severe.
- Scenario S2: Off-stream storage: Improvements to the existing raw water transfer system, full emergency connection to the regional supply, construction of a 200 ML off-stream storage and new WTP. High stream flows would be transferred to fill the off-stream storage. Water from the storage will be treated at the new WTP and transferred to the township.
- Scenario S3: Permanent connection to RCC regional supply: In this scenario, Mullumbimby would form part of the RCC regional supply network with bulk treated water transferred to the Azalea Street reservoirs.
- Scenario S4: Supplementary groundwater: Improvements to the existing raw water transfer system, a new WTP, full emergency connection to the regional supply, construction of new bores to the south-west of Mullumbimby with raw water transferred either to the weir or the new WTP for treatment and distribution to the township.

Scenarios S1, S2 and S4 are all local scenarios as they rely on local infrastructure to service Mullumbimby. Scenario S3 is a regional scenario fully relying on the Rous regional water supply.

The scenarios are illustrated on the following figures and Table 55.

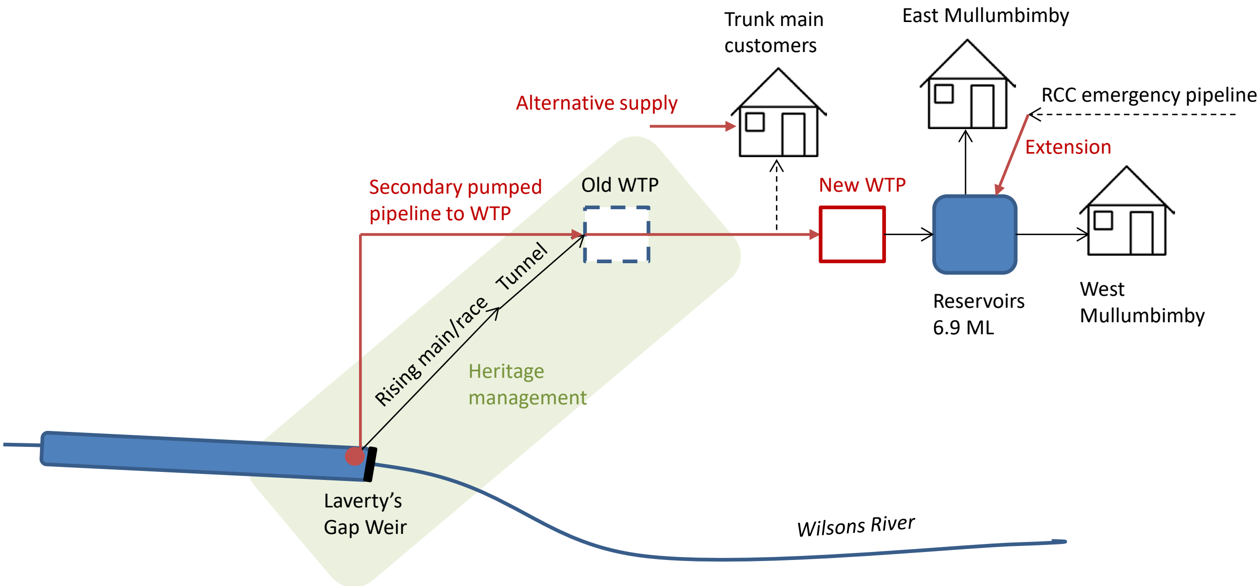


Figure 67: Scenario S1: Base Case

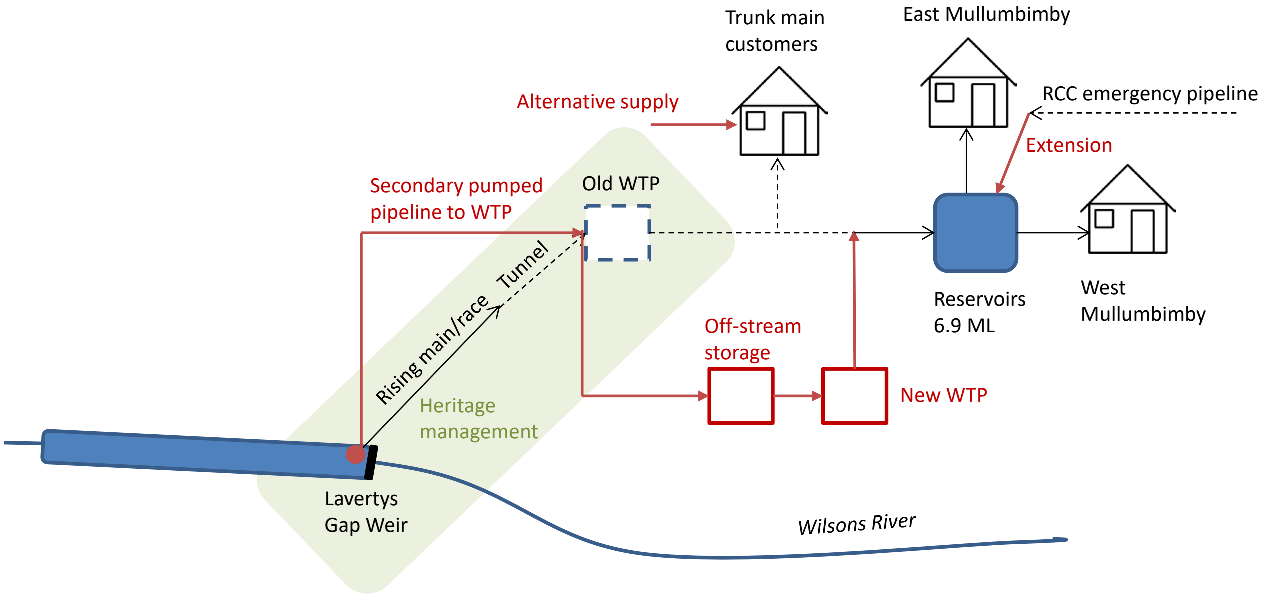


Figure 68: Scenario S2: Off-stream Storage

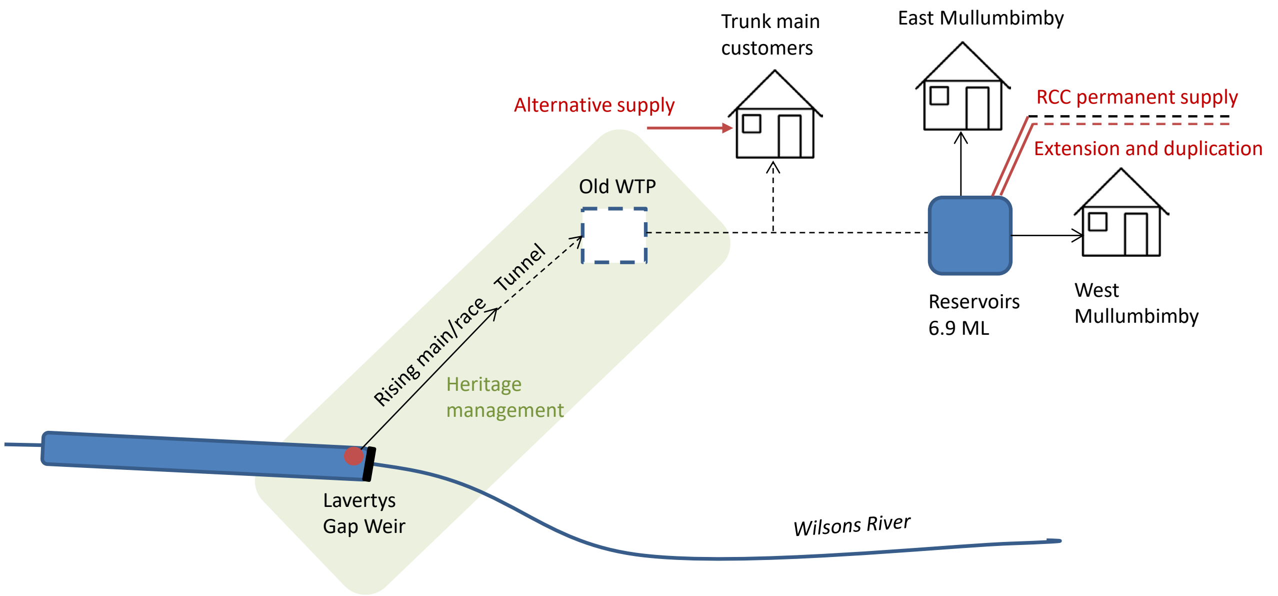


Figure 69: Scenario S3: Permanent connection to RCC regional supply

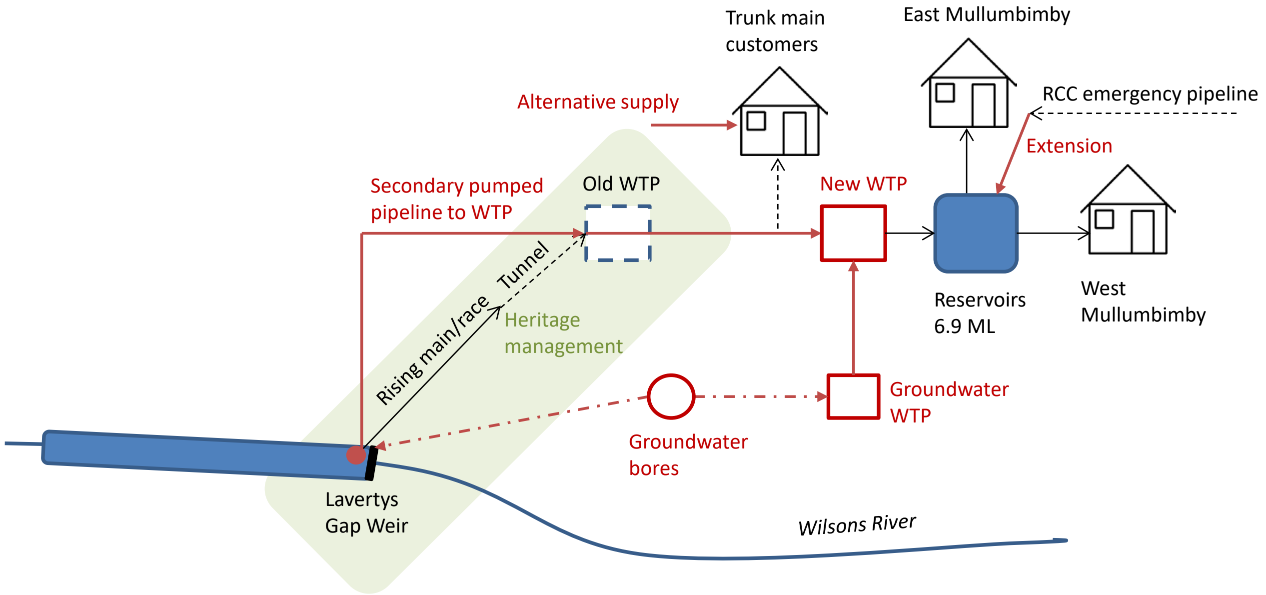


Figure 70: Scenario S4: Supplementary groundwater

Table 55: Water supply scenarios

Scenario	S1	S2	S3	S4
Upgrade raw water transfer system from weir[1]	✓	✓		✓
WTP replacement	✓	✓		✓
Option 1 - Do Nothing	✓			
Option 3 - Off-stream Storage		✓		
Option 4A - RCC (permanent)			✓	
Option 4B - RCC (emergency extension)	✓	✓	✓	✓
Option 5 - Groundwater				✓

13.2 Scenario Comparison

13.2.1 Methodology

The scenario comparison methodology used in this project has been developed with consideration of the comparison of options (Section 12.6) and the IWCM Information Sheet 2 - *Evaluation of integrated water cycle management scenarios* (NSW Department of Industry, 2019). The triple-bottom-line (TBL) assessment criteria are discussed in Table 56.

Table 56: TBL assessment criteria

Criteria	Description	Information used
Environmental (ranked considering the biodiversity management hierarchy - avoid, minimise, rehabilitate, offset)		
Aquatic	Impact on groundwater and surface water quality and aquatic ecology and measures to offset those impacts.	Aquatic biodiversity impacts (e.g. high value aquatic ecosystems, threatened species, water quality, groundwater dependent ecosystems) and offsets proposed (e.g. environmental flows).
Terrestrial	Impact on terrestrial ecology and measures to offset those impacts.	Terrestrial biodiversity impacts (e.g. high value terrestrial ecosystems, threatened species) and offsets proposed (e.g. stewardship/ compensation).
Energy consumption	Energy requirements	Operational energy consumption (comparative).
Social		
Community acceptance	Predicted community acceptance	Community consultation has not yet been undertaken.
Security of supply	Year of augmentation required (following implementation of the scenario)	Secure yield assessment of each option.
Economic		
NPV	NPV of capital and operating costs (80 years) at 5% discount rate.	Estimated capital and operating costs.
Life-cycle cost	Total cost over 30 years	Estimated capital and operating costs.

A weighted score (higher is better) has been calculated for each scenario. Ranking has been calculated as follows:

$$(\text{Environmental Score} + \text{Social Score})/\text{NPV}$$

Weightings are assigned to each criterion based on relative importance so that the sensitivity of the weightings can be tested.

13.2.2 Environmental Criteria

Terrestrial and aquatic biodiversity impacts have been assessed using the available information as summarised in this report. A summary of impacts on hydrology and ecology for each scenario is provided in Table 57. All surface water options (Wilsons Creek extraction for S1 and S2 and Rocky Creek extraction for S3) rely on existing river regulation (weir/dam) and extraction from the Richmond River system.

Surface water supplies require major infrastructure that results in significant direct impacts at the infrastructure site, interruption of longitudinal fauna passage by instream structures, large-scale inundation of terrestrial and riverine habitats as well as alteration of downstream flow regimes. Following the initial impacts of dam construction and filling, an altered ecology will establish within the storage area and the downstream ecosystem will eventually equilibrate to the changed hydrological regime. Despite the inevitable colonisation of new habitats by new biota, it is often the case that the species which originally utilised the site can no longer persist and therefore a shift in the species assemblage is likely to occur. This often results in the loss of local native species. Despite the significant initial impacts, once established, the incremental environmental cost of increasing the extraction from a large instream dam is relatively low, providing that there is not continued reduction in any environmentally significant downstream flows. In contrast, the construction of a new storage, or raising of an existing smaller storage, has significant additional environmental impact and should generally only be considered when a large increase in yield is required.

To reduce overall environmental impact, the utilisation of existing water infrastructure (within sustainable limits) should be considered in preference to the exploitation of new resources. The connection to the RCC bulk supply system provides the opportunity to utilise existing dam/treatment infrastructure and reduce the potential for over-extraction from the Wilsons River at Lavertys Gap. It is recognised that the RCC regional water supply also requires augmentation due to the reduction in yield that will result from climate change and predicted growth in the existing regional supply area. The RCC bulk water supply system requires future augmentation with or without the permanent connection to Mullumbimby and S1 and S3 will only incrementally increase any impacts of the regional supply. S1 (with the existing emergency supply) represented approximately 0.1% of the total regional demand in 2019/20, whereas S3 (with permanent connection) would be approximately 4.7% of the total regional demand by 2030. As a result of this minor increase in demand, the Rous system would continue to operate within the approved operational parameters for the system.

The harvesting of flood flows and utilisation of off-stream storages is often regarded as a viable strategy for surface water extraction. Typically, this results in the preservation of the low-flow hydrological regime downstream, with a relatively small proportion of the highest flows being affected. Whilst this may have geomorphological implications due to reduction of scouring flows, and hence long-term effects on downstream habitats, the impact on instream waterways can be minimised. If a suitable site, with minimal inherent environmental values can be used for the off-stream storage, the ecological impacts of S2 can be minimised. Other environmental factors such as water losses (due to evaporation), pumping costs/ energy/ carbon emissions, loss of agricultural land etc. become more important.

Scenarios relying on groundwater supplies (S4 – potentially a local fractured rock groundwater supply and S3 – proposed future coastal sand aquifer supply at Tyagarah as part of the regional water supply) have the potential to impact on groundwater dependent ecosystems (GDEs). However, these impacts are expected to be adequately managed through site selection and extraction regimes, although this needs to be undertaken with a clear understanding of the aquifer hydrology and the degree of connectivity to GDEs. The environmental response of aquifers and GDEs to extraction can be long-term, hence the impacts of over-extraction tend to be masked and more difficult to detect in monitoring. For this reason, it is prudent to build groundwater extraction schemes incrementally to ensure that there is time to detect impacts on GDEs and adjust extraction accordingly. Any impacts on the terrestrial environment at groundwater extraction sites are expected to be adequately managed through site selection.

The predicted impacts on the aquatic and terrestrial environment for all four scenarios are similar in magnitude. The dominant impacts are largely related to the existing water supply arrangements and are not expected to be significantly altered with ongoing use of these supplies. The impacts of proposed system augmentation to achieve secure yield requirements (off-stream storage in S2 and groundwater in S3 and S4) are also expected to be adequately managed.

While limited environmental investigations have been undertaken, the predicted impacts on biodiversity for each scheme are low and impacts are considered to be manageable for each scenario. Actions to reduce these impacts (e.g. an environmental flow regime and terrestrial biodiversity offsets) will be developed for each local scenario where required and suitable measures will potentially be put in place to obtain planning approval and ensure stakeholder acceptance of each scenario although detailed investigations and consultation are required to confirm this. RCC is responsible for the offset of biodiversity impacts for the regional scenario (S3) and is incorporating these considerations in the development of the groundwater supply options.

In terms of energy consumption, the most favourable option is the regional scenario (S3) as no additional energy consumption would be required. The energy requirements for the other scenarios including pumping systems, bores, aeration system and WTP operations as relevant.

There has been no assessment undertaken of the cumulative impact of the options for Mullumbimby involving connection to RCC supplies, however it is considered that connection to a regional water supply scheme would result in lower environmental impact than development of an additional local supply source and infrastructure in Mullumbimby. In addition, reduced extraction from Lavertys Gap Weir and potentially taking the weir out of service may improve environmental outcomes for the Wilsons River system over the long-term. Other beneficial uses of the weir may also be identified by Council.

The environmental benefits of centralisation of water supplies and regional interconnection were recognised in a previous study undertaken by NOROC (Hydrosphere Consulting, 2013) which noted that the development of significant infrastructure raises extensive planning and approval challenges and a regional approach allows access to a wider range of options to improve environmental outcomes.

As the environmental impacts of each scenario are similar, selection of the preferred scenario has focused on social and economic considerations (refer Sections 13.2.3 and 13.2.4).

Table 57: Summary of environmental impacts of each scenario

Option	Supply source/s	Entitlement	Storage	Hydrology and environmental flows	Aquatic ecology	Terrestrial ecology
S1: Base case	Lavertys Gap Weir, Wilsons Creek (existing)	535 ML/a (increase required from 2023)	73 ML	The weir impacts on all flow components in Wilsons Creek, except for the highest flood flows. Inflow to the weir storage is generally high and the weir frequently overflows to Wilsons Creek. However, during low rainfall, inflows are significantly reduced and the weir level falls below the crest. As there is no environmental flow release (not a requirement of the licence), there is no dedicated flow downstream of the weir when the water level is below the weir crest. These conditions have been in place since the weir was constructed in the 1920s. However, leakage from the raw water channel to Wilsons Creek downstream of the weir in more recent years would have provided some minor flow. During the drought of 2019/20, there was no downstream flow for 118 days between September 2019 and February 2020. With climate change, the frequency and duration of droughts (and storms) is expected to increase.	Wilson's Creek is likely to support a diverse assemblage of both native and introduced fish species. Upstream migration is blocked by the weir and diadromous species (e.g. Australian Bass) would no longer be expected upstream of the weir. Although the weir pool is an altered habitat, the aquatic ecology is likely to have reached a new equilibrium given the age of the structure. Platypus (vulnerable) have been sighted within the vicinity of the weir. Platypus require access to pool and riffle habitat as the major source of food and to firm banks for the construction of burrows and the nest used for rearing young. The ecology of the weir pool is vulnerable to over-extraction as significant drawdowns have the potential to dewater important shallow water habitats. The ecology in the weir pool and downstream has been modified by the weir but downstream fauna would rely on at least intermittent flows.	The weir pool is within a wider area of high natural biodiversity with both temperate and tropical species and a significant number of species that are endemic to the region. However, most of the vegetation surrounding the weir pool is dominated by camphor laurel with other weed species and rainforest remnants. The catchment includes rural developments including on-site sewage management systems, roads and waterway crossings which have impacted on terrestrial ecology through sediment and nutrient runoff. Continued use of the water supply is not expected to alter the terrestrial environment.

Option	Supply source/s	Entitlement	Storage	Hydrology and environmental flows	Aquatic ecology	Terrestrial ecology
S1: Base case (cont.)	Emergency Rous connection	0.5 ML/d (service level agreement)	-	Supplied from St Helena reservoir (Rocky Creek Dam and Wilsons River Source supply) – refer S3.		
S2: Off-stream storage	Lavertys Gap Weir, Wilsons Creek (existing)	535 ML/a (increase required from 2023)	73 ML	High flows (i.e. above those flows that overtop the weir with allowance for environmental flows) would be transferred from the weir to fill the new off-stream storage. There would be a slight modification to the high flow regime downstream of the weir and low flows would be unchanged (with potentially long periods of no flow downstream) - refer S1.	Refer S1. Reducing the incidence or magnitude of peak flows has the potential to reduce geomorphic scouring downstream. Scouring is important to reduce stream bed siltation and maintain habitat structure. These impacts can be minimised through the design of a suitable extraction regime.	Refer S1.
	Off-stream storage		Nominal 200 ML			Potential locations for the off-stream storage reservoir are predominantly cleared grazing land. As such the construction of the dam is expected to have minimal impact on terrestrial ecology.

Option	Supply source/s	Entitlement	Storage	Hydrology and environmental flows	Aquatic ecology	Terrestrial ecology
S3: Permanent connection to RCC regional supply	Rocky Creek Dam, Rocky Creek (existing)	12,358 ML/a	14,000 ML	There are no provisions for environmental flow releases from the dam (not a requirement of the licence). Downstream flow in Rocky Creek below the dam occurs as a result of overflows (spilling) of the dam during high flow conditions and seepage through the dam wall (approximately 0.7 ML/d). These conditions have been in place since the dam was constructed in the early 1950s. The dam impacts on all flow components in Rocky Creek, except for the highest flood flows (> 500 ML/d). The dam spills very infrequently from late winter, through spring into early summer when the only downstream flow can be seepage through the wall (Hydrosphere Consulting, 2021a). The additional impacts resulting from the connection to Mullumbimby would not be significant as this would not result in any change to the operating regime.	Previous assessments have identified that there are downstream ecological impacts due to the dam and that these impacts are exacerbated by modified catchment conditions downstream of the dam. The flora and fauna in Rocky Creek are adapted to a flow regime dominated by disruptive high flows that move large and small sediments and scour in-stream and riparian vegetation (Hydrosphere Consulting, 2021a). The additional impacts resulting from the connection to Mullumbimby would not be significant.	The catchment is dominated by largely pristine forest protected within the Nightcap National Park and Whian Whian State Conservation Area. Catchment lands are managed by NPWS and RCC (Hydrosphere Consulting, 2021b). Continued use of the water supply is not expected to alter the terrestrial environment. The pipeline route is expected to follow existing roads within urban areas of Mullumbimby and terrestrial impacts are expected to be minimal.

Option	Supply source/s	Entitlement	Storage	Hydrology and environmental flows	Aquatic ecology	Terrestrial ecology
S3: Permanent connection to RCC regional supply (cont.)	Wilsons River Source	5,400 ML/a	-	Environmental flow requirements are built into the water access licence pumping rules based on Wilsons River flows. Abstractions from the tidal pool cause changes to flow rates in the Wilsons River below the abstraction point creating a slight decrease in the volume/rate of low to moderate flows (Parsons Brinkerhoff, 2006).	The Environmental Impact Statement for the abstraction proposal (Parsons Brinckerhoff, 2006) concluded that the regime was not likely to have a significant impact on any species of conservation significance or on the survival of any species within the catchment.	The catchment has largely been cleared for cattle grazing, horticulture and urban development (Hydrosphere Consulting, 2021b). Continued use of the water supply is not expected to alter the terrestrial environment.
S3: Permanent connection to RCC regional supply (cont.)	Tyagarah groundwater (proposed)	N/A	-	The groundwater source is a deep sandy unconfined aquifer with fresh rainwater recharge. Further assessment of hydrogeological impacts is required although the development of this groundwater source is considered likely to be feasible (Hydrosphere Consulting, 2021a).	Limited environmental investigations have been undertaken for groundwater options and potential impacts on groundwater dependent ecosystems require further assessment (Hydrosphere Consulting, 2021a).	Terrestrial impacts are limited to the sites required for bore, treatment and transfer system infrastructure and are expected to be minimal.
S4: Supplementary groundwater	Lavertys Gap Weir, Wilsons Creek (existing)	535 ML/a	73 ML	Refer S1.	Refer S1.	Refer S1.
	Groundwater	At least 400 ML/a required	-	Potential supply from North Coast Volcanics groundwater source (fractured rock). Groundwater hydrology has not been investigated. Further assessment of hydrogeological impacts is required if this option is considered further.	Limited environmental investigations have been undertaken for groundwater options and potential impacts on groundwater dependent ecosystems require further assessment.	Terrestrial impacts are limited to the sites required for bore, treatment and transfer system infrastructure and are expected to be minimal.

13.2.3 Social Criteria

Although community consultation has not yet been undertaken, the predicted community acceptance has been compared based on the expected frequency, duration and severity of restrictions, the extent of investment, infrastructure modifications, energy requirements and service delivery required for each scenario. The combined of these factors is expected to influence community opinion on the preferred scenario.

The security of supply criterion considers the long-term requirement to service customers beyond the life and secure yield of each option when considering climate change. While the infrastructure solutions (WTP, transfer systems, bores and off-stream storage) can generally be upsized to meet longer-term demand, the impact of larger schemes (beyond what is required for the 2050 planning horizon) has generally not been considered in this report (the nominal 200 ML size of the off-stream storage is expected to provide security until 2060). The regional scenario (S3) provides a security of supply equivalent to the regional scheme and as with the remainder of the Byron Shire water supplies, BSC would delegate the responsibility for water supply security to RCC if the regional scenario is adopted.

The impact on customer bills has been represented by the life cycle cost of each scenario. The expenditure would be funded through customer bills, water supply fund reserves and potentially external grant funding (depending on eligibility and availability).

13.2.4 Economic Criteria

Capital, operating and whole of life and NPV cost estimates for the water supply scenarios are shown in the following table. The costs do not include current operating costs, staff costs or costs of infrastructure modifications for heritage preservation as these are common to all scenarios. NPV calculations are included in Appendix 2.

Table 58: Scenario cost estimates (2021 $)

Component	S1: Base case	S2: Off-stream Storage	S3: Permanent connection to RCC regional supply	S4: Groundwater
Capital items (30 years)				
Raw water supply upgrade	770,000	770,000	-	770,000
WTP short-term upgrades	330,000	330,000	330,000	330,000
New WTP	6,700,000	6,700,000	-	6,700,000
WTP renewals[1]	3,350,000	3,350,000	-	3,350,000
Emergency pipeline extension	1,282,000	1,282,000	1,282,000	1,282,000
Pipeline duplication	-	-	2,650,000	-
Off-stream storage	-	20,680,000	-	-
Land acquisition, siteworks, engineering[1]	2,000,000	4,000,000	-	3,000,000
Groundwater bores	-	-	-	2,855,000
Total capital cost	*14,430,000*	*35,830,000*	*4,264,000*	*18,149,000*
Total operating cost	4,862,000	5,363,000	20,910,000	5,497,000
Whole-of-life (30 years)	19,296,000	41,197,000	25,174,000	23,646,000
NPV (30 years @ 5%)	13,410,000	29,538,000	13,748,000	15,792,000
Yield (2050) ML/a[2]	560	879	754	754
NPV/ML secure yield p.a. (2050)	23.9	33.6	18.2	20.9

1. Allowance only - not yet estimated.

2. The secure yield of S3 and S4 is equal to the demand at 2050.

The expenditure profile of each scenario and a comparison of the scenarios is shown in the following figures.

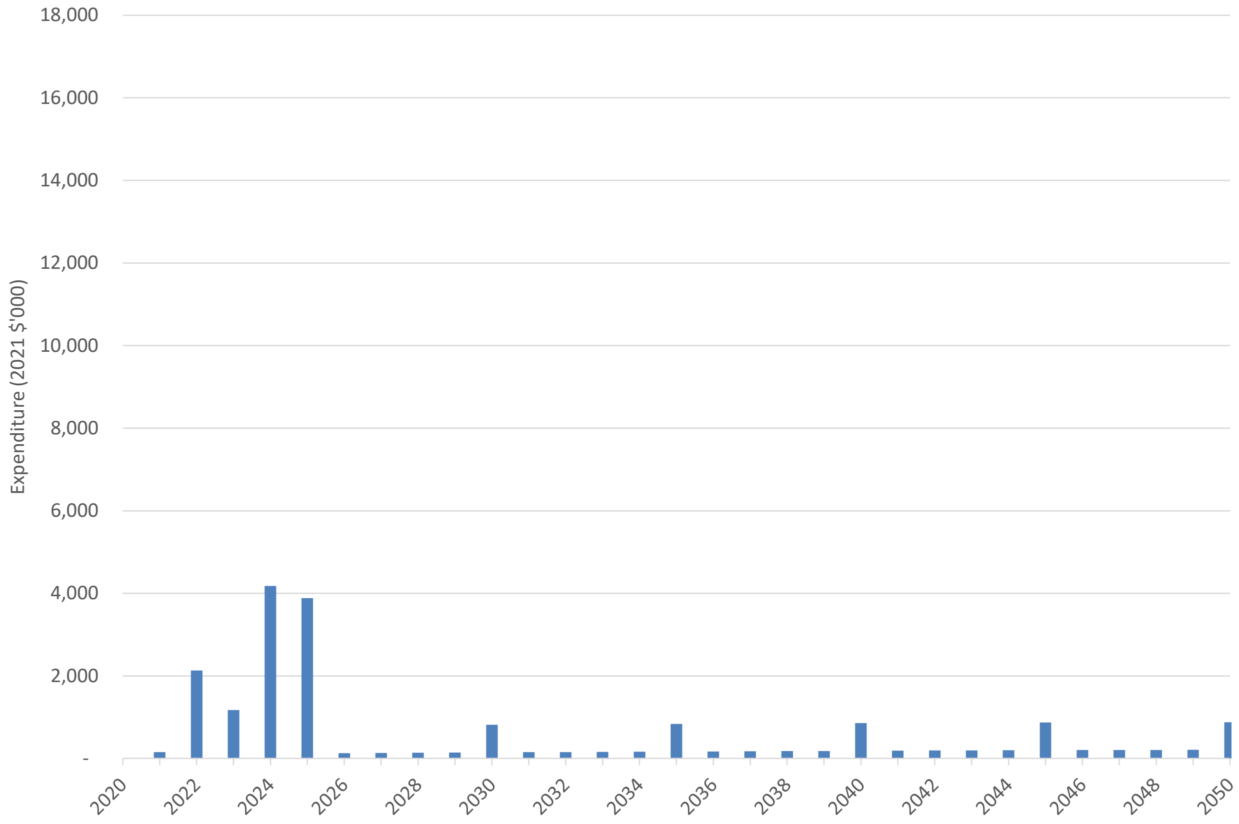


Figure 71: Expenditure profile - Scenario S1: Base Case

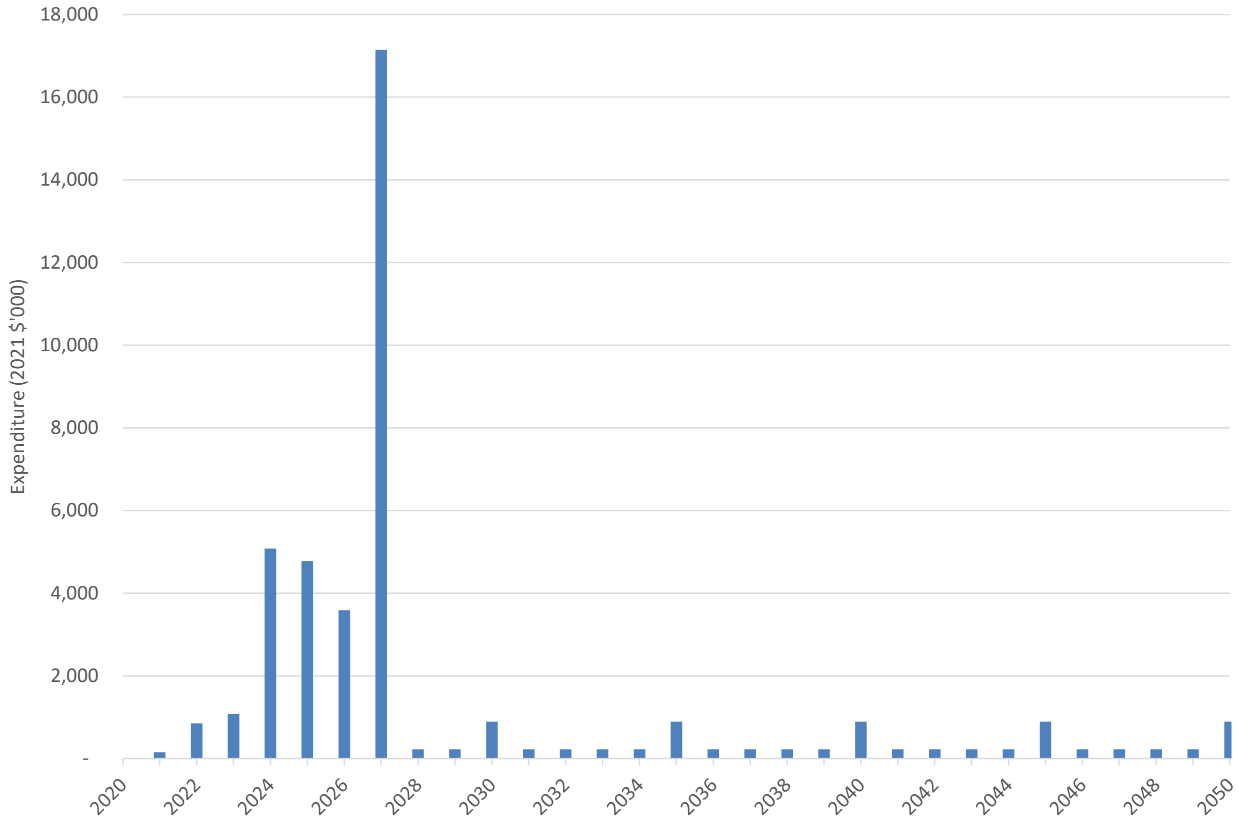


Figure 72: Expenditure profile - Scenario S2: Off-stream Storage

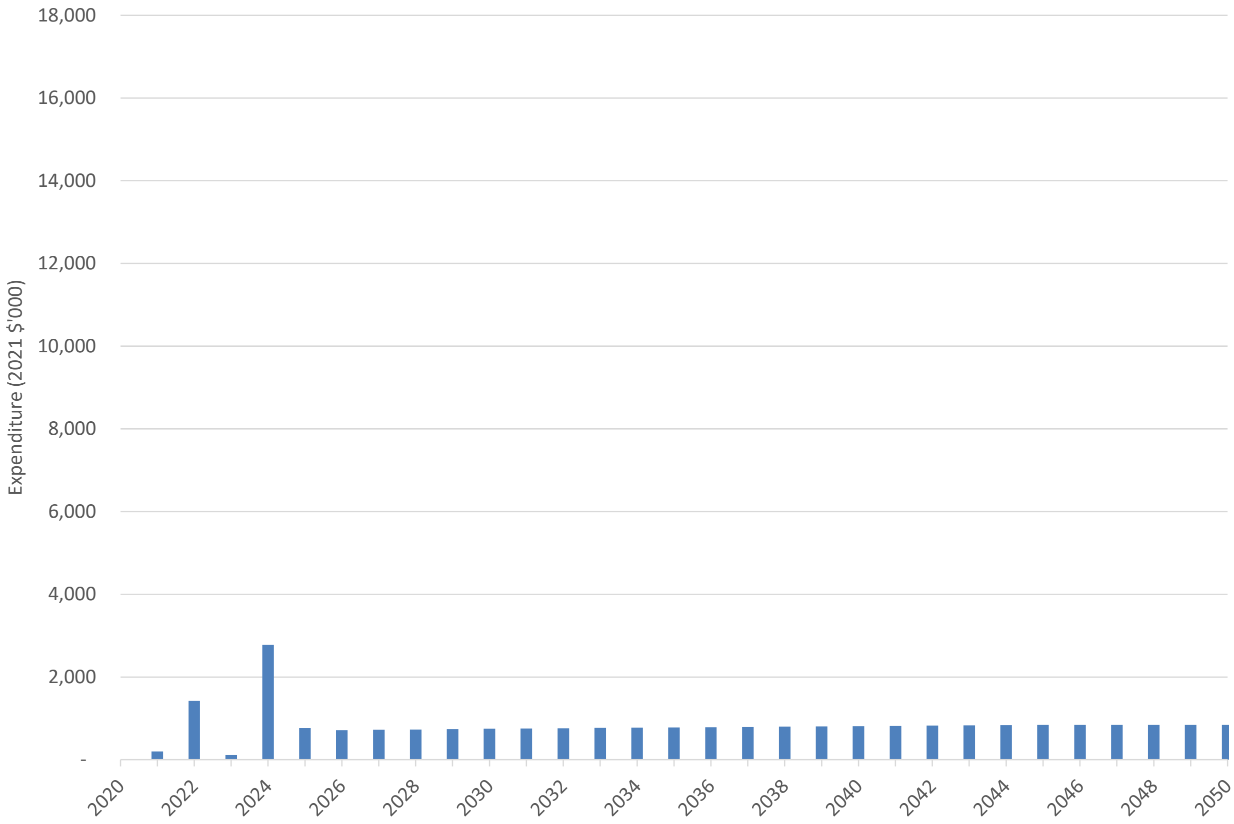


Figure 73: Expenditure profile - Scenario S3: Permanent connection to RCC regional supply

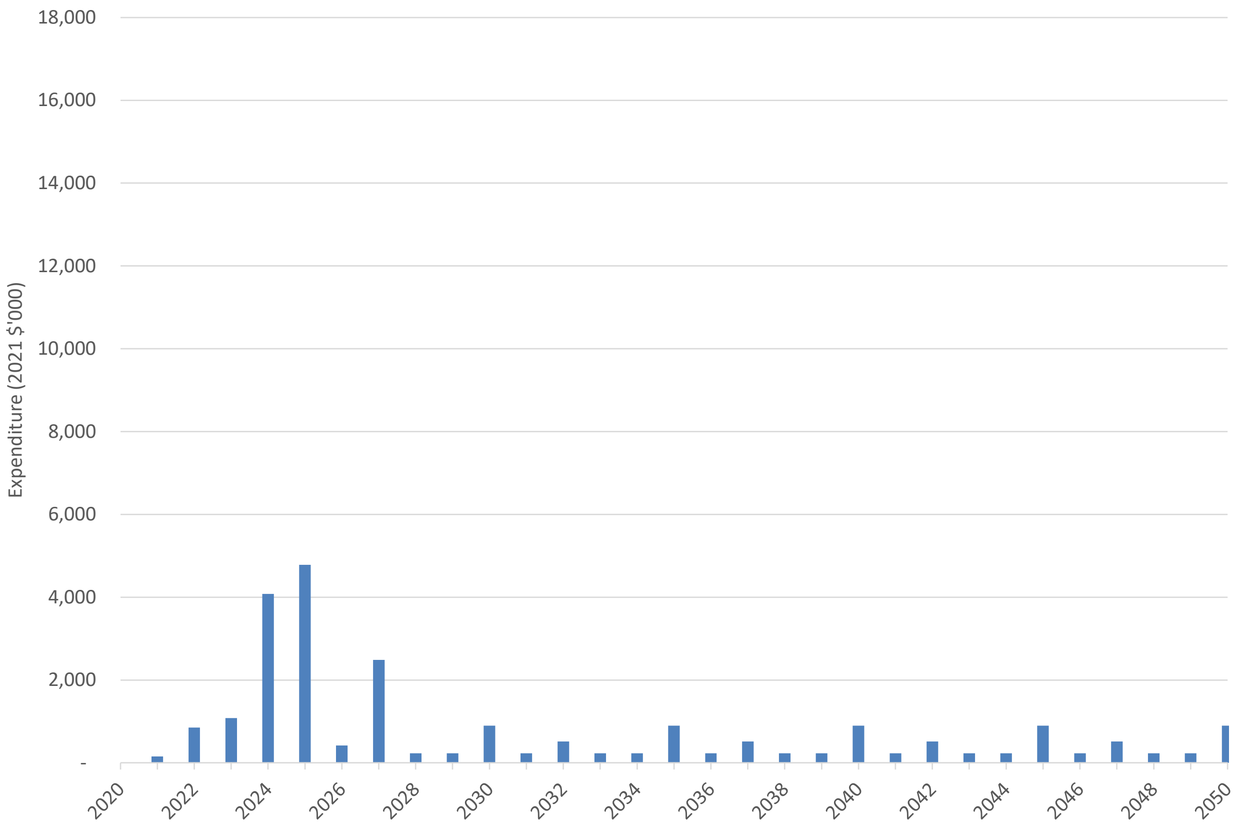


Figure 74: Expenditure profile - Scenario S4: Groundwater

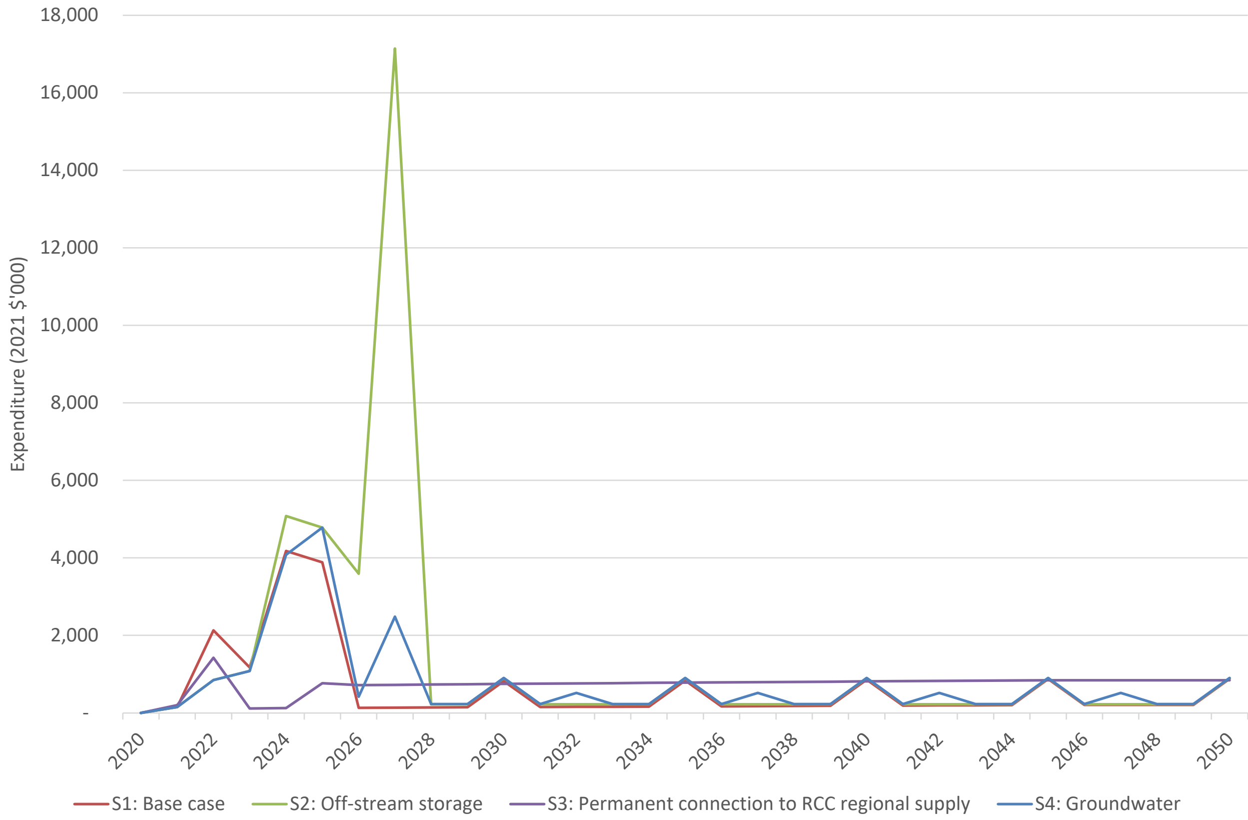


Figure 75: Expenditure profile - scenario comparison

13.2.5 Preferred Scenario

A summary of the TBL assessment (with equal weighting for each criteria) is provided in the following table. Changing the weightings does not change the outcomes of the multi-criteria analysis (MCA) ranking. The TBL assessment is included in Appendix 4.

Table 59: Summary of MCA outcomes

Scenario	Weighted environmental score (/5)	Weighted social score (/5)	Total score (per $ NPV)	Rank (based on MCA)
S1: Base Case	4.50	1.00	205	3
S2: Off-stream Storage	3.67	3.50	121	4
S3: Permanent connection to RCC regional supply	4.67	4.00	315	1
S4: Groundwater	3.67	3.25	219	2

Based on the TBL assessment, the most favourable scenario is S3: Permanent connection to the RCC regional supply (Figure 3). This scenario would have minimal incremental environmental impact and the security of supply is only limited by the security of the RCC regional supply. The addition of Mullumbimby to the regional supply is unlikely to affect RCC's overall bulk supply strategy and the major environmental impacts associated with the regional scheme are fixed regardless of the inclusion of Mullumbimby in the regional scheme. Social acceptance of this scenario has not yet been determined but when other factors such as energy consumption, infrastructure modifications and required investment are considered, the regional supply has significant benefit over the local scenarios.

The NPV of the regional scenario is the lowest of all scenarios. There are significant capital cost savings in avoiding the need to replace the Mullumbimby WTP, upgrade the weir supply and construction of new infrastructure however the ongoing costs of a regional supply are higher than local scenarios.

The benefits of centralisation of water supplies and regional interconnection have been recognised in a previous study undertaken by the Northern Rivers Regional Organisation of Councils (now Joint Organisation) including improved financial outcomes through economies of scale, access to a wider range of options to improve efficiency, system resilience and operational flexibility. Financial benefits would result from regional opportunities for staging of water source development, increased flexibility in scheme development, reduced duplication of infrastructure and sharing of costs over a larger customer base. There is also the potential to reduce the risk of supply shortage in the region through supply diversity, supply redundancy, climate resilience and system flexibility. A regional scheme also allows access to a wider range of options to improve environmental and social outcomes than a local scheme.

14. RISK MANAGEMENT

The implementation risks associated with the preferred scenario are considered to be less significant than the other scenarios. The RCC regional supply is considered to be secure until 2024 (Hydrosphere Consulting, 2021a) and RCC is currently investigating options for augmenting the regional supply and has adopted a preferred strategy utilising groundwater sources. RCC has considered the connection of local water supplies such as Mullumbimby in the development of its long-term strategy. BSC should continue to liaise with RCC regarding the security of the regional supply. Risk management considerations are discussed in Table 60.

Table 60: Risk management measures

Risk	Description	Mitigation
Drought conditions are experienced in the near future (prior to full connection to the RCC regional supply)	Secure yield modelling suggests the existing supply (including the RCC emergency supply) can meet demand until 2027 in a repeat of the worst drought on record. The weir supply will fail in a worse or more prolonged drought than has been experienced in the past.	The RCC emergency supply can service customers in East Mullumbimby (at a cost of approximately $2,400 per day). Water would be carted to other customers in Mullumbimby (at a cost of up to $14,300 per day). The emergency supply pipeline should be extended to the Azalea Street reservoirs as soon as possible to service the entire town. Full emergency supply to the whole of Mullumbimby is estimated to cost $4,000 per day.
The scenario costs are higher than assumed in this report.	The estimated cost of the regional supply scenario does not include headworks contributions, the transfer of assets and reflect the 2020/21 notional price of bulk water.	BSC should commence consultation with RCC as soon as possible regarding costs and asset management considerations.
Community acceptance of the preferred scenario is low.	The Mullumbimby community may reject connection to the regional supply in preference to remaining independent with a local supply.	BSC should commence community consultation as soon as possible to communicate the proposed strategy and determine any community concerns that are unresolved (Section 15.1.6).
RCC is unable to provide a secure supply over the long-term.	RCC is currently developing its long-term strategy and will continue to investigate actions required to implement its preferred strategy.	BSC should continue to liaise with RCC regarding implementation of the Future Water Project 2060 for the whole Byron Shire.

15. IMPLEMENTATION

A secure water supply is critical to ensure the Mullumbimby community's health and quality of life as well as a sustainable environment and continued economic prosperity and BSC has a duty to ensure that there is enough water available to meet the long-term needs of Mullumbimby. Assuming that water loss reduction measures are implemented and the emergency supply is available for the whole town, the supply will be secure until 2027. After this time, the existing system cannot meet forecast demand without the potential for more frequent, longer and severe water restrictions. Based on the current demand and secure yield forecasts, investment in new water sources cannot be continuously deferred and eventually new sources of water will be required to meet the town's long-term water needs. By 2050, the secure yield of the Mullumbimby water supply (Lavertys Gap weir) is forecast to be 377 ML/a. Based on the forecast dry year demand of 754 ML/a in 2050, the forecast annual yield deficit is 377 ML/a. The RCC emergency supply pipeline can supply 183 ML/a if operated continuously, leaving an additional 194 ML/a to be sourced from an alternative supply.

It is recommended that the Mullumbimby Water Supply Strategy include a diversified portfolio of actions to meet the community's water needs based on connection to the RCC regional supply:

- Priority actions: improved drought resilience and treatment performance.
- Ongoing actions: reducing potable water demand including water loss management and the increased use of recycled water.

These components are discussed further in the following sections.

15.1 Priority Actions

15.1.1 Emergency pipeline extension

The priority action is to extend/augment the existing RCC emergency supply pipeline to the Azalea Street reservoirs to enable supply to the whole town. Required actions are:

- Confirmation of demand (nominally level 4 demand of 0.83 ML/d) through review of drought management requirements.
- Hydraulic analysis of the existing pipeline, design of the pipeline extension and confirmation of required disinfection for emergency supply in the short-term and upgrade to a permanent regional supply as soon as possible.
- Environmental assessment and approvals.
- Liaison with RCC to modify the existing service level agreement to reflect the potential increased demand.
- Detailed design and construction of pipeline extension.

15.1.2 Pipeline duplication

To ensure redundancy and allow continued supply in the event of pipeline failure, duplication of the supply pipeline from the intersection of Tandys Lane and Gulgan Road (RCC regional supply) to the Azalea Street reservoir is likely to be required. This should be considered in the hydraulic analysis of the existing pipeline and design of the pipeline extension (Section 15.1.1).

15.1.3 WTP upgrades

Short-term WTP upgrades are required to ensure water quality meets health and aesthetic requirements including operational improvements and upgrades to flocculation, filtration, supernatant return, chemical dosing, chlorine dosing and clear water storage in accordance with the recommendations of CWT (2020).

15.1.4 Asset management planning

To enable implementation of the preferred long-term strategy, the long-term asset management options for BSC's existing assets (including the weir, channel, WTP and trunk mains) should be investigated including removal from service, potential adaptive reuse options and decommissioning/removal over various timeframes.

15.1.5 Drought management and emergency response planning

Operating the emergency pipeline and/or transferring to pumped flow from the weir soon after the weir ceases to overtop will conserve water during a dry period. The drought management plan should be reviewed and updated, including a trigger for operating the RCC emergency pipeline and documentation of other operational requirements identified in this strategy. The restriction regime will be updated to be consistent with the other water supplies in the Byron Shire and the region.

15.1.6 Consultation

To enable implementation of the preferred long-term strategy, the following consultation actions are required:

- Liaison with RCC regarding connection to the regional water supply including:
    - Long-term security.
    - Costs of connection to the regional supply.
    - Revision of service level agreement.
- Community engagement on the proposed strategy including First Nations representatives.
- Liaison with trunk main customers to develop alternative water supply options.
- Consultation with Essential Energy regarding assets associated with the hydroelectric facility.
- Consultation with relevant agencies such as DPI - Fisheries, Heritage NSW, DPIE - Water and NSW Health.
- Request for increase in water extraction licence from DPIE - Water and NRAR.

15.1.7 Heritage

To enable implementation of the preferred long-term strategy, the following heritage management actions are required:

- Revision of the Conservation Management Plan to provide a holistic assessment and policies/ guidance on adaptive re-use and the long-term maintenance and management of the assets.
- Approvals under the *Heritage Act 1977* (potentially S60 application for any adaptive reuse proposal).

15.1.8 Financial planning

The draft *BSC Water Supply and Sewerage Strategic Plan: 2017 Review* (Hydrosphere Consulting, 2017) included a financial analysis of the BSC water supply funds to provide information to BSC on the required revenue to be recovered through residential bills. The main output of the financial plan is the typical residential bill (TRB) which is defined as the annual bill paid by a customer who is not a pensioner and not a vacant lot and uses the average water demand. The financial modelling provides an indication of the relative cost to BSC and its customers of the water supply services. The financial analysis recommended that Council maintain the water supply TRB at the current level for the medium-term (until 2021). That analysis assumed that the cost of the implementation of the Mullumbimby water supply strategy would be $5.0 million (similar to the estimated capital cost of the preferred strategy, Section 15.3) and would be completed by 2021.

The financial analysis undertaken as part of the 2017 Strategic Business Plan should be updated to consider the preferred water supply strategy including:

- Confirmation of capital and operating cost estimates following investigation of the short-term actions discussed in the previous sections. Current capital cost estimates are provided in Section 15.3.
- Confirmation of the required implementation program.
- Review and update of other water supply expenditure requirements.
- Updated financial modelling to determine medium-term impact on the water supply TRB.

15.2 Ongoing Actions

15.2.1 Demand management

The RDMP provides a series of demand management measures to be implemented by RCC and the constituent councils between 2019 and 2022 as discussed in Section 4. The Regional Water Supply Agreement Liaison Committee is overseeing the plan implementation and ensuring the actions specified in the RDMP are completed. The Committee is also responsible for assessing if the plan is meeting its objectives and how best to adapt the plan to incorporate the latest knowledge, experience and technology in a process of continuous improvement. Success of the RDMP will be gauged through:

- Reporting of action implementation (including timing and completeness).
- KPIs as specified for each RDMP action.
- Local and regional demand indicators and achievement of targets.

Annual review of the RDMP is undertaken by 30 September of each year and includes:

- A review of demand data.
- An evaluation of the effectiveness of RDMP actions.
- Review of the appropriateness of the KPIs.
- Feedback from the customers.
- An assessment of the impact of RDMP actions on RCC and the constituent councils in terms of costs, resourcing and operations.

The RDMP will be reviewed in four years (by June 2023) and a revised plan will be prepared with consideration of the outcomes of the annual reviews. The revised plan will specify demand management measures to be implemented over the four-year period between 1 July 2024 and 30 June 2028.

15.2.2 Effluent reuse opportunities

Continued identification and implementation of urban effluent reuse opportunities to reduce potable water demand is a key component of the Mullumbimby water supply strategy. Council has commissioned the Water Sensitive Cities Institute (WSCI) to develop an evidence-based urban water metabolism framework to support integrated urban water management decisions. 'Urban water metabolism' evaluation provides a big-picture perspective of urban water performance based on the concept of urban metabolism which has been operationalised to evaluate material and energy flows through urban areas and specifically adapted for evaluating urban water performance. The evaluation generates a comprehensive account of all flows of water (natural and anthropogenic) between an urban area and the supporting environment to produce an urban water mass balance, from which indicators of water metabolism performance are derived. These indicators relate to metabolic aspects such as water efficiency, degree of supply internalisation, and the extent to which natural hydrological flow are altered (Renouf, *et al*., 2018).

The urban water metabolism evaluation project will include (WSCI, 2020):

- Conceptual water mass balances for Mullumbimby to define the urban system boundaries to be applied for the township and identify the current urban water stocks and flows (including storages) and inter-connectivity.
- Numerical modelling of urban water mass balance.
- Identification of current and projected water cycle pressure points and short-, mid- and long-term drivers and associated strategies and actions for changes to the existing water cycle systems.
- Development of a long list of potential strategic management actions, in particular opportunities for recycled water, to address key stressors.
- Simulation of alternative future urban water cycle scenarios using the urban water metabolism evaluation approach.
- Evaluation of the economic costs and benefits of each scenario.

Based on the findings of this study, opportunities for potable water substitution including dual reticulation will be investigated as discussed in Section 12.7.1.

15.2.3 Ongoing review

On-going monitoring and review are required to ensure the strategy actions effectively resolve the identified issues. In accordance with the DPIE - Water requirements for IWCM, it is recommended that the Council-wide Water Supply and Sewerage Strategic Plan and financial plan (refer Section 15.1.8) are reviewed by 2022 and every four years after that. Annual reviews of capital and operating expenditure and financial planning should also be undertaken.

15.3 Implementation Plan

The expected delivery of the preferred scenario (capital and operating cost estimates and timing) is shown in Table 61. These estimates are based on available information and will be continually reviewed. The cost estimates do not include staff time or existing strategic planning or operational expenditure which are not influenced by the preferred strategy for Mullumbimby. The implementation plan assumes that the permanent connection to the regional supply will be available from 2025.

Strategic planning actions such as financial planning and demand management would be undertaken for all BSC water supplies as part of existing budgets and have not been included here. Effluent reuse opportunities are currently unknown and costs have not yet been estimated. These actions are part of Council's shire-wide water supply strategic planning and delivery and would be included in all future water supply scenarios.

Table 61: Mullumbimby water supply strategy implementation - cost estimates

Delivery Program year		Year 5	Year 1	Year 2	Year 3	Year 4	Year 1	Year 2	Year 3	Year 4	Year 1
Year		1	2	3	4	5	6	7	8	9	10
Action/cost estimate (2021 $'000)	Ten-year cost	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Emergency pipeline extension - planning, design and approval	*100*	100									
Emergency pipeline extension - construction	*1,182*		1,182								
Pipeline duplication - planning, design and approval	*100*		150								
Pipeline duplication - construction	*1,182*			2,500							
Emergency water supply - purchase of water (allowance)	*170*	50	60	60							
WTP upgrades	*330*	106	112	112							
Regional water supply - purchase of water	*4,800*				650	660	670	690	700	710	720
Asset management planning	*200*		100	100							
Drought management plan review	*50*	50									
Consultation	*170*	50	50	50	20						
Heritage management	*100*		50	50							
Totals	***9,751***	**356**	**1,704**	**2,872**	**670**	**660**	**670**	**690**	**700**	**710**	**720**

Planning and approvals	Construction	Operation

REFERENCES

Ballina Shire Council, (2002) *The Ballina Shire Urban Water Management Strategy Analysis of Desalination Options*

Bill Jordan and Associates (2020) *Mullumbimby raw water supply race structural & heritage assessment*

BSC (2014) *Byron Local Environmental Plan 2014*

BSC (2017) *Byron Shire Effluent Management Strategy (draft) 2017-2027*

BSC (2019a) *Byron Shire draft Residential Strategy*, public exhibition version 2019

BSC (2019b) *Information on anticipated additional business premises in Byron Shire*, pers. comm. N. Hancock, 1712/19

BSC (2019c) *Byron Shire Business and Industrial Lands Strategy*, December 2019

BSC (2020a) *Report to inform infrastructure planning (dwelling forecasts)*

BSC (2020b) *Byron Shire Residential Strategy*, December 2020

CWT (2020) *Mullumbimby WTP Assessment and Options Investigation*, October 2020

Detection Services (2019) *Byron Shire Council Water Loss Management Plan*, V1, June 2019

DLWC (1998) *Aquifer Risk Assessment Report*, NSW Department of Land and Water Conservation.

DPI (2012) *Factsheet - Eastern Freshwater Cod* Maccullochella ikei

DPIE (2020) *Draft Regional Water Strategy*, Far North Coast: Long list of options

Ellsmore, D. (2008) *Mullumbimby Water Treatment Plant, Lavertys Gap, Investigation of Significance* in HydroScience Consulting (2008)

Environmental Hydrogeology Associates (2008) *Tweed district water supply augmentation options study: Input to stage 1 - Identification of feasible options*, prepared for MWH Australia

Entura (2018) *Mullumbimby Mini-Hydro Prefeasibility Assessment*

FRC Environmental, (2003), *Mullumbimby Water Supply Preliminary Ecological Assessment*, Appendix D of Mullumbimby Long Term Water Supply Scheme Strategy

GANDEN, (2017) *Ballina Shire Council: Ballina WWTP Desalination Options Investigation* Rev E

Hill, T. and M. Finlayson (2021) *Mullumbimby Water Supply Race, Mullumbimby NSW: Statement of Heritage Impact*. Everick Heritage Pty Ltd unpublished report prepared for Hydrosphere Consulting and Byron Shire Council.

HydroScience Consulting (2008) *Mullumbimby Water Treatment Plan Refurbishment*, March 2008

HydroScience Consulting (2009) *Mullumbimby Water Treatment Plan Concept Design Report*, December 2009

HydroScience Consulting (2016) *Byron Shire Council Wastewater Management System*

HydroScience Consulting (2014) *Mullumbimby Drought Management Plan*

Hydrosphere Consulting (2008) *Analysis of Jabour weir Raising Options*, Stage 1 Investigations

Hydrosphere Consulting (2013) *Northern Rivers Regional Bulk Water Supply Study*, NOROC, October 2013

Hydrosphere Consulting (2017) *Byron Shire Council Water Supply and Sewerage Strategic Plan: 2017 Review*

Hydrosphere Consulting (2019) *Mullumbimby Water Supply, Lavertys Gap Weir - Secure Yield Assessment*

Hydrosphere Consulting (2020) *Rous County Council Bulk Water Supply - Demand Forecast: 2020 – 2060,* October 2020

Hydrosphere Consulting (2021a) *Future Water Project 2060 Integrated Water Cycle Management Strategy,* July 2021

Hydrosphere Consulting (2021b) *Rous County Council Catchment Management Plan 2021-2025*

i20water (2019) *Advanced Pressure Management Case Study* - Byron Shire Council, Australia

.id (2020) *Byron Shire Community Profile - Mullumbimby population estimates* https://profile.id.com.au/byron/population-estimate?WebID=130

Jacobs, (2015) *Identification and assessment of groundwater sources: working paper 2: Assessment of Sources,* prepared for Rous Water

Jacobs, (2020) *Future Water Strategy, Groundwater Schemes and Whole of Life Costings Report B,* Rev C Final, Rous County Council

JWP (2005) *Mullumbimby Long Term Water Supply Scheme Strategy*

MWH (2014) *Future Water Strategy- Integrated Water Planning Process*, Rous Water

McKibbon, D. (1995) *Upper North Coast Groundwater Resource Study*, NSW Department of Land and Water Conservation (Water Resources), Technical Services Division, August 1995

NSW Department of Industry (2019) *IWCM Information Sheet 2 - Evaluation of integrated water cycle management scenarios*

NSW DPI Water (2016a) *Background document - Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources*

NSW DPI Water (2016b) *Background document - Water Sharing Plan for the Brunswick Unregulated and Alluvial Water Sources*

NSW DPI Water (2016c) *Background document - Water Sharing Plan for the North Coast Coastal Sands Groundwater Sources*

NSW DPI Water (2016d) *Background document - Water Sharing Plan for the Richmond River Unregulated, Regulated and Alluvial Water Sources*

NSW Government (2018) *Drought and Emergency Relief for Regional Town Water Supplies*

NSW Office of Water (2013) *Assuring future urban water security: Assessment and adaption guidelines for NSW local water utilities*, December 2013

NSW Office of Water (2014) *Water Sharing Rules, Commenced Water Sharing Plan for the Richmond River Area Unregulated, Regulated and Alluvial Water Sources, 2010*

NSW Public Works (2012) *Jabour weir Fishway Concept Design*, Report No. DC12064, December 2012

NSW Urban Water Services (2018) *Mullumbimby Water Supply Yield Study Report* in Hydrosphere Consulting (2019)

Parsons Brinckerhoff (2006) *The Lismore Source Abstraction of Water from the Wilsons River at Howards Grass Environmental Impact Statement*. Prepared for Rous Water and NSW Department of Commerce.

Parsons Brinkerhoff, (2011) *Future water strategy groundwater options - position paper*, Rous Water, September 2011

Public Works Department (1984) *Richmond - Brunswick Regional Water Supply Study Discussion Paper*, prepared for Rous County Council and Ballina Shire Council, report no. 230, December 1984

Queensland Government (2020) *SILO - Australian Climate Data from 1889 to Yesterday*, https://www.longpaddock.qld.gov.au/silo/point-data/, accessed May 2020

Renouf, M. A., Kenway, S. J. Lam. K. A, Weber, T., Roux, E, Serrao-Neumann, S., Choy, D. L. and Morgan, E. A (2018) *Understanding urban water performance at the city-region scale using an urban water metabolism evaluation framework*, in *Water Research* 137 (2018) 395 - 406

MWH, (2014) *The Rous Water Future Water Strategy Integrated Water Planning Process*

Rous County Council (2019) *Statement of Revenue Policy - 2019/20*

SMEC (2003) *Lavertys Gap Weir Options for Raising*, Appendix E of Mullumbimby Long Term Water Supply Scheme Strategy

Swann, G. (1997) *The Occurrence of Groundwater in South East Queensland*, Queensland Government, Department of Natural Resources, Brisbane, Australia

Walgett Shire Council (2014) *Walgett weir 11A Raising Concept & Fishway Feasibility*

Willow + Sparrow (2020a) *Mullumbimby Raw Water Supply Race - Inspection Summary Report*, letter to Byron Shore Council, 10 February 2020

Willow + Sparrow (2020b) *Hydraulic Options Study Mullumbimby Raw Water Supply Race, Lavertys Gap NSW* for Byron Shire Council, October 2020

WSCI (2020) *Implementing an urban water metabolism approach to guide recycled water strategic planning*, proposal to Byron Shire Council, 4 December 2020

GLOSSARY AND ABBREVIATIONS

ADD	Average day demand
ADWG	Australian Drinking Water Guidelines
AGWR	Australian Guidelines for Water Recycling
AWBM	Australian Water Balance Model
BASIX	Building Sustainability Index
BLEP	Byron local environmental plan
BSC	Byron Shire Council
DPI	Department of Primary Industries
DPIE	Department of Planning, Industry and Environment
ET	Equivalent tenement
FSL	Full supply Level
FSV	Full supply volume
GCM	Global Climate Model
GDE	Groundwater dependant ecosystems
IPR	Indirect potable Reuse
IWCM	Integrated Water Cycle Management
kL	Kilolitres
kL/a	Kilolitres per annum
kL/d	Kilolitres per day
KPI	Key performance indicator
L	Litres
L/s	Litres per second
MCA	Multi-criteria analysis
ML	Megalitres (one thousand litres)
ML/a	Megalitres per annum
ML/d	Megalitres per day
NPV	Net present value - the present value of a series of future payments
NRAR	National Resources Access Regulator
PDD	Peak day demand
RCC	Rous County Council
RDMP	Regional Demand Management Plan
SA	Surface area
Secure yield	The highest annual water demand that can be supplied from a water supply headworks system while meeting the '5/10/10 design rule'

STP	Sewage treatment plan
TBL	Triple bottom line
TRB	Typical residential bill
UV	Ultraviolet
WSCI	Water sensitive cities institute
WTP	Water Treatment Plant

Appendix 1. LEGISLATIVE CONSIDERATIONS

Table 62 and Table 63 outline the legislative requirements and approvals required relevant to the augmentation options.

Table 62: Summary of legislation and regulatory requirements

Legislation	Summary of requirements/approval required
NSW Weir Policy	The policy states that: "Proposals to enlarge an existing weir should not be approved unless it can be demonstrated that the primary component of the proposal is necessary to maintaining the essential social and economic needs of the affected community." and "An increase in town water supply for the purposes of meeting projected population demand cannot be used as a justification to approve a proposal to build a new, or expand an existing weir, if environmentally friendlier alternatives to meeting that demand exist, which are also economically feasible"
Environmental Planning and Assessment Act 1979	An assessment of the likely impacts of a proposal which may have an impact on the environment is required under the Act prior to a decision to proceed with the proposal. The Act imposes requirements for controlling development. The proposed works may require consent under the Act.
Water Management Act 2000	The *Water Management Act 2000* recognises the need to allocate and provide water for the environmental health of our rivers and groundwater systems, while also providing licence holders with more secure access to water and greater opportunities to trade water through the separation of water licences from land. The main tool in the Act for managing the state's water resources are water sharing plans. These are used to set out the rules for the sharing of water in a particular water source between water users and the environment and rules for the trading of water in a particular water source. Section 90 of the Act requires an approval to undertake water supply work including work for the purpose of capturing or storing water or any work that has, or could have, the effect of impounding water in a water source. Approval would be required from the Department of Planning, Industry and Environment (DPIE) - Water for the raised weir, either in the form of a new works approval/licence or an amendment to the existing works approval/licence.

Legislation	Summary of requirements/approval required
Fisheries Management Act 1994	All proposals for the construction of, or modification to, dams, weirs or similar structures are required to be referred to DPI - Fisheries for assessment. For the construction or the major modification or alteration of dams, weirs and regulators the construction of a fishway may be required. Under Section 200 of the Act a local government authority must not carry out dredging work or reclamation work except under the authority of a permit. The definition of dredging work includes any work that involves excavating water land, or any work that involves moving material on water land or removing material from water land. The definition of reclamation work includes any work that involves: • Using any material (such as sand, soil, silt, gravel, concrete, oyster shells, tyres, timber or rocks) to fill in or reclaim water land; or • Depositing any such material on water land for the purpose of constructing anything over water land. Water land means land submerged by water either permanently or intermittently. The proposed works are considered to constitute dredging and reclamation work and therefore require a dredging and reclamation permit issued under Section 200 of the Act. The Act contains schedules of species, populations and ecological communities that have been listed as 'threatened'. Where a proposed development is in the potential range of a listed threatened species, population or ecological community under the Act and/or the Environment Protection and Biodiversity Conservation Act 1999 and the area has not been declared a critical habitat, then the preparation of the 'test of significance' on the subject species, population or community is required. The 'test of significance' is used to determine whether the proposed development is likely to significantly affect threatened species, population or ecological communities. If the determining/consent authority determines that the project will not have a significant impact after considering the test of significance, then the proposal may be accepted. If the determining/consent authority determines that the proposed project will have a significant impact via the 'test of significance', then a Species Impact Statement (SIS) is required to be prepared, or the proposal may require modification where possible.
National Parks and Wildlife Act 1974	Under the Act it is an offence to cause harm or desecration to any Aboriginal heritage items, objects or places discovered during operations.
Biodiversity Conservation Act 2016	The Act provides provisions for the protection of threatened or protected animal and plant species, threatened ecological communities and areas of outstanding biodiversity value. The Biodiversity Values Map identifies land with high biodiversity value that is particularly sensitive to impacts from development and clearing. The map forms part of the Biodiversity Offsets Scheme Threshold which is one of the triggers for determining whether the Biodiversity Offset Scheme applies to a clearing or development proposal. Wilsons River at Lavertys Gap is mapped as high biodiversity value.

Legislation	Summary of requirements/approval required
Protection of the Environment Operations Act 1997	Under the Act it is an offence to cause pollution. The Act enables the issue of environment protection licences (EPL) for scheduled and non-scheduled development work or activities. The licence provides a defence against a pollution of waters offence for those pollutants specifically regulated under the licence as long as the pollutants discharged to waters are within the limits specified in the licence. In general, the EPA will not issue a non-scheduled activity licence where there is a low likelihood of impact on waters and where pollution should not occur if the activity is carried out in a competent manner. The need for an EPL is subject to final design and construction methodology.
Local Government Act 1993	Under Section 60 of the Local Government Act 1993 a Council must seek approval of the Minister for Primary Industries to construct or extend a dam for the impounding or diversion of water for public use or any associated work.
NSW Heritage Act 1977	All non-Aboriginal archaeological relics across NSW (including NPWS estate) over 50 years old are managed under the Heritage Act 1977. Any works or activities that may disturb non-Aboriginal archaeological relics must have an Excavation Permit, which is a separate approval under the Heritage Act 1977.
Dam Safety Act 2015	The Objectives of the Dam Safety Act are to ensure that any risks that may arise in relation to dams (including any risks to public safety and to environmental and economic assets) are of a level that is acceptable to the community, as well as regulating the management and risks associated with dam safety.
Environmental Protection Biodiversity Conservation Act 1999	The Act lists threatened species or ecological communities that are recognised as a matter of national environmental significance. Under the EPBC Act an action will require approval from the Commonwealth Minister if the action has, will have, or is likely to have, a significant impact on a matter of national environmental significance. In order to determine whether an action is likely to have a significant impact, an assessment of significance on relevant matters is required.

Table 63: Relevant Environmental Planning Instruments

Instrument	Summary of requirements/approval required
The *State Environmental Planning Policy (Infrastructure) 2007* (Infrastructure SEPP)	Under Part 3, Division 24, Clause 125 (2) “Development for the purpose of water storage facilities may be carried out without consent if it is carried out by or on behalf of… any public authority on land in Zone RU1 Primary Production, Zone RU2 Rural Landscape, Zone SP1 Special Activities, Zone SP2 Infrastructure or an equivalent land use zone”. Water storage facility means “a dam, weir or reservoir for the collection and storage of water, and includes associated monitoring or gauging equipment”.
SEPP - State and Regional Development 2011	Under Schedule 3 of the Policy development for the purpose of water storage or water treatment facilities (not including desalination plants) carried out by or on behalf of a public authority that has a capital investment value of more than $30 million is considered to be state significant infrastructure. If the project was projected to exceed the $30 million threshold then the project would be considered as state significant infrastructure and require the preparation of an Environmental Impact Statement.

Instrument	Summary of requirements/approval required
SEPP 44 - Koala Habitat Protection	This Policy aims to encourage the proper conservation and management of areas of natural vegetation that provide habitat for koalas to ensure a permanent free-living population over their present range and reverse the current trend of koala population decline. The SEPP requires a plan of management for areas of more than one hectare that contain koala habitat and for which a development application has been lodged under Part 4 of the EP & A Act. If koala habitat was found to be impacted by the proposed works it would be assessed under the requirements of the *Biodiversity and Conservation Act 2016* and *Environment Protection Biodiversity Conservation Act 1999.*
Byron Local Environmental Plan (BLEP) 1988 and 2014	The weir and the entire area of inundation for all modelled scenarios (refer Section 12.2.4) is contained within land zoned as Deferred Matter in the BLEP 2014 and Environmental Protection 7(c) Water Catchment in the BLEP 1988. Schedule 12 of the BLEP1998 (Development by public authorities) allows for water supply development such as underground pipes without consent apart from the erection of buildings, the installation or erection of plant or other structures or erections and the reconstruction or alteration of buildings, so as materially to affect their design or external appearance. All or parts of land zoned 7(c) Water Catchment Zone in the BLEP 1988 and identified as Deferred Matter in the BLEP 2014 may transition to an Environmental Zone (E zone) which is designed to protect or manage land that has important environmental value. The assessment of the subject land is ongoing and dependant on whether the primary land use and vegetation are consistent with the E-zone criteria. The final zoning will be legislated in 2020 and the BLEP 2014 will be amended.

Appendix 2. COST ESTIMATES

Cost estimate				
5 m weir raising				
	Quantity	**Unit**	**Rate**	**Sub-total**
Capital				
Preliminary investigations		item		$200,000
Site establishment		item		$150,000
Excavation	2,000	m^3	$30	$60,000
Concreting	5,120	m^3	$450	$2,304,000
Concrete cap	600	m^3	$600	$360,000
Training walls	231	m^3	$1,200	$277,200
Grouting, surface preparation		item		$150,000
Fishway		item		$8,000,000
Sub-total				*$11,501,200*
Engineering and approvals	15%			$1,725,180
Contingency	20%			$2,300,240
Project management	10%			$1,150,120
Total capital cost				**$16,676,740**
Operation and maintenance				
Weir	p.a.			$50,000
Fishway	p.a.			$100,000
Total O&M cost				**$150,000**

Cost estimate				
200 ML off-stream storage				
	Quantity	**Unit**	**Rate**	**Sub-total**
Capital				
Preliminary investigations		item		$200,000
Site establishment		item		$150,000
Excavation	76,000	m^3	$15	$1,140,000
Recompaction for walls	76,000	m^3	$10	$760,000
Drainage	200	m^3	$70	$14,000
Services, access roads, fencing etc.		item		$600,000
Water quality		item		$100,000
Land acquisition	50	ha	$60,000	$3,000,000
Pumps/pipes		item		$300,000
Fishway		item		$8,000,000
Sub-total				*$14,264,000*
Engineering and approvals	15%			$2,139,600
Contingency	20%			$2,852,800
Project management	10%			$1,426,400
Total capital cost				**$20,682,800**
Operation and maintenance				
Storage	p.a.			$100,000
Fishway	p.a.			$100,000
Total O&M cost				**$200,000**

Regional supply connection					
Headworks contribution	2,000	ET	$8,872	per ET	$17,744,000
Emergency pipeline extension	3,000	m	$427	per m	$1,282,254
					including contingency
Reference rate	250mm PVC		$170	2003$	
	Construction difficulty		$75	2003$	
	Sub-total		$245	2003$	
	Escalation to 2017		1.62		
	Escalation to 2021		1.74		
	Rate		$427		
Pipeline duplication (permanent)	6,200	m	$427	per m	$2,649,991
Cost of water (regional supply)	406,000	kL	$1.72	per kL	20/21
Costs savings (WTP, raw water etc.)	406,000	kL	$0.60	per kL	
Bulk rate			$4.78	per kL	

Groundwater supply					
based on Jacobs (2020) Alstonville costs					
Construction (2 bores @ 2.5ML/d)				$1,969,000	
Design, Project Management and Permits (20%)	20%			$393,800	
Contingency (25%)	25%			$492,250	
Total capital				$2,855,050	
Operation and maintenance					
Maintenance	0.50%			$9,845	p.a.
Staffing				$60,000	p.a.
Utilities				$96,000	
Licences				$25,000	
Support				$15,000	
Total O&M				$205,845	

S1: Base case																																
Year		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Capital Expenditure	**Source**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**
Upgrade weir supply	Willow+Sparrow (2020) - option 4			770																												
WTP - short-term upgrades	CWT (2020)		106	56	56	56	56																									
New WTP	CWT (2020)					3,000	3,700																									
WTP land acquistion, drainage,	Estimate				1,000	1,000																										
WTP renewal	Estimate - 10% of capital every 5 years											670					670					670					670					670
Emergency supply extension	Estimate			1,282																												
Total capital cost		*-*	*106*	*2,109*	*1,056*	*4,056*	*3,756*	*-*	*-*	*-*	*-*	*670*	*-*	*-*	*-*	*-*	*670*	*-*	*-*	*-*	*-*	*670*	*-*	*-*	*-*	*-*	*670*	*-*	*-*	*-*	*-*	*670*
Operational expenditure																																
Upgrade weir supply	Willow+Sparrow (2020) - base demand				25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
WTP - short-term	CWT (2020)		47	24																												
New WTP	Assume no change																															
Emergency supply extension	Estimate				91	98	102	106	111	115	120	124	129	132	136	139	143	147	150	154	158	162	165	169	173	177	180	181	182	183	184	185
Total operating cost		*-*	*47*	*24*	*116*	*123*	*127*	*131*	*136*	*140*	*145*	*149*	*153*	*157*	*161*	*164*	*168*	*171*	*175*	*179*	*183*	*186*	*190*	*194*	*198*	*201*	*205*	*206*	*207*	*208*	*209*	*210*
Total cost		***-***	***153***	***2,133***	***1,172***	***4,179***	***3,883***	***131***	***136***	***140***	***145***	***819***	***153***	***157***	***161***	***164***	***838***	***171***	***175***	***179***	***183***	***856***	***190***	***194***	***198***	***201***	***875***	***206***	***207***	***208***	***209***	***880***
Whole-of life cost	19,296																															
30 year NPV	13,410	5%																														
Secure yield at 2050	560	ML/a																														
NPV/yield	23.9	$/ML/a																														

S2: Off-stream storage																																
Year		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Capital Expenditure	**Source**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**
Upgrade weir supply	Willow+Sparrow (2020) - option 4			770																												
WTP - short-term	CWT (2020)		106	56	56	56	56																									
New WTP	CWT (2020)					3,000	3,700																									
WTP land acquistion, drainage,	Estimate				1,000	1,000																										
WTP renewal	Estimate - 10% of capital every 5 years											670					670					670					670					670
Off stream storage	Estimate							3,566	17,117																							
OSS land acquisition	Estimate					1,000	1,000																									
Total capital cost		*-*	*106*	*826*	*1,056*	*5,056*	*4,756*	*3,566*	*17,117*	*-*	*-*	*670*	*-*	*-*	*-*	*-*	*670*	*-*	*-*	*-*	*-*	*670*	*-*	*-*	*-*	*-*	*670*	*-*	*-*	*-*	*-*	*670*
Operational expenditure																																
Upgrade weir supply	Willow+Sparrow (2020) - base demand				25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
WTP - short-term	CWT (2020)		47	24																												
New WTP	Assume no change																															
OSS	Estimate									200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Total operating cost		*-*	*47*	*24*	*25*	*25*	*25*	*25*	*25*	*225*	*225*	*225*	*225*	*225*	*225*	*225*	*225*	*225*	*225*	*225*	*225*	*225*	*225*	*225*	*225*	*225*	*225*	*225*	*225*	*225*	*225*	*225*
Total cost		***-***	***153***	***850***	***1,081***	***5,081***	***4,781***	***3,591***	***17,142***	***225***	***225***	***895***	***225***	***225***	***225***	***225***	***895***	***225***	***225***	***225***	***225***	***895***	***225***	***225***	***225***	***225***	***895***	***225***	***225***	***225***	***225***	***895***
Whole-of life cost	41,197																															
30 year NPV	29,538	5%																														
Secure yield at 2050	879	ML/a																														
NPV/yield	33.6	$/ML/a																														

S3: Permanent connection to RCC regional supply																																
Year		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Capital Expenditure	**Source**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**
WTP - short-term	CWT (2020)		106	56	56	56	56																									
Emergency supply extension	Estimate			1,282																												
Pipeline duplication (permane	Estimate					2,650																										
Total capital cost		*-*	*106*	*1,339*	*56*	*2,706*	*56*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Operational expenditure																																
WTP - short-term	CWT (2020)		47	24																												
Emergency supply			50	60	60	70																										
Regional supply							709	716	724	732	741	749	757	763	769	775	781	787	794	800	806	813	819	826	832	838	845	845	845	845	845	845
Total operating cost		*-*	*97*	*84*	*60*	*70*	*709*	*716*	*724*	*732*	*741*	*749*	*757*	*763*	*769*	*775*	*781*	*787*	*794*	*800*	*806*	*813*	*819*	*826*	*832*	*838*	*845*	*845*	*845*	*845*	*845*	*845*
Total cost		***-***	***203***	***1,423***	***116***	***2,776***	***765***	***716***	***724***	***732***	***741***	***749***	***757***	***763***	***769***	***775***	***781***	***787***	***794***	***800***	***806***	***813***	***819***	***826***	***832***	***838***	***845***	***845***	***845***	***845***	***845***	***845***
Whole-of life cost	25,174																															
30 year NPV	13,748	5%																														
Secure yield at 2050	754	ML/a																														
NPV/yield	18.2	$/ML/a																														

S4: Groundwater																																
Year		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Capital Expenditure	**Source**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**
Upgrade weir supply	Willow+Sparrow (2020) - option 4			770																												
WTP - short-term	CWT (2020)		106	56	56	56	56																									
New WTP	CWT (2020)					3,000	3,700																									
WTP land acquistion, drainage,	Estimate				1,000	1,000																										
WTP renewal	Estimate - 10% of capital every 5 years											670					670					670					670					670
Groundwater	Estimate							394	2,461																							
Groundwater land acquisition,	Estimate						1,000																									
Groundwater renewal	Estimate - 10% of capital every 5 years													286					286					286					286			
Total capital cost		*-*	*106*	*826*	*1,056*	*4,056*	*4,756*	*394*	*2,461*	*-*	*-*	*670*	*-*	*286*	*-*	*-*	*670*	*-*	*286*	*-*	*-*	*670*	*-*	*286*	*-*	*-*	*670*	*-*	*286*	*-*	*-*	*670*
Operational expenditure																																
Upgrade weir supply	Willow+Sparrow (2020) - base demand				25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
WTP - short-term	CWT (2020)		47	24																												
New WTP	Assume no change																															
Groundwater	Estimate									206	206	206	206	206	206	206	206	206	206	206	206	206	206	206	206	206	206	206	206	206	206	206
Total operating cost		*-*	*47*	*24*	*25*	*25*	*25*	*25*	*25*	*231*	*231*	*231*	*231*	*231*	*231*	*231*	*231*	*231*	*231*	*231*	*231*	*231*	*231*	*231*	*231*	*231*	*231*	*231*	*231*	*231*	*231*	*231*
Total cost		***-***	***153***	***850***	***1,081***	***4,081***	***4,781***	***419***	***2,486***	***231***	***231***	***901***	***231***	***516***	***231***	***231***	***901***	***231***	***516***	***231***	***231***	***901***	***231***	***516***	***231***	***231***	***901***	***231***	***516***	***231***	***231***	***901***
Whole-of life cost	23,646																															
30 year NPV	15,792	5%																														
Secure yield at 2050	754	ML/a																														
NPV/yield	20.9	$/ML/a																														

Appendix 3. CLIMATE CORRECTION METHODOLOGY AND RESULTS

Daily water demand patterns are highly variable and are likely to be influenced by a broad range of factors. Despite variability in the demand data there is an intuitive connection between climate and water demand which has been considered in the analysis of the Mullumbimby demand.

Using the current NSW Security of Supply Methodology, water security is achieved if the secure yield of a water supply is at least equal to the unrestricted dry year annual demand (NSW Office of Water, 2013). Modelling has been undertaken to attempt to correlate key climate influencing factors such rainfall, temperature and evaporation to changes in demand. This has been used to estimate the unrestricted dry year annual demand.

Daily correlation of climate factors to daily water demand is difficult due to factors such as:

- Variable household demand patterns, overall water requirements and thresholds for water use.
- Variable thresholds for factors that may trigger increased water use.
- Variable timing of response to climatic factors.
- Complex inter-actions between climatic factors.

Correlation of a broad range of factors, over variable timeframes, for variable thresholds etc. is not practical and is likely to be very specific to a particular data set. For a methodology that can be applied to multiple situations, it is considered more appropriate to determine whether broad combinations of climatic factors can be used to predict periods of increased water usage.

The adopted methodology has been developed with the following assumptions:

- Dry weather (indicated by low rainfall or low net rainfall) will increase outdoor water use (mainly irrigation) once a duration threshold has been reached. This is likely to be due actual or perceived low soil moisture or visible signs of plant stress.
- Hot weather will increase water usage. This is likely to be due to increased use of pools, showers after visiting the beach etc. and perceived garden irrigation needs during periods of high temperature. This is likely to be a shorter-term effect than dry weather and is not necessarily linked to soil moisture.
- High evaporation rates will increase outdoor water use when there is no rainfall. Such conditions would occur during periods of low humidity, high wind, high temperatures etc. This is considered to be linked to actual or perceived plant evaporation stress.

A simplified method has been adopted which investigates the ability of a sub-set of environmental factors to predict periods of increased water usage. A tool (excel macro) has been developed which allows identification of time periods where combinations of the following factors occur for a user-specified period:

- Rainfall.
- Temperature.
- Evaporation.
- Net rainfall.
- Humidity.

Various combinations of climate factors and thresholds are tested to determine whether these can independently identify the water usage peaks. The simplest combination which is considered to adequately predict these peaks is then used as the basis for further analysis.

Water usage data for peak usage periods are identified and the average water usage during these periods is compared to average water usage for periods of non-peak use. The additional usage is calculated as a percentage increase which is applicable to these dry/hot weather events.

Data used in the analysis and results are shown in Table 64 and Figure 76.

Utilising the same thresholds and analysis techniques, it is possible to identify the extent of climate occurrences for predicted future data sets with application of the daily climate factor. However, at this time, there are no available data on future climate parameters and future prediction of climate corrected demand has not been undertaken.

In this demand forecast, the increase in demand due to dry weather (from Table 64) has been applied to the average consumption for each connection type. The average for the previous eight years (since 2012) has been used to remove any influences due to pricing and water efficient behaviour over longer periods. Due to the expected increase in outdoor use the residential consumption, is likely to increase during hot/dry weather, although due to the lack of short-term consumption data and the expected influence of other factors (such as pricing, demographics, lot type and size and soil types), the impact on consumption for each customer type, particularly non-residential customers is not quantifiable. Hence as a conservative approach, the increase in consumption during a dry year has been applied to all customer types.

In some cases, the maximum metered demand per connection over the previous eight years is higher than the dry year demand. This may be due to the other factors that influence demand as discussed above but may also be a result of the lack of short-term consumption data available for the analysis.

Table 64: Climate correction data, parameters and results

Location	Climate data[1]	Bulk supply data[2]	Average % of time with hotter/drier weather events (%)[3,4]	Additional usage during peak times compared to non-peak usage (%)[3,5]	% correlation of prediction[6]	% of time with hotter/drier weather events in "worst case" year[4,7]	Predicted "dry weather" increase in demand in a "worst case year" (%)[8]
Mullumbimby	Lat: - 28.55 Long: 153.49	1/7/2011 - 7/11/2019	22%	22%	75%	36% (2019)	3.24%

1. Sourced from Queensland Government (2020) from 1/1/1970 to 2020.

2. Restrictions were imposed from 7 November 2019, therefore only data before 7 November 2019 have been used.

3. For all years of climate and bulk supply data.

4. "Hotter/drier weather events" are the days which meet the climate variables which best predict usage increases for Mullumbimby.

5. 'Peak' usage defined as when the 14-day average daily demand per connection is greater than the average demand per connection for the entire data set and the 90-day average demand is greater than the 360-day average demand per connection.

6. % of time that "hotter/drier weather events" (based on the climate variables selected) accurately predict periods of increased water demand.

7. "Worst case" year is the year with the highest number of days of "hotter/drier weather events".

8. Additional usage during peak times x additional time with hotter/drier events

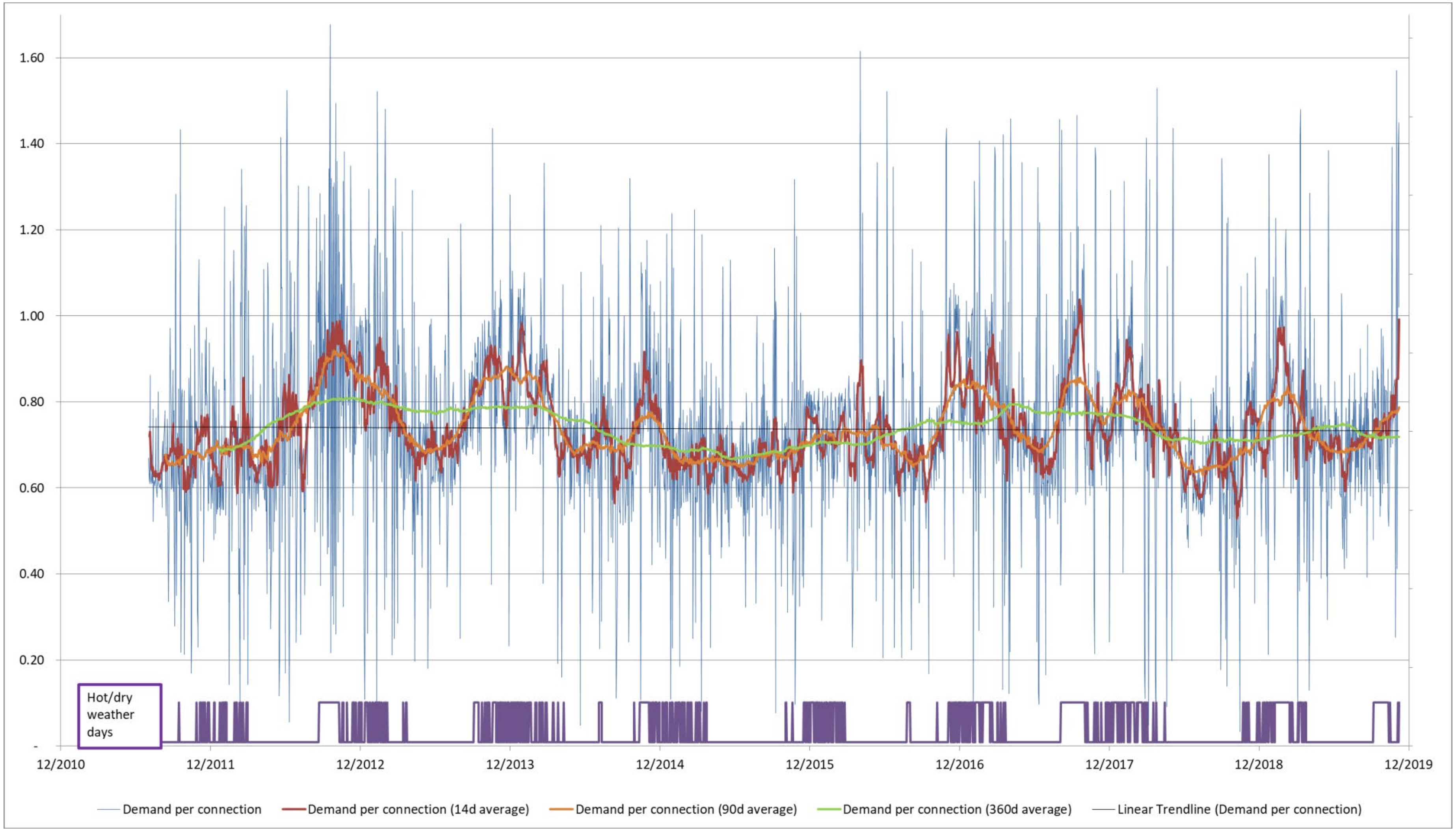


Figure 76: Climate correction analysis - Mullumbimby

Appendix 4. TRIPLE-BOTTOM LINE ASSESSMENT

zz	Environmental Criteria			Environmental Score	Environmental Weighting	Social Criteria		Social Score	Social Weighting	Net present value ($ million)	Life-cycle cost ($ million)	Total Score per $NPV
	Aquatic	Terrestrial	Energy consumption			Community acceptance	Security of supply					
Description	Impact on groundwater and surface water quality and aquatic ecology and measures to offset those impacts.	Impact on terrestrial ecology and measures to offset those impacts.	Energy requirements	Weighted criteria score	Weighting compared to social criteria	Predicted community acceptance	Year of augmentation required (following implementation of the scenario)	Weighted criteria score	Weighting compared to environmental criteria	NPV of capital and operating costs (80 years) at 5% discount rate	Total cost over 30 years	10^{3x}(Environmental Score + Social Score)/NPV
Criteria weighting	33%	33%	33%	100%		50%	50%	100%				
Scenario S1: Base Case												
Result	No additional impacts	No additional impacts	Raw water upgrade, WTP replacement	**4.50**		Moderate investment, energy requirements, restrictions	2027	**1.00**		13.4	19.3	**205**
Score	5.0	5.0	3.5			1.0	1.0					
Scenario S2: Off-Stream Storage												
Result	No additional impacts	Minimal	Raw water upgrade, WTP replacement, raw water transfer to storage	**3.67**	50%	High investment, infrastructure modifications, energy requirements	2060	**3.50**	50%	29.5	41.2	**121**
Score	4.0	4.0	3.0			2.5	4.5					
Scenario S3: Permanent connection to RCC regional supply												
Result	No additional impacts	Minimal	Minimal	**4.67**		Modified service delivery	Equivalent to RCC security	**4.00**		13.7	25.2	**315**
Score	5.0	4.5	4.5			3.0	5.0					
Scenario S4: Groundwater												
Result	Impacts can be minimised through site selection	Minimal	Raw water upgrade, WTP replacement, groundwater transfer and treatment	**3.67**		Moderate investment, energy requirements, potential for competing use of groundwater	2050	**3.25**		15.8	23.6	**219**
Score	4.0	4.0	3.0			2.5	4.0					
Score out of 5	5 - highest											