Fraser Coast Water Supply Security Strategy

Planning Report

R2020084

Prepared for
Fraser Coast Regional Council

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Cardno

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Executive Summary

Queensland has a dynamic climate with some of the highest and lowest rainfalls in the country. Planning for a secure water supply is essential in this variable climate to support our industry, agriculture and population growth.

Recognising that water is our most valuable resource, Fraser Coast Regional Council (Council) has engaged Cardno to undertake a Water Supply Security Strategy for the region.

Council is seeking to determine a water security Level of Service (LOS) that is reflective of the community's expectations. This includes understanding the community's desirable LOS, impacts that the LOS will have on the community and their willingness to fund this LOS.

This project's broad aims are to determine the following:

> The current water supply security level for each scheme.

> The desired LOS expected by the community (i.e. how often the community are willing to accept water restrictions).

> Identification for all viable future water source options.

> The suitability of the option demonstrating the best value to the community in meeting the desired LOS and from that, a recommended LOS that best meets the community's desires and willingness/capacity to pay.

> The scope, cost estimate and timing of infrastructure required to meet the recommended LOS.

The following recommendations have been made as a result of the water security strategy consultative process.

General

> Pursue regulatory and legislative approvals to support implementation of the preferred water security strategy.

> Invest in ongoing communication of strategy milestones and achievements to engage the community and encourage awareness, ownership and confidence in the Fraser Coast water supply systems.

> Acknowledge that implementation of the Strategy will lead to an increase in:
  - rates and charges, which are paid by the entire community; and,
  - water and wastewater infrastructure charges, which are paid by way of developer contributions.

> Acknowledge that increases to water and wastewater rates and charges also reflect the benefit of water security that the strategy provides to residents and economic prosperity.

> Undertake detailed economic analyses to determine an appropriate mix of increased:
  - infrastructure charges
  - water and wastewater rates and charges

  with the aim of minimising the financial impacts on the ratepayers over the strategy timeframe

Short Term Initiatives

> Completion of a Demand Management Strategy and commencement of its implementation.

> Continue implementation of system loss reduction initiatives for Maryborough to reduce losses to 10% of demand.

> Commencement of planning and land acquisitions to enable construction of the Maryborough to Hervey Bay Interconnector.

> Design and construction of Maryborough to Hervey Bay interconnector by 2026.

> Complete planning and design of infrastructure to enable connection of emergency desalination plants for Hervey Bay and Maryborough

Long Term Initiatives

> Complete planning, design and construction of a desalination plant (or other identified bulk source of water) capable of supplying a minimum 7.5ML/day of treated water to the Hervey Bay system by 2036.

Level of Service

Based on the identified strategy and the desired LOS, the recommended LOS to be adopted by Council for all water supply systems within the Fraser Coast is summarised in shown below.

Proposed Fraser Coast Level of Service

Restriction Level	Severity	Frequency
Level 1	N/A	Permanent
Level 2	5% use reduction	1 year ARI
Level 3	20% use reduction	5 year ARI
Level 4	40% use reduction	40 year ARI
Emergency Supply	100 L/person/day	100 year ARI
Supply Shortfall (Dead Storage Level)	Supply Shortfall	>1000 year ARI

1 Introduction

Queensland has a dynamic climate with some of the highest and lowest rainfalls in the country. Planning for a secure water supply is essential in this variable climate to support our industry, agriculture and population growth.

Recognising that water is our most valuable resource, Fraser Coast Regional Council (Council) has engaged Cardno to undertake a Water Supply Security Strategy for the region.

Council is seeking to determine a water security Level of Service (LOS) that is reflective of the community's expectations. This includes understanding the community's desirable LOS, impacts that the LOS will have on the community and their willingness to fund this LOS.

The outcomes of this study will underpin the forward planning for the region's water schemes including the updating of the Fraser Coast Water Supply Strategy, each schemes Drought Management Plan and Council's Drought Management Implementation Plan.

Cardno assembled a multidisciplinary team to deliver the project. The project team consisted of:

> Cardno – Study lead and hydrodynamic modelling;
> Articulous – Community Engagement; and
> Marsden Jacobs – Economists.

1.1 Outcomes

This project's broad aims are to determine the following:

> The current water supply security level for each scheme.
> The desired LOS expected by the community (i.e. how often the community are willing to accept water restrictions).
> Identification for all viable future water source options.
> The suitability of the option demonstrating the best value to the community in meeting the desired LOS and from that, a recommended LOS that best meets the community's desires and willingness/capacity to pay.
> The scope, cost estimate and timing of infrastructure required to meet the recommended LOS.

The delivery of the project is informed by the *Water Security Level of Service Objectives – Guidelines for development* which was published by the Department of Natural Resources, Mines and Energy (DNRME) in April 2018.

1.2 Why do we need a strategy?

The water security strategy is needed to understand the future water demand projections to assess the suitability of the region's existing water supply to meet this demand.

Without a long-term strategy to address future water supply issues in Fraser Coast:

> further water restrictions may be needed to maintain adequate levels of water supply services.
> industrial, urban and agricultural expansion and new development will be limited, affecting the economic prosperity of the region.

1.3 Modelling

To understand the future performance of the water supply schemes and the likelihood of triggering restrictions or running out of water, a water balance model has been created using OPSIM, an operational simulation tool for the assessment, design, and management of water resource systems.

The water balance model is based on a number of inputs including:

> Rainfall and evaporation (statistically generated 1,000 years of rainfall based on actual rainfall records)

> Projected future water demand from residents, industry and agriculture from now to 2051
> Physical characteristics of the infrastructure (i.e. dam storage volumes, spillways, pipelines, treatment plant capacities)
> Operational rules (i.e. requirement to release flows for environmental reasons, reduction in demand based on restriction level).

The model provides outputs for each of the schemes that show the following:

> The Average Recurrence Interval (ARI) of a particular level of water restriction being triggered in a year
> The length of restrictions being in place for each level of restriction (i.e. durations of 1 month, 3 months, 6 months)

The same model has been used to look at future scenarios (i.e. non-infrastructure and infrastructure improvements) and what impact these will have on the LOS.

A report detailing the model inputs, assumptions, model build, calibration and results is included in **Appendix A**.

1.4 Community Engagement

In line with the DNRME Guidelines on the development of LOS, engagement with the community was undertaken throughout the strategy development. The objectives of the engagement were to:

> Determine from the community, through release of information and feedback, the desired LOS for our water sources. That is, what frequency and / or duration would water restrictions (at various severity levels) be acceptable to the community?
> How much is the community willing to pay for the desired LOS?
> Understand impacts to businesses and the community when water restrictions are applied
> Send a message that efficient water usage can prolong our water sources without necessarily compromising lifestyle.

The engagement strategy included the following methods:

> **Engagement panel** – A community panel of 42 members was created as a reference group for the project to provide feedback and direction on behalf of the community. The engagement panel were directly engaged with through a series of three workshops, an online information portal and a number of surveys and live polling.
> **Online community survey** – The survey asked about the community's water use habits as well as specific questions on how often and long they would be willing to accept each level of restriction.
> **Community Pop-up Stands** – were undertaken by Council staff at the Maryborough and Hervey Bay markets.

Information gathered from the engagement methods were used to determine the desired LOS for the water supply scheme, willingness to pay and community acceptance of various water sources.

A report detailing the engagement undertaken and results is included in **Appendix B**.

2 Fraser Coast's Water Supplies

The Fraser Coast consists of three separate water sources that service the townships of Hervey Bay, Maryborough and Tiaro. These water schemes are all owned and operated by Wide Bay Water (WBW), a business unit of Council.

2.1 Hervey Bay

WBW operates the Wide Bay Water Supply Scheme (WBWSS) in accordance with the Mary Basin Resource Operations Plan (Department of Environment and Resource Management, 2011).

The township of Hervey Bay primarily sources its water from the Burrum River System, in which three storages have been constructed: Lake Lenthall, Burrum Weir No.1 and Burrum Weir No.2. The Hervey Bay township is further supplemented by two small dams situated on Beelbi Creek; Cassava Dam 1 and Cassava Dam 2 which act as balance storages for the raw water from Burrum River. The connection between WBWSS and Hervey Bay township reticulated water supply system is shown in Figure 2-1.

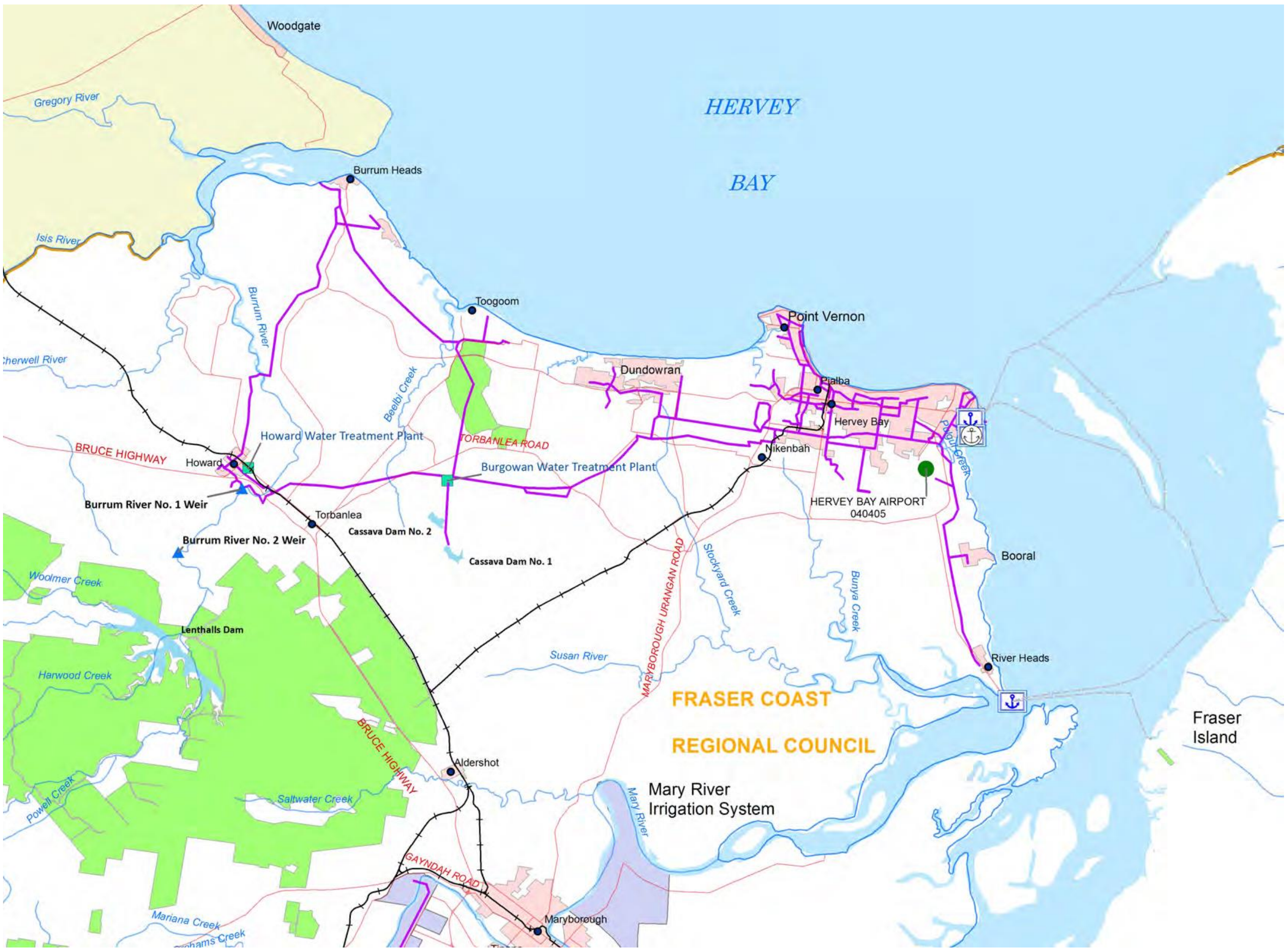

Figure 2-1 Hervey Bay reticulated water supply system

Lake Lenthall comprises the major storage for the WBWSS, with a total supply volume of 28,400ML and a minimum operating volume of 500ML. The contributing catchment area to Lake Lenthall is approximately 709 km^2 and intercepts flows from Logbridge, Doongal, Harwood, Duckinwilla and Woolmer Creeks. Water is released from Lake Lenthall to maintain downstream Burrum Weir No. 2 (full supply capacity 2,242 ML) and Burrum Weir No. 1 (full supply capacity 1,715ML). Water is extracted from Burrum Weir No. 1 to the Water Treatment Plants (WTPs) for processing and delivery to the reticulation network.

The WBWSS is provided an annual water allocation (ML/year) that represents the safe yield from Lake Lenthall. This value considers both high and medium priority water allocations and represents the maximum volume water that can safely be harvested from the system in any given year. The existing high and medium priority allocations are 14,020 ML and 453ML respectively.

2.2 Maryborough

2.2.1 Primary Source

Maryborough's water supply is primarily sourced from Tinana Creek which is a tributary of the Mary River. There have been two storages constructed along Tinana Creek; the Tallegalla and Teddington Weirs. The Teddington Weir Water Supply Scheme (TWWSS) and its assets are managed by WBW. The connection between the TWWSS and Maryborough township reticulated water supply system is shown in Figure 2-2.

Tallegalla Weir is the upstream storage of the Tinana Creek and has a full supply capacity of 385ML and a minimum supply volume of 0ML. Water discharges from Tallegalla Weir downstream to Teddington Weir, which is the offtake location to transfer raw water to Teddington WTP. Teddington Weir has a full supply volume of 3,710ML and minimum operating volume of 400ML.

The existing water allocations for the Teddington Weir are 6,819ML for high priority water and 2,690ML for medium priority water. The assessment of the TWWSS will consider both high and medium priority water.

2.2.2 Supplementary Source

The TWWSS can further be supplemented by sourcing its raw water from the Mary River, via the Owanyilla channel and pipeline system. The offtake location for the Owanyilla pipeline system is situated within the designated storage component of the Mary Barrage, which is situated downstream of the Owanyilla takeoff. The Mary Barrage is a SunWater owned and maintained asset that primarily provides medium priority water to irrigators along the Mary River, under the Lower Mary Water Supply Scheme (LMWSS).

The Mary Barrage has a full supply capacity of 12,000ML and a minimum operating volume of 5,050ML. The existing water allocations for the Mary Barrage consists of 1,809ML of high priority water and 32,653ML of medium priority water.

From the total 1,809ML of high priority allocation, 1,360 ML comprises the supplementary supply volume available to the TWWSS.

From the total 32,563ML of medium priority allocation, 3,426ML comprises the supplementary supply volume available to the TWWSS.

If necessary, the supplementary high and medium priority water allocation is transferred to the Teddington Weir via the 2km long Owanyilla channel and 2.5km long Owanyilla pipeline, at a maximum transfer rate of 92ML/Day. This diverted water is then available to supply water to medium priority water allocation holders who pump from the weir, and to supplement high priority water usage for the Maryborough City.

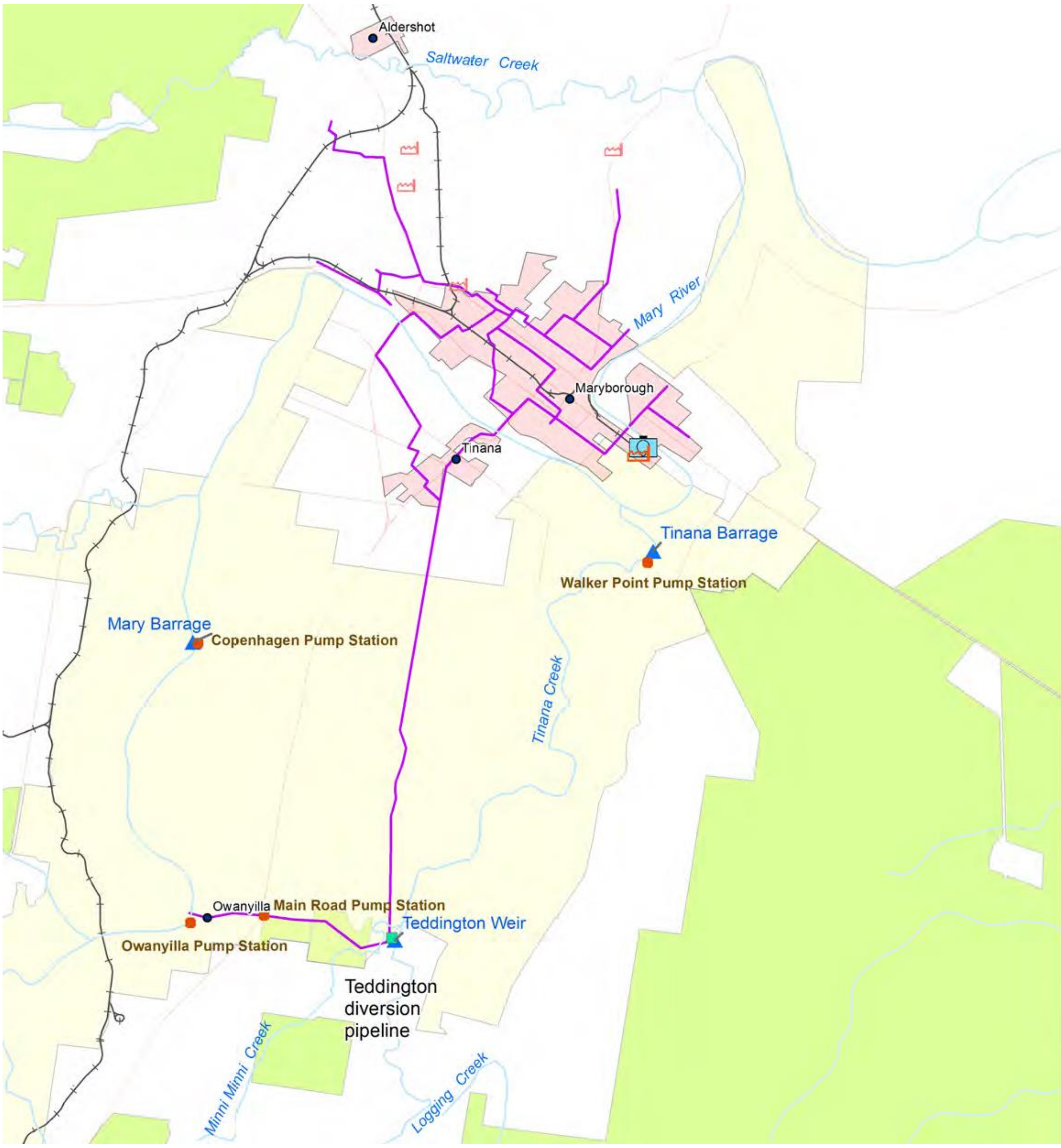

Figure 2-2 Maryborough reticulated water supply system

2.3 Tiaro

Tiaro's raw water supply is sourced directly from the Mary River via a pumping system (located approximately 20km upstream of the Mary Barrage). Although there is no constructed storage for the Tiaro supply system, there is an informal storage at the Tiaro offtake location, which supplies adequate volume for harvesting when the Mary River levels are low or not flowing. The Tiaro reticulated water supply system is managed by WBW and is shown in Figure 2-3.

The informal storage at the Tiaro offtake location is estimated to provide approximately 908ML at full supply capacity.

The existing high priority water allocation for the Tiaro township is 120ML per annum and comprises part of the total Mary Barrage high priority water allocation.

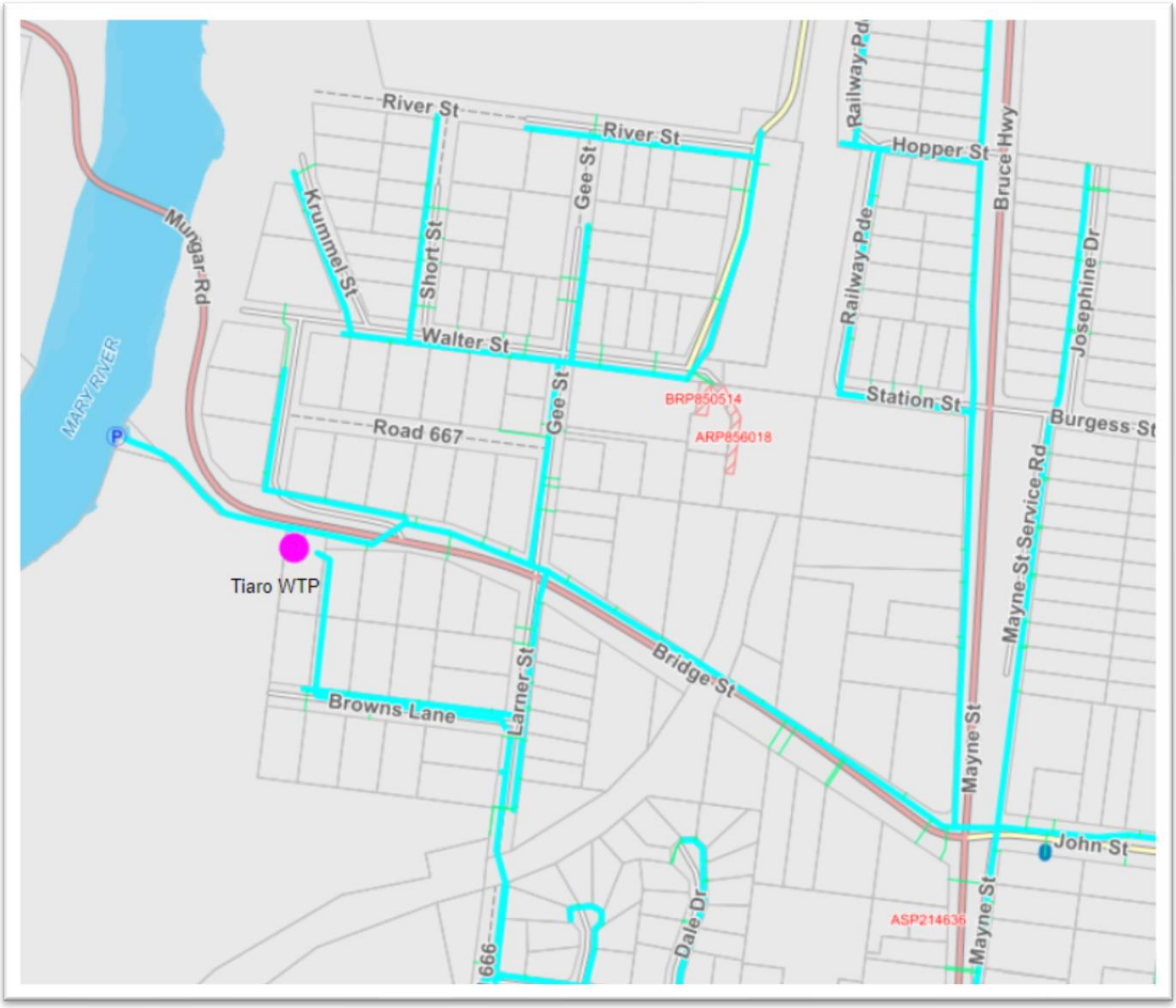

Figure 2-3 Tiaro reticulated water supply system

3 Water Restrictions

The intent of water restrictions is to extend the available supply volume by reducing user consumption. The basis of implementing water restrictions is to ensure that the scheme does not encounter a water shortfall, an event where the available supply volume is an unable to satisfy user demands. Through the target reduction in demands resulting from water restriction, the available water supply is intended to be prolonged until the next rainfall event, minimizing the risk of encountering supply shortfall.

Fraser Coast has implemented water restrictions to extend the available supply within raw water storages for as long as possible while aiming to achieve minimal social and economic impacts. The basis of implementing water restrictions within a specific system are related to the capacity of the supplying raw water source.

Historically, Council has adopted an approach to implementing water restrictions that has provided a consistent approach throughout the region. In this approach, the triggering of water restrictions in any particular system results in every scheme entering restrictions. For example, if Hervey Bay were to enter water restrictions, both the Maryborough and Tiaro systems would also enter restrictions, irrespective of the volume of water available within their suppling water sources.

Note: the 2021 water restrictions were applied to the individual systems not consistently across all.

3.1 Hervey Bay

The Hervey Bay system sources its water from three major storages, Lake Lenthall and the downstream Burrum Weirs, with the offtake location for supply being from Burrum Weir 1. The water restrictions for the Hervey Bay system are governed by the water levels within Lake Lenthall and are summarised in Table 3-1.

Table 3-1 Hervey Bay Restrictions

Water restriction level	Level in Lake Lenthall (m AHD)	Target reduction in demand	Restricted average water consumption (580 L/ED/d)
Level 1 (permanent)	> 23.96	Nil	580 L/ED/d
Level 2	22.64 – 23.96	5%	551 L/ED/d
Level 3	20.62 – 22.64	20%	464 L/ED/d
Level 4	< 20.62	40%	348 L/ED/d

3.2 Maryborough

The water restrictions for the Maryborough system are governed by the water levels within Teddington Weir, with the supplementary supply being regulated by both Teddington Weir and the Mary Barrage. The current water restriction regime for water restrictions for the Maryborough system are shown in Table 3-2.

Table 3-2 Maryborough Restrictions

Water restriction level	Level in Teddington Weir (m AHD)	Target reduction in demand	Restricted average water consumption (580 L/ED/d)
Level 1 (permanent)	> 7.8	Nil	580 L/ED/d
Level 2	7.26 – 7.8	5%	551 L/ED/d
Level 3	6.56 – 7.26	20%	464 L/ED/d
Level 4	< 6.56	40%	348 L/ED/d

3.3 Tiaro

The Tiaro system sources its water from an informal storage along the Mary River which provides a reliable supply of water even when the Mary River is not flowing.

The current water restriction regime for water restrictions for Tiaro are shown in Table 3-3. Water restrictions within the Tiaro system are governed by water levels within the Mary Barrage. Currently, the high priority water allocation for the Tiaro township comprises only a small portion of the total allocations from the Mary River, with the majority of demands sourced from the Mary River being for medium priority water allocation holders.

Table 3-3 Tiaro Restrictions

Water restriction level	Level in Mary Barrage (m AHD)	Target reduction in demand	Restricted average water consumption (420 L/ED/d)
Level 1(permanent)	> 1.5	Nil	420 L/ED/d
Level 2	1 – 1.5	5%	399 L/ED/d
Level 3	< 1 minimal inflow	20%	336 L/ED/d
Level 4	< 1 not flowing	40%	252 L/ED/d

4 Future Water Demand

Future demand for water forms the basis for determining the anticipated requirements for the 30- year term of the strategy. Forecasting future demand is strongly associated with projected population growth and associated economic activity.

The proposed baseline water demand forecast for the strategy has been provided by Council for each of the three systems. The key assumptions used in this forecast are:

> Medium population growth forecast, as documented by the Queensland Regional Statistical Information System (QRSIS).

> A total system water demand of 580 litres per equivalent dwelling per day for Hervey Bay and Maryborough. And 420 litres per equivalent dwelling per day for Tiaro.

> An allowance for non-residential demand to grow in direct proportion to population growth. This represents the water demand for economic activity associated with the future population.

Figures 4-1, 4-2 and 4-3 show the medium and high growth demand projections for each of the three systems. A sensitivity analysis has been completed using the high growth demand scenario and is discussed in Section 5.5.

Further detail of future water demand can be found in the Fraser Coast Regional Water Supply Security Assessment completed as part of this project.

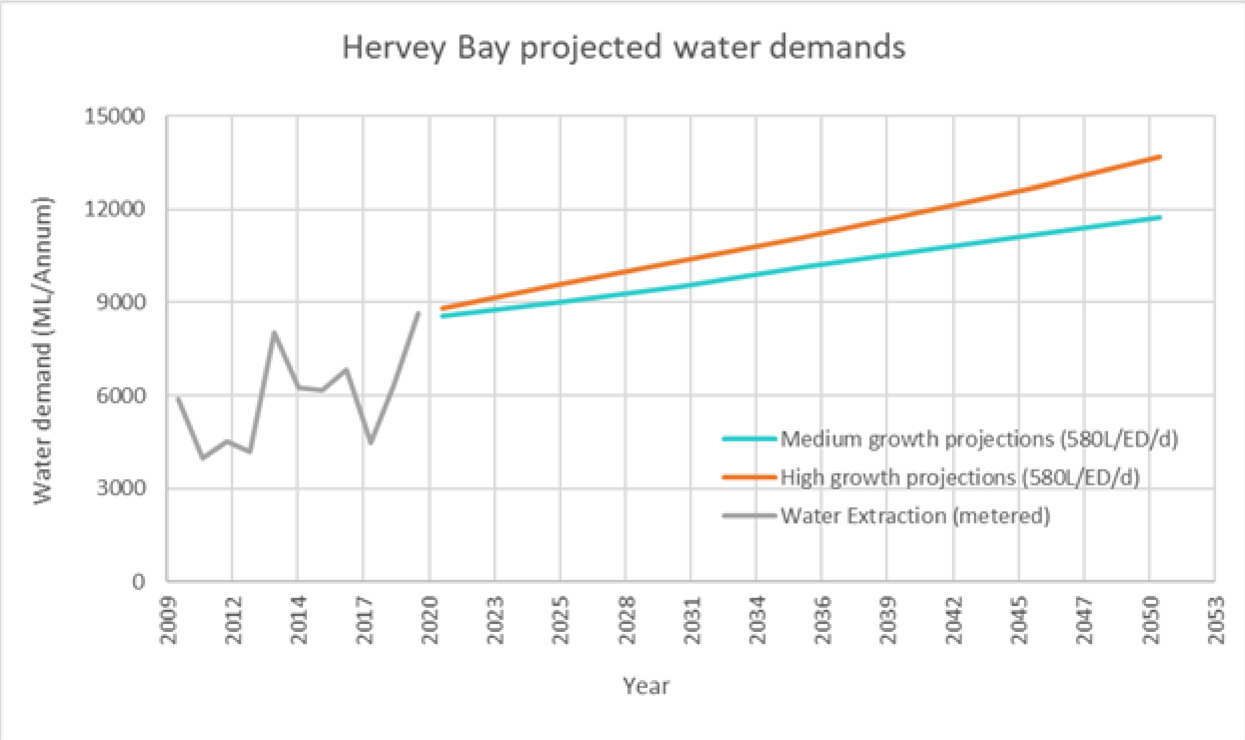

Figure 4-1 Hervey Bay System Water Demand Projections

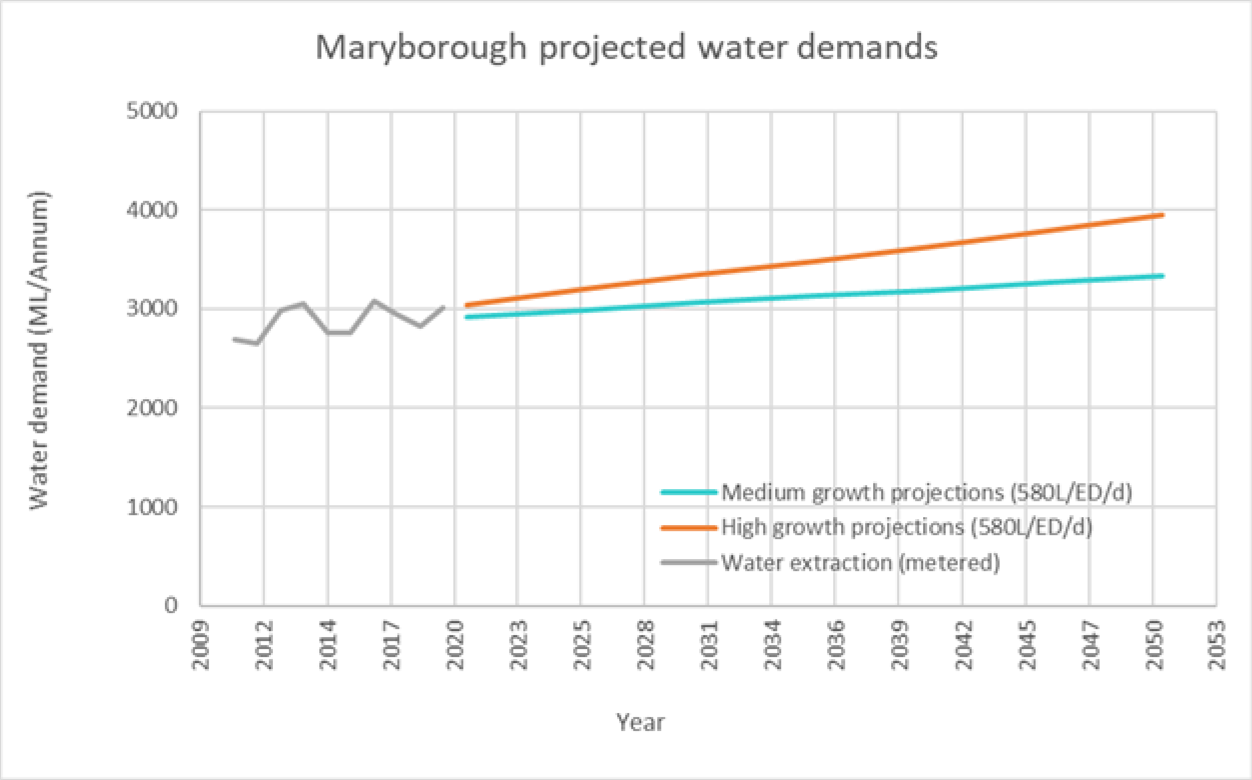

Figure 4-2 Maryborough System Water Demand Projections

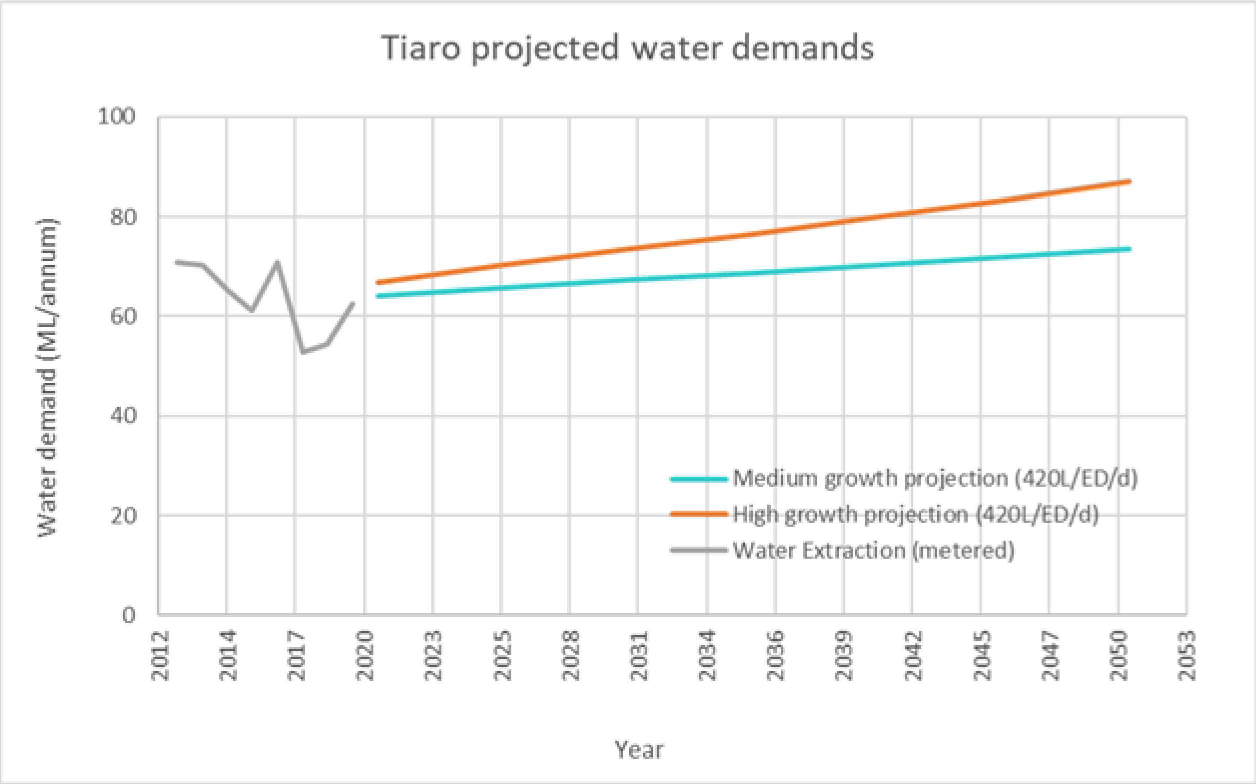

Figure 4-3 Tiaro System Water Demand Projections

5 Existing Scenario – Do we have enough water?

The existing water supply systems have been assessed using the water balance model to evaluate the system capacity to service current and future projected water demands. Hydrologic and hydrodynamic modelling was undertaken using the systems existing infrastructure and operational criteria to determine the current and forecast LOS for the 2021-2051 time frames.

Details of this analysis are included in **Appendix A**.

5.1 Hervey Bay Water Supply System

The forecast performance of the Hervey Bay system for the 2021 – 2051 timeframe is shown in Figure 5-1.

Table 5-1 summarises the frequency of restrictions for the current year and the planning horizon of 2051.

Table 5-1 Current and 2051 Level of Service – Hervey Bay

	Level 2 (ARI)	Level 3 (ARI)	Level 4 (ARI)	Dead Volume (ARI)	Supply Shortfall (ARI)
Current LOS	3	7	48	4,000	>1,000
2051 LOS	2	4	11	500	>1,000

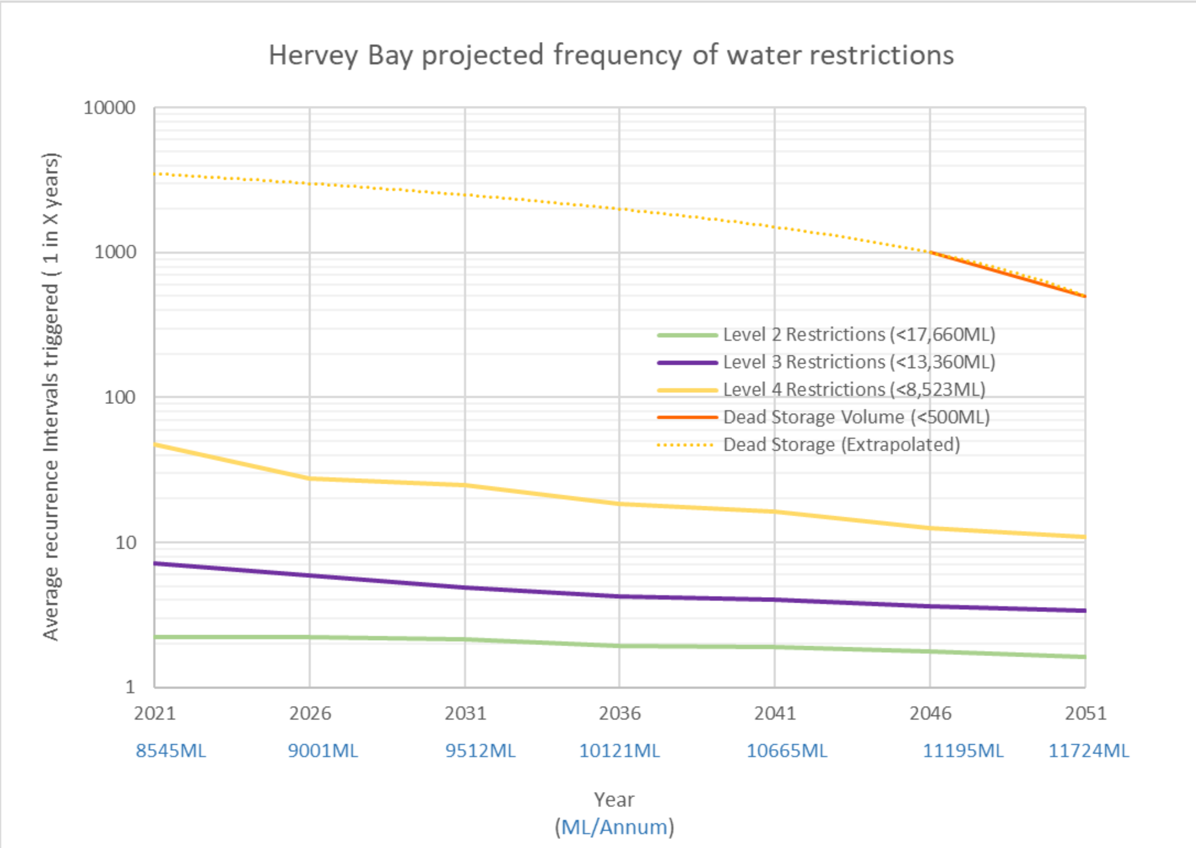

Figure 5-1 Frequency of water restriction and supply shortfall compared to total annual demand – Hervey Bay system

The results in Figure 5-1 illustrate that as the demands within the system increase, there is a consequent reduction in average recurrence interval (ARI), indicating an increased frequency of water restrictions. The results predict that by 2051 the frequency of Level 2 water restrictions will increase to 1 in 2 years, when compared to the current (2021) frequency of 1 in 3 years. Level 4 water restrictions are anticipated to increase to a 1 in 11-year frequency by 2051, when compared to the current 1 in 48-year occurrence.

It is noted that based on the long-term climatic data set, Lake Lenthall is not predicted to reach the dead storage volume until 2046, with results prior to this being extrapolated. The likelihood of Lake Lenthall experiencing a water supply shortfall was not encountered in the modelling, indicating a recurrence interval greater than 1 in 1000 years.

In addition to the frequency of water restriction occurrences, the duration of time spent in water restrictions is another aspect that contributes to determining the LOS of a system.

Figure 5-2 displays the simulated numbed of occurrences over the 1,000 period in which Hervey Bay is anticipated to experience Level 2 water restrictions. The results indicate that as the demands on the system increase, the duration of time spent in water restrictions also increases for periods of 1 month, 3 months and 6 months. A comparison between the 2021 (current) and 2051 results are summarized in Table 5-2.

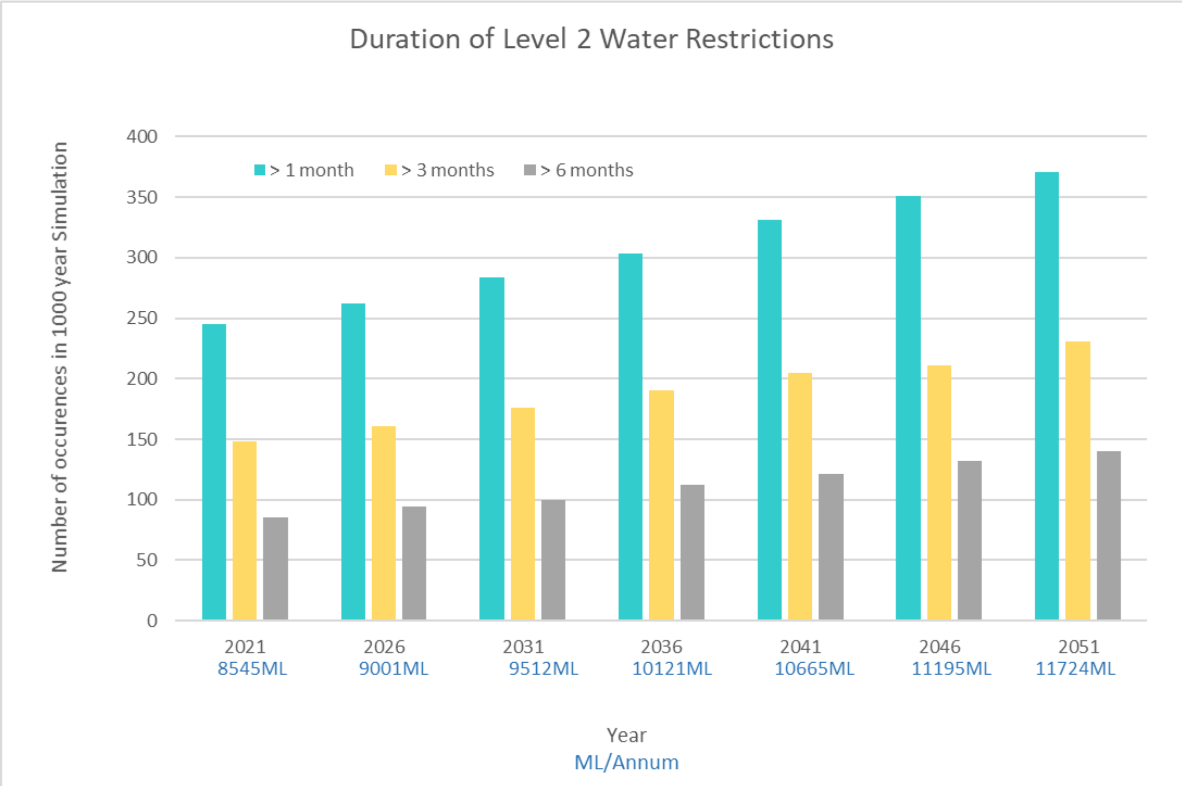

Figure 5-2 Number and duration of level 2 water restrictions – Hervey Bay system

Table 5-2 Summary of current and 2051 LOS for Hervey Bay system (Level 2 Restrictions).

	>1 month	>3 months	>6 months
Current LOS	245 occurrences	148 occurrences	85 occurrences
2051 LOS	371 occurrences	234 occurrences	140 occurrences

The same information is displayed in Figure 5-3 and Table 5-3 for Level 4 water restrictions.

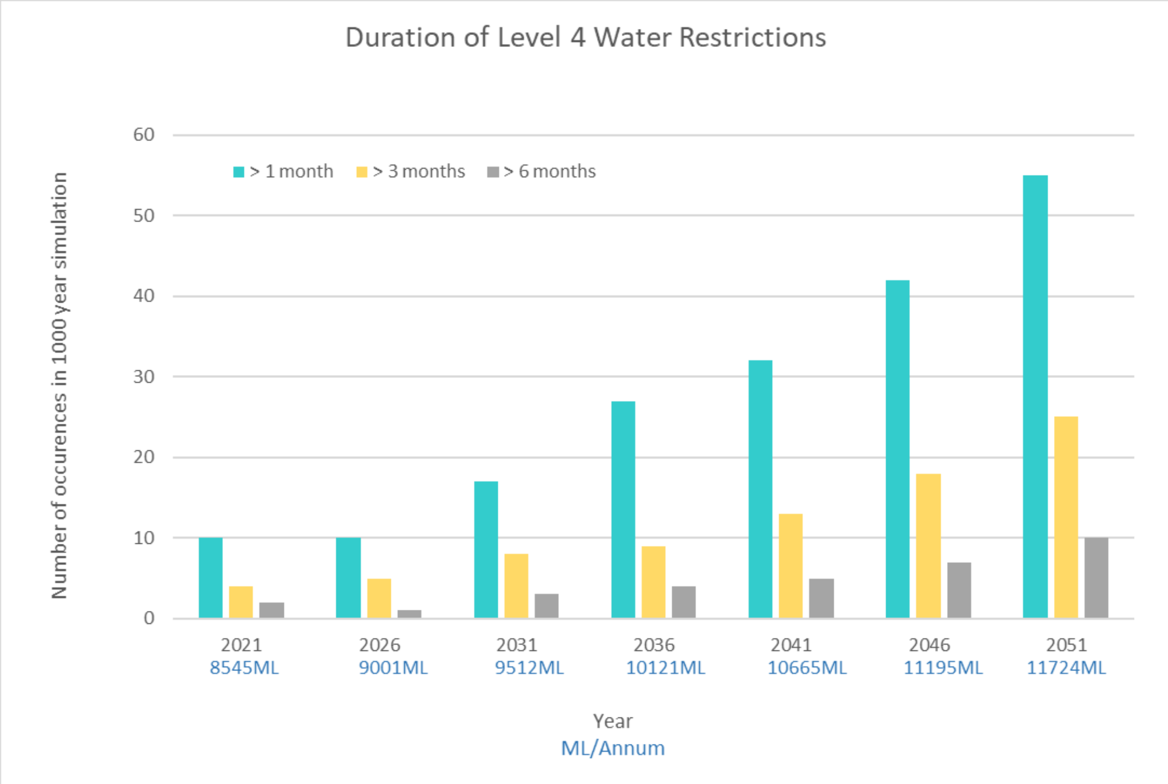

Figure 5-3 Number and duration of level 4 water restrictions – Hervey Bay system

Table 5-3 Summary of current and 2051 LOS for Hervey Bay system (Level 4 Restrictions).

	>1 month	>3 months	>6 months
Current LOS	10 occurrences	4 occurrences	2 occurrences
2051 LOS	55 occurrences	25 occurrences	10 occurrences

5.2 Maryborough Water Supply System

The forecast performance of the Maryborough system for the 2021 – 2051 timeframe is shown in Figure 5-4.

Table 5-4 summarises the current LOS for the Maryborough system when compared to the predicted 2051 LOS.

Table 5-4 Summary of current and 2051 LOS for Maryborough

	Level 2 (ARI)	Level 3 (ARI)	Level 4 (ARI)	Dead Volume (ARI)	Supply Shortfall (ARI)
Current LOS	2	17	83	>1,000	>1,000
2051 LOS	1	10	42	>1,000	>1,000

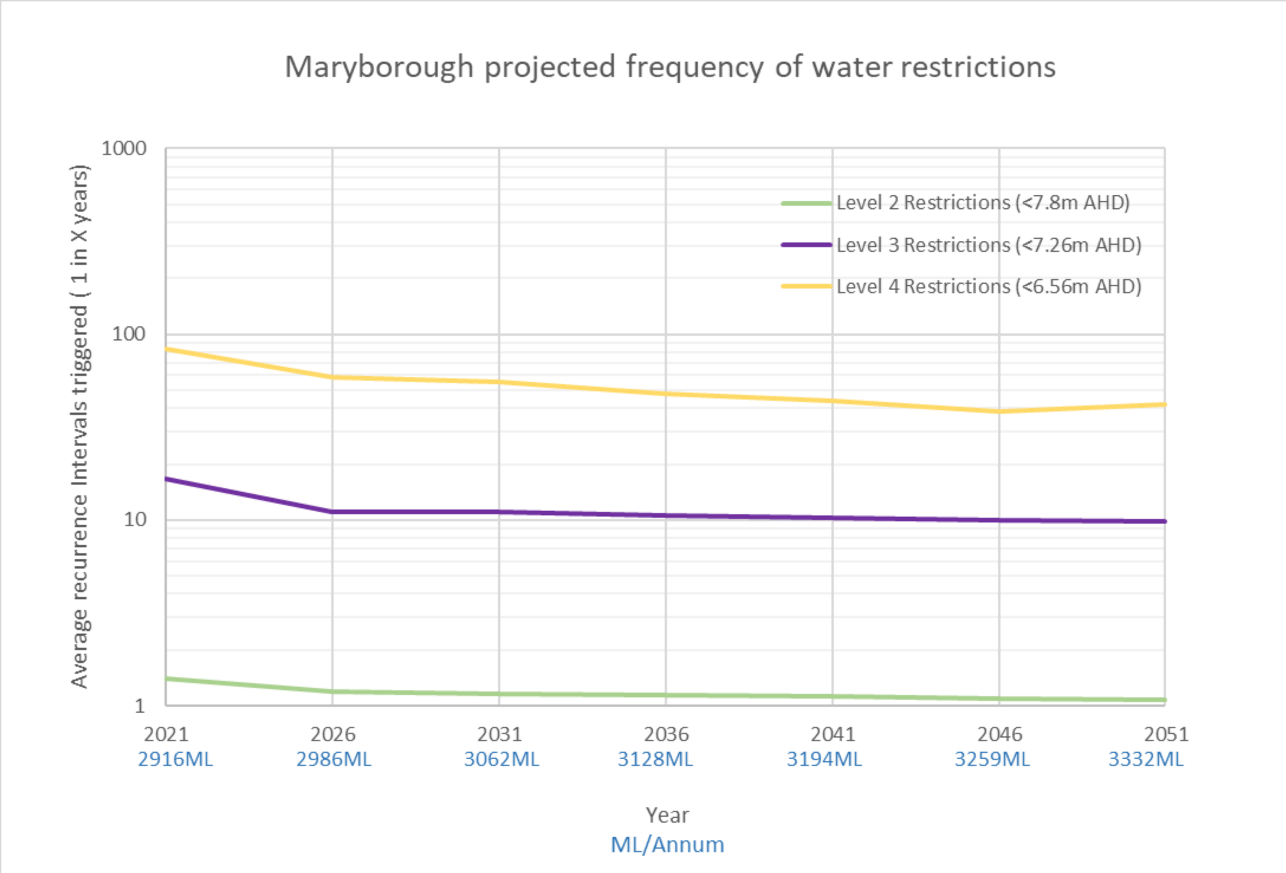

Figure 5-4 Frequency of water restriction and supply shortfall compared to total annual demand – Maryborough system

The results predict that by 2051 the frequency of Level 2 water restrictions will increase to 1 in 1 years (i.e. every year), when compared to the current (2021) frequency of 1 in 2 years. Level 4 water restrictions are anticipated to increase from 1 in 83 years to 1 in 42 years.

The simulated results predicted that Teddington Weir would not reach the dead storage volume, or experience a water supply shortfall for a duration based on the current demands. The likelihood of these events occurring are greater than the 1 in 1,000-year event.

Figure 5-5 displays the simulated number of occurrences over the 1,000 period in which Maryborough is anticipated to experience Level 2 water restrictions. The results indicate that as the demands on the system increase, the duration of time spent in water restrictions also increases for periods of 1 month, 3 months and 6 months. A comparison between the 2021 (current) and 2051 results are summarised in Table 5-5.

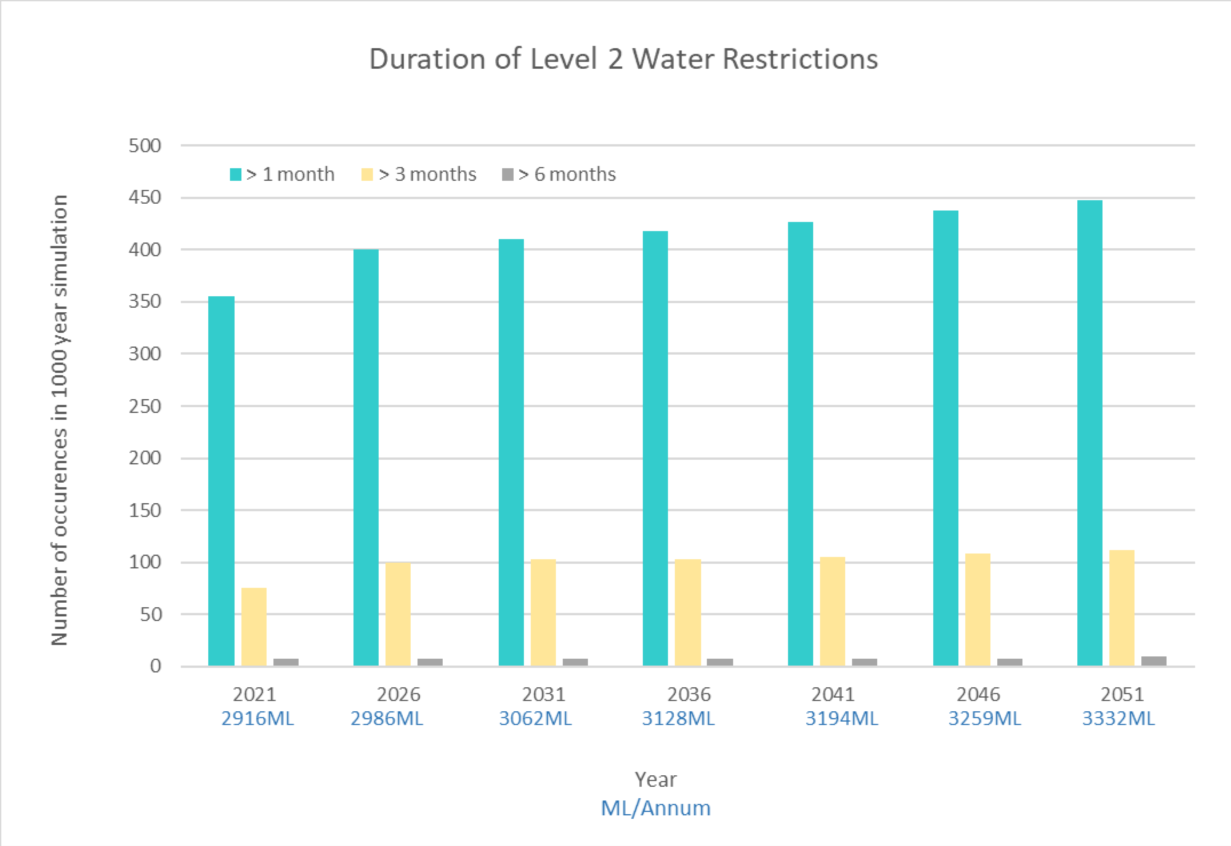

Figure 5-5 Number and duration of level 2 water restrictions – Maryborough system

Table 5-5 Summary of current and 2051 LOS for Maryborough system (Level 2 Restrictions)

	>1 month	>3 months	>6 months
Current LOS	355 occurrences	76 occurrences	7 occurrences
2051 LOS	448 occurrences	112 occurrences	10 occurrences

The number of occurrences spent in Level 2 water restriction for durations greater than 6 months are infrequent, indicating that Teddington Weir is generally recharged in a short time frame after water restrictions are implemented.

The same information is displayed in and Figure 5-6 and Table 5-6 for Level 4 water restrictions.

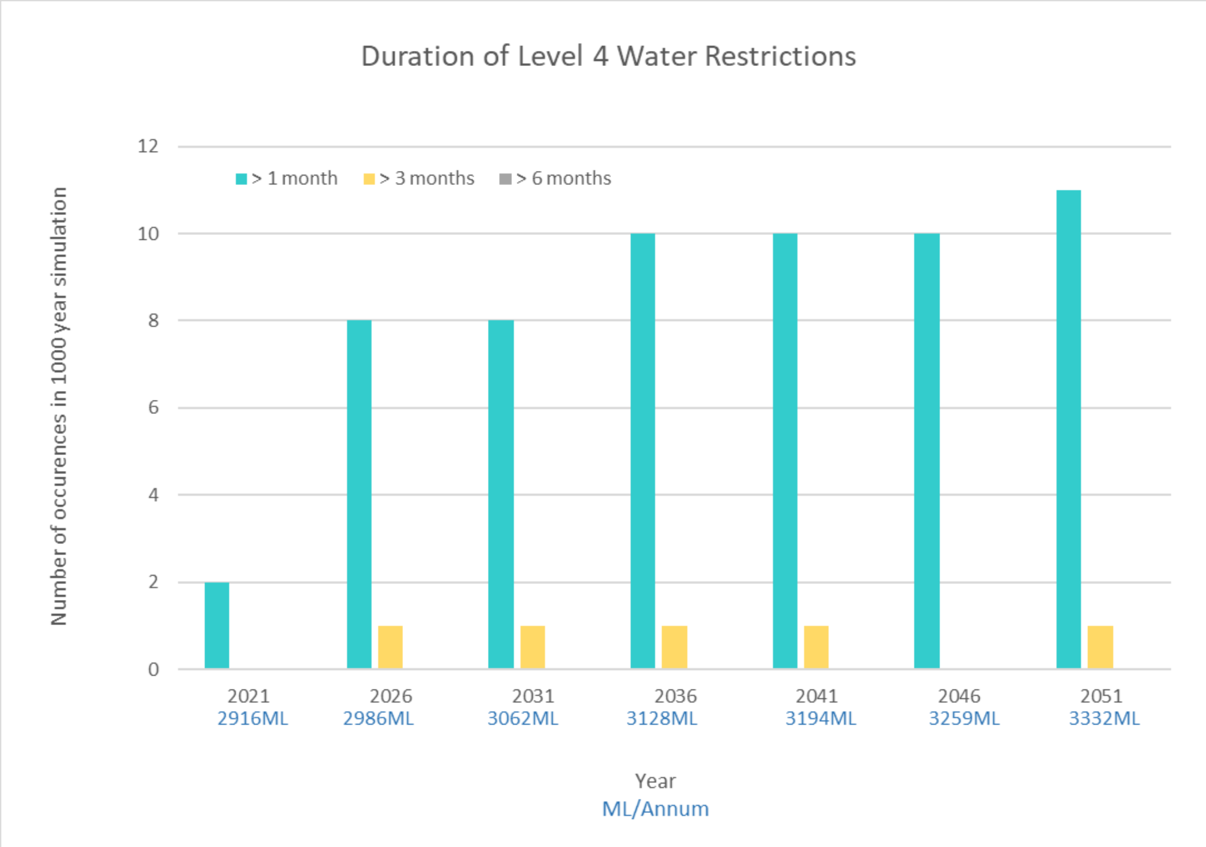

Figure 5-6 Number and duration of level 4 water restrictions for Maryborough system

Table 5-6 Summary of current and 2051 LOS for Maryborough system (Level 4 Restrictions)

	>1 month	>3 months	>6 months
Current LOS	2 occurrences	0 occurrences	0 occurrences
2051 LOS	11 occurrences	1 occurrence	0 occurrences

Teddington Weir is currently anticipated to trigger Level 4 water restriction once in every 83 years. When Level 4 restrictions are entered, the duration of occurrence is only for 30 days, indicating that the system recovers to Level 3 restrictions or better in a short time frame. In 2051, there is only anticipated to be one occurrence of Level 4 water restrictions for greater than 3 months.

5.3 Tiaro Water Supply System

The forecast performance of the Tiaro system for the 2021 – 2051 timeframe is shown in Figure 5-7.

Table 5-7 summarises the current LOS for the Tiaro system when compared to the predicted 2051 LOS.

The results illustrate that there is no change in frequency of water restrictions from now to 2051, based on the predicted demands on the system. In comparison to the volume allocation held by Sunwater customers for the Mary River, the demands of the Tiaro townships are relatively insignificant for the system. As such, the current performance of the Mary River is not anticipated to be impacted by the increasing demands projected for Tiaro.

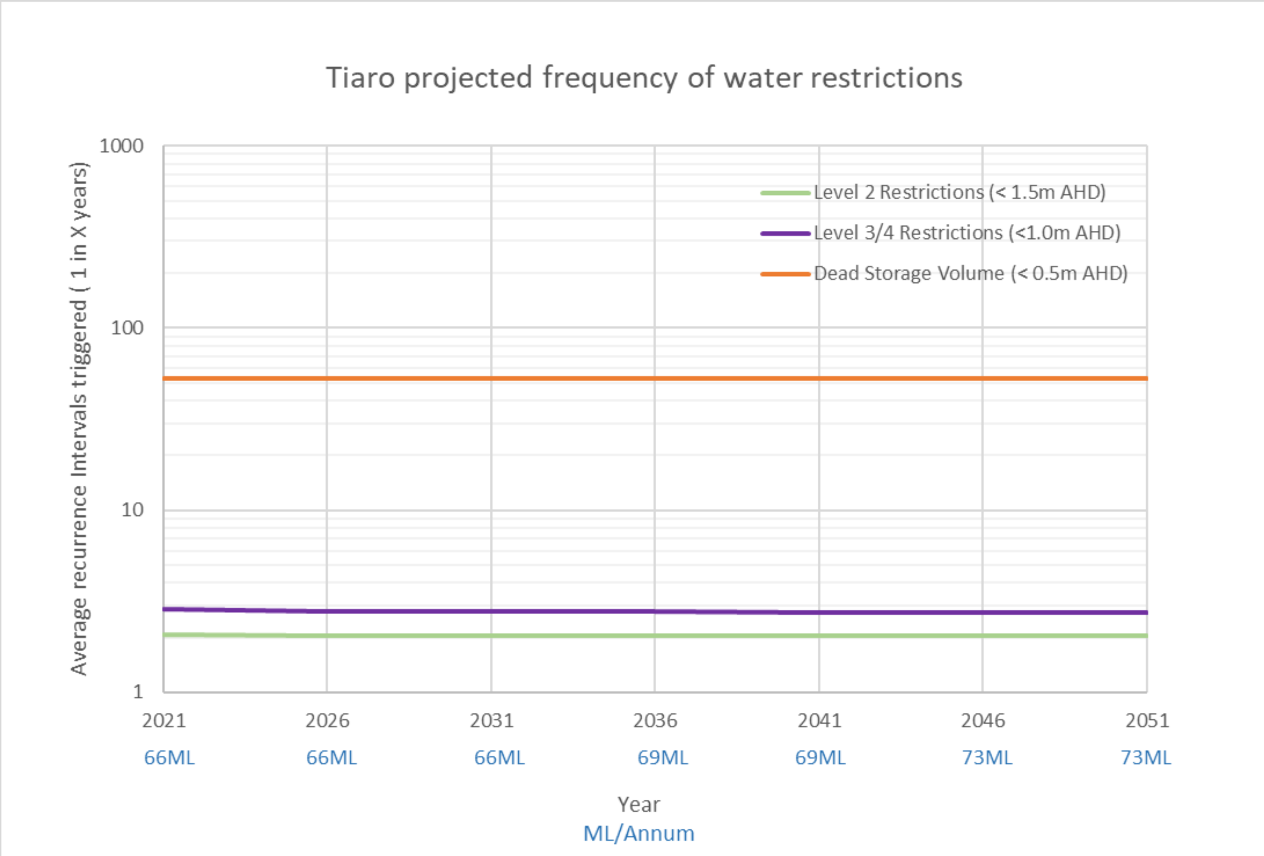

Figure 5-7 Frequency of water restriction and supply shortfall compared to total annual demand – Tiaro system

Table 5-7 Summary of current and 2051 LOS for Tiaro

	Level 2 (ARI)	Level 3 (ARI)	Level 4 (ARI)	Dead Volume (ARI)	Supply Shortfall (ARI)
Current LOS	2	3	3	50	>1,000
2051 LOS	2	2	3	50	>1,000

Modelling indicates that the Mary Barrage enters Level 2 water restrictions once in every 2 years and Level 3/4 water restrictions once in every 3 years. Although the occurrence of restrictions appears relatively frequent, this is largely influenced by the timing of when third party irrigators harvest water from the system. Based on historic behaviour, when allocations are taken from the system, this generally corresponds with entering both level 2 and 3 water restrictions, based on the small volume difference between the current triggers levels. Once allocations have been drawn from the system, the Mary Barrage generally recovers to levels of near fully supply capacity.

Based on the long-term climatic data set, the Mary Barrage is predicted to reach the dead storage volume once in every 50 years. This does not correspond to a water supply shortfall for the Tiaro system due to the adequate informal storage volume available at the offtake location.

Refer to Figure 5-8 for the number and duration of Level 2 water restrictions within the Mary Barrage from 2021 – 2051. A comparison between the 2021 (current) and 2051 results are summarized in Table 5-8.

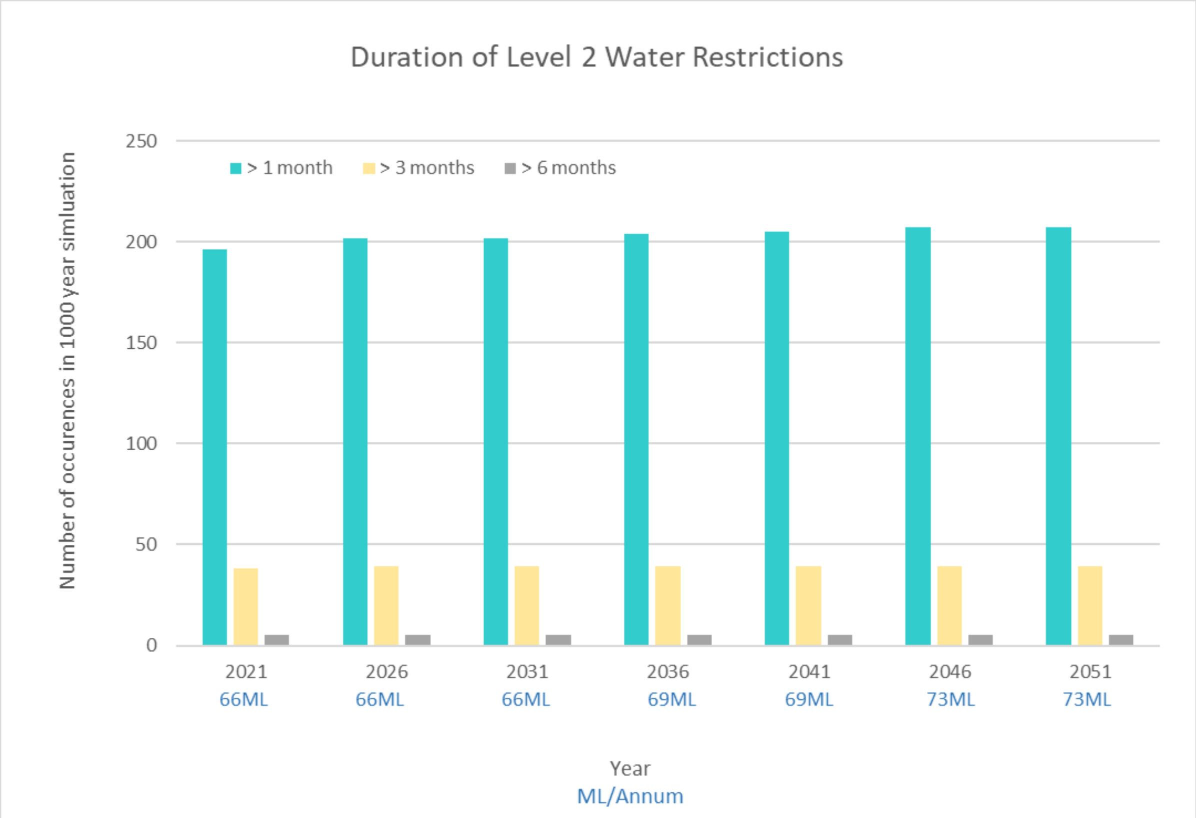

Figure 5-8 Number and duration of level 2 water restrictions – Tiaro system

Table 5-8 Summary of current and 2051 LOS for Tiaro system (Level 2 Restrictions)

	>1 month	>3 months	>6 months
Current LOS	196 occurrences	38 occurrences	5 occurrences
2051 LOS	207 occurrences	39 occurrences	5 occurrences

Figure 5-8Figure 5-8 displays the simulated numbed of occurrences over the 1,000 period in which Tiaro is anticipated to experience Level 2 water restrictions. The results indicate there is minimal to no change in the number of occurrences for durations greater than 1 month - 6 months from now to 2051. As mentioned previously, this is due to the Tiaro township demands being relatively insignificant for the Mary River.

There is five (5) occurrence of Level 2 water restriction being entered for greater than 6 months, indicating that the Mary Barrage is generally recharged in a short time frame after water restrictions are implemented.

The same information is displayed in and Figure 5-9 and Table 5-9 for Level 4 water restrictions.

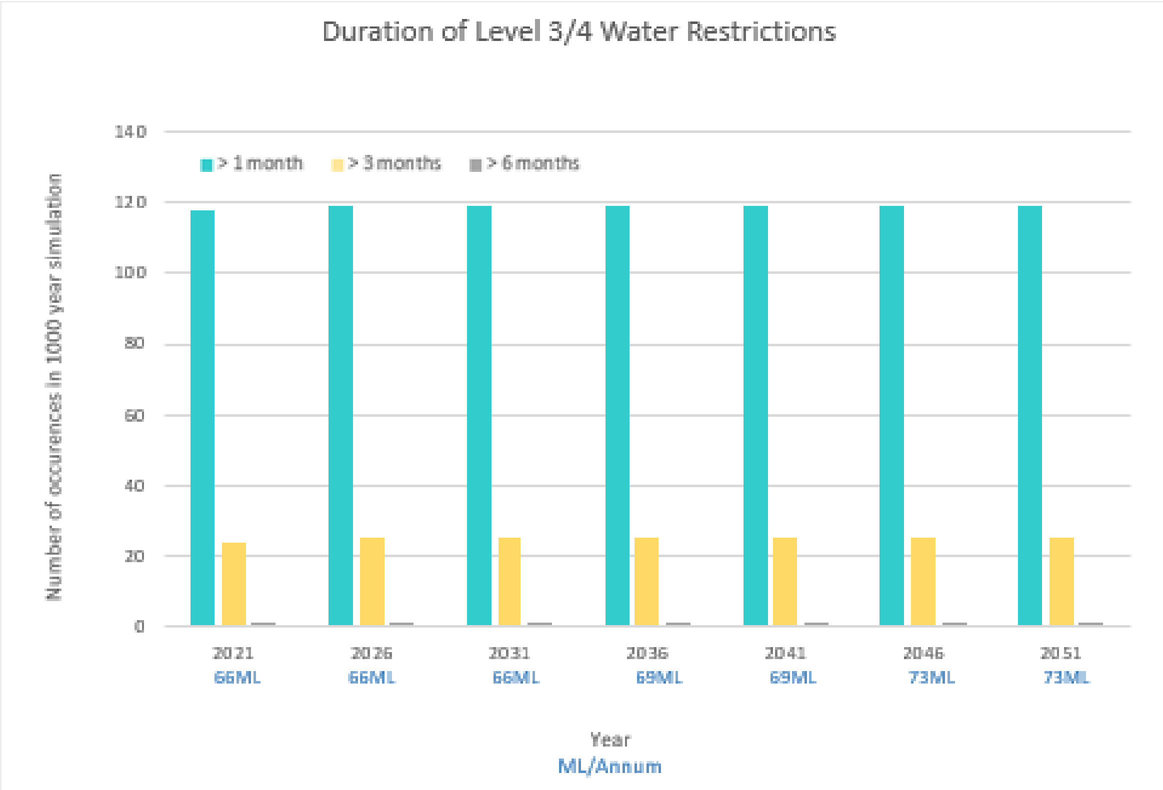

Figure 5-9 Number and duration of level 4 water restrictions – Tiaro system

Table 5-9 Summary of current and 2051 LOS for Tiaro system (Level 4 Restrictions)

	>1 month	>3 months	>6 months
Current LOS	118 occurrences	24 occurrences	1 occurrence
2051 LOS	119 occurrences	25 occurrences	1 occurrence

Although the Mary Barrage enters Level 4 water restrictions once in every 3 years, the duration of time spent in Level 4 restrictions is generally only for periods of 1 month. The Mary Basin Resource Plan Prohibition on Take rule for medium priority water allocation holders coincides with the trigger level for of Level 4 water restrictions. As such, when Level 4 restrictions are entered, the major demand on the system (medium priority water) is removed, and the system rapidly recovers to Level 2 restrictions or better in a short time frame.

Based on the frequency and duration of water restrictions currently exhibited for the Mary Barrage, the system is not impacted by the current of future demands for Tiaro township and is largely influenced by the regime of harvest from LMWSS allocation holders.

5.4 Allocations

A review of the current allocations for the Hervey Bay and Maryborough systems has been undertaken to determine if additional allocations should be gained during the planning horizon of this strategy. Based on both the medium and high growth demand scenarios, there are sufficient allocations to 2051 for all water supply schemes.

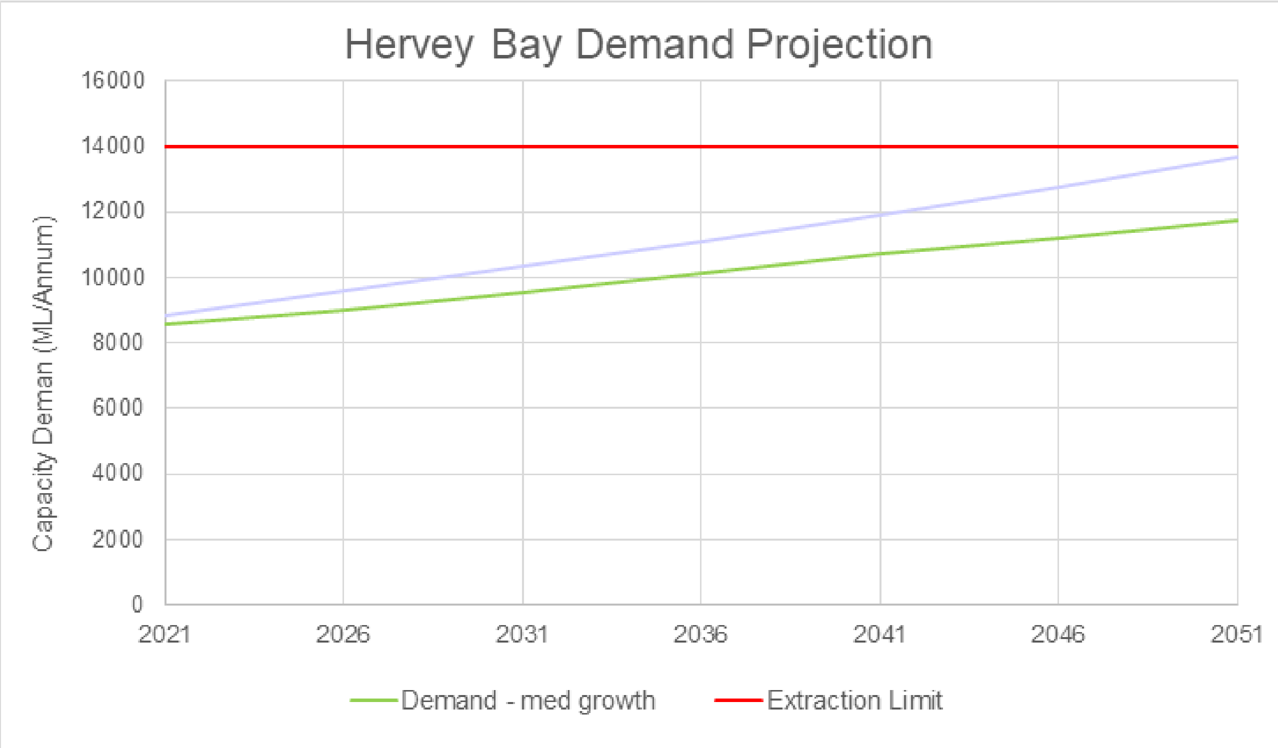

Figure 5-10 Hervey Bay Demand Projection

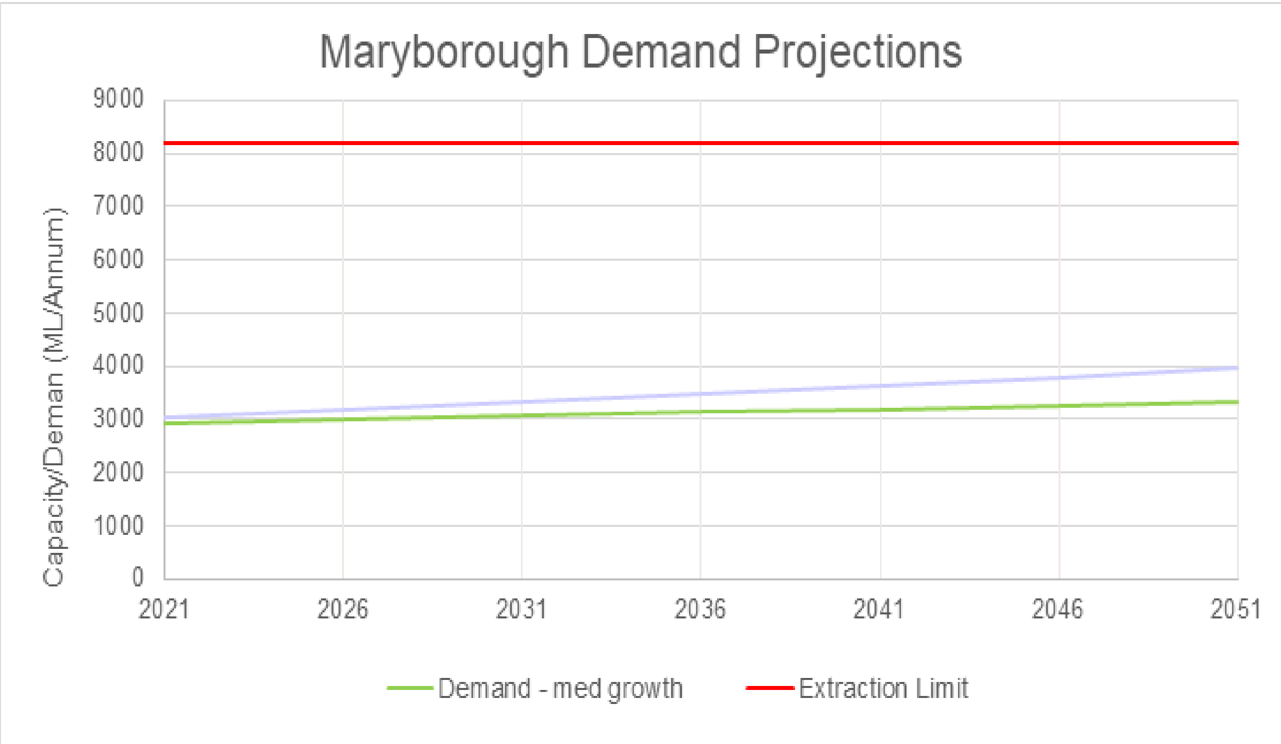

Figure 5-11 Maryborough Demand Projections

5.5 Sensitivity Analysis

Since the release of the predicted growth rates published by QGISO in 2018, there has been a spike in growth within the Fraser Coast Region. As such, it was deemed necessary to carry out a sensitivity check on the original model by simulating a revised high growth scenario (HGS) and comparing the impact it has on forecasted LOS for the 2021-2051 time cohorts.

As future augmentation options will be developed from the LOS results generated from the existing model, it is important that the most accurate representation of growth/demand data is captured within the base case model.

The high growth rates adopted within the HGS scenario were determined as follows;

- The medium series growth rates for the Hervey Bay and Maryborough regions were calculated using the Projected population (medium series), by statistical area level 2 (SA2), SA3 and SA4, Queensland, 2016 to 2041.
- The medium and high growth series for the Fraser Coast Region was calculated using the Projected population (high & medium series), by local government area, Queensland, 2016 to 2041.
- The medium growth rates predicted for Fraser Coast, Hervey Bay and Maryborough were analysed to develop ratios to define the Maryborough to Fraser Coast growth rate and Hervey Bay to Fraser Coast growth rate.
- As no high growth rates were published for Hervey Bay and Maryborough, the high growth rates were estimated by using the ratio determined for the medium growth scenario, and applying that to the high growth rate predictions for the Fraser Coast Region.

The results of the high growth rate analysis are presented in Table 5-10. Note, as no data was published for 2041 onwards, the same growth rate as per 2036 was applied for proceeding years.

Table 5-10 QGISO Medium and High Growth Rates Review

	2016	2021	2026	2031	2036	2041	2046	2051
Medium Growth								
Fraser Coast	4.72%	5.44%	5.70%	4.56%	3.98%	3.98%	3.98%	3.98%
Hervey Bay (HB)	5.75%	5.90%	6.18%	5.08%	4.58%	4.58%	4.58%	4.58%
Maryborough (MB)	4.45%	4.11%	3.63%	2.98%	2.71%	2.71%	2.71%	2.71%
Ratio HB to Fraser Coast	1.217	1.085	1.083	1.114	1.152	1.152	1.152	1.152
Ration MB to Fraser Coast	0.941	0.757	0.637	0.655	0.681	0.681	0.681	0.681
High Growth								
Fraser Coast	6.24%	7.87%	8.24%	6.81%	6.28%	6.28%	6.28%	6.28%
Ratioed Hervey Bay (HB)	7.59%	8.54%	8.92%	7.59%	7.24%	7.24%	7.24%	7.24%
Ratioed Maryborough (MB)	5.87%	5.96%	5.25%	4.46%	4.28%	4.28%	4.28%	4.28%

The existing system was simulated for the revised high growth rates for time cohorts from 2021 to 2051. The results for each system are presented in the following tables.

5.5.2 Hervey Bay High Growth Rates Results

Table 5-11 Summary of current and 2051 LOS for Hervey Bay (High Growth Rates)

	Level 2 (ARI)	Level 3 (ARI)	Level 4 (ARI)	Dead Volume (ARI)	Supply Shortfall (ARI)
Current LOS	3	7	37	1,000	>1,000
2051 LOS	1	3	8	250	>1,000

Table 5-12 Summary of current and 2051 LOS for Hervey Bay Scheme (Level 2 Restrictions)

	>1 month	> 3 months	> 6 months
Current LOS	258 occurrences	154 occurrences	91 occurrences
2051 LOS	431 occurrences	267 occurrences	174 occurrences

Table 5-13 Summary of current and 2051 LOS for Hervey Bay system (Level 4 Restrictions)

	>1 month	> 3 months	> 6 months
Current LOS	10 occurrences	5 occurrences	1 occurrence
2051 LOS	77 occurrences	40 occurrences	18 occurrences

5.5.3 Maryborough High Growth Rates Results

Table 5-14 Summary of current and 2051 LOS for Maryborough (High Growth Rates)

	Level 2 (ARI)	Level 3 (ARI)	Level 4 (ARI)	Dead Volume (ARI)	Supply Shortfall (ARI)
Current LOS	1	11	56	>1,000	>1,000
2051 LOS	1	8	28	1,000	>1,000

Table 5-15 Summary of current and 2051 LOS for Maryborough system (Level 2 Restrictions)

	>1 month	> 3 months	> 6 months
Current LOS	411 occurrences	101 occurrences	8 occurrences
2051 LOS	533 occurrences	129 occurrences	14 occurrences

Table 5-16 Summary of current and 2051 LOS for Maryborough (Level 4 Restrictions)

	>1 month	> 3 months	> 6 months
Current LOS	8 occurrences	1 occurrence	0 occurrences
2051 LOS	18 occurrences	2 occurrences	0 occurrences

5.5.4 Tiaro High Growth Rates Results

Table 5-17 Summary of current and 2051 LOS for Tiaro (High Growth Rates)

	Level 2 (ARI)	Level 3 (ARI)	Level 4 (ARI)	Dead Volume (ARI)	Supply Shortfall (ARI)
Current LOS	2	3	3	50	>1,000
2051 LOS	2	3	3	50	>1,000

Table 5-18 Summary of current and 2051 LOS for Tiaro system (Level 2 Restrictions)

	>1 month	> 3 months	> 6 months
Current LOS	202 occurrences	39 occurrences	5 occurrences
2051 LOS	214 occurrences	40 occurrences	5 occurrences

Table 5-19 Summary of current and 2051 LOS for Tiaro (Level 4 Restrictions)

	>1 month	> 3 months	> 6 months
Current LOS	119 occurrences	25 occurrences	1 occurrence
2051 LOS	123 occurrences	25 occurrences	1 occurrence

The LOS results obtained from the high growth rates were compared to the original results within section 6.1 to 6.3There are notable differences in the LOS results obtained in the Level 3 and Level 4 trigger levels ARI's, however no change in ARI was encountered for supply shortfall.

Upon consultation with Council, it was decided that the original results using the supplied growth rates, would be adopted to progress with augmentation options.

6 Desired Level of Service

As part of the community engagement for the strategy, a community survey was undertaken. The survey was open from 19/02/2021 to 14/03/2021 via Councils engagement hub and drop in stalls with a total of 186 surveys received. The majority of survey respondents were from the Hervey Bay stakeholders (125 responses). It is noted that there were no survey responses from Tiaro stakeholders.

The same survey was also sent to the community engagement panel to complete so that a comparison between the two could be undertaken.

Surveys and project discussions were also held through pop up stands at the Hervey Bay and Maryborough markets by Council Staff.

The purpose of the survey was to seek feedback from the community on their desired LOS for water supply security. The survey asked about the community’s water use habits as well as specific questions on how often and long they would be willing to accept each level of restriction.

Based on the results of the survey the Desired LOS has been determined as summarised in Table 6-1.

Table 6-1 Community Desired LOS

	Desired LOS
Level 2 Frequency	Every year
Level 2 Duration	< 3 months
Level 3 Frequency	5 years
Level 3 Duration	1 - 3 months
Level 4 Frequency	40 years
Level 4 Duration	< 1 month

The desired LOS has been overlain on the existing system performance to 2051 (Figures 6-1, 6-2 and 6-3). These graphs show:

> The Maryborough system meets the desired LOS.

> The Hervey Bay system no longer meets the desired LOS from 2026 for level 4 restrictions and 2031 for level 3 restrictions.

> The Tiaro system does not meet the desired LOS for Level 3/4 restrictions from the current scenario, although historically restrictions have not been triggered based on the level at the Mary River Barrage.

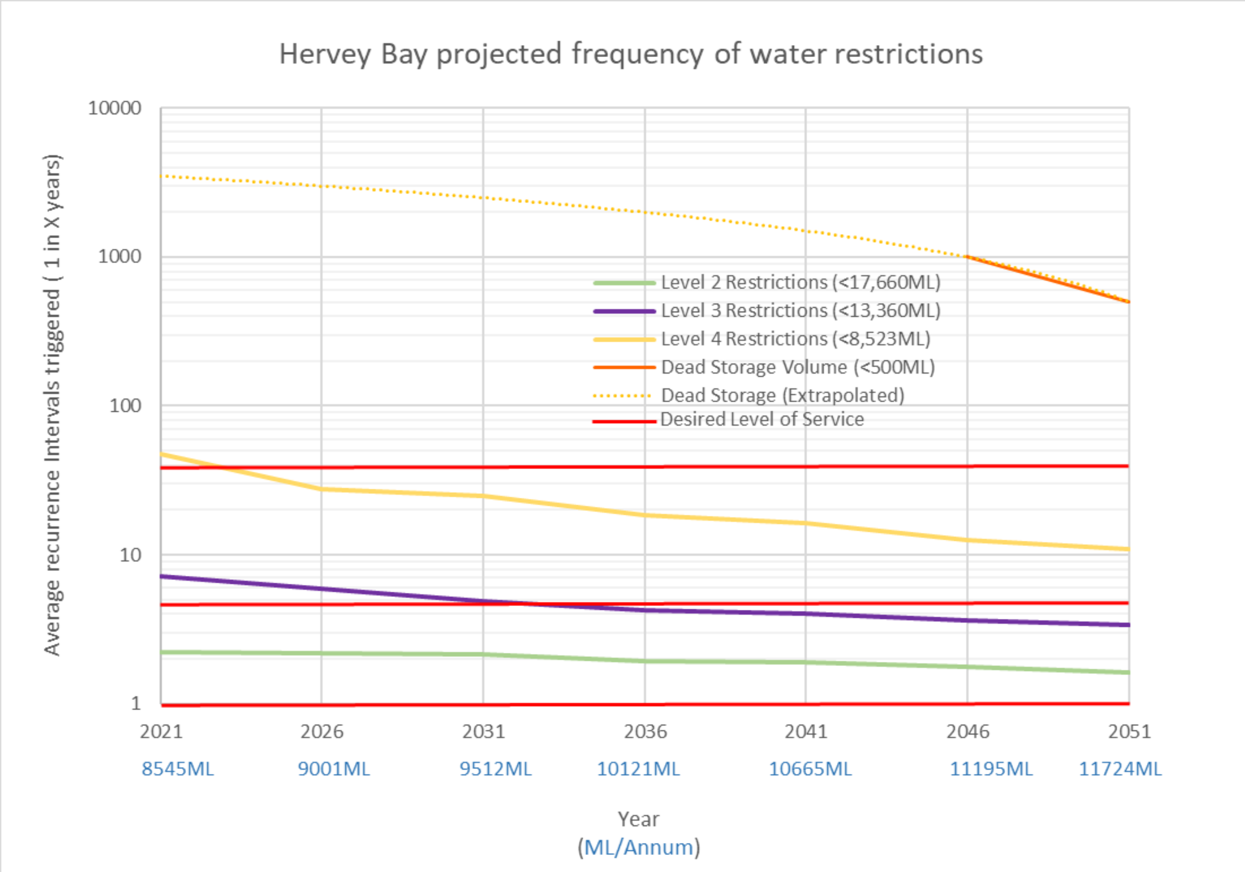

Figure 6-1 Hervey Bay system future performance v desired LOS

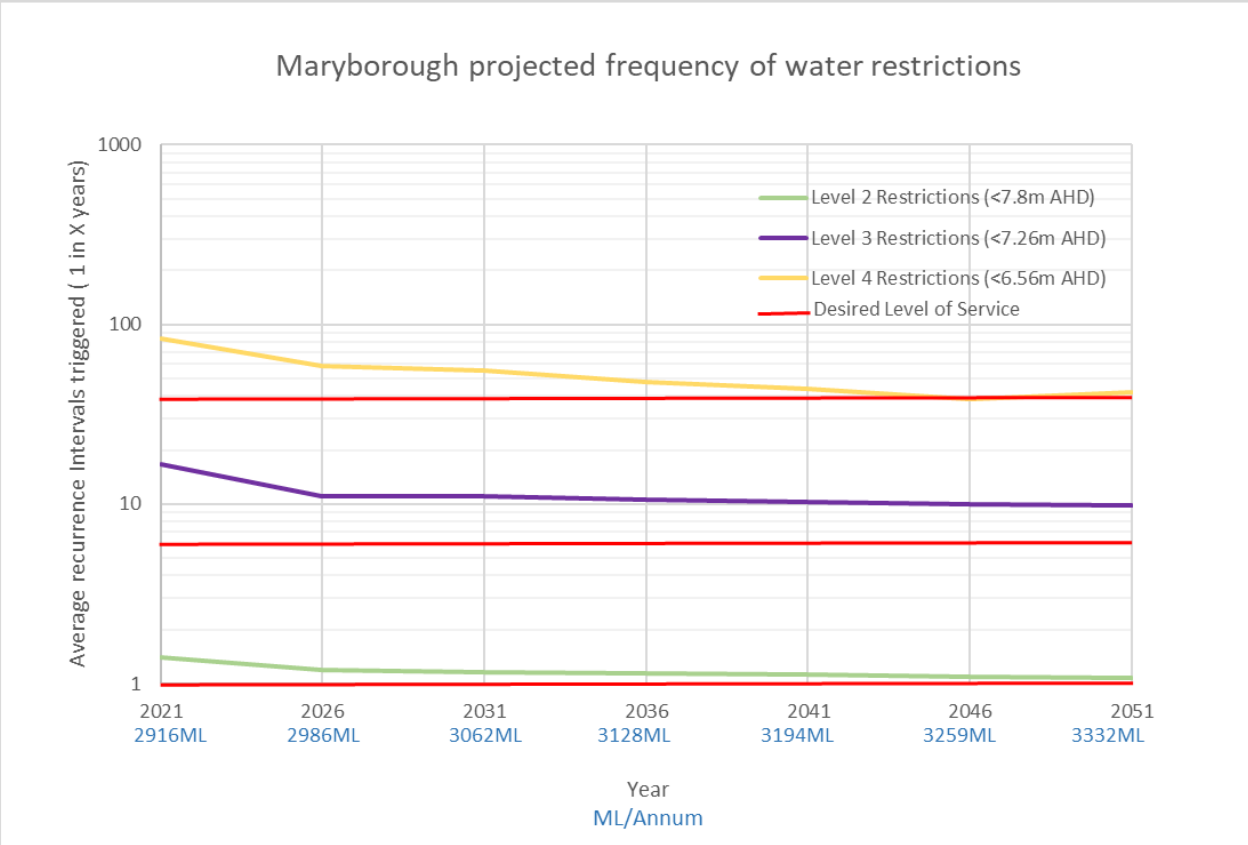

Figure 6-2 Maryborough system future performance v desired LOS

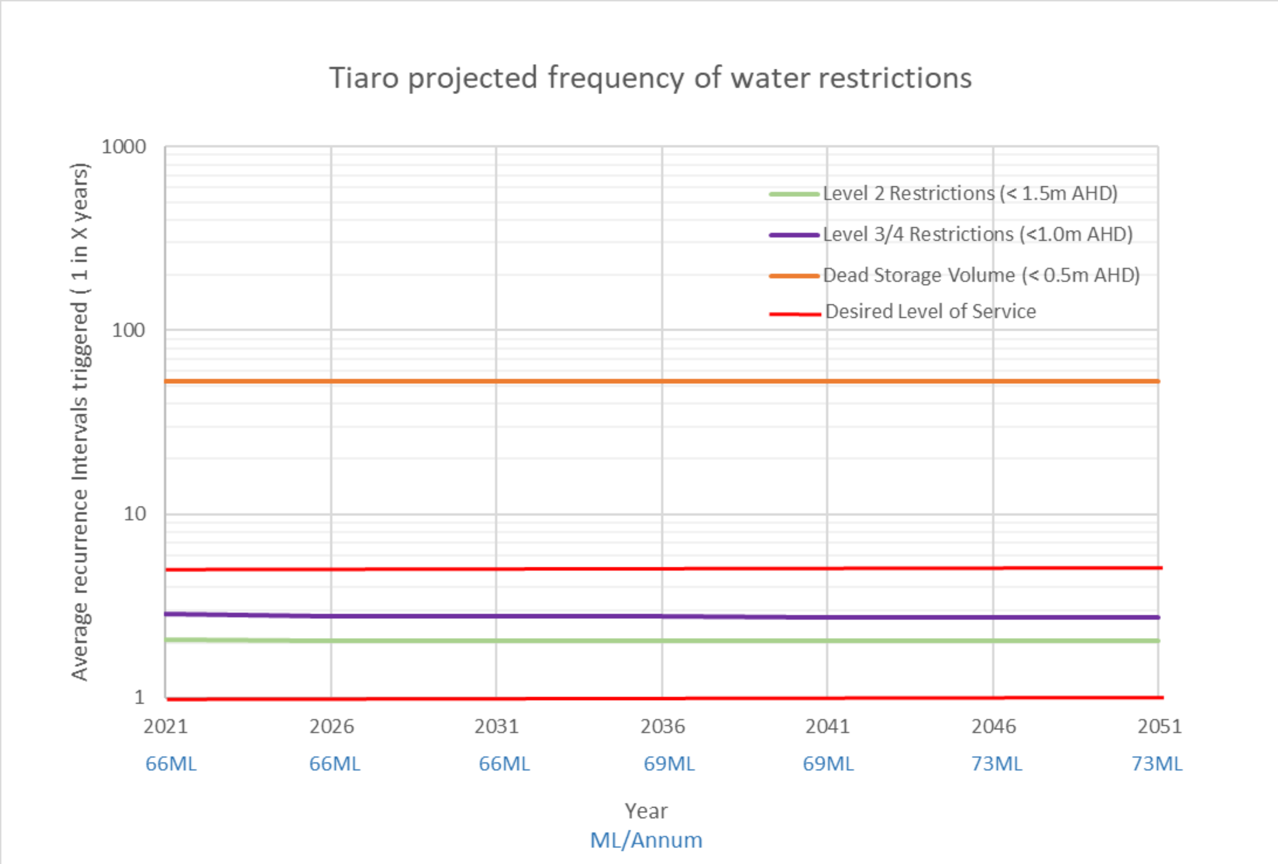

Figure 6-3 Tiaro system future performance v desired LOS

7 Water Security Options

It is identified that at current demand projections, in 2026 the desired LOS will not be met for the Hervey Bay system.

A variety of non-infrastructure and infrastructure options have been investigated for the supply system to both improve and meet the desired LOS.

7.1 Non-infrastructure options

The traditional response to achieving the desired water balance is to install or increase bulk water supply capacity by constructing water storage and distribution assets – dams, pipes.

Over time, water storage sites are becoming relatively costly to access, the costs of ensuring dam safety and environmental compliance are increasing, and climatic conditions more variable.

More focus is being directed to alternatives which include:

a. **less-traditional bulk supply infrastructure** including water recycling, desalination and inter-connection (grids)

b. **infrastructure options to reduce demand** including smart metering, leak detection, system loss reduction, re-use schemes (such as irrigating local cane fields)

c. **non-infrastructure options to reduce demand** including education campaigns and pricing.

Options (b) and (c) are intended to conserve water through changes in customer behaviour by increasing customer awareness and ability to change usage patterns and by operational and infrastructure initiatives which support such objectives – they are collectively referred to as Water Demand Management (WDM) strategies (Figure 7-1).

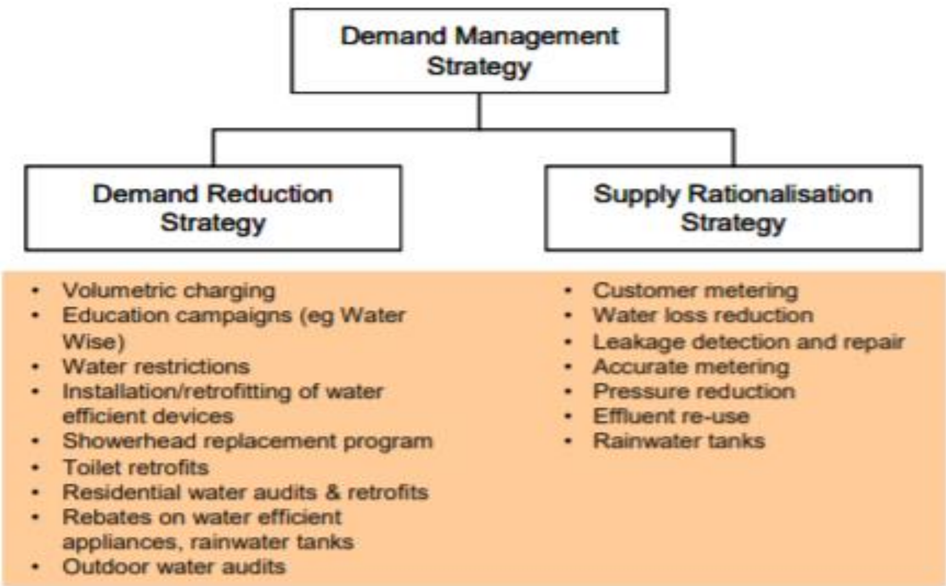

Figure 7-1 Demand Management (Department of Natural Resources and Mines, April 2010 amended March 2014)

The initiatives can be general in nature (education campaigns) or focus on key groups (different LOS for different groups or specific measures - residential water audits, requiring Water Efficiency Management Plans (for large business/industry users)). (Department of Natural Resources and Mines, April 2018).

7.1.2 In principle

By reducing demand consumption per customer, supply capability can be extended over time, the costs of transferring and treating water can be reduced and the capital investment required to meet the needs of growing communities deferred. Potential benefits include (Qld Water Directorate , 2021):

- **lower operating and capital costs** and lower water bills (there are also associated savings in operational costs for wastewater treatment (Smith & McDonald, 2010))
- **lower energy bills** resulting from reduced hot water use. Lower energy consumption leads to a reduction in greenhouse gas emission
- **environment benefits** from reducing extraction from rivers and aquifers leading to increased flows and improved river health.

The Intergovernmental Panel on Climate Change described demand management as a no-regrets solution to cope with future vulnerability of water supplies in the face of climate change impact (Bates, 2008).

7.1.3 Potential for further improvement

The Fraser Coasts residential consumption is estimated to be about 240 litres/person/day (l/p/d). This compares with about 156 l/p/d in SEQ (Seqwater, 2021), 158 l/p/d in Stanthorpe with a target of 120 (Southern Downs Regional Council, 2021).

This would suggest that overall water consumption is not excessive. However, there are a range of new efficient technologies, behavioural interfaces, data driven programs and regulatory instruments, which are being identified which could alter potable water demand in our cities. (Fane, et al., 2018).

Moreover, it is the cost of options necessary to achieve the desired level of security, whether customers are prepared to pay those costs and what are the consequences of reliance upon water restrictions determines whether further effort is required to reduce demand.

The answer to that question is dependent on location specific factors including:

- the extent to which relevant initiatives have been applied to date
- the scope for further reduction in demand which in turn is dependent upon
  - nature of the underlying drivers of water demand
  - the level/s of service of concern
  - the ability of affected groups to respond
  - the willingness of the community to pay (also relevant are the relative cost of other options)
  - the availability of data required to implement the option (see implementation issues below).

A high level assessment of the required demand reduction to meet the desired LOS for the Hervey Bay scheme has been undertaken (Table 7-1). This shows that at 2051 a demand reduction of 30% is required for the existing schemes infrastructure to meet the desired LOS. It also shows that small reductions in demand throughout the planning horizon of the strategy could delay the requirement for significant capital investment in infrastructure.

Table 7-1 Demand reduction to meet desired LOS for Hervey Bay

Year	Population (EP's)	Average Dam (ML/Day)	L/Person/day (incl. commercial)	Demand Reduction
2021	67214	23.41	348.2	0%
2026	71705	23.41	326.4	6%
2031	76961	23.41	304.1	13%
2036	81429	23.41	287.4	17%
2041	85397	23.41	274.1	21%
2049	90568	23.41	258.4	26%
2051	96053	23.41	243.7	30%

7.1.4 Costs and effectiveness

There is little published information on the cost and effectiveness of implementing specific option/s. The information that is available indicates there is no single intervention approach that could be clearly identified as "best practice" from the studies conducted to date and further research is warranted (Fane, et al., 2018).

In most instances, information relates to packages of initiatives.

Our assessment based on an analysis of around 21 projects involving such initiatives are below.

Table 7-2 Overview of (more reliable) data on cost and effectiveness

Intervention type	Central estimate of water savings [Error margins] (%)	Estimated life of water savings (years)	Estimated cost $/customer	Average cost of water saved(a)	Number of projects (reliable data)
Personalised water coaching	3% [±1%]	5			2
Behaviour change correspondence (letters)	1% [± 1%]	1-2	33 (6)[a]	$6.40[a]	4
Behaviour change correspondence (emails)	3-7% [±8%]	1-2			2
Plumbing audit, repair and retrofit services	4% [±2%]	10	260-1,236[b]	$2.20[b]	5
Showerhead swap	3% [±5%]	10	23 (showerhead)	$0.30	1
Irrigation system and controller resetting (reticulation audit)	2% [±5%]	2	n.r.	$2.63	2
Rebates for water efficient products.	6% [±10%]	10		NA	1

Notes: a includes some community campaign and personal coaching

b. includes elements of behaviour change, data logging and retrofitting

Source: Marsden Jacob Associates.

With ED's heading towards 55,000 for HB and 16,000 for MB by 2051 whether we are looking at annual or once-off costs – the numbers are material. For example, behaviour change initiatives solely represent an annual cost of $2.2 million or about $15m in net present value (NPV) terms at (7% real).

Recently Townsville's Water Smart package was announced to provide renters, homeowners and body corporates in Townsville with vouchers and rebates for water-saving products and efficient watering systems opened in July 2019 and was fully subscribed by November 2019 with more than 22,000 properties registering at a cost of $10 million (Townsville City Council, 2020).

7.1.5 Water Charges Pricing

In terms of pricing, WBW achieves an economic rate of return of 2.4% and has in place a two-part tariff with a fixed charge of $484.50 p.a. and a single step variable charge of $1.91/kL for usage.

Independent Pricing and Regulartory Tribunal (IPART) has set a real (post tax) rate of return of 3.2% for Sydney Water in its current review. Standard usage charges vary from $2.35 kL when dams are above 60% capacity and $3.18 when below 60%. Fixed charges were reduced from $96 to $40 to allow 'vulnerable customers to better manage their bills by controlling their water usage and provides a greater reward for customers who become more water efficient' (IPART, 2020).

What effect would an increase in overall prices have:

- in 1997 MJA estimated a twenty percent reduction in per capita consumption in the first year of implementing two-part tariffs (Marsden Jacob Associates, 1997)
- a 10% percent increase in the price of water is associated with a reduction in the quantity demanded of about 5% (Griffith University, 2006).
- recent analysis of QUU data shows that a 10 per cent increase in water prices will decrease demand by 1.24% (Abbott & Tran, 2020).

- IPART has estimated a typical price elasticity of -.218 for residences and -.264 for non-residences (IPART, 2020) but noted a drought effect of 4.7% with prices increasing from $2.63 to $3.18/kL
- in the United States, price responsiveness – while varying significantly depending on place and time – averages 3–4% of urban residential water use reduction for every 10% price increase. The same studies show that long-term price elasticity for households is somewhat larger, at 6% reduction for 10% increase. (Stavenhagen, et al., 2018).

The more recent data (at a time when two-part tariffs and full cost pricing were already in place) indicate quite high price increases would be required to further reduce demand materially. Other options now being trialled in other jurisdictions include increases in prices at times of reduced supply capacity (see Sydney Water).

7.1.6 Demand Management Recommendations

To date, WBW has focussed primarily on infrastructure related matters including pressure management and system loss reduction/leakage.

The main current initiatives relate to a Waterwise program (information), water restrictions regime, re-use of water for public parks, treated wastewater for golf courses, turf farms, sporting fields and sugar cane crops and native trees and is reviewing the effluent reuse strategy. Also in place is a two-part pricing regime.

Note, the use of recycled water only provides and benefit to water demand management when it is used as a substitute to potable or raw water application.

No recent new behavioural customer focussed non-infrastructure initiatives have been trialled or adopted.

- One example was the Fraser Coast Regional Council/ Wide Bay Water – Schools Gardening Competition (2006) Engaging children through school activities. Wide Bay Water successfully used the extensive range of DEWS Waterwise materials to develop a school gardening competition. Now in its eighth year, the competition has evolved over time to become a strong engagement program involving local schools and businesses.

To identify and define the appropriate initiatives, it is necessary to build the information base to understand how and where water is used, and the impact of individual initiatives.

Some of the key characteristics of "historical" best practice that the "next generation" of leading programs should take forward include:

- targeting of market segments, sub-segments and end uses;
- using piloting for both program testing and data collection; and
- using evaluation – now considered throughout the lifecycle of a program (Fane, et al., 2018).

Key relevant considerations include:

- Key customer groups requiring improved levels of service, their end uses and drivers of demand
- Identifying demand management measures relevant for each end use
- Establishing the potential water savings from each initiative
- Identifying the "longevity" of water savings
- Assessing whether there are synergies in implementing multiple options concurrently
- Assessing the costs and benefits of demand management options by estimating the present value cost of implementing the option and the present value benefits that are accrued by avoiding and/or deferring any existing capital or operating costs associated with current supplies or any planned supply augmentation.
- Sequencing – depends on information on impact and cost of the initiatives
- Ensuring a management commitment to ensure initiatives are appropriately implemented are in place these include:
  - Establishing appropriate responsibilities
  - Ensuring that the data relevant to that project is carefully collated and saved
  - Tracking savings over time using econometric techniques (preferably)
  - Identifying any lessons or potential improvements to the program.

7.2 Non-bulk Infrastructure Options

7.2.1 Option 1 – Tiaro Revised Trigger Levels

At present, the water restrictions for the Tiaro township are governed by the water levels within the Mary Barrage. As a result, the model results for the Tiaro system showed frequently occurring Level 2, 3 and 4 water restrictions due to the fluctuating levels within the Barrage.

The Tiaro offtake location, which comprises of an informal storage of approximately 860ML, is an online storage of the Mary River. The informal storage is understood to provide adequate volume to service the Tiaro township in dry conditions even when the Mary River is not flowing. Due to the relatively small demands of the Tiaro township when compared to the volume available within the informal storage, it was deemed appropriate to determine a set of trigger levels relative to the offtake location.

The trigger levels for water restrictions were set to achieve the desired LOS by the community as detailed within Table 7-3.

Table 7-3 Tiaro Offtake Trigger Levels

Water restriction level/ % of full supply volume	Level in Tiaro Offtake (ML)	% of Full Supply Volume (860.25ML)	Target reduction in demand
Level 1 (permanent)	> 860.10	Nil	Nil
Level 2	860.07 – 860.10	99.9%	5%
Level 3	857.00 – 860.07	99.9%	20%
Level 4	< 857.00	94.3%	40%

As detailed in Table 7-3, the trigger levels show minimal volumetric difference between Level 1-4 water restrictions. This is as the Tiaro offtake storage is generally at full capacity, as it is situated along the Mary River, which is flowing the majority of the time. As the water levels within the formal offtake rarely recede lower than the designated spillway (the spillway indicates when the Mary River is flowing) the triggers are set to nearly 100% capacity of the Tiaro offtake as capacities below this occur less frequently than the target LOS triggers.

The resulting trigger levels depend significantly on the stage storage curve developed for Tiaro offtake location. It is noted that this was largely developed from LiDAR data, with survey bathymetry only available for a portion of the area. Assumptions were also made for the downstream spillway which currently models when the Mary River is flowing. It is recommended that before these trigger levels are enforced, that additional survey is carried out to better define the stage storage of the Tiaro offtake location.

As such, it is difficult to set realistic trigger levels for the informal storage with the data currently on hand. In the interim, it is recommended that the water restrictions for the Tiaro Township are based off the Maryborough and Hervey Bay systems, similar to what is currently implemented.

7.2.2 Option 2 – Maryborough System Loss Reduction

Currently, the existing representation of the Maryborough system exceeded the desired LOS for the Fraser Coast Region for Level 3 and Level 4 Water restriction criteria. As such, the Maryborough system has been flagged to subsidise the Hervey Bay scheme through the implementation of a water grid system.

In order to maximise the volume of water that can be transferred from the Maryborough to the Hervey Bay system, without resulting in a reduction in LOS below the desired community target, the Maryborough system has been optimised via the reduction of system losses. The system losses (currently at 20%) were reduced to 10%, which is in-line with the system losses recorded for the Hervey Bay and Tiaro systems and in line with industry standards. The results for the 10% system losses reduction scenario are presented below.

Table 7-4 Summary of forecast LOS for Maryborough (10% system losses)

Restriction	2026	2031	2036	2041	2046	2051
Level 2 Frequency (ARI)	1	1	1	1	1	1
Level 3 Frequency (ARI)	15	14	14	13	12	11
Level 4 Frequency (ARI)	71	71	71	71	67	63

As detailed in Table 7-4, there is improvement in the LOS for Level 3 and Level 4 criteria when system losses are reduced from 20% to 10%. There was no notable change for the frequency of Level 2 water restrictions.

Council already has a program of works underway for the replacement of the ageing Maryborough water network to address the high system losses being experienced. As this should already be allowed for in future operational and maintenance budgets no consideration of costs have been included in this strategy.

For all other infrastructure options considered in this strategy it has been assumed that Maryborough will reach the target 10% system losses.

7.2.3 Rainwater Tanks

This option involves implementation of either requiring or incentivising the installation of rainwater tanks of 5000 litres capacity to all new buildings. In 2020, WBW completed a planning report into the viability of installing rainwater tanks to all new buildings in the region (Wide Bay Water, 2020). This study found that the mandating or incentivising of rainwater tanks was not viable due to the following reasons:

- The cost/benefit analysis determined that the cost of supply from a rainwater tank, based on a $5000 installation cost and operating costs for 20 years, was $3.18 per kilolitre compared to the current reticulated water supply cost of $1.91 per kilolitre. It is financially much more expensive compared to water from the reticulated supply.
- Rainwater tanks rely on seasonal rainfall patterns that impacts the overall annual yield.
- Rainwater tanks posed health risks due to the potential for faecal contamination; this is particularly pertinent to Hervey Bay with multiple colonies of bats and a significant bird population. There is also concern that rainwater tanks not maintained will become breeding reservoirs for mosquitos.
- Rainwater tanks are entirely rainfall dependent and do not reduce the infrastructure capacity required to be supplied by Council.

Due to its unreliability and negative cost benefit compared to reticulated water, rainwater tanks could not be considered a net benefit to the Community and are not recommended as an option for further consideration in this strategy.

7.3 Infrastructure Options

7.3.1 Option 3 – Maryborough to Hervey Bay Interconnector

The Maryborough to Hervey Bay interconnector considers a pipeline connection between Maryborough and Hervey Bay to establish a water grid between the two systems. In 2018, KBR completed a MIPP Early Stage Assessment looking at the connection of the two water supply schemes (KBR, 2018). This planning report looked at a number of options including consideration of a treated and a raw water supply connection. The report recommended that the preferred option for an interconnector between the two schemes is for a treated water connection that enables the transfer of water in both directions.

7.3.1.1 Modelling

Factors which have been considered in determining the optimum volume of water to be transferred from the Maryborough to the Hervey Bay system include the safe yield volume for Teddington Weir and maintaining an acceptable LOS for the Maryborough system.

According to the Mary River Basin Operational Plan, the safe yield volume for Teddington Weir is 8,179ML/annum. Based on the projected 2051 demand rates of 3,285ML/Day for the Maryborough system, this results in a maximum safe volume of 4,894ML/annum (8,179ML – 3,285ML) available to transfer to the Hervey Bay system.

The previous model developed to assess the 2051 Hervey Bay and Maryborough system performance was adapted for the analysis of this option. The model was modified by adding a transfer function between the two systems. The maximum available volume (13ML/Day) was trialled with a range of different trigger levels to determine the maximum LOS that could be achieved for the Hervey Bay system, while having the least impact on the Maryborough system. The modelling has shown that a trigger level in Lake Lenthall of 21.33m AHD achieves the desired LOS.

It is noted that the Maryborough system was modelled with 10% system losses in this scenario.

Table 7-5 details the results of transfer volumes and trigger levels that were carried out for the water interconnection for each time cohort.

Table 7-5 Maryborough to Hervey Bay Connection LOS

Time Cohort	Transfer Volume	Transfer Trigger Level (Lake Lenthall)	Hervey Bay Level 4 LOS	Maryborough Level 4 LOS
2026	5 ML/Day	21.33m AHD	1 in 47yrs	1 in 47yrs
2031	7 ML/Day	21.33m AHD	1 in 40yrs	1 in 41yrs
2036	11 ML/Day	21.33m AHD	1 in 43yrs	1 in 28yrs
2041	13 ML/Day	21.33m AHD	1 in 38yrs	1 in 24yrs
2046	13 ML/Day	21.33m AHD	1 in 28yrs	1 in 21yrs
2051	13 ML/Day	21.33m AHD	1 in 21yrs	1 in 19yrs
2051	7.5ML/Day	NA – always transferring	1 in 40yrs	1 in 8yrs

Results indicate that up to the 2031 cohort, the Maryborough system can supplement the Hervey Bay system to achieve the target LOS, while still achieving the desired 1 in 40yr LOS. From 2036, an additional source of water would be required.

7.3.1.2 Infrastructure

This option consists of extending the treated water supply from the Boys Avenue Reservoirs to the Burgowan WTP Clear Water Storage (CWS).

The preliminary scope for this option consists of:

> utilising the existing treated water mains from Teddington WTP to Boys Avenue Reservoirs

> installation of a new section of treated water main from Boys Avenue Reservoirs to Burgowan WTP.

There are a number of potential alignments for the new pipeline section from Boys Avenue Reservoirs to Burgowan WTP. Three potential alignments for this option were considered in the 2018 planning report and are shown below in Figure 7-2. All options are approximately 24-25km long and a DN500 pipeline with a nominal capacity of 15ML/day was assumed. Pumping capacity would be required at both ends of the pipeline to enable transfer in both directions.

The existing capacity of the Maryborough network to transfer the additional treated water to Boys Avenue has not been considered at this stage. Upgrades could include treatment capacity at Teddington WTP and transfer pumps.

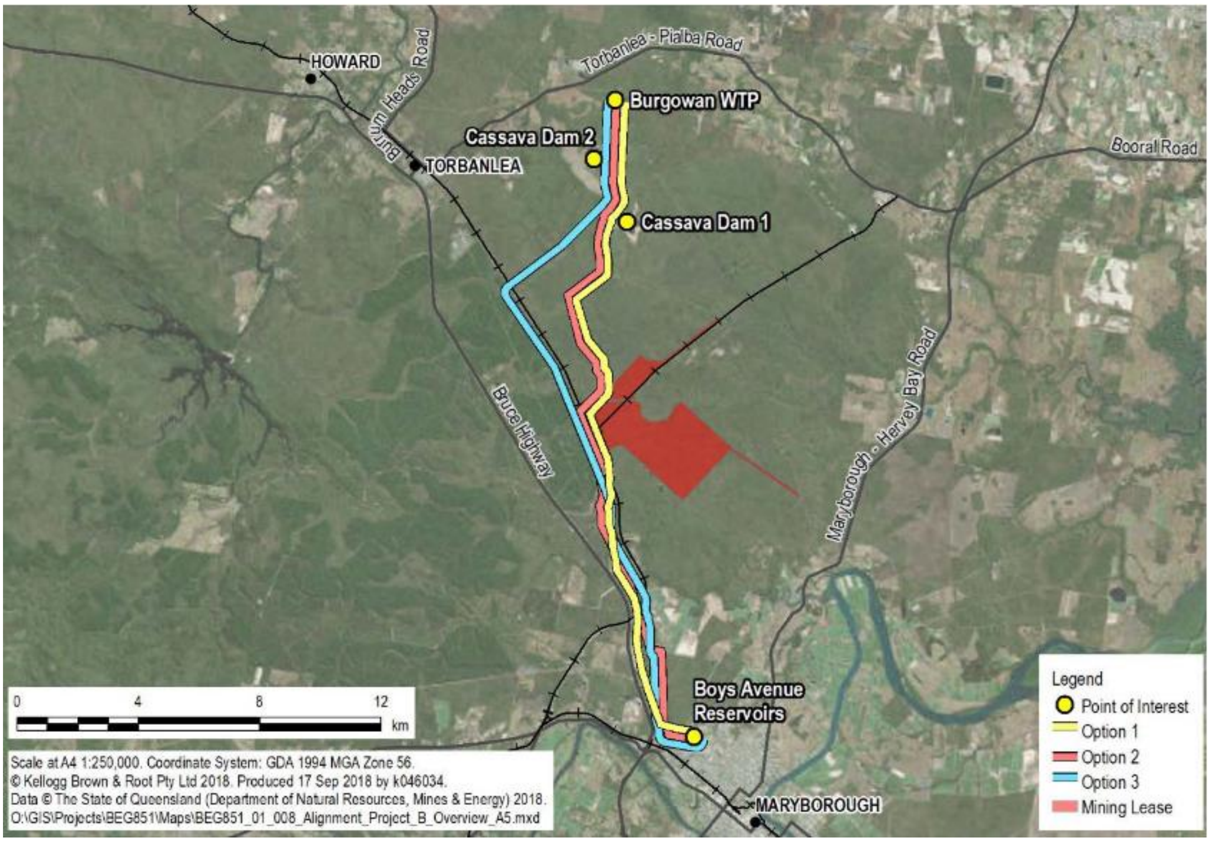

Figure 7-2 Maryborough to Hervey Bay Interconnector Alignment Options

Table 7-6 Maryborough to Hervey Bay Interconnector Cost Estimates

	Cost Estimate
500mm dia pipeline (25km long)	$21,300,000
Land acquisition	$500,000
Pumping infrastructure	$2,000,000
Contingency (30%)	$7,140,000
Capital Cost Total	**$31,000,000**
Operational Cost (per annum)	$100,000

7.3.2 Option 4 – Hervey Bay Additional Source

This option has been developed to predominantly address the Level 4 LOS criteria and involves supplementing the Hervey Bay system with an additional water source. A key assumption that has been adopted when investigating this solution is that the additional source will always have adequate capacity to subsidise the Hervey Bay system.

The previous model developed to assess the 2051 Hervey Bay system performance was adapted for the analysis of this option. The 2051 demands were utilised in order to conservatively size any infrastructure. The model was simulated by extracting water from the additional source (kL/Day) when Lake Lenthall reached a certain trigger level. A constant daily transfer between the additional source and Lake Lenthall was also investigated to determine whether the target LOS could be achieved.

An iterative process was carried out between the daily transfer volume and the trigger level within Lake Lenthall in order to achieve the desired Level 4 LOS of 1 in 40 years.

Table 7-7 Additional Source to Hervey Bay Transfer LOS

Time Cohort	Transfer Volume	Transfer Trigger Level (Lake Lenthall)	Hervey Bay Level 4 LOS
2051	18 ML/Day	21.33m AHD	1 in 40yrs
2051	7.5 ML/Day	NA – always transferring	1 in 40yrs

Hydrodynamic modelling indicated that two (2) different approaches could be adopted to achieve the desired Level 4 LOS, a daily transfer of 7.5ML/Day or a 18ML/Day transfer when Lake Lenthall reached RL 21.33m AHD.

A number of options have been considered for the delivery of an additional source of water to Hervey Bay to provide the additional identified volumes of water.

Additional Source Option 1 – Paradise Dam Connection

In 2018 KBR completed a Preliminary Evaluation for a connection from the Burnett River (Paradise Dam) to the Howard Water Supply Pipeline (KBR, 2018). The report looked at a number of alignment options (Figure 7-3) and also considered the economic outcomes for the construction of the pipeline (including potential agricultural uses).

The KBR report identifies a number of risks associated with the proposed pipeline connection. Namely, the uncertainty of the future capacity of Paradise Dam (although currently there is spare allocation available), future allocation costs, demand from agricultural users and the high capital and operational costs associated with the option.

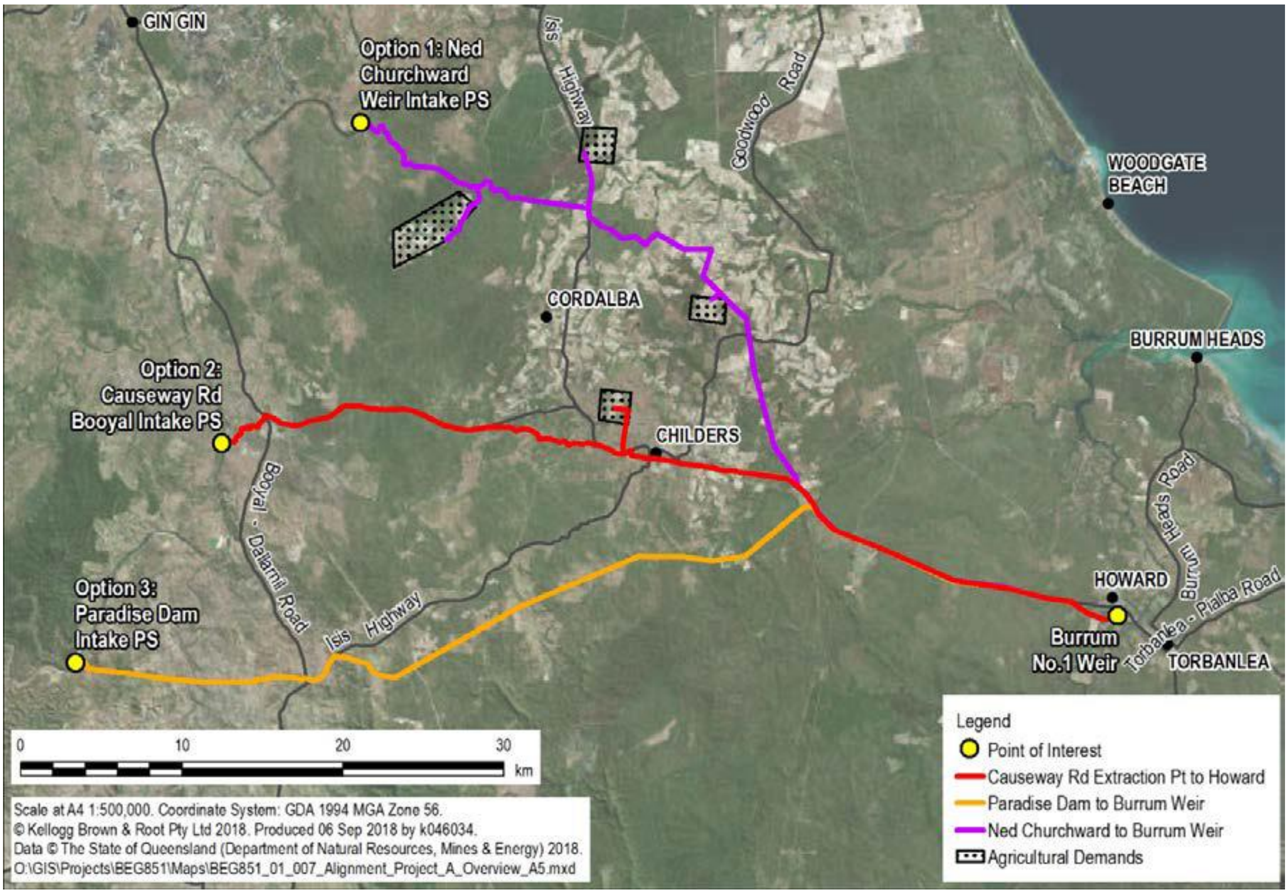

Figure 7-3 Paradise Dam to Howard Pipeline Options (KBR, 2018)

The KBR report included capital and operational cost estimates for the Paradise dam connection. These estimates have utilised for this strategy with indexation to current costs (2% per annum) and are summarised in Table 7-8.

Table 7-8 Paradise Dam Cost Estimates

	Cost Estimate
Capital Cost	$146,234,000
Operational Cost (per annum)	$1,109,000

Additional Source Option 2 – Purified Recycled Water/Indirect Potable Reuse (IPR)

Purified recycled water comes from treated wastewater. The wastewater undergoes a number of advanced water treatment processes to meet the stringent standards set by the Australian Drinking Water Guidelines. After the wastewater is treated, it is added to the raw water source for the scheme. Then it is treated once more at a traditional WTP.

The implementation of indirect potable reuse for the Hervey Bay system would involve augmenting the Nikenbah wastewater treatment plant (WWTP) to enable it to perform advanced treatment (reverse osmosis and advanced oxidation) to produce Purified Recycled Water (PRW). Water would then be piped to Cassava Dam and, subsequently, used as a raw water source for the Burgowan WTP.

Assessment of indirect potable reuse has been undertaken for two options, a 10ML/day plant that would operate at all times and a 20ML/day plant that would only operate when level 3 restrictions are triggered. Estimates of cost have been completed at a concept level (+/-30%) and are summarised in Table 7-9.

Table 7-9 Indirect Potable Reuse Capital Cost Estimates

	10ML/day Plant	20ML/day Plant
Nikenbah WWTP upgrade	$26,900,000	$53,800,000
Pipeline to Cassava Dam	$5,600,000	$8,700,000
Pumping infrastructure	$2,000,000	$3,000,000
Contingency (30%)	$10,500,000	$19,650,000
Capital Cost Total	**$45,000,000**	**$85,000,000**
Operational Cost (per annum)	$1,500,000	$3,000,000

Additional Source Option 3 – Desalination

Desalination is a water supply option that is used widely around the world and involves taking the salt out of water to make it drinkable. Many countries use desalination as a way of creating a more reliable water supply that is not dependant on rain.

This option involves the construction of a desalination plant as an additional water source as well as providing additional water treatment. Potentially, desalination could be provided as a single larger plant at the eastern end of Hervey Bay (drawing and discharging into the Great Sandy Strait) or could consist of smaller plants distributed across Hervey Bay (i.e. Burrum Heads to Booral).

There is also potential to use a desalination plant to provide the emergency water supply in the unlikely case of a supply shortfall.

Assessment of desalination has been undertaken for two options, a 10ML/day plant that would operate at all times and a 20ML/day plant that would only operate when level 3 restrictions are triggered. Estimates of cost have been completed at a concept level (+/-50%) and are summarised in Table 7-10.

Table 7-10 Desalination Plant Capital Cost Estimates

	10ML/day Plant	20ML/day Plant
Land acquisition	$1,000,000	$1,000,000
Desalination plant including intake and outfall	$32,000,000	$51,000,000
Pumping infrastructure	$2,000,000	$3,000,000
Contingency (30%)	$10,500,000	$19,650,000
Capital Cost Total	**$45,000,000**	**$85,000,000**
Operational Cost (per annum)	$2,400,000	$6,200,000

Additional Source Option 4 – K'Gari (Fraser Island)

K'Gari (Fraser Island) is known for its fresh water lakes and creeks and is often mentioned as potential source of raw water to supply the main land.

This option involves sourcing water from the Bogimbah Creek area either via a borefield or directly from the creek flow itself. Water would be transferred to the mainland through a sub marine pipeline. A report completed by JWP in 1994 indicates that the scheme could extract up to 54ML/day from the aquifer without any detrimental effect. A subsequent report by JWP (2001) dismisses K'Gari (Fraser Island) as a viable option because of environmental constraints and likely community resistance.

This option was further considered in the 2018 KBR Strategic Assessment of Service Requirements Report (KBR, 2018) which identified a capital cost of $56million. This cost has been utilised for this planning report with indexing to current costs (2% per annum) (Table 7-11).

Table 7-11 K'Gari Water Source Cost Estimates

Item	Cost Estimate
Capital Cost	$63,065,000
Operational Cost	$450,000 per annum

Although K'Gari (Fraser Island) is not currently viewed as a viable option due to the cultural and environmental constraints, it is recommended that this assumption is revisited in the future to identify if the approvals environment has changed and it becomes a viable water source.

Alternative Source Option 5 – Raising Lenthalls Dam

Lenthalls Dam was constructed in 1983 to augment the Burrum River catchment and provide water supplies to the Hervey Bay area. A further 2.0m raising (to RL 26.0m) was completed in 2007 and provided for approximately 27,900 ML of commandable storage plus an additional 3,084 ML in Burrum Weir No.1 and No. 2. The approvals process to raise Lenthalls Dam by 2.0m took close to 10 years and resulted in almost doubling the storage capacity of the reservoir.

One of the reasons behind the decision to raise Lenthalls Dam by 2.0m rather than 6.0m was the impact to culturally sensitive areas such as the Wongi Waterholes. To raise the dam water level beyond the existing level will inundate the waterholes and would not be well received with the local indigenous community and environmental groups.

Further raising of Lenthalls Dam would also require raising or reconstruction of the dam wall and a number of saddle dams upstream.

Due to the sensitive cultural impacts of any further raising of Lenthalls Dam as well this option not providing diversification or rainfall resilience, it has not been considered any further in this strategy.

7.3.3 Option 5 – Maryborough to Hervey Bay Connection with Teddington Offtake

Previous studies carried out by SunWater have investigated the viability of constructing an offline storage near the existing Teddington Weir structure. The Teddington offline storage would be a flood harvesting device, with water being transferred from Teddington Weir to the offline storage when the weir was overflowing.

The original feasibility study was intended to increase the supply yield for the Maryborough system, however for the purpose of this investigation, the offline storage is acting to supplement supply to Hervey Bay and would require construction of the Maryborough to Hervey Bay interconnector.

The arrangement has been modelled to operate by transferring water from Teddington Weir to the offline storage when the weir was overflowing. The transfer from Maryborough to Hervey Bay would then occur from the offline storage first, with any additional water being sourced from Teddington weir, if required. It is noted that the total transfer capacity between the schemes has still been limited to 13ML/Day.

The Teddington offline storage was modelled with parameters as detailed in Table 7-12, based on the information contained within a planning report completed by SunWater report (SunWater, 2006). The LOS results achieved when utilised the off-stream storage for the 2051 cohort are presented in Table 7-13.

Table 7-12 Teddington Offtake Stage Storage Relationship

Stage (m)	Area (ha)	Volume (ML)
0	62.5	0
8	90.0	6100

*Note that a pumping rate of 259,200kL/Day has been applied to transfer water from Teddington Weir to the offline storage, as defined within the SunWater report.

Table 7-13 Maryborough to Hervey Bay Connection with Teddington Offtake

Time Cohort	Transfer Volume	Transfer Trigger Level (Lake Lenthall)	Hervey Bay Level 4 LOS	Maryborough Level 4 LOS
2051	13 ML/Day	21.33m AHD	1 in 21yrs	1 in 62yrs
2051	7.5ML/Day	NA – always transferring	1 in 40yrs	1 in 62yrs

Results indicate that the incorporation of the Teddington offline storage improves the performance of the Maryborough system and allows the target LOS to be achieved even when transferring water to the Hervey Bay Scheme. Review of the Teddington offtake storage throughout the 1,000 year simulation indicates that the storage provides the required volume to service the Hervey Bay system, without requiring Teddington Weir as a supplementary source.

The 2006 report by Sunwater estimated a construction cost of $44million. This estimate has been indexed to 2021 values (2% per annum). As the Teddington off stream storage is required to be constructed in conjunction with the Maryborough to Hervey Bay interconnector, this capital cost is also included in the capital cost summarised below.

Table 7-14 Teddington Offstream Storage Cost Estimates

Item	Cost
Maryborough to Hervey Bay Interconnector	$31,000,000
Teddington offstream storage	$59,000,000
Capital Cost	**$90,000,000**
Operational Cost (per annum)	$100,000

7.3.4 Option 6 – Maryborough to Hervey Bay Connection with Mary River Offtake

The construction of an offline storage near the Mary Barrage has been considered as a potential option for system augmentation. The Mary Barrage offline storage would be a flood harvesting device, with water being transferred from the Mary Barrage Spillway to the offline storage when the weir was overflowing. Water would then be transferred via the existing Owanyilla channel/pipelines system to Teddington Weir.

For the purpose of this investigation, the offline storage is acting in supplementing the Maryborough to Hervey Bay interconnector.

The arrangement has been modelled to operate by transferring water from the Mary Barrage to the offline storage when the weir was overflowing. The transfer to Teddington Weir would then occur to supplement the transfer from Maryborough to Hervey Bay. It is noted that the total transfer capacity between the systems has still been limited to 13ML/Day.

The Mary River offline storage was modelled with parameters as detailed in Table 7-15, and have been assumed for modelling purposes only. The LOS results achieved when utilising the off-steam storage for the 2051 cohort are presented in Table 7-15.

Table 7-15 Mary River Offtake Stage Storage

Stage (m)	Area (ha)	Volume (ML)
0	62.5	0
8	90	6100

*Note that the existing pumping rate of 92,000kL/Day for the Owanyilla pipelines has been applied to transfer water from the offline storage to the Teddington Weir.

Table 7-16 Maryborough to Hervey Bay Connection -With Mary River Offtake

Time Cohort	Transfer Volume from offline storage	Transfer Volume from MB - HB	Transfer Trigger Level (Lake Lenthall)	Hervey Bay Level 4 LOS	Maryborough Level 4 LOS
2051	5 ML/Day	7.5ML/Day	NA – always transferring	1 in 40yrs	1 in 40yrs

Results indicate that the incorporation of the Mary River offline storage improves the performance of the Maryborough system and allows the target LOS to be achieved even when transferring water to the Hervey Bay system. Review of the Mary River offtake storage throughout the 1,000 year simulation indicates that the storage provides the required volume to service the Hervey Bay system, with an average daily transfer of 5ML/Day to Teddington Weir.

This infrastructure would likely be owned and operated by Sunwater and while no details are known at the time of writing it is possible that a contribution towards infrastructure or the purchase of allocations or both may be required to secure high priority water in this scenario.

It is also worth noting that our current allocations from the Mary are insufficient to meet the demand on this scenario, therefore additional HP allocation will be needed.

A preliminary cost estimate has been prepared for this option for both capital and operational costs (Table 7-16). It is expected that this option will required the purchase of additional allocations from the Mary River. The capital cost assumes $2,200/ML for high priority water from the Lower Mary River. The operational cost assumes a Part A price of $24.83/ML and a Part B price of $9.94/ML (total of $34.77/ML).

Table 7-17 Mary River Offstream Storage Cost Estimates

Item	Cost
Maryborough to Hervey Bay Interconnector	$31,000,000
Mary River offstream storage	$39,150,000
Capital Cost	**$70,150,000**
Operational Cost (per annum)	$263,000

7.4 Levelised cost of infrastructure options

Table 7-18 sets out the capital and operating cost assumptions for each of the options assessed as part of the strategy together with assumptions relating to the LOS yield provided by each of the options and the assumed economic lives. The table also provides estimates for the levelised cost per ML based on two levels of demand:

> The annualised cost (capital and operating) per ML based on the LOS yield provided by each of the options. This measure is useful in comparing options on the basis of their costs and contribution to improving the LOS yield of the system if the option was implemented.

> The annualised cost (capital and operating) per ML spread across the total demand of the Hervey Bay system. It provides a strategic assessment of the impact to customers expressed on a per ML basis of each of the options.

The levelised costs are based on a 7% real discount rate but are assessed over different time frames. A 7% real discount rate is the nominated discount rate specified in the Queensland Department of State Development, Infrastructure, Local Government and Planning - Cost Benefit Analysis Guide Business Case Development Framework Release 3 (Queensland Department of State Development, 2021).

The annualised cost per LOS yield is assessed over the economic life assumed for each of the options whereas the annualised cost per ML of demand is assessed over the 30-year period 2022 to 2051 for which demands have been assessed.

Table 7-18 Option costs and levelised costs per ML (7% real discount rate)

Option	Capex	Opex	LOS Yield	Economic Life	Annual Cost/ML LOS Yield	Annual Cost/ ML Levelised Demand
	$000s	$000s	ML	Years	$/ML	$/ML
Maryborough to Hervey Bay Interconnector	31,000	100	4,000	100	568	261
Paradise Dam Connection	146,234	1,109	4,000	100	2,830	1,299
Hervey Bay Desal - Full time	45,000	2,400	3,650	40	1,582	663
Hervey Bay Desal - Part time	85,000	6,200	3,650	40	3,445	1,443
Hervey Bay IPR - Full time	45,000	1,500	3,650	40	1,336	559
Hervey Bay IPR - Part time	90,000	3,000	3,650	40	2,671	1,119
K'Gari (Fraser Island) Source	63,065	450	3,650	100	1,334	559
Teddington Offstream Storage	90,218	167	2,738	100	2,371	745
Mary River Offstream Storage	70,015	263	5,825	100	2,156	593

Note: Levelised demand is assessed at 8,715 ML/a based on a 7% real discount rate and a 30-year period of 2022 to 2051.

Key outcomes from the assessment include:

> On a levelised cost per ML of LOS yield, the Mary River to Hervey Bay Interconnector has the lowest cost estimated at $568/ML. This is substantially lower than the next lowest cost options – Fraser Island ($1,334/ML) and Hervey Bay IPR – Full-time ($1,336/ML). The desalination option running full-time is the next lowest cost estimated at $1,582/ML. The remaining options are all substantially higher cost.

> The Maryborough to Hervey Bay Interconnector also has the lowest cost impact per ML of demand at $261/ML followed by the Hervey Bay IPR (full-time) and Fraser Island options ($559/ML). Paradise Dam and the two part-time climate independent options (IPR and desalination) have the highest costs per ML of demand.

8 Assessment of Infrastructure Options

In October 2021 a multicriteria assessment workshop was held with various internal WBW stakeholders to assess each of the infrastructure options identified and produce a preferred infrastructure recommendation for meeting the desired LOS.

Each of the options were assessed against a number of criteria which are shown in Table 8-1. For each of the criteria a traffic light system was utilised to show which options were more feasible.

Table 8-1 Multicriteria Assessment Framework

No.	Criteria	Score and Description (Red)	Score and Description (Orange)	Score and Description (Green)
1	**Meets the desired level of service** Does the option meet the desired level of service for the timeframe?	Does not meet the desired LOS for any timeframe	Meets desired LOS to 2036	Meets the desired LOS to 2051
2	**Constructability** Consider the ability to construct each option, including safety, availability of materials, availability of suitably qualified contractors, ground conditions, impact on existing services.	Constrained or limited access and egress for construction, significant impacts to day to day usage of the area. High WHS risk. Poor ground conditions. Complex work requiring specialist contractors.	Average access and egress for construction, some impacts to day to day usage of the area. Moderate WHS risk.	Easy access and egress for construction, minimal impacts to day to day usage of the area. Low WHS risk. Good ground conditions. Lower complexity work.
3	**Social Impact** Impact of water charges on community	High $ impact	Moderate $ impact	Low or positive $ impact
4	**Environmental** Consider environmental impacts and risks and the risk associated with obtaining environmental approvals. Is there anything associated with the option that has a significant environmental impact that can not be managed.	Adverse/significant impact to key environmental values	Minor impact to key environmental values	No impact to key environmental values
5	**Community acceptance** Consider the community acceptance of the option	Option is unacceptable from community's perception (high perceived risks)	Community has moderate concerns of option (moderate perceived risks)	Option is accepted and supported by the community
6	**Project Definition Risk** Consider risk associated with level of definition and potential for currently unknown issues to impact schedule and budget.	Absence of available information for project definition increases the potential for project delays and budget exceedance.	Reasonable level of project definition achieved. Typical project, with standardised design and construction needs. Moderate risk for project delays and budget exceedance.	High level of project definition. Typical project, with standardised design and construction needs.
7	**Heritage, Planning and Approvals** Consider impacts and risks associated with obtaining approvals.	Potential for extended approvals period. Risk of approvals not obtained.	Moderate risk extended approvals period. Moderate risk approvals not obtained.	Extended approvals period unlikely. Low risk of approvals not being obtained.
8	**Reliability of Source** Source reliability on rainfall	Entirely reliant on rainfall	Partially rainfall dependent	Not reliant on rainfall (drought resilient)

Table 8-2 gives a summary of the advantages and disadvantages identified for each of the options which informed the MCA results. Table 8-3 shows the outcome of the MCA.

Table 8-2 Summary of infrastructure options advantages and disadvantages

Option	Advantages	Disadvantages
Desalination	• Climate resilient and rainfall independent. • Unlimited supply with production only limited by the size or number of plant and energy availability. • Increases treated water capacity as well as bulk supply for the scheme. Would delay capital investment to increase capacity of Burgowan WTP. • Can be used for emergency water source in a supply shortfall or other emergency scenario.	• Expensive CAPEX and OPEX. • Disposal of waste brine may be difficult or problematic. • Requires specialist training in operation. • Requires relatively clean input water. • Desalination plants require a minimum base load and if not required for use need to be temporarily decommissioned. • The community panel were not as supportive of desalination due to environmental concerns.
Maryborough to Hervey Bay Interconnector	• Allows better distribution of capacity. • Allows redirection of flow for drought or if specific treatment plant is out of service. • Provides a link between the two systems for any new source augmentation. • Achievable piece of infrastructure by 2026 • The community panel is very supportive of a water grid	• Does not offer any additional capacity (only ability to distribute existing capacity). • Expensive OPEX pumping costs. •
Paradise Dam Connection	• Full benefit of high priority water. • Potential to supply additional water for agricultural production.	• Expensive initial CAPEX outlay. • Uncertainty of future for Paradise Dam capacity and future works • Demand for agricultural use along pipeline route is uncertain
K'Gari (Fraser Island) water Source	• Abundant water supply. • Relatively close to mainland Hervey Bay. • Low Total Dissolved Solids (TDS) and protected catchment.	• Environmentally sensitive and heritage listed area. • Submarine water pipeline crossing through Sandy Straits. • Potentially high in color and potentially requiring additional treatment to stabilize the water. • 45% of the community panel supported K'Gari (Fraser Island) as a source of water
Indirect Potable Reuse	• Does not rely on surface water storage which is susceptible to droughts. • Higher class of use of resource to current irrigation.	• Public resistance to the scheme. • A pipeline is required from Nikenbah WWTP to Cassava Dam. • Cannot supply total volume required. Supplementary source only.

	• Can be used all year around as opposed to irrigation, therefore less storage required.	• Potentially expensive OPEX. • Some components may require a minimum base load and if not required for use need to be temporarily decommissioned. • Part time plant is not feasible as 20ML/day would not be available during a level 3 restriction • During workshop 2, the community panel were more supportive of indirect potable reuse than desalination
Teddington Weir Offstream Storage	• Would meet desired LOS • Relatively cheap water compared to other options.	• Difficult construction due to embankment height, topology and geology • Planning report in 2006 was not favourable • Would be a referable dam • Lack of available land in close proximity to Teddington Weir • Does not increase source diversity from existing.
Mary River Offstream Storage	• Relatively cheap water compared to other options. • Potential for project to be delivered jointly with SunWater • Uses existing infrastructure to transfer to Teddington WTP	• Long term security may be an issue if there is competition for water source in the upstream catchment. • Does not increase source diversity from existing. • Requires purchasing of additional allocations.

Table 8-3 MCA Assessment

Options	Annual Levelised Cost/ML	Criteria 1: Meet desired level of service	Criteria 2: Constructability	Criteria 3: Social Impact	Criteria 4: Environmental Impact	Criteria 5: Community Acceptance	Criteria 6: Project Definition Risk	Criteria 7: Heritage, Planning and Approvals	Criteria 8: Relibility of Source	Criteria 9: Emergency Supply	Fatal Flaw ?
Option1: Maryborough to Hervey Bay Interconnector	**$261.00**										
Option 2: Teddington Off Stream (including Interconnector)	**$745.00**										
Option 3: Paradise Dam	**$1,299.00**										
Option 4: Hervey Bay Desalination Plant (Full-time)	**$663.00**										
Option 5: Hervey Bay Desalination Plant (Part-time)	**$1,443.00**										
Option 6: Hervey Bay Indirect Potable Reuse (Full-time)	**$559.00**										
Option 7: Hervey Bay Indirect Potable Reuse (Part-time)	**$1,119.00**										Y
Option 8: K'Gari (Fraser Island)	**$559.00**										Y
Option 9: Mary River Offstream Storage (incl Interconnector)	**$560.00**										

9 Water Security Strategy Response

9.1 Preferred Infrastructure Strategy

Based on the communities desired LOS and the outcomes of the Multicriteria assessment the preferred strategy is:

> Construction of the Maryborough to Hervey Bay Interconnector by 2026 to enable the transfer of treated water from Maryborough system to Hervey Bay system; and

> Construction of a desalination plant to supply Hervey Bay by 2036 to supply an additional 7.5ML/day to the Hervey Bay system.

Figure 9-1 shows the frequency of water restrictions that will occur for the Hervey Bay system (the critical system) with the proposed infrastructure strategy.

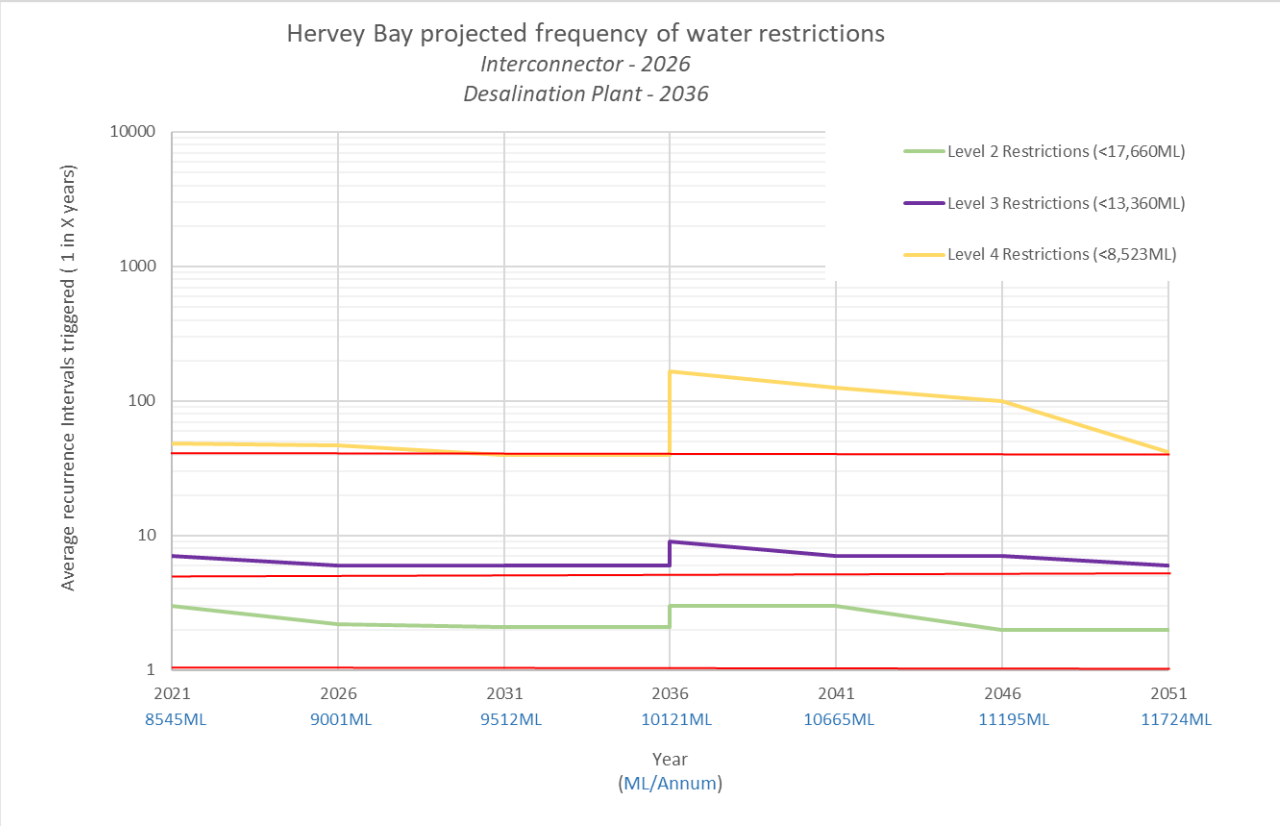

Figure 9-1 Proposed water security infrastructure strategy restriction frequency

9.1.2 Portfolio Assessment

A simplified portfolio assessment was undertaken for the preferred infrastructure option. The rationale for assessing this portfolio is that it comprises the lowest cost option as an initial development followed by the desalination option which can fill the role as the supplementary source.

Key assumptions include:

> Construction is assumed to commence in 2024 for the Maryborough to Hervey Bay Interconnector with supply being available from 2026 and is able to contribute 4,000 ML to Hervey Bay's LOS system yield.

> The desalination plant is assumed to be commissioned and operating by 2036 with a two-year construction period.

> Capital and annual operating costs are as set out in Table 7-18.

The portfolio analysis assesses the order of magnitude impact of the two options per ML of demand and therefore provides an indication of the impact on customers expressed in terms of $/ML. Costs were assessed for two alternative periods:

> Assessment period 2024 to 2051. This reflects the period for which demands have been assessed as part of the strategy with a start year assumed to be 2024 i.e. costs assumed to be recovered from customers from the commencement of construction and over the period to 2051. The desalination costs are assumed to be recovered over the period from 2034 to 2051 i.e. from commencement of construction to 2051. These periods acknowledge that Council is unlikely to increase prices before commencing construction of an option.

> Assessment period 2024 to 2065. This extended assessment period considers the fact that both options will still have operational life beyond the 2051 date for which demands were assessed as part of the 30-year strategy. The effective life of the desalination plant is likely to be around 30-years hence the choice of 2065 end year for this assessment.

The cost impacts per ML of demand under the first assessment period (2024 to 2051) are illustrated in Figure 9-2 with Figure 9-3 illustrating the cost impacts under the second and longer assessment period (2024 to 2065).

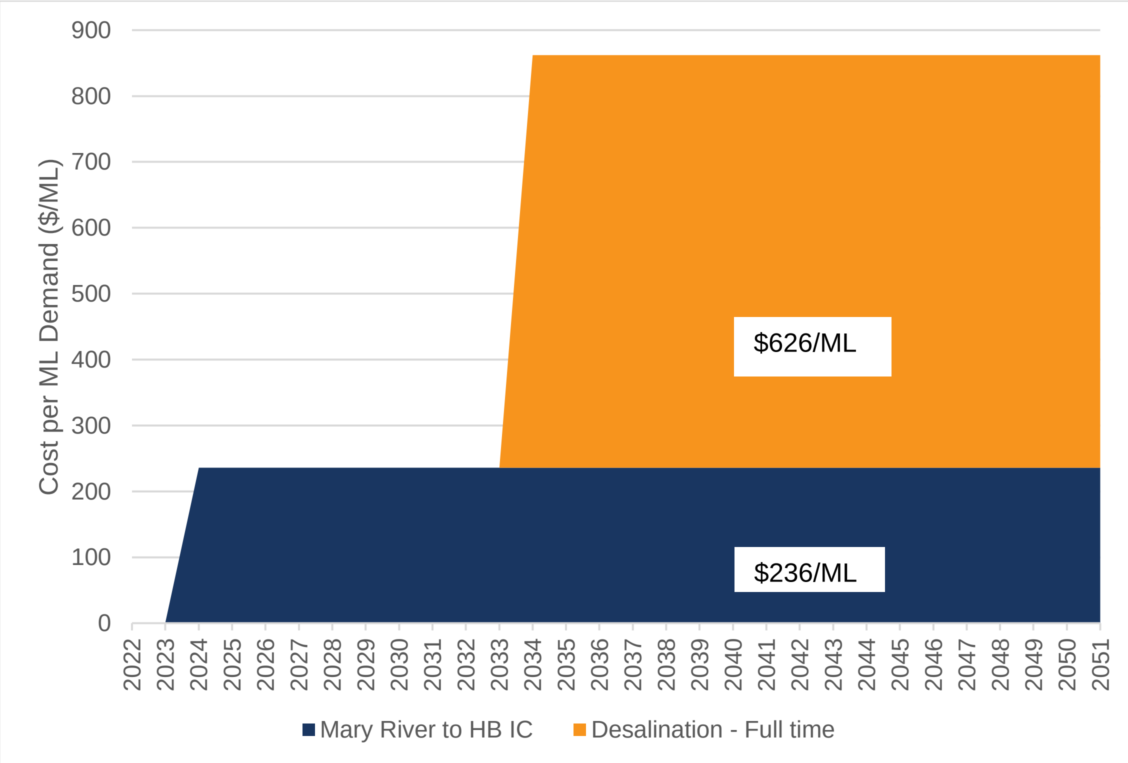

Figure 9-2 Levelised costs based on 2024 to 2051 demands

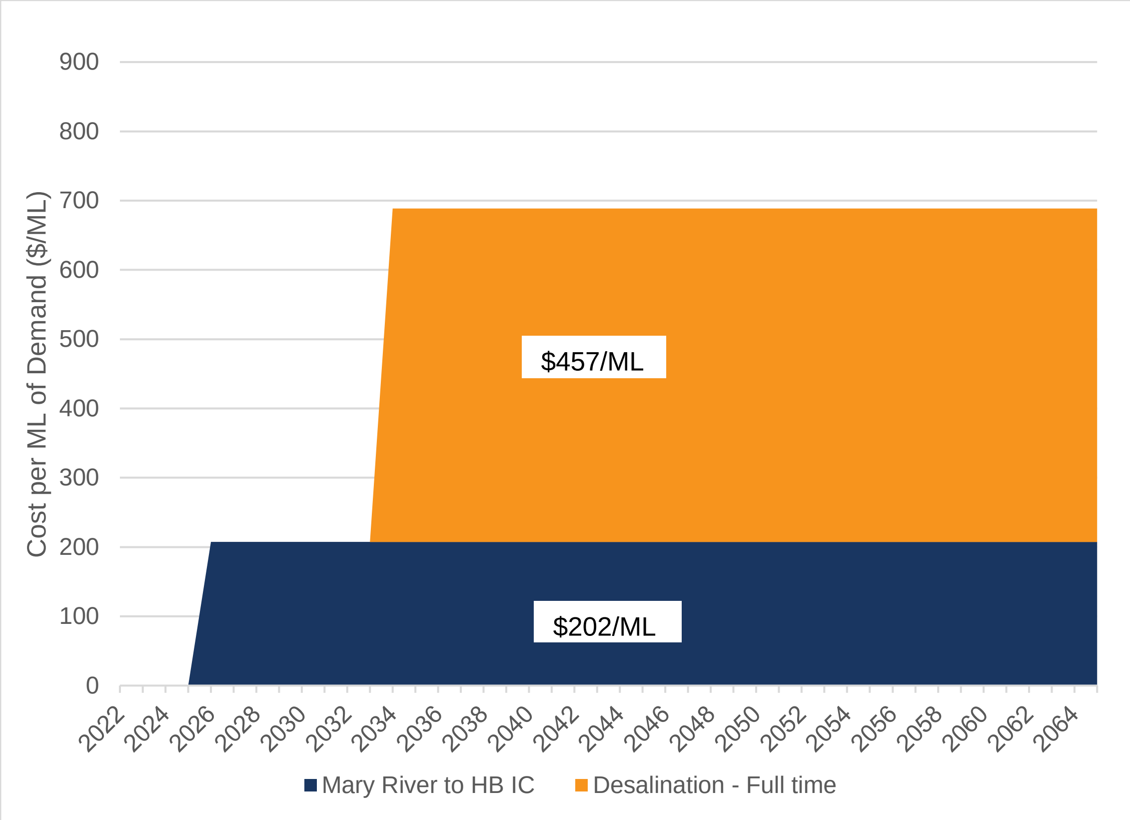

Figure 9-3 Levelised costs based on 2024 to 2065 demands

Key findings include:

- Under the shorter assessment period (2024 to 2051) the cost impact of the Mary River to Hervey Bay Interconnector is estimated at $236/ML with the per ML cost increasing by $626/ML from 2034 with the commencement of construction of the desalination plant resulting in a total impact of the combined options of $862/ML or $0.86/kL.
- Under the longer and considered to be more realistic assessment period (2024 to 2065) the costs reduce to $202/ML and $457/ML for the Maryborough to Hervey Bay Interconnector and Desalination Plant options respectively with a total cost post-2034 estimated at $659/ML or around $0.66/kL.

9.1.3 Willingness to Pay

During the community survey, 52% of the community said they were opposed to additional costs associated with improved LOS, with 27% saying they were supportive and 21% being neutral on new charges. The reason for this could be that the need to consider investing in water infrastructure options is not understood by the community.

52% of panellists opposed any additional costs associated with an improved LOS, with 31% agreeing supporting new charges and 17% being neutral. At this point in time the panel had some understanding of the need to consider investing in water infrastructure from the first workshop.

In the third and final Workshop, all panel members indicated they were supportive of the indicative cost to maintain the acceptable LOS in the future. The most common reasons given were about water security and the importance of water. By this point in time the panel had an excellent understanding of water security options and their need from the information provided in the three workshops.

Whilst the community could pay for the proposed infrastructure, there could be an argument that the new source should be funded by growth. This should be considered by Council.

9.2 Emergency Response

Emergency water supply is a planned, temporary response which aims to provide a restricted daily demand in the scenario where there are inadequate supplies in the primary water supply scheme to meet demands.

Emergency water supply, according to the 2016 Water Regulation Act, defines the essential minimum supply volume as *"the volume needed to supply an average of 100L for each person for each day for residential and non-residential water use".*

The information which has been investigated to inform the planning of emergency water supply options includes:

> Trigger levels for when emergency water supply options should be activated;

> Minimum supply volumes required to service the 2051 growth scenario; and

> Two (2) Infrastructure options viable for the Fraser Coast.

9.2.1 Option 1 – Temporary Desalination Plant

A viable option for an emergency supply source for the Hervey Bay and Maryborough systems is the use of temporary desalination plants. Temporary or portable desalination plants are a containerised plant that provide a plug and play solution to supply potable water to a community.

In 2018, DNRME conducted a study to access the efficiency of portable desalination plants to inform consideration of their use to supplement water supplies during extreme drought or emergency situations.

There are several portable desalination plants, both, brackish water RO and sea water RO, are available in the market that have the capacities to treat 70 to 300kL/d (small) and 1 to 5 ML/d (large) of raw water. These plants can be hired for short and long term (> 12 months) periods.

The longest lead time for the supply of a temporary desalination plant would be for the manufacturing of a new large plant. The DNRME report found that a lead time of 14 weeks would be required.

9.2.2 Option 2 – Water Transfer

The construction of the interconnector between Maryborough and Hervey Bay would provide the ability to transfer water between the two schemes during a supply shortfall in either system. This would be dependent on the conditions in both systems being capable of providing this supply (i.e. both systems not being in or at risk of a supply shortfall).

Due to the length of supply main required, it is not expected that this infrastructure could be a temporary solution.

9.2.3 Emergency Supply Trigger Levels

When planning for the implementation of emergency water supply options, it is imperative that there are clear criteria in place to govern the timing and planning of when emergency options are to be triggered within the scheme. This is required so that there is adequate lead time to procure and construct an alternative water supply option to service the community and ensure that a water supply shortfall event is not encountered.

As such, a conservative approach has been adopted when determining the time frames required for when emergency supply options would be required to be enforced in each scheme.

9.2.3.1 Trigger Level Modelling

According to hydrodynamic modelling, all three systems were not predicted to encounter a water supply shortfall in a 1 in 1,000 year drought. This assessment was carried out using stochastic sampling of 1,000 years of rainfall data, in which the longest duration of no rain (daily rainfall = 0mm) was 61 days and the longest period of daily rainfall under 5mm was 161 days.

Provided that the 1 in 1,000 year drought conditions did not simulate conditions in which supply shortfall was encountered, it was required to assess the system under long term "no rain" conditions to allow timings of storage draw-down to be extracted from the model in order to adequately plan for an emergency water supply scenario. Note that the "no rain" scenario represents severe dry weather conditions, greater than a 1 in 1,000 year drought and provides conservative estimates for the timing of storage draw-down to the dead volume.

The emergency water supply option model was developed for the 2051 cohort growth conditions for the Hervey Bay and Maryborough systems. The following changes were made to the existing model;

> Initial water level at the current level 4 trigger level

> Rainfall file contains 0mm/hr

The model was simulated until the dead storage volume was engaged for each scheme, with results detailed in Table 9-1.

Table 9-1 Times for Emergency Supply Action

Scheme	Scenario	Days
Hervey Bay	Lake Lenthall Level 4 Trigger (20.62m AHD) to Lake Lenthall Dead Volume (14m AHD)	273 (9 months)
Hervey Bay	Lake Lenthall Dead Volume (14m AHD) to Burrum Weir No. 1 Dead Volume (4.87m AHD)	113 (4 months)
Maryborough	Teddington Weir Level 4 Trigger (6.56m AHD) to Teddington Weir Dead Volume (2.979mAHD)	270 (9 months)
Tiaro	Mary River not flowing (RL3.25) to Tiaro defined storage volume = 0ML	1089 (3 years)

The results in Table 9-1 indicate that under "no rain conditions" there is approximately 13 months for Lake Lenthall, and 9 months for Teddington Weir to reach the dead storage volumes, when an initial water level of Level 4 trigger levels is applied.

The defined storage area at the Tiaro supply intake had approximately 3 years of supply volume available at Level 4 demands in 2051.

9.2.3.2 Timing of Commissioning Temporary Desalination Plant

As per the DNRME research completed, a temporary desalination plant can take up to 14 weeks for manufacturing and supply to site. (Department of Natural Resources, Mines and Energy, 2018)

It is recommended that Council should undertake the planning of how temporary desalination plants would be utilised for each scheme (i.e. where they would be located, intake points, connection to the existing network and pumping requirements) in the immediate future.

This infrastructure should then be constructed when a Level 3 restriction occurs and rainfall is not expected in the immediate future.

When Level 4 restrictions are enacted, Council should commence procurement of a portable desalination plant to allow time for Council procurement processes.

9.2.4 Essential Supply Volumes

The 2016 water acts states that a minimum of 100L per person per day is required during an emergency supply scenario. In order to estimate the total volume of water required to service the Hervey Bay and Maryborough Scheme under emergency conditions, population data was utilised to determine the minimum volume required to service time cohorts from 2021-2051. Note that the population data used to determine the minimum supply volumes was consistent with the values utilised to determine the Equivalent Demand (ED) values utilised within the existing condition modelling. Refer to Table 9-2 to 9-4 for the minimum essential supply volumes to be provided for all three schemes.

Table 9-2 Hervey Bay Emergency Supply Volumes

Year	ED (res + nonres)	EP	ML/Day
2020	38400	92160	9.22
2021	40356	96854	9.69
2026	42517	102041	10.2
2031	44926	107822	10.78
2036	47809	114742	11.47
2041	50385	120924	12.09
2046	52877	126905	12.69
2051	55379	132910	13.29

Table 9-3 Maryborough Emergency Supply Volumes

Year	ED (res + nonres)	EP	ML/Day
2020	13553	32527	3.25
2021	13784	33082	3.31
2026	14107	33857	3.39
2031	14457	34697	3.47
2036	14784	35482	3.55
2041	15082	36197	3.62
2046	15402	36965	3.7
2051	15746	37790	3.78

Table 9-4 Tiaro Emergency Supply Volumes

Year	ED (res + nonres)	EP	kL/day
2020	412	988	98.8
2021	419	1007	100.7
2026	429	1030	103
2031	440	1055	105.5
2036	449	1077	107.7
2041	459	1102	110.2
2046	470	1127	112.7
2051	479	1151	115.1

10 Recommendations

The objective of the Fraser Coast Water Supply Security Strategy was to identify the Level of Service to be achieved by the water supply systems for the region as well as identify the preferred strategy for delivering this Level of Service to 2051.

The following recommendations are made as a result of the water security strategy consultative process.

10.1 General

> Pursue regulatory and legislative approvals to support implementation of the preferred water security strategy.

> Invest in ongoing communication of strategy milestones and achievements to engage the community and encourage awareness, ownership and confidence in the Fraser Coast water supply systems.

> Acknowledge that implementation of the Strategy will lead to an increase in:

- rates and charges, which are paid by the entire community; and,
- water and wastewater infrastructure charges, which are paid by way of developer contributions.

> Acknowledge that increases to water and wastewater rates and charges also reflect the benefit of water security that the strategy provides to residents and economic prosperity.

> Undertake detailed economic analyses to determine an appropriate mix of increased:

- infrastructure charges
- water and wastewater rates and charges

with the aim of minimising the financial impacts on the ratepayers over the strategy timeframe

10.2 Short Term Initiatives

> Completion of a Demand Management Strategy and commencement of its implementation.

> Continue implementation of system loss reduction initiatives for Maryborough to reduce losses to 10% of demand.

> Commencement of planning and land acquisitions to enable construction of the Maryborough to Hervey Bay Interconnector.

> Design and construction of Maryborough to Hervey Bay interconnector by 2026.

> Complete planning and design of infrastructure to enable connection of emergency desalination plants for Hervey Bay and Maryborough

10.3 Long Term Initiatives

> Complete planning, design and construction of a desalination plant (or other identified bulk source of water) capable of supplying a minimum 7.5ML/day of treated water to the Hervey Bay system by 2036.

10.4 Emergency Measures

It is recommended that Council should undertake the planning of how temporary desalination plants would be utilised for each system (i.e. where they would be located, intake points, connection to the existing network and pumping requirements) in the immediate future.

This infrastructure should then be constructed when a Level 3 restriction occurs and rainfall is not expected in the immediate future.

When Level 4 restrictions are enacted, Council should commence procurement of a portable desalination plant to allow time for Council procurement processes.

10.5 Level of Service

Based on the identified strategy and the desired LOS, the recommended LOS to be adopted by Council for all water supply systems within the Fraser Coast is summarised in Table 10.1.

Table 10-1 Fraser Coast Level of Service

Restriction Level	Severity	Frequency
Level 1	N/A	Permanent
Level 2	5% use reduction	1 year ARI
Level 3	20% use reduction	5 year ARI
Level 4	40% use reduction	40 year ARI
Emergency Supply	100 L/person/day	100 year ARI
Supply Shortfall (Dead Storage Level)	Supply Shortfall	>1000 year ARI

10.6 Strategy Review and Monitoring

The work completed has identified a snapshot in time for the potential future demand and reliability of the water supply system of the Fraser Coast. A number of assumptions have been fed into this strategy including future population growth and water demand.

It is recommended that an annual review of the fundamental assumptions that underpin the strategy is completed to ensure supply planning remains on track to meet demand. The review should consider:

- Unexpected changes in water requirements
- Amendments to Water Resource Plans
- Climatic conditions
- Economic assumptions
- Significant advances in emerging technologies or changes in community attitudes.

A formal review of the Fraser Coast Water Supply Security Strategy should be completed every 5 years or when there is sufficient change in the fundamental assumptions that have informed the strategy.

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12 Glossary

Term	Definition
Allocation	A water allocation is an authority to take water in areas covered by a Resource Operations Plan.
Aquifer	An underground layer of water-bearing rock, sediment or soil.
Bulk water source / Bulk supply	Point of supply of a significant source of water to a local authority. May be a treated water source or a raw water source (e.g. dam).
Capital cost	Cost to build and set up the infrastructure.
Climatic risk	Risk associated with the inherent variability of climate, and the impact that it may have on dam operation (e.g. the risk of experiencing a drought worse than any on record).
Dead storage	The minimum level that a dam can be drawn down to i.e. no further water can be extracted from the dam.
Demand	Total water use requirements for a designated area/community; a measure of the need for water.
Demand management	any program that decreases the level and / or delays the timing of demand for water to meet current and projected needs.
Desalination	Process of converting saline water to drinking (potable) water.
Drought management techniques	Measures available to water service providers when water resources are particularly low—for example, water restrictions are considered a drought management technique.
Entitlement	A water entitlement is the general term used to describe water authorities granted under the *Water Act 2000*; this can be either a water allocation, interim water allocation or a water licence.
Environmental flows	Flow requirements necessary to maintain and support aquatic biota and ecosystem processes.
Groundwater	Underground water which is defined in the *Water Act 2000* as artesian and subartesian water.
High priority	a water allocation that has a relatively high level of performance when compared to medium priority water allocations. High priority water allocations are mostly used for urban and industrial purposes, although they are also sometimes used for irrigation, particularly for high value, long lived crops such as fruit trees.
Levels of service (LoS)	the frequency, duration and severity of water restrictions that would be experienced by the community on average over the long term.
Loss reduction	Mechanisms that reduce the amount of water lost through the delivery of water to a water user.
Medium priority	a water allocation having a relatively lower level of performance compared to high priority water allocations. Medium priority water allocations are generally used for irrigation purposes.
Megalitre (ML)	One million litres
Net present value (NPV)	Net value of all costs and income, whether incurred now or in the future, expressed as a single investment required now, calculated using a nominated discount rate.
Non-potable reuse	Use of recycled water for purposes that do not require drinking water; for example toilet flushing and irrigation of gardens and lawns.
Non-potable supply	A supply of water that is not suitable for drinking.
Operating and maintenance costs	Ongoing costs associated with operating and maintaining infrastructure (including labour, material and energy costs).
Performance	The performance of a water supply in terms of its suitability for an intended use, considered in terms of a number of key attributes including, for example, the severity, frequency and duration of restrictions.
Potable water	Water treated to a standard suitable for consumption (i.e. drinking and cook- ing).
Raw water	Natural water found in the environment such as rainwater, groundwater and water from lakes and rivers. It is considered to be 'raw' as it has not undergone any form of water treatment or purification.
Recycled water	Highly treated wastewater suitable for use for specific purposes: for example toilet flushing and irrigation of gardens and lawns.

Recycled Water Treatment Plant	A facility that processes treated water from a wastewater treatment plant to a higher quality for reuse in the community.
Reservoir	Tank designed for short-term storage of water within the water supply network.
Resource Operations Plan (ROP)	is a plan that details the operating rules for water infrastructure and other management rules that will be applied in the day-to-day management of water supplies. A ROP might address, among other things: • the conversion of water entitlements to tradable water allocations • the process and location in which water allocations will be traded • the process for release or reservation of unallocated water that is identified in the corresponding water resource plan • the detailed operating rules for infrastructure operators so management of dams and weirs complies with the water resource plan's objectives for water users and the environment • the detailed practices needed to meet the monitoring and reporting requirements specifi ed in the water resource plan.
Reuse	The beneficial use of recycled water.
Reverse osmosis	A filtration process commonly used for desalination that removes dissolved salts and metallic ions from water by forcing it through a semi-permeable mem- brane.
Trunk network	Parts of the water supply network that transfer potable water from a treatment plant to distribution reservoirs (including larger diameter pipes, pump stations and some reservoirs, and not including pipes that transfer water to individual houses).
Unallocated water	water that it is possible to make available for future consumptive use by urban, rural or industrial sectors without compromising the environment or the security of supply to existing water users.
Wastewater	The used water from the community and/or industry – also referred to as sew- age.
Wastewater system	System of pipes and pumping stations that collect and transport wastewater to a wastewater treatment plant – also referred to as a sewerage system.
Wastewater Treatment Plant (WWTP)	A facility that treats wastewater to remove pollutants and produce treated water and biosolids.
Water allocation	a water allocation is an entitlement established through a resource operations plan. Water allocations are tradable separate to land according to limits and rules defi ned in a resource operations plan. In a trading market, water allocations can be bought, sold or leased, in part or full, permanently or temporarily. The water allocation holder's details and specifi cations for water allocations are recorded on a water allocation register, similar to the existing system for registering land titles.
Water cycle	Continuous cycle of water movement through the environment, including the oceans, the atmosphere, surface water systems and groundwater.
Water Service Area	The area or locality supplied by a treated water network.
Water Supply Scheme	The raw water supply source (i.e Wide Bay Water Supply Scheme, Teddington Weir Water Supply Scheme)
Water Treatment plant (WTP)	A facility that treats wastewater to remove pollutants and produce treated wa- ter.
Waterways	All streams, creeks, rivers, estuaries, inlets and harbours.
Whole-of-life	Relating to the entire useful life of an asset. Whole-of-life costs, therefore, in- clude both capital costs and operating and maintenance costs for the useful life of the asset.

APPENDIX

A

MODELLING REPORT

Fraser Coast Water Supply

Modelling Report

R2020084

Prepared for
Fraser Coast Regional Council

1 March 2022

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1 Introduction

Fraser Coast Regional Council (FCRC) is seeking to determine a water security level of service (LOS) that is reflective of the community's expectations from 2021 to 2051. This includes understanding the community's desirable LOS and impacts that the LOS will have on the community and their willingness to fund this LOS.

The outcomes of this study will underpin the forward planning for the regions water schemes including updating of the Fraser Coast Water Supply Strategy, each schemes Drought Management Plan and FCRC's Drought Management Implementation Plan. The schemes that are operating under the Fraser Coast Water Supply Strategy include the Wide Bay Water Supply Scheme (WBWSS) and Teddington Weir Water Supply Scheme (TWWSS). Fraser Coast consists of three separate water sources that service the townships of Hervey Bay, Maryborough, and Tiaro.

The initial step in determining the future LOS and any potential augmentation of the existing three systems to achieve this LOS, is to define the existing system and its capacity to service future forecast growth.

This report will provide a summary of the existing three systems, discuss key parameters governing the operational criteria for each system and will define the current and future LOS for the Hervey Bay, Maryborough and Tiaro systems under the forecast demands from now to 2051.

1.1 Data Acquisition

Information pertaining to the Hervey Bay, Maryborough, and Tiaro systems was received from FCRC and used to derive an understanding on the operation of the three systems. Key information that was provided from FCRC to allow the existing conditions of the system to be defined was:

> Historical water use and demand on each system;
> Previous water restrictions, including level and time of restrictions;
> Future population growth data and future forecast demands on each system;
> Third party allocations on each system;
> Water supply system and infrastructure details;
> Operational criteria for storages and water treatment plants;
> 2014 Survey data for the Tiaro River Bed; and
> Previous Studies and reports including:
  - Fraser Coast Water Supply Strategy;
  - Interconnection of Hervey Bay and Maryborough water supply schemes - Strategic assessment of service requirement (Nov 2018);
  - Burnett River (Paradise Dam) to Howard water supply pipeline - Preliminary evaluation (Nov 2018); and
  - Mary Basin Resource Operations Plan - September 2011.

Data that was sourced externally to carry out the initial assessment was:

> 1890-2008 IQQM Model for the Hervey Bay and Maryborough system, *DES;*
> Historic rainfall and evaporation data for the system, *QLD Government SILO;*
> Historic gauge data for stations 138001A_mary_river_at_miva, 138903A_tinanCK_bauple_east and 137303A_ Burrumriver_lenthalls_dam_headwater, 138013B_mary_river_Barrage_HW, *QLD Government Water Monitoring Information Portal*;
> STRM derived 1 second DEM Version 1.0 for the Mary River and Lenthall's Dam Catchment, *Geoscience* Australia; and
> Queensland Government population projections, 2018 edition; Australian Bureau of Statistics, Population by age and sex, regions of Australia, 2016 (Cat no. 3235.0).

1.2 Assumptions & Limitations

In defining the existing Fraser Coast system, the supplied data has in some circumstances not been conclusive, and as such there have been a range of limitations and assumptions which have been adopted to allow features of the system to be defined with the available information. The list of assumptions which have been made with respect to the existing system are listed below.

1.2.1 General Assumptions

> For the supply and demand assessment, the extent of the defined systems has been terminated at a dummy node which represents the total available reservoir storage for each system. It is assumed that the limiting factors for LOS will be the storage capacity of the dams/weirs and the operational capacity of the Water Treatment Plant (WTP) and not the downstream reticulation system. As such it was deemed appropriate to end the assessment at the reservoirs.

> Daily demand figures for high priority water usage were provided for the 2020 – 2051 time cohorts which provides an average usage figure based on current and forecast population data. A conservative approach has been adopted in which these demand values are fully allocated and removed from the system on a daily basis.

> The daily production rates for the WTP's have been set at the value required to keep reservoirs at full supply level, limited to the maximum production rate of the plant.

> The demand from the township upon the reservoirs has been set at the AD value (factoring in monthly seasonal fluctuation in demands).

> Medium priority water allocations as published within the Mary Basin Resource Operations Plan are total allocation which are deemed to be a finite amount. As such, it is assumed that medium priority water allocations will remain constant for the 2021-2051 time cohorts.

> The demand values provided from FCRC are inclusive of system losses and represent the total volume sourced from the WTP.

> The medium priority allocations for each system have been sourced from the Mary Basin Resource Operations Plan and state a nominal allocation of water (ML) to be supplied to each party at the start of the water year. A conservative approach has been applied in which the entire nominal allocated has been demanded from the system, when water levels in the governing storages allow this to occur.

> External "third party" allocations on the system, upstream of the storage locations, are largely unknown and present difficulty to quantify. In oppose to specifying a demand volume for third party allocations on each system, an approach has been adopted that reviews the long term rainfall data, evaporation and the gauge data, and based on the long term relationship between these 2 data sets, develops a set of AWBM parameters. Intrinsic to this derivation is the historical pattern of external demand on the river system which has climatic feedback incorporated. Based on this methodology, individual extraction demands and/or allocations on each system will not need to be modelled for the current or future system. An AWBM parameter set will be generated for the Hervey Bay, Maryborough and Tiaro systems using gauged rainfall, evaporation and flow data and utilised in all future modelling scenarios moving forward.

> It is our understanding that water restrictions within the Fraser Coast region are triggered when any specific scheme enter into a low alarm level, irrespective of the available capacity of the storages within the other schemes. To accurately represent the water security within the region, water restrictions for each system have been modelled for their respective raw water storage source. This process will allow the performance of each system to modelled independently and provide information on which system is likely to trigger water restrictions for the region. Frequency and duration of water restrictions have however been analysed and reported on for the entire Fraser Coast region as this is the current operating criteria for the region.

> It is assumed that the reduction in water supply at the triggering of water restrictions will remain at the 5%, 20% and 40% reduction rates for high priority for the 2021-2051 time cohorts.

> It has been assumed that all infrastructure within the model remains operational at the maximum capacity.

1.2.2 Hervey Bay Assumptions

> The stage storage data supplied for storages within each scheme were not complete data sets. For the Hervey Bay system, an RL vs Volume relationship was supplied by FCRC, which required surface area to be interpolated. Estimated surface areas will result in variance in factors such as evaporation losses

when compared to recorded data. Stage storage relationships for all schemes are provided in Appendix A.

> Low flow release criteria outside of the October – April seasonal conditions was not provided as a numeric value. Information sourced from FCRC states that release outside of the seasonal time frame can be conducted when required to supply to the Hervey Bay township. It has been assumed that Burrum Weir 1 is to be kept to an operating level of RL 4.8m AHD to ensure that adequate quantity and quality of harvested water for the Hervey Bay township is available.

> It is understood that Cassava Dam 1 contributes to the Burgowan WTP when water quality within Burrum Weir 1 is poor. It has been assumed that transfer from Cassava Dam 1 to the Burgowan WTP occurs when Burrum Weir has a volume of 700ML, which is approaching the dead volume of the storage.

> It is our understanding that Howard WTP is currently acting as a stand-by plant that services the Hervey Bay township when the Burgowan WTP is under maintenance, cannot accommodate for daily demands or water quality is an issue from the Burrum Weir 1. It has been assumed that the Howard WTP will commence operation when the combined Hervey Bay reservoir levels fall below the designated full supply volume. As scheduled maintenance has not been factored into the model, this will trigger the Howard WTP to become operational when the AD demand for the Hervey Bay township exceeds the capacity of the Burgowan WTP (41ML/Day).

1.2.3 Mary River Assumptions

> For the Mary River water sources (Teddington Weir and Mary Barrage), no stage storage data was supplied by FCRC, and as such information was derived from the IQQM models. The data within these models was not complete, and did not correspond to known parameters on the storages, such as minimum operating levels and volumes. As such for all Storages within the Mary River Schemes, stage storage relationships were created based on information published within the Mary Basin Resource Operations Plan such as minimum operating levels and full supply levels. Estimated storage volumes and surface areas within a storage will influence the performance of the system in terms of water supply reliability as the derived stage/storage relationships ultimately govern the behaviour of the storage.

2 Existing Water Supplies Overview

2.1 Hervey Bay

2.1.1 Scheme Overview

Wide Bay Water (WBW) operates the Wide Bay Water Supply Scheme (WBWSS) in accordance with the Mary Basin Resource Operations Plan.

The Hervey Bay raw water supply is primarily sourced from the Burrum River System, in which three storages have been constructed: Lenthalls Dam, Burrum Weir No.1 and Burrum Weir No.2. The township of Hervey Bay is further supplemented by two small dams situated on Beelbi Creek; Cassava Dam 1 and Cassava Dam 2 which act as balance storages for the raw water from Burrum Weir.

Water from Burrum Weir 1 is transferred to the Burgowan Water Treatment Plant (WTP), which is the primary treatment plant that supplies to the township of Hervey Bay. A standby treatment plant, Howard WTP, also sources water from the Burrum River, and has historically been used when demands on the Burgowan WTP have exceeded operating capacity or maintenance works have been undertaken. Cassava Dam 1 acts a supplementary raw water supply to the Burgowan WTP when the water quality within Burrum Weir 1 is poor.

A schematic of the Hervey Bay System is provided in Figure 2-1.

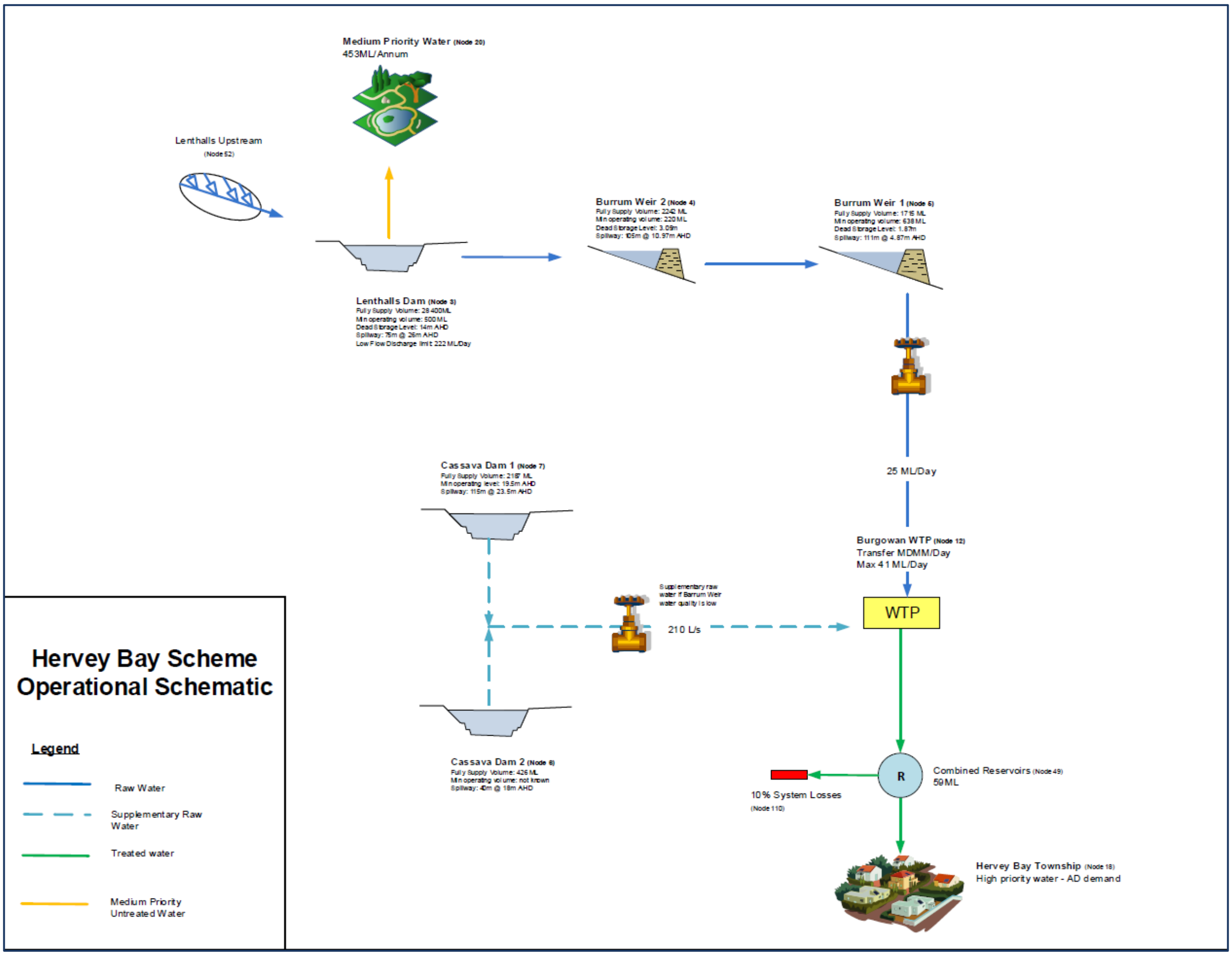

Figure 2-1 Hervey Bay Operational Schematic

2.1.2 Current infrastructure Summary

A summary of the infrastructure operating within the Hervey Bay water system is summarised in Table 2-1 to Table 2-3.

Table 2-1 Hervey Bay Storage Infrastructure Summary

Storage Name	Full Supply Capacity	Min Operating Criteria	Spillway Level	Spillway Length	Surface Area at Full Supply
Lake Lenthall	28,411 ML	14m AHD	25.83m AHD	75m	720ha
Burrum Weir 2	2,242 ML	3.05m AHD	10.97m AHD	104m	58ha*
Burrum Weir 1	1,715 ML	1.87m AHD	4.87m AHD	111m	41ha*
Cassava Dam 1	2,187 ML	19.5m AHD	23.50m AHD	115m	105ha
Cassava Dam 2	426 ML	Not known	18.00m AHD	40m	35ha

*Surface Areas for Burrum Weir No. 2 and No.1 have been back calculated based on provided stage/volume data.

Table 2-2 Hervey Bay Raw Water Transfer Infrastructure Summary

Raw Water Transfer	Description of Infrastructure	Full Transfer Capacity
Lake Lenthall low flow release to Burrum Weir 2	500mm diameter cone valve through dam embankment	220ML/Day
Burrum Weir 1 pumping to Burgowan Dynasand WTP	Pump	25ML/Day
Burrum Weir 1 pumping to Burgowan Ozone WTP	Pump	25ML/Day
Burrum Weir 1 pumping to Howard WTP	Pump	22 ML/Day
Cassava Dam 1 pumping to Burgowan Dynasand WTP	Vacuum pump	210L/s

Table 2-3 Hervey Bay Water Treatment Plant Summary

Water Treatment Plant	Secure Capacity	System Losses
Burgowan Dynasand	30ML/Day	10%
Burgowan Ozone	11ML/Day	
Howard	18ML/Day	

2.1.2.2 System Losses

FCRC has previously conducted analysis of metered data for the region and developed an estimate of system losses for each scheme. It is understood that the system losses are experienced from the reservoirs to the township. For the Hervey Bay Scheme, FCRC has estimated the system losses to be 10%. FCRC has advised that system losses are factored into the average demand data provided for this study.

2.1.3 Water Restrictions

Fraser Coast has implemented water restrictions to extend the available supply within raw water storages for as long as possible while aiming to achieve minimal social and economic impacts. The basis of implementing water restrictions within a specific system is related to the capacity of the supplying raw water source. Historically, FCRC has adopted an approach to implementing water restrictions that has provided a consistent approach throughout the region. In this approach, the triggering of water restrictions in any particular system results in every scheme entering restrictions.

The level of water restrictions for the Fraser Coast Region are described from Level 1 – Level 4. Level 1 water restrictions have remained as the minimum water restriction in places since 2006 and represent a “normal” water consumption scenario. Trigger values within the raw water sources have been adopted to provide guidance on when each level of water restriction is to be entered, however the decision to enter restrictions is ultimately governed by FCRC’s Chief Executive Officer. A target reduction in demand has been established for each level of water restrictions and is the goal reduction in high priority water consumption for each stage of restrictions. It is noted that these target reduction rates in consumption may not be representative of “actual usage” when a certain level of restrictions is entered, however for modelling purposes, these values have been adopted to provide a benchmark for the assessment.

Further information on the triggers and the target volumetric reduction in water consumption for each level of restrictions is provided in Table 2-4.

Table 2-4 Hervey Bay water restriction trigger levels and target water demand reduction

Water restriction level	Level in Lake Lenthall (m AHD)	Target reduction in demand	Restricted average water consumption (580 L/p/d)
Level 1 (permanent)	< 23.96	Nil	580 L/p/d
Level 2	22.64 – 23.96	5%	551 L/p/d
Level 3	20.62 – 22.64	20%	464 L/p/d
Level 4	< 20.62	40%	348 L/p/d

It is noted that the above values are in relation to high priority water (i.e. Township demands). For the Hervey Bay system, there are a separate set of water restrictions and target reductions for medium priority water. The medium priority water restrictions are summarised in Figure 2-2.

Column 1	Column 2
Storage level in Lenthalls Dam (m AHD) (percentage of full capacity)	**Announced allocation for medium priority group water allocations**
23.84 (60.0%)–25.86 (100%)	100%
23.56 (57.5%)–23.83 (59.9%)	95%
23.36 (55.0%)–23.55 (57.4%)	90%
23.16 (52.5%)–23.35 (54.9%)	85%
22.97 (50.0%)–23.15 (52.4%)	80%
22.66 (47.5%)–22.96 (49.9%)	75%
22.36 (45.0%)–22.65 (47.4%)	70%
22.16 (42.5%)–22.35 (44.9%)	65%
21.93 (40.0%)–22.15 (42.4%)	60%
21.56 (37.5%)–21.92 (39.9%)	55%
21.26 (35.0%)–21.55 (37.4%)	50%
20.96 (32.5%)–21.25 (34.9%)	45%
11.86 (0.00%)–20.95 (32.4%)	40%

Figure 2-2 Hervey Bay medium priority water restrictions (sourced from DOCSHBCC – 2863560-v1)

2.1.4 Water Allocations

The Hervey Bay Water Supply System is provided an annual water allocation (ML/year) that represents the safe yield from Lake Lenthall. This value considers both high and medium priority water usage and represents the maximum volume water that can safely be harvested from the system in any given year. The maximum water allocations for Hervey Bay system have been summarised within Table 2-5.

Table 2-5 Hervey Bay Allocation Summary

Time Cohort	High Priority	Medium Priority	Total Allocation
2020 -2051	14,020 ML	453 ML	14,473 ML

2.1.5 Demand Projections

Demand projections for high priority water have been provided by FCRC, which summarise the anticipated increase in daily water demands based on forecast population growth within the region. The demand values have been determined based on 580L per equivalent dwelling (ED) and includes system losses.

The daily demands values for the 2020-2051 time cohorts are listed in Table 2-6.

Table 2-6 Hervey Bay Demand Projections

Time Cohort	Average Day (AD) Demand (ML/Day)	Mean Day Maximum Month (MDMM) Demand (ML/Day)	Peak Day (PD) Demand (ML/Day)
2020	22.27	28.95	35.64
2021	23.41	30.43	37.45
2026	24.66	32.06	39.46
2031	26.06	33.87	41.69
2036	27.73	36.05	44.37
2041	29.22	37.99	46.76
2046	30.67	39.87	49.07
2051	32.12	41.76	51.39

It is noted that once the annual AD demand exceeds the high priority allocation of 14,020 ML for Lake Lenthall, system augmentation is required. Review of the above demands indicates that this is not anticipated to occur up to the 2051 time cohort with a 2051 Average Annual Demand of 11,723ML (32.12ML/Day x 365 Days) anticipated for the region.

2.1.5.2 Demand Analysis

In addition to the annual demand values listed above, FCRC provided a summary of monthly production data that captures the seasonal fluctuation in demand throughout the year. The ratio of consumption on a monthly basis is detailed in Table 2-7.

Table 2-7 Factored Average Monthly Consumption

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Factor	1.20	1.12	0.91	0.92	0.86	0.89	0.91	0.98	1.16	0.93	1.12	1.07

The above factors have been applied to the Average Demand (AD) values to determine the township consumption on a monthly basis.

2.2 Maryborough

2.2.1 Scheme Overview

Maryborough's raw water supply is primarily sourced from the Tinana Creek (a tributary of the Mary River), There have been two storages constructed along Tinana Creek: the Tallegalla and Teddington Weirs. The Teddington Weir Water Supply Scheme (TWWSS) and its assets are managed by WBW. The township of Maryborough can further be supplemented by sourcing from the Mary River, via the Owanyilla pipeline system.

Water from the Teddington Weir is transferred to the Teddington WTP, which is the only treatment plant that supplies to the township of Maryborough .

A schematic of the Maryborough Bay System is provided in Figure 2-3.

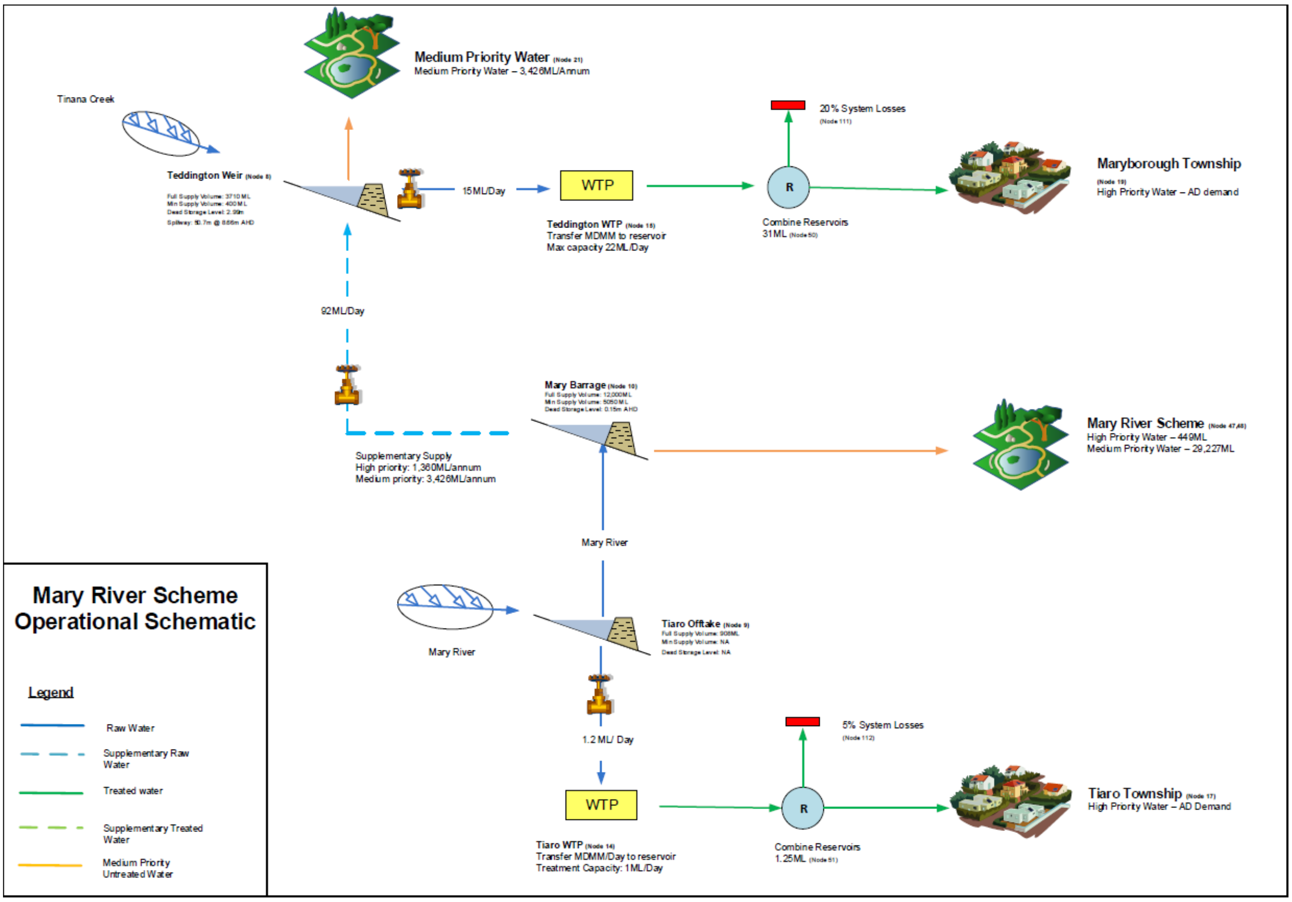

Figure 2-3 Maryborough Operational System

2.2.2 Current infrastructure Summary

A summary of the infrastructure operating within the Maryborough system is summarised in Table 2-8 to Table 2-10.

Table 2-8 Maryborough Infrastructure Summary

Storage Name	Full Supply Capacity	Min Operating Criteria	Spillway Level	Spillway Length	Surface Area at Full Supply
Teddington Weir	3,710 ML	400 ML	8.66m AHD	50.7m	92ha*
Talegalla Weir	385 ML	0 ML	14.49m AHD	17.6m	2ha*
Mary Barrage	12,000 ML	5,050 ML	2.90m AHD	136m	299ha*

*Surface Areas for Mary Barrage, Teddington, and Tallegalla Weirs have been back calculated based on minimum and maximum operating volumes and RL's.

Table 2-9 Maryborough Raw Water Transfer Infrastructure Summary

Raw Water Transfer	Description of Infrastructure	Full Transfer Capacity
Teddington Weir to Teddington WTP	Pump	15ML/Day
Owanyilla pipeline to Teddington Weir	Pipeline system	92ML/Day

Table 2-10 Maryborough Water Treatment Plant Summary

Water Treatment Plant	Secure Capacity	System Losses
Teddington WTP	22ML/Day	20%

2.2.2.2 System Losses

For the Maryborough system, FCRC has estimated the system losses to be 20%.

2.2.3 Water Restrictions

A summary of the triggers and the target volumetric reduction in water consumption for each level of restrictions within the Maryborough system is provided in Table 2-11.

Table 2-11 Maryborough water restriction trigger levels and target water demand reduction

Water restriction level	Level in Mary Barrage (m AHD)	Target reduction in demand	Restricted average water consumption (580 L/p/d)
Level 1 (permanent)	> 7.8	Nil	580 L/p/d
Level 2	7.26 - 7.8	5%	551 L/p/d
Level 3	6.56 – 7.26	20%	464 L/p/d
Level 4	< 6.56	40%	348 L/p/d

It is noted that the above restrictions relate to high priority water within the Maryborough system. Based on information received from FCRC, it is prohibited to take medium priority when the RL of Teddington Weir falls below RL 7.7m AHD.

The prohibition of take (POT) criteria for supplementary water supply from the Mary Barrage are detailed in Table 2-12.

Table 2-12 Prohibition on take trigger levels for supplementary water supply

Source of Water	Criteria	POT Condition
Mary Barrage (MB)	MB < 1m AHD and TW < 7.7m AHD	0% for medium priority allocation holders. POT removed when MB > 1.2m and TW >7.7m
Mary Barrage (MB)	MB < 0.5m or TW > 7.7m AHD	0% for high priority allocation holders. POT removed when MB > 0.5m and TW <7.7m

2.2.4 Water Allocations

Maryborough water system is provided an annual water allocation (ML/year) that represents the safe yield from the Teddington Weir, based on system inflows from Tinana Creek and transfer from the Mary Barrage. This value considers both high and medium priority water usage and represents the maximum volume of water that can safely be harvested from the system in any given year. It is noted that the supplementary water allocations are available from the Mary Barrage when water levels within the Teddington Weir and Mary Barrage are within a certain range.

The maximum water allocations for Teddington system have been summarised within Table 2-13.

Table 2-13 Teddington Weir Allocation Summary

Time Cohort	High Priority	Medium Priority	Total Allocation
2020 -2051	**8,179ML** 6,819ML – sourced from Tinana Creek 1,360ML – Supplementary transfer from Mary Barrage	**3,426ML** 2,690ML – Teddington Scheme allocation (this can be transferred from the Mary Barrage under certain criteria) 736ML – Lower Tinana Creek allocation (this can be transferred from the Mary Barrage under certain criteria)	**11,605 ML**

2.2.5 Demand Projections

Demand projections for high priority water have been provided by FCRC, which summarise the increase in daily water demands based on forecast population growth within the region. The daily demands values for the 2020-2051 time cohorts are listed in Table 2-14.

Table 2-14 Maryborough Demand Projections

Time Cohort	Average Day (AD) Demand (ML/Day)	Mean Day Maximum Month (MDMM) Demand (ML/Day)	Peak Day (PD) Demand (ML/Day)
2020	7.86	10.22	12.58
2021	7.99	10.39	12.79
2026	8.18	10.64	13.09
2031	8.39	10.90	13.42
2036	8.57	11.15	13.72
2041	8.75	11.37	14.00
2046	8.93	11.61	14.29
2051	9.13	11.87	14.61

It is noted that once the annual AD demand exceeds the high priority allocation of 8,179ML for Teddington Weir, system augmentation is required. Review of the above demands indicates that this is not anticipated to occur up to the 2051 time cohort with a 2051 Average Annual Demand of 3,332 ML (9.13ML/Day x 365Days) anticipated for the region.

2.3 Tiaro

2.3.1 Scheme Overview

Tiaro's raw water supply is sourced directly from the Mary River via a pumping system (located approximately 20km upstream of the Mary Barrage). Although there is no constructed storage for the Tiaro supply system, there is an informal storage at the Tiaro offtake location, which supplies adequate volume for harvesting when the Mary River levels are low or not flowing.

Water from the Mary River is pumped directly to the Tiaro WTP.

The Tiaro reticulated water supply system is managed by WBW and is shown in Figure 2-3.

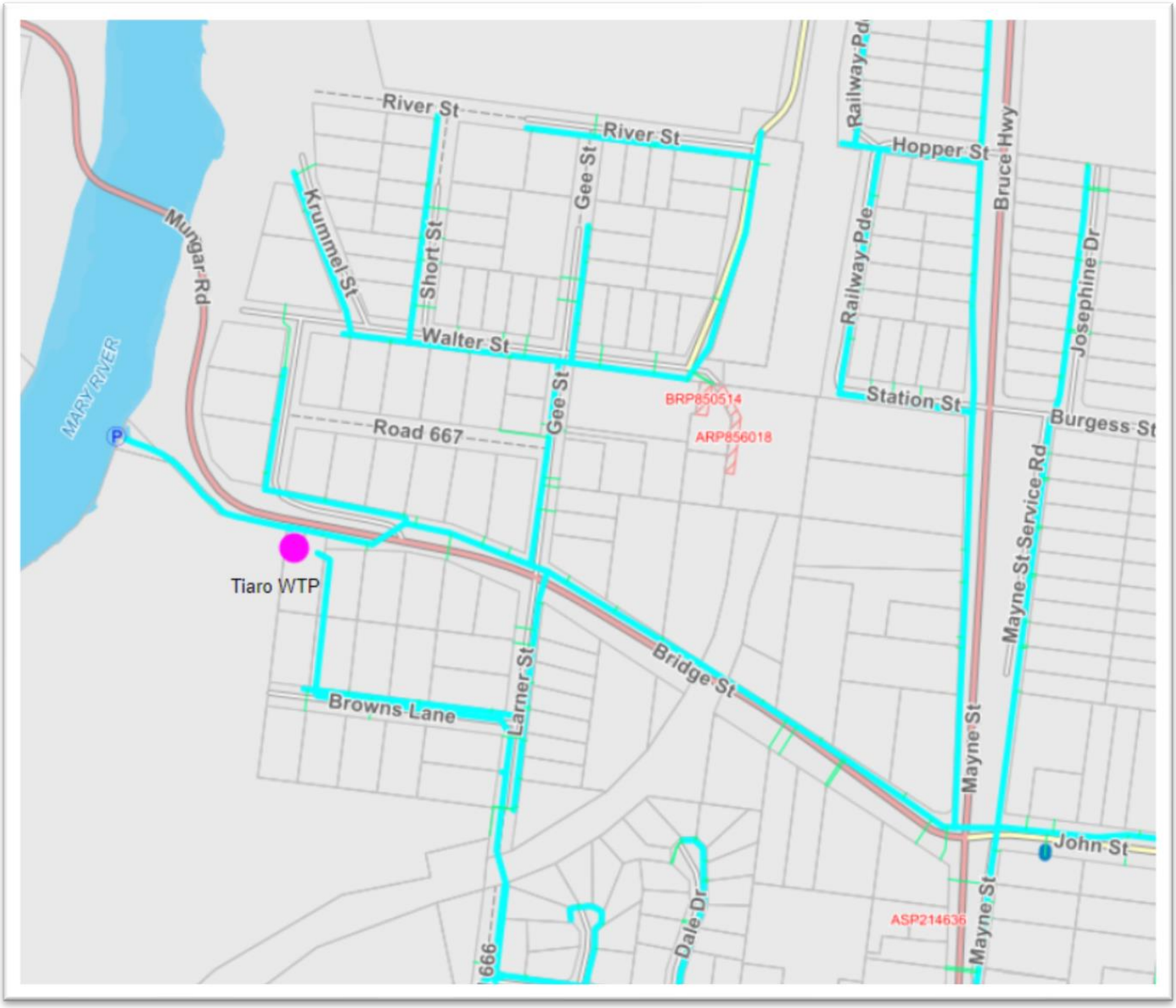

Figure 2-4 Tiaro reticulated water supply system

2.3.2 Current infrastructure Summary

A summary of the infrastructure operating within the Tiaro system is summarised in Table 2-15 to Table 2-17.

Table 2-15 Tiaro Infrastructure Summary

Storage Name	Full Supply Capacity	Min Operating Criteria	Spillway Level	Spillway Length	Surface Area at Full Supply
Tiaro Informal Storage	908 ML	NA	NA – along Mary River	NA – along Mary River	19.5 ha
Mary Barrage	12,000 ML	5,050 ML	2.90m AHD	136m	299ha

*For the Tiaro System, volume and area have been calculated from the provided river bed survey and LiDAR. Mary Barrage surface area estimated based on IQQM model.

Table 2-16 Tiaro Raw Water Transfer Infrastructure Summary

Raw Water Transfer	Description of Infrastructure	Full Transfer Capacity
Tiaro Informal Storage to Tiaro WTP	Pump	1.2 ML/Day

Table 2-17 Tiaro Water Treatment Plant Summary

Water Treatment Plant	Secure Capacity	System Losses
Tiaro WTP	1 ML/Day	5%

2.3.2.2 System Losses

For the Tiaro system, FCRC has estimated the system losses to be 5%.

2.3.3 Water Restrictions

A summary of the triggers and the target volumetric reduction in water consumption for each level of restrictions within the Tiaro system is provided in Table 2-18

Table 2-18 Tiaro water restriction trigger levels and target water demand reduction

Water restriction level/ % of full supply volume	Level in Mary Barrage (m AHD)	Target reduction in demand	Restricted average water consumption (420 L/p/d)
Level 1 (permanent)	> 1.5	Nil	420 L/p/d
Level 2	1.0 – 1.5	5%	399 L/p/d
Level 3	< 1.0 minimal inflow	20%	336 L/p/d
Level 4	< 1.0 no inflow	40%	252 L/p/d

2.3.4 Water Allocations

The township of Tiaro is provided an annual water allocation (ML/year) that represents the safe yield from the Mary River. This value consists only of high priority water allocations. Medium priority allocations in this region are distributed from the Mary Barrage, which is owned and operated by SunWater.

The maximum water allocations for Tiaro system have been summarised within Table 2-19

Table 2-19 Tiaro Allocation Summary

Time Cohort	High Priority	Medium Priority	Total Allocation
2020 -2051	120ML	NA	120ML

Demand projections for high priority water have been provided by FCRC, which summarise the increase in daily water demands based on forecast population growth within the region. The daily demands values for the 2020-2051 time cohorts are listed in Table 2-20.

Table 2-20 Tiaro Demand Projections

Time Cohort	Average Day (AD) Demand (ML/Day)	Mean Day Maximum Month (MDMM) Demand (ML/Day)	Peak Day (PD) Demand (ML/Day)
2020	0.17	0.22	0.28
2021	0.18	0.23	0.28
2026	0.18	0.23	0.29
2031	0.18	0.24	0.30
2036	0.19	0.25	0.30
2041	0.19	0.25	0.31

2046	0.20	0.26	0.32
2051	0.20	0.26	0.32

It is noted that once the annual AD demand exceeds the high priority allocation of 120ML for the Tiaro scheme, system augmentation is required. Review of the above demands indicates that this is not anticipated to occur up to the 2051 time cohort with a 2051 Average Annual Demand of 73ML (0.20ML/Day x 365Days) anticipated for the region.

2.4 Mary Barrage

2.4.1 Scheme Overview

The Mary Barrage is a SunWater asset that primarily provides medium priority water to irrigators along the Mary River, under SunWater's Lower Mary Water Supply Scheme (LMWSS). The Mary Barrage also acts as a supplementary supply source for the TWWSS while also influencing the triggering of water restrictions for both Maryborough and Tiaro .

The Mary Barrage has the ability to transfer water to the Teddington Weir via the Owanyilla pipeline system, which has a maximum transfer capacity of 92ML/Day. There is a supplementary annual allocation of 1,360ML of high priority water and 3,426ML of medium priority water when the Mary Barrage and Teddington Weir meets certain volumetric criteria.

2.4.2 Current Infrastructure Summary

A summary of the Mary Barrage is provided in Table 2-21, with the allocation volumes defined in Table 2-22.

Table 2-21 Mary Barrage Infrastructure Summary

Storage Name	Full Supply Capacity	Min Operating Criteria	Spillway Level	Spillway Length	Surface Area at Full Supply
Mary Barrage	12,000 ML	5,050 ML	2.90m AHD	136m	299ha

*The Mary Barrage surface area was estimated based on the data within the Maryborough IQQM model.

Table 2-22 Mary Barrage Allocation Summary

Time Cohort	High Priority	Medium Priority	Total Allocation
2020 -2051	**1,809ML** 449ML – SunWater customers 1360ML -supplementary supply to Teddington Weir	**32,653ML** 29,227ML – SunWater irrigators 3,426ML – Supplementary supply to Teddington Weir	**34,462ML**

2.4.3 Water Restrictions

As the Mary Barrage is a SunWater owned and maintained asset, this system operates independently to the other Fraser Coast systems. According to the Mary Basin Operations plan, taking water for irrigation use under medium priority water allocations from the Mary Barrage is prohibited with the water level is equal to or less than 1.0m AHD.

The high-priority restrictions and demand reductions for the Mary Barrage are as detailed within in Table 2-18 for the Tiaro system.

3 Methodology

The following section outlines the methodology used to establish the hydrological and hydrodynamic parameters adopted to model the operation of the existing Tiaro, Maryborough, and Hervey bay systems. The Hydrological modelling was conducted using primarily using eWater's rainfall runoff toolkit while the hydrodynamic assessment was carried out within the OPSIM platform, an operational simulation tool for the assessment, design, and management of water resource systems.

3.1 Hydrology

Hydrologic modelling was undertaken to derive a range of AWBM parameter sets that simulate the catchment rainfall runoff response at gauge locations within each scheme. Long term rainfall data sets and gauge data has been incorporated into the model and based on this historical record, sets of AWBM runoff parameters have been generated. The parameter set captures the general flow regime of the catchment at the gauge locations. Since the recorded gauge data, will incorporate the influence on flows from external "third party" allocations, the AWBM parameter set will intrinsically incorporate the influence of these allocations.

In the absence of specific details around individual third party water allocations on the system, the adopted methodology represents the relationship between rainfall and resulting flow at gauge locations. Intrinsic to this derivation is the historical pattern of external demand on the river system with has climatic feedback incorporated. Based on this methodology, individual extraction demands and or allocations on each scheme will not need to be modelled for the current or future system. The assumption that the historical pattern of third party water usage will continue will be made for modelling of future water balance scenarios.

Based on this methodology, an AWBM parameter set will be generated for the Maryborough, Hervey Bay and Mary River systems using gauged rainfall, evaporation and flow data and utilised in all future modelling scenarios moving forward.

The hydrologic modelling was carried out using a combination of CatchmentSIM and the eWater Rainfall and Runoff Library Tool.

3.1.1 Catchment Definition

CatchmentSIM is a software package that provides hydrologic analysis of terrain to assist in catchment mapping and the delineation of flow paths within an area of interest.

The sub catchments were delineated using STRM derived DEM data. Catchment outlets were defined at each major storage/offtake location, as well as at gauge locations. A schematic of the delineated catchments for the Hervey Bay and Mary River systems are shown in Figure 3-1 and Figure 3-2 respectively. The sub-catchment and total sub-catchment areas for each major offtake locations within the Fraser Coast systems areas detailed in Table 3-1.

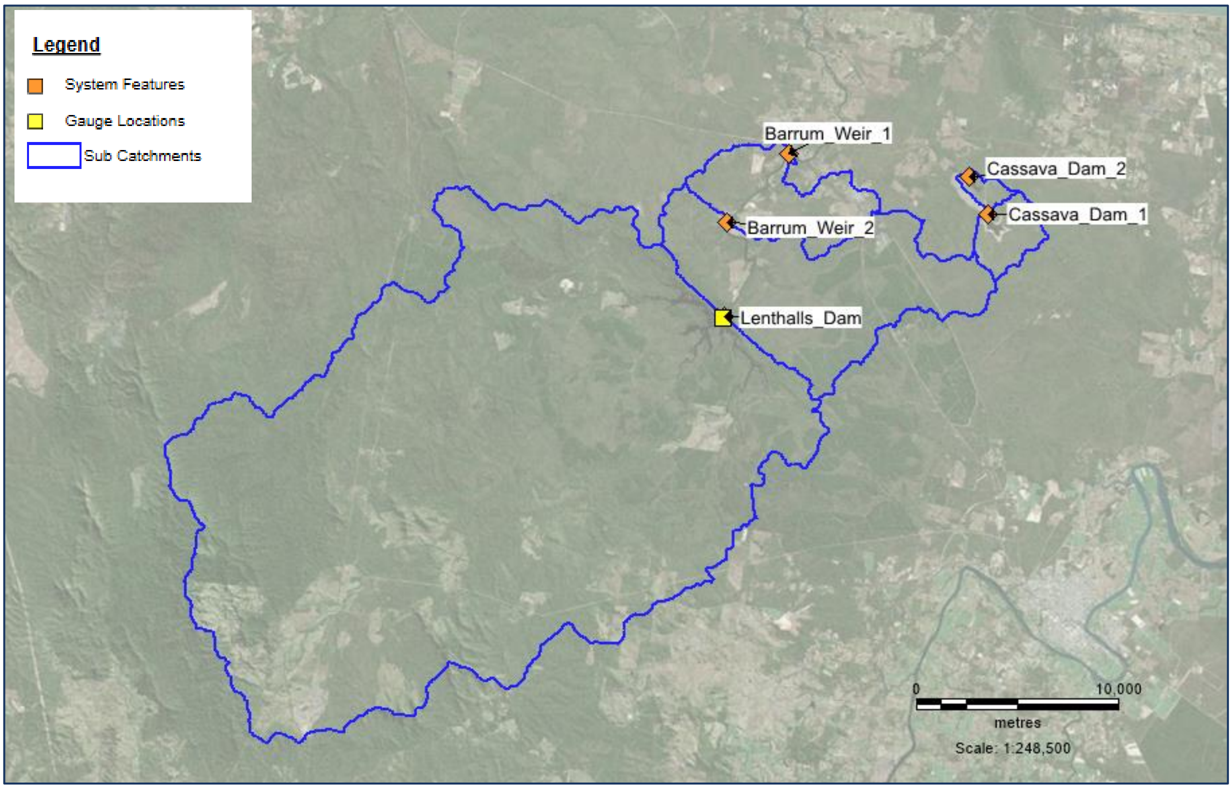

Figure 3-1 Hervey Bay Sub Catchment Delineation

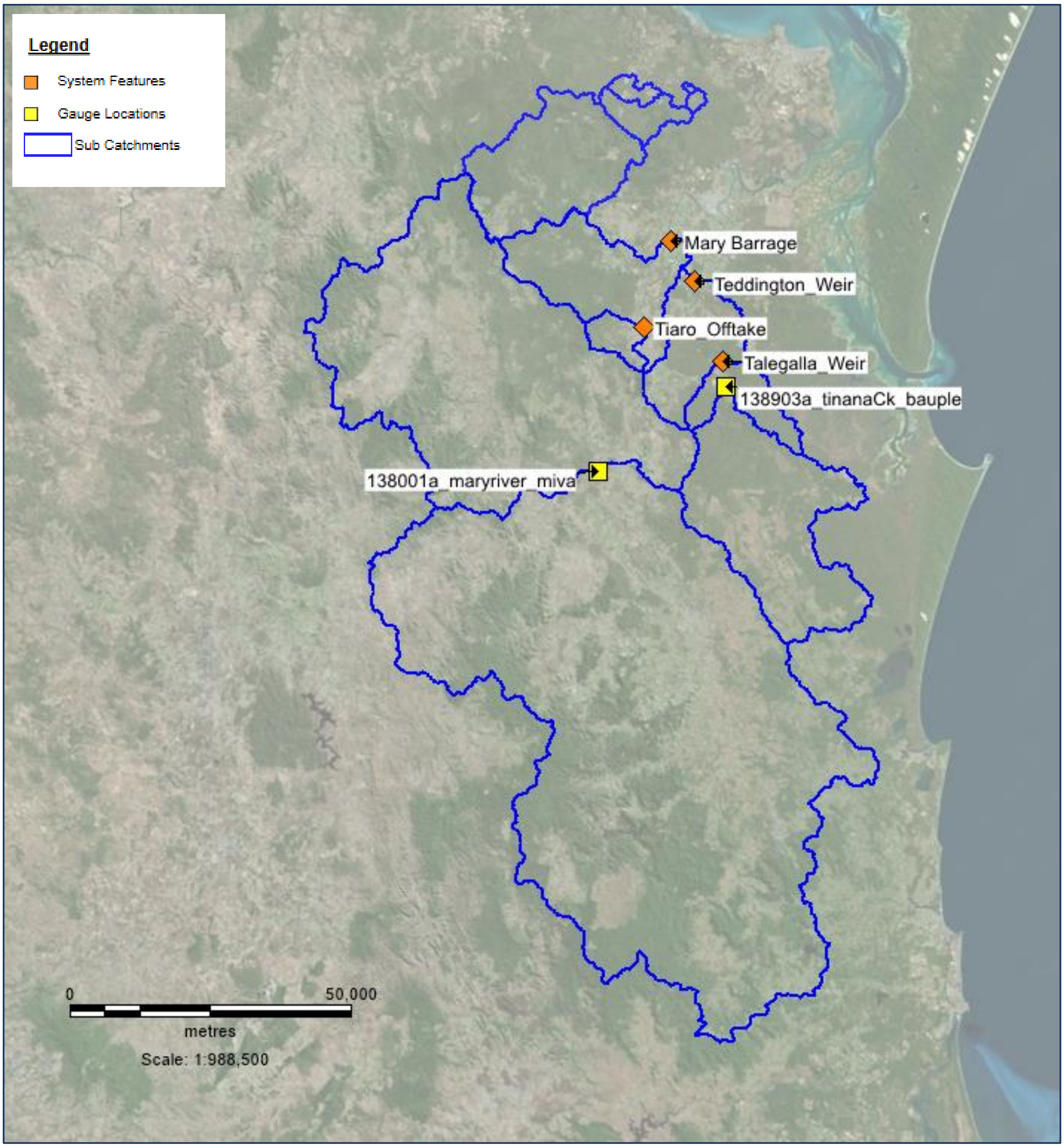

Figure 3-2 Mary River Sub Catchment Delineation

Table 3-1 Fraser Catchment Summary

Location	Catchment Area (km^2)	Total Contributing Catchment Area (km^2)
Lenthalls Dam	512.90	512.90
Burrum Weir 2	77.96	590.86
Burrum Weir 1	28.59	619.45
Cassava Dam 1	9.55	9.55
Cassava Dam 2	5.74	5.74
Tallegalla Weir	921.40	921.40
Teddington Weir	272.10	1193.50
Tiaro Offtake	6925.85	6925.85
Mary Barrage	423.30	7349.15

3.1.2 Rainfall Evaporation Data

Historic rainfall and evaporation data were sourced from the SILO LongPaddock service for the time period 1889 to 2020. It is noted that BOM gauge data was reviewed within the catchment, however the available data did not align with the recorded gauge flow data and included a large number of data gaps and was therefore deemed not fit for calibration purposes.

This information was selected for key locations within each catchment that were deemed to provide an accurate representation of the rainfall patterns for that catchment. It is noted that singular point rainfall data was selected for the Lenthall's Dam and Tinana Gauge catchments. The catchment contributing to the Mary River gauge was assigned three rainfall data sets due to the large extent of the catchment and variability in catchment terrain and rainfall patterns in this region. Based on the three rainfall stations, a weighted rainfall average over the catchment was adopted for the Mary River gauge.

Evaporation data at the centroid was compared to various locations throughout the catchment and it was determined that the variability in data was minimal and would have no significant impact on calibration results. As such, the evaporation data set selected for use was at a location central to all three systems.

The selected rainfall data points for each catchment are shown in Figure 3-3 below.

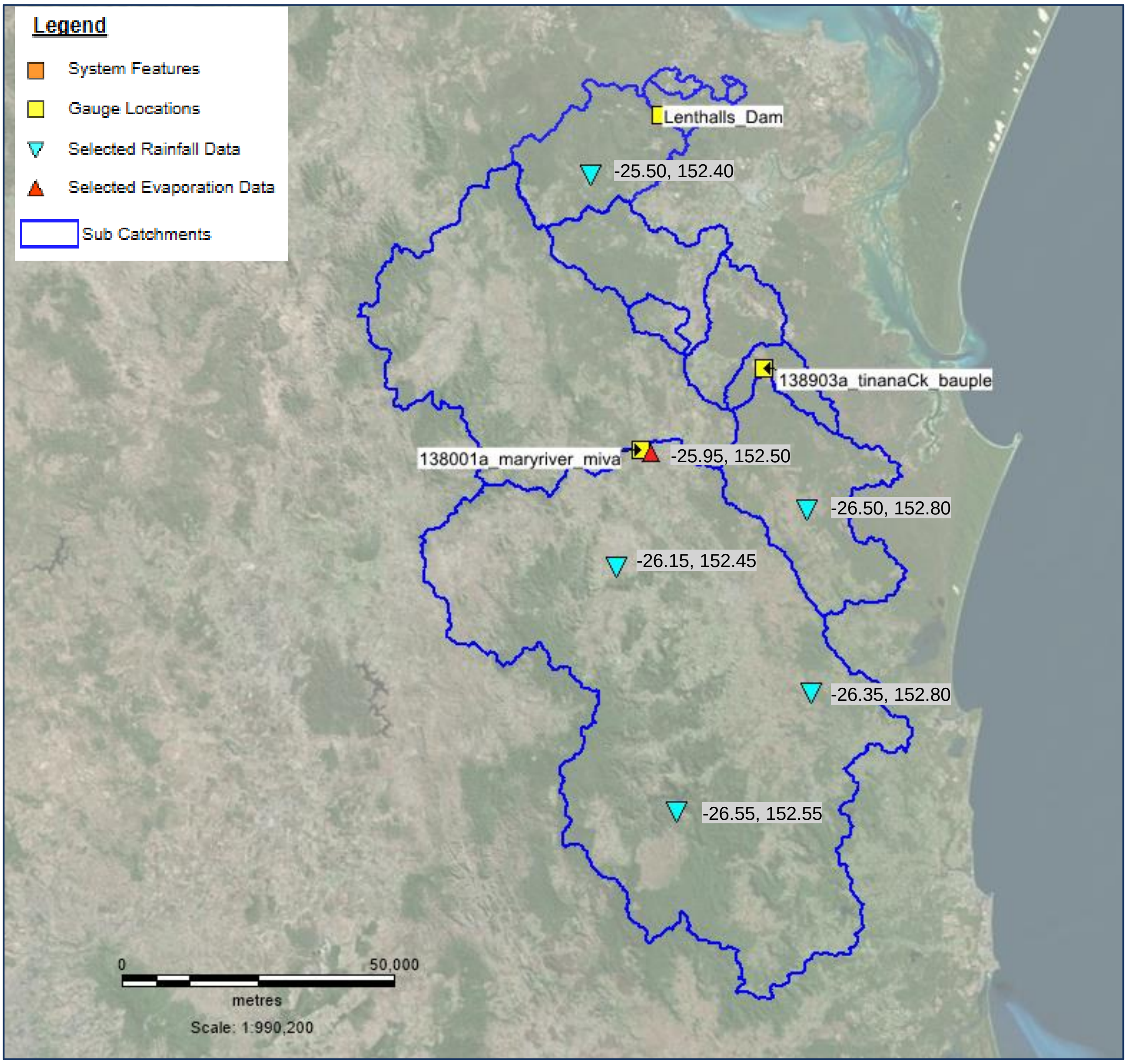

Figure 3-3 Calibration Locations for Fraser Coast Systems

3.1.3 Gauge Flow Data

Gauge flow data was sourced for each system at the locations outlined in Figure 3-3. The gauge data provides historic flow rate (ML/Day) recorded at each location. For the Mary River and Tinana gauges, the data ranges from 1910-2020 and 1981-2020 respectively. The Lenthalls dam data has been sourced from the provided FCRC dam inflow data set, which provided information for the time frame 2009-2020.

It is noted that the selected gauge points are upstream of the offtake points for each system. As mentioned earlier, this approach has allowed the calibration parameter set to incorporate any third party demands on the system that impact the flow regime of each river system.

3.1.4 Calibration

The rainfall runoff toolkit from eWater was used to determine the AWBM parameter sets to represent the catchment rainfall runoff response for each system. The rainfall runoff tool is a modelling framework that estimates daily catchment water yield and runoff characteristics at an outlet location based on catchment size, input rainfall, evaporation, and flow data. The AWBM rainfall-runoff model was adopted as the hydrologic method used in the analysis process.

The historic rainfall, evaporation, and gauge flow data for each system was input into the model and set to run for the time frame of the available data. Using the inbuilt calibration tools, the AWBM optimising algorithm was selected to generate a set of parameters that best simulated the recorded flow data. In addition to this, the parameter sets where further optimised to best match the flow duration curve graphs for each gauge.

The calibration results are provided in the following Figures and Tables.

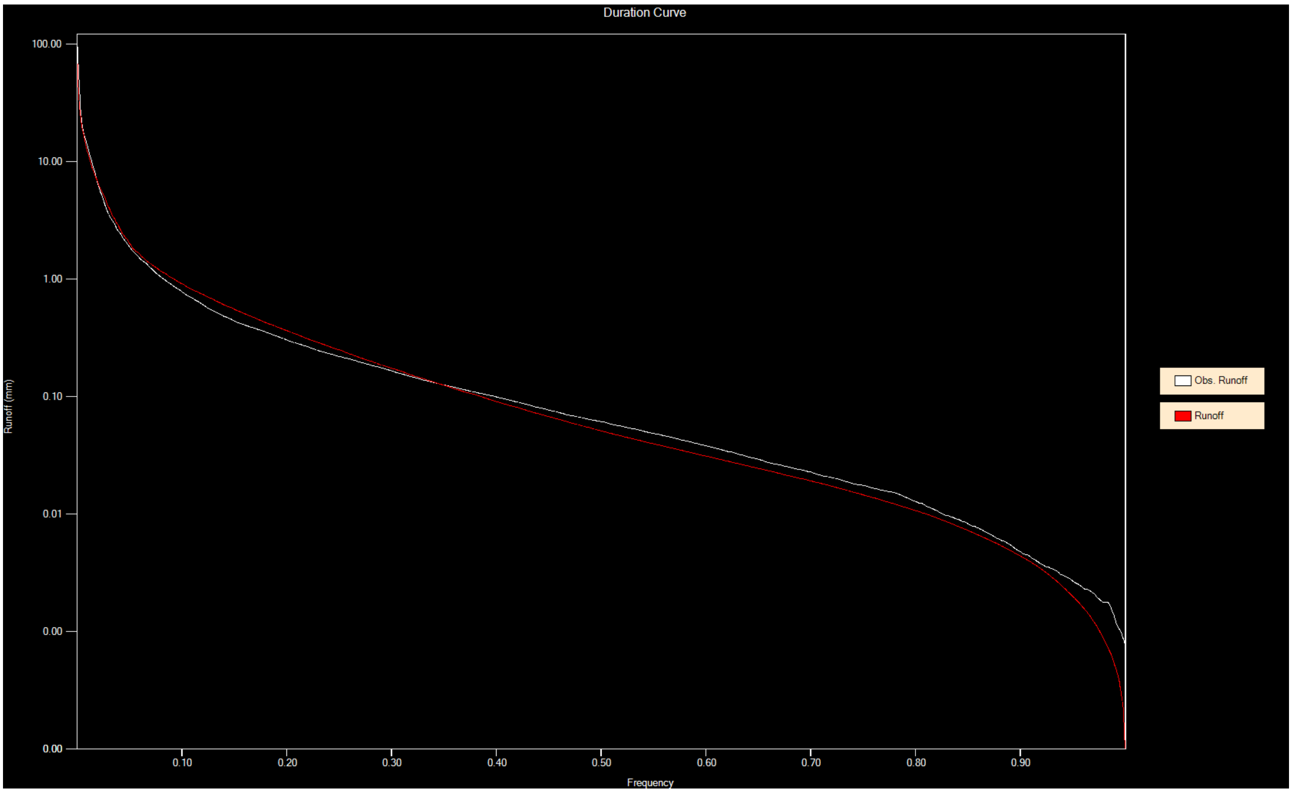

Figure 3-4 Tinana Creek Gauge Calibration Results

Table 3-2 Tinana Creek Calibration Results

Data Range	Recorded Runoff (mm)	Calibrated Runoff (mm)	% Difference
1982-2020	9072	9000	-0.795

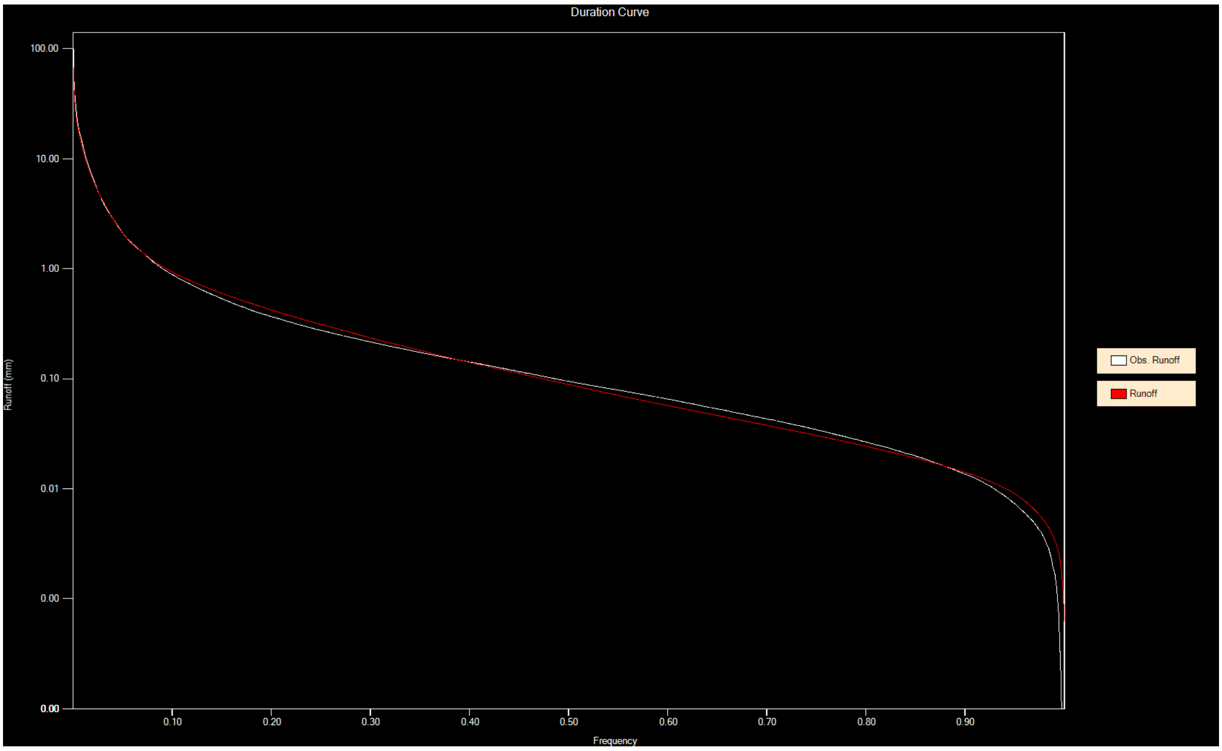

Figure 3-5 Mary River Gauge Calibration Results

Table 3-3 Mary River Calibration Results

Data Range	Recorded Runoff (mm)	Calibrated Runoff (mm)	% Difference
1910-2020	27510	27542	0.115

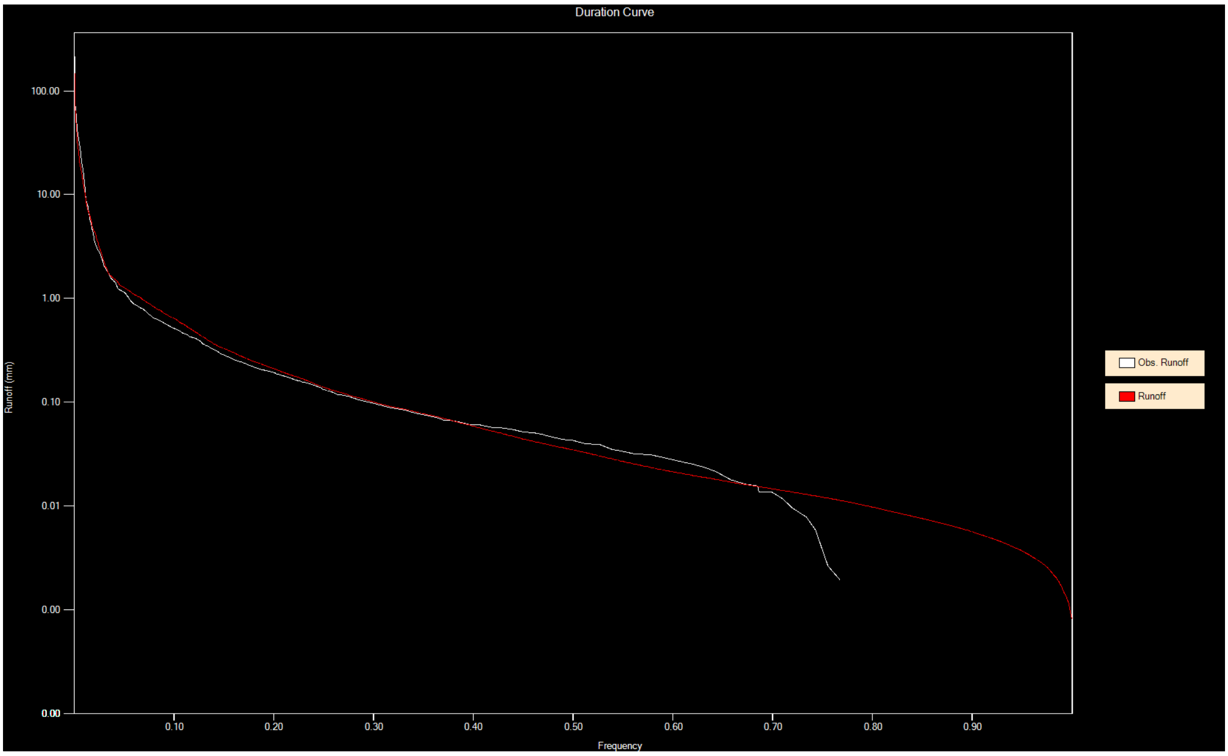

Figure 3-6 Lenthalls Dam Inflow Calibration Results

Table 3-4 Lenthalls Dam Calibration Results

Data Range	Recorded Runoff (mm)	Calibrated Runoff (mm)	% Difference
2009 – 2020	2661	2661	0.026

When comparing the simulated and recorded total runoff generated for each catchment, all systems are within 1% of the recorded value. This demonstrates that the hydrological results estimated using the derived AWBM parameters sets shows an accurate relationship with recorded data for catchment rainfall/runoff response and yield.

It is noted that the AWBM parameter sets derived from this analysis form the initial inputs into the OPSIM model. Upon creation of the OPSIM model, the AWBM parameters may require further adjusting to ensure calibration is achieved to recorded water levels and inflow/outflow behaviour of the major storages within in each.

Table 3-5 Calibrated AWBM Parameter Sets for Fraser Coast Schemes

Parameter	Tinana Gauge	Mary River Gauge	Lenthalls Dam
A1 Partial area of surface store 1 (Proportion of the catchment)	0.134	0.134	0.134
A2 Partial area of surface store 1 (Proportion of the catchment)	0.433	0.433	0.433
A3 Partial area of surface store 1 (Proportion of the catchment)	0.433	0.433	0.433
BFI (Base Flow Index) Proportion of excess runoff going into the base flow store	0.200	0.250	0.850
C1 Capacity surface store 1	9.40	6.1	4.4
C2 Capacity surface store 1	96.5	62.1	44.5
C3 Capacity surface store 1	193	124.1	88.9
KBase (Base flow recession constant) Proportion of moisture depth remaining per time-step	0.963	0.973	0.050
KSurf (Surface flow recession constant) Proportion of moisture depth remaining per time-step	0.660	0.620	0.975

3.3 Hydrodynamic Modelling

OPSIM is a modelling tool used for the operational simulation of water distribution systems. OPSIM has a broad range of in-built hydrological capabilities and features that allows a system to be assessed and analysed while also providing a platform for the operational forecasts of system behaviour. OPSIM simulations can be run on a daily or sub-daily timestep to best represent the degree of output for the study. For this study, a daily time step has been adopted at there is no access to long term sub-daily rainfall data sets.

An OPSIM model has been built to represent the current behaviour and operational performance of the Hervey Bay, Maryborough, and Tiaro systems to determine the current LOS for each system.

3.3.1 OPSIM Model Set up

3.3.2 General Overview

An OPSIM “scenario” is defined as an independent model within the program interface. An OPSIM scenario is made up from nodes, which represent a specific element of the water system. Nodes can be defined as storage, demand, and source nodes, which all have their own characteristics, parameters, and operating rules. Within the scenario, nodes can be interlinked to simulate the behaviour of a system. Nodes respond to factors such as internal node setup conditions as well as external operational rules from connected nodes.

A base case scenario was developed for the year 2015, as this time frame falls mid-way through the recorded historic data sets and provides a reference point for calibration purpose.

The base case scenario comprised of the recorded 2015 demand values, initial water level conditions and the current infrastructure/operating conditions that best represent the system currently. Once this scenario showed strong replication to recorded behaviour within each scheme, it was adapted to develop the scenario for the 2021-2051 time cohorts. The forecast daily demand values were the only factors that changed in the 2021-2051 scenarios.

3.3.3 Data Inputs

Rainfall

In OPSIM, rainfall stations allow for the input of historic daily rainfall data for a specific location. The daily rainfall data is used to calculate the direct rainfall/runoff response for a catchment, based on the selected hydrologic model. Multiple rainfall data sets can be added to a specific catchment node to allow for the weighted application of rainfall to best represent spatial variability in rainfall patterns across the catchment.

For model calibration, the same rainfall runoff sets as used within the rainfall runoff model had been input into the OPSIM. The historic rainfall data is for the time period 1889 to 2020 and provides daily rainfall recordings.

Evaporation Parameter Set

In OPSIM, Evaporation data is used to define the rate of evaporation for a given scenario. Only one (1) evaporation data set can be adopted per scenario and as such an evaporation data set has been generated for the centroid location of all systems. As discussed previously, the evaporation data showed minimal change based on spatial variability within the catchment and therefore a centroid set was deemed appropriate for all three systems.

Using the SILO LongPaddock raw data, an evaporation set has been generated for the centroid locations and provides a continuous sequence of historic daily evaporation and monthly Lake factors.

3.3.4 AWBM Set

The AWBM parameter sets, as estimated within the rainfall runoff toolkit, were adopted as the initial values used within the model to represent each natural catchment. A secondary set of AWBM parameter sets were developed to simulate the response of runoff on a water surface, and have been applied to the storage surface areas.

The rainfall/runoff and water level response generated from these parameters were analysed at the main storages within the system and compared to historic metered data. The parameter sets were adjusted to best simulate the recorded behaviour of the storage under the defined operating conditions. The finals sets adopted within the model are as follows;

Table 3-6 Calibrated AWBM Parameter Sets for Fraser Coast Systems

Parameter	Tinana Gauge	Mary River Gauge	Lenthalls Dam
A1	0.134	0.134	0.134
A2	0.433	0.433	0.433
BFI	0.200	0.250	0.200
C1	9.40	6.10	11.00
C2	96.50	62.10	96.50
C3	193.00	124.10	193.00
KBase	0.963	0.973	0.900
KSurf	0.660	0.620	0.660

It is noted that the parameter sets adopted for the Tinana and Mary River systems are the same as those derived in the eWater runoff kit. The Lenthalls Dam parameter set required adjusting to better replicate the drawdown and recharge response of the Dam.

3.3.5 Operational Criteria

OPSIM simulates the performance of a given system using a set of predefined operating rules and criteria. The instructions define the interaction between nodes and control aspects such as pump/spillway transfer, time-varying releases, and demand management criteria. Based on the provided infrastructure data from FRCR a set of operational criteria were defined for each node. The key operational criteria for each aspect of the system are summarised below.

Table 3-7 Hervey Bay Operational Criteria

Infrastructure	Operating Criteria
Lenthalls Dam	➢ Between October 1 and April 30 and when RL> 23.86m AHD, releases a daily volume equal to the inflow, up to a maximum of 220ML/Day ➢ Between October 1 and April 30, when RL> 23.86m AHD and when inflow is > 5000ML/Day, release a daily volume equal to the inflow ➢ Outside of October – April and when RL > 16m AHD, maintain Burrum Weir 1 at RL 4.80, releasing a max of 220ML/Day ➢ Spillway discharge to Burrum Weir 2 ➢ If volume < 17,660ML, enter water restrictions ➢ Dead Volume 500ML
Burrum Weir 2	➢ Receives inflow from Lenthalls Dam low flow and release and local catchment ➢ Spillway discharge to Burrum Weir 1 ➢ Dead Volume 220ML
Burrum Weir 1	➢ Receives local catchment and overflow from Burrum Weir 2 ➢ Transfer max 25ML/Day to Burgowan WTP ➢ Spillway discharge to Burrum Weir downstream ➢ Dead Volume 638ML
Cassava Dam 1	➢ Transfer max 210L/s to Burgowan WTP, when Burrum Weir 1 is at 700ML ➢ Spillway discharge to Cassava downstream
Burgowan WTP	➢ Transfer volume to keep Hervey Bay Reservoir full, with a maximum of 41ML/Day
Howard WTP	➢ Transfer a maximum of 18ML/Day to Hervey Bay Reservoir when reserve volume falls below designated full volume
Hervey Bay High Priority Restrictions	➢ If Lenthalls >60%, transfer 100% AD from Hervey Bay Reservoir to township ➢ If Lenthalls 45 - 60%, transfer 95% AD from Hervey Bay Reservoir to township ➢ If Lenthalls 30 - 45%, transfer 80% AD from Hervey Bay Reservoir to township ➢ If Lenthalls <30%, transfer 60% AD from Hervey Bay Reservoir to township
Hervey Bay Medium Priority Restrictions	➢ If Lenthalls >60.0%, transfer 100% AD from Hervey Bay Reservoir to township ➢ If Lenthalls 57.5 – 60.0%, transfer 95% AD from Hervey Bay Reservoir to township

	➢ If Lenthalls 55.0 - 57.5%, transfer 90% AD from Hervey Bay Reservoir to township ➢ If Lenthalls 52.5 – 55.0%, transfer 85% AD from Hervey Bay Reservoir to township ➢ If Lenthalls 50.0 – 52.5%, transfer 80% AD from Hervey Bay Reservoir to township ➢ If Lenthalls 47.5 – 50.0%, transfer 75% AD from Hervey Bay Reservoir to township ➢ If Lenthalls 45.0 – 47.5%, transfer 70%AD from Hervey Bay Reservoir to township ➢ If Lenthalls 42.5 – 45.0%, transfer 65% AD from Hervey Bay Reservoir to township ➢ If Lenthalls 40.0 – 42.50%, transfer 60% AD from Hervey Bay Reservoir to township ➢ If Lenthalls 37.5 – 40.0%, transfer 55% AD from Hervey Bay Reservoir to township ➢ If Lenthalls 35.0 – 37.5%, transfer 50%AD from Hervey Bay Reservoir to township ➢ If Lenthalls 32.5 – 35.0%, transfer 45% AD from Hervey Bay Reservoir to township ➢ If Lenthalls 0.0 -32.5 %, transfer 40% AD from Hervey Bay Reservoir to township

Table 3-8 Maryborough Operational Criteria

Node Name	Operating Criteria
Teddington Weir (TW)	➢ Transfer maximum of 15ML/Day to Teddington WTP ➢ Spillway discharge to Tinana Creek downstream ➢ If RL < 7.8m AHD, enter high priority water restrictions ➢ If RL < 7.7m AHD, prohibition on take occurs for medium priority allocation holders ➢ Dead Volume 400ML
Mary Barrage (MB)	➢ If Mary Barrage (MB) >1m AHD, and Teddington Weir (TW) is < 7.96m AHD, transfer 2690ML/annum med priority to TW via Owanyilla Pipeline ➢ If MB >1m, and TW is < 7.96m AHD, transfer 736ML/annum med priority to Tinana Barrage via Owanyilla Pipeline ➢ If MB < 1m, and TW < 7.7m AHD, prohibition on take (POT) of medium priority water. POT removed when MB > 1.2m AHD (for LMRWSS) and 7.7m for TWWSS ➢ If MB >0.5m AHD and TW < 7.7m AHD, transfer 1360ML/annum to TW for high priority use (ensuring level not raised >7.7m, when POT would cease ➢ Maximum transfer rate via Owanyilla pipeline (92ML/Day) ➢ Spillway discharge to Mary River downstream ➢ Dead Volume 220ML
Teddington WTP	➢ Transfer MDMM to Maryborough Reservoir, with a maximum of 22ML/Day
Maryborough High Priority Restrictions	➢ If Teddington Weir > 7.8m AHD, transfer 100% AD from Maryborough Reservoir to township ➢ If Teddington Weir 7.26m – 7.8m AHD, transfer 95% AD from Maryborough Reservoir to township ➢ If Teddington Weir 6.56m – 7.26m AHD, transfer 80% AD from Maryborough Reservoir to township ➢ If Teddington Weir < 6.56m AHD, transfer 60% AD from Maryborough Reservoir to township
Maryborough Medium Priority Restrictions	➢ If Teddington Weir > RL 7.7m AHD, transfer 100% medium priority allocation permitted ➢ If Teddington Weir < RL 7.7m AHD, stop medium priority take

Table 3-9 Tiaro Operational Criteria

Node Name	Operating Criteria
Tiaro Informal Storage (TW)	➢ Transfer maximum of 1.2ML/Day to Tiaro WTP ➢ Discharge to Mary River
Tiaro WTP	➢ Transfer volume to keep Tiaro Reservoir full, with a maximum of 1ML/Day
Tiaro High Priority Restrictions	➢ If Mary Barrage > 1.5m AHD, transfer 100% AD from Maryborough Reservoir to township ➢ If Mary Barrage is 1.0m AHD, transfer 95% AD from Maryborough Reservoir to township ➢ If Mary Barrage <1.0m AHD and flowing, transfer 80% AD from Maryborough Reservoir to township ➢ If Mary Barrage < 1.0m AHD and not flowing, transfer 60% AD from Maryborough Reservoir to township. It is noted that the trigger level for level 3 and 4 water restrictions for the Mary Barrage are currently set at the same water level (RL 1.0m AHD) and is distinguished only by the visual condition of the river at the time. For modelling purposes, the results for frequency and duration Level 3 and 4 restrictions will be the same as post processing is generated from the water level within the storage. Ultimately it is the decision of WBWC on whether Level 3 or 4 restriction are entered

3.5 OPSIM Analysis

3.5.1 Calibration

An OPSIM scenario was developed for the year 2015 and was used to carry out calibration against recorded data for each system. Factors such as historic water levels within each system, and periods of water restrictions where the key factors used in the calibration process for each system. Recorded data on water levels and metered production rates were provided by FCRC from 2010 to 2020.

The 2015 scenario was run under historic simulation conditions for the 2010-2020 time frame to best match the availability of historic recorded data. The 2015 demands, as provided by FRCR, were deemed a good average value to adopt for the 2010 to 2020 periods. In OPSIM, a “historic simulation” extracts the recorded rainfall and evaporation data for the specified time frame and simulates the performance of the system on a specified time step.

In general, there was a good correlation achieved between the historic and simulated water levels within each storage. There were a range of factors which limited the calibration process and were primarily in relation to the reliability of the supplied data for recorded peak water levels and stage storage information/hydraulic outlet configuration. It is noted that the hydraulic characteristics of the storages have been modelled as per the provided data outlined in Section 2. As such, the AWBM parameters set derived from the Rainfall Runoff Toolkit where the only factor adjusted to achieve a better match of simulated to recorded data.

The calibration focussed largely on ensuring that the drawdowns within the storages, which correspond to the system entering water restrictions, have been replicated as best as possible with the available data. The minor drawdowns throughout the period show some deviation from the recorded data however it is to be noted that our system models at a constant daily demand leaving the storage, whereas the real life demand from the system would fluctuate considerably, which has been confirmed by the review of the raw water extraction rates. As the performance of the storage at full supply level is not critical to this study, minor deviations in this region are not deemed significant.

It is noted that there are large difference between the recorded and simulated maximum water levels within all storages following significant afflux of water into the storage resulting from large rainfall events. Based on the extreme peaks shown in the recorded data, it is likely that the maximum instantaneous water levels within the storage for any given days have been captured in the historic data sets. It is noted that the calibrated AWBM parameter set and OPSIM model are simulated on a daily time step, and capture the average performance of the system throughout the day, which is deemed to be more representative of the total flow rate passing through the storage for a given time and not related to the available storage remaining after the event. As such, any deviation in the peaks above storage spillway level have not been deemed significant.

3.5.1.1 Lenthalls Dam Calibration

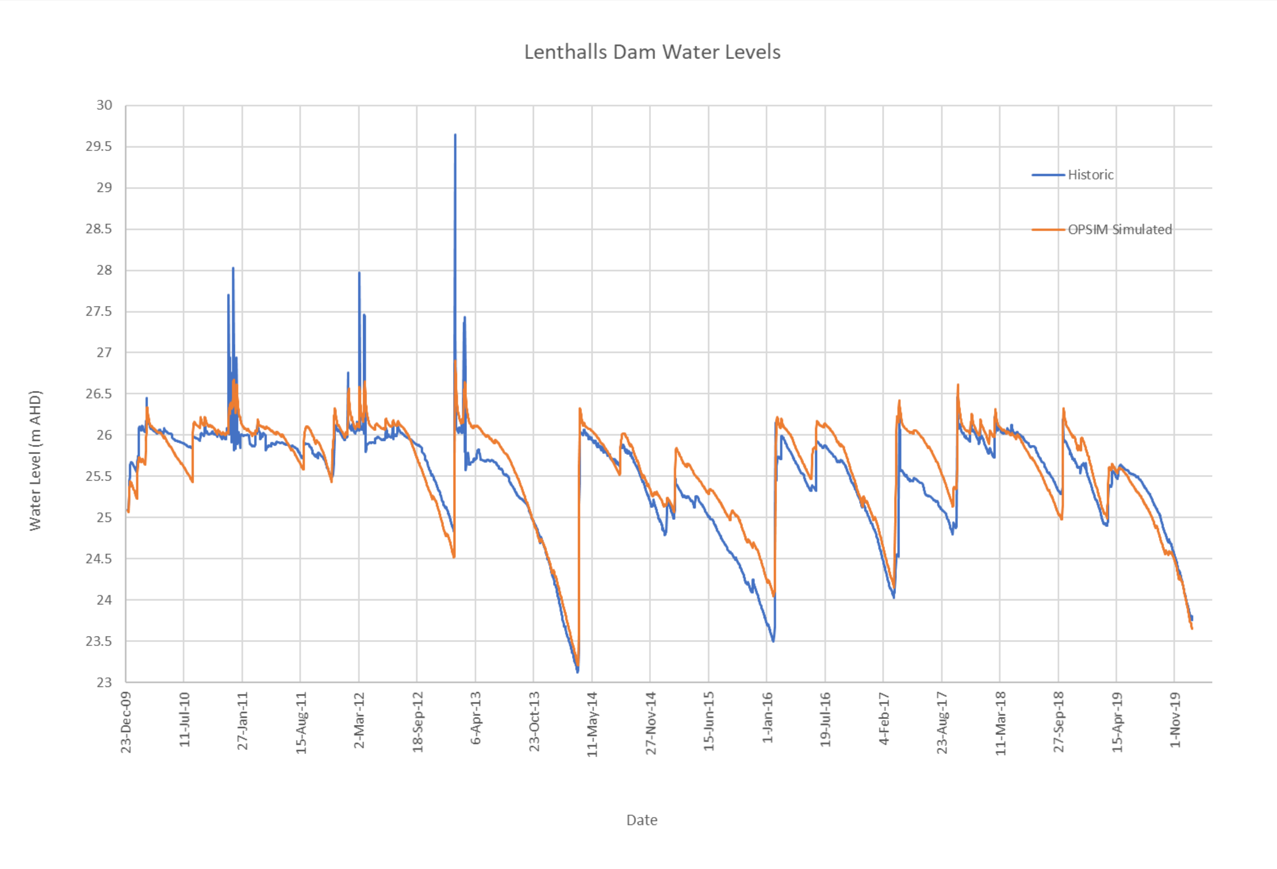

Figure 3-7 Lenthalls Dam Calibration Results (OPSIM)

The historic water levels within Lenthalls Dam for the 2009 -2020 timeframe (post dam upgrade) are illustrated in Figure 3-7. As can be seen, the storage generally shows a cyclical nature that corresponds to a seasonal rainfall year. The storage is relatively responsive to rainfall, with wet season inflows resulting in a recharge of the storage followed by a gradual drawdown outside of this period. There have been three (3) major drawdowns resulting in water restrictions being triggered in the past 10 years (2013, 2016, 2019) which have corresponded to a reduced/delayed wet season inflow.

The calibration results for Lenthalls Dam generally replicate the recorded water level within the storage over the 2010-2020 period. It is noted that after large peaks in the water levels above the spillway, the gates generally drop (shown by sharp decreased in the water levels). This was unable to be captured within the model, which can be seen by the slower initial draw down in the OPSIM simulated results. However, after the initial drop, the draw down gradients generally match that of the recorded data set and reached the same low levels within the dam which corresponded to entering water restrictions. The OPSIM simulated results strongly replicate the performance of Lenthalls Dam for the past 10 years, providing confidence that the model is fit for purpose to carry out the system review and assessment.

3.5.1.2 Teddington Weir Calibration

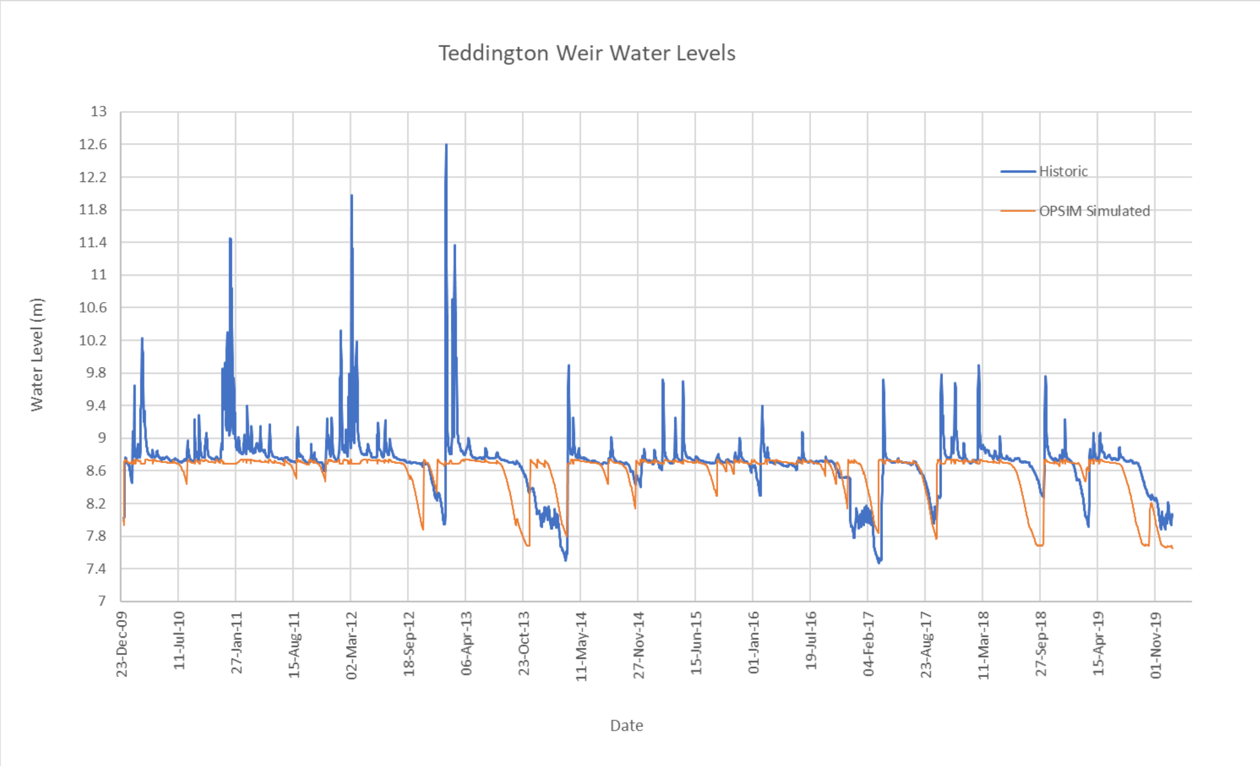

Figure 3-8 Teddington Weir Calibration Results (OPSIM)

The historic water levels within Teddington Weir for the 2009 -2020 timeframe are illustrated in Figure 3-8. As can be seen, the weir generally shows a cyclical nature that corresponds to a seasonal rainfall year. Being situated on the Tinana River, the weir is very responsive to rainfall, with wet season inflows resulting in a recharge/exceedance of the full supply level of the weir (RL 8.7m AHD). In general, the water levels within the weir remain at near full capacity, with drawdowns being recharged by the subsequent seasonal inflow. There have been two (2) major drawdowns resulting in water restrictions being triggered in the past 10 years (2013, 2016) which have corresponded to a reduced/delayed wet season inflow. The duration of time within water restrictions have historically been less than two months.

The calibration results for Teddington Weir generally replicate the recorded water level within the storage over the 2010-2020 period. It is noted that occurrences of extreme water level drawdowns and peaks within the Teddington Weir were unable to be captured in the OPSIM model. Examples of this include a 400ML daily draw down in Teddington Weir in January 2016 in conditions where the water level was below the spillway. Further examples include significant peaks in water level above the spillway in the recorded data set based on maximum recorded values, which based on the daily time step and spillway configurations within OPSIM, where also not able to be captured.

Other key differences between the recorded and simulated water levels include a timing shift in some of the draw downs. Reasons for this include the daily model time step, which may not fully capture long term base flow/recharge of the Teddington Weir and discrepancies between the LongPaddock and BOM recorded data during these times. However, the strong hydrological calibration for catchment yield (mm runoff) and the consistent draw down gradients between the recorded and OPSIM results, provided the degree of confidence to utilise the model to conduct the system review and assessment.

3.5.1.3 Mary Barrage Calibration

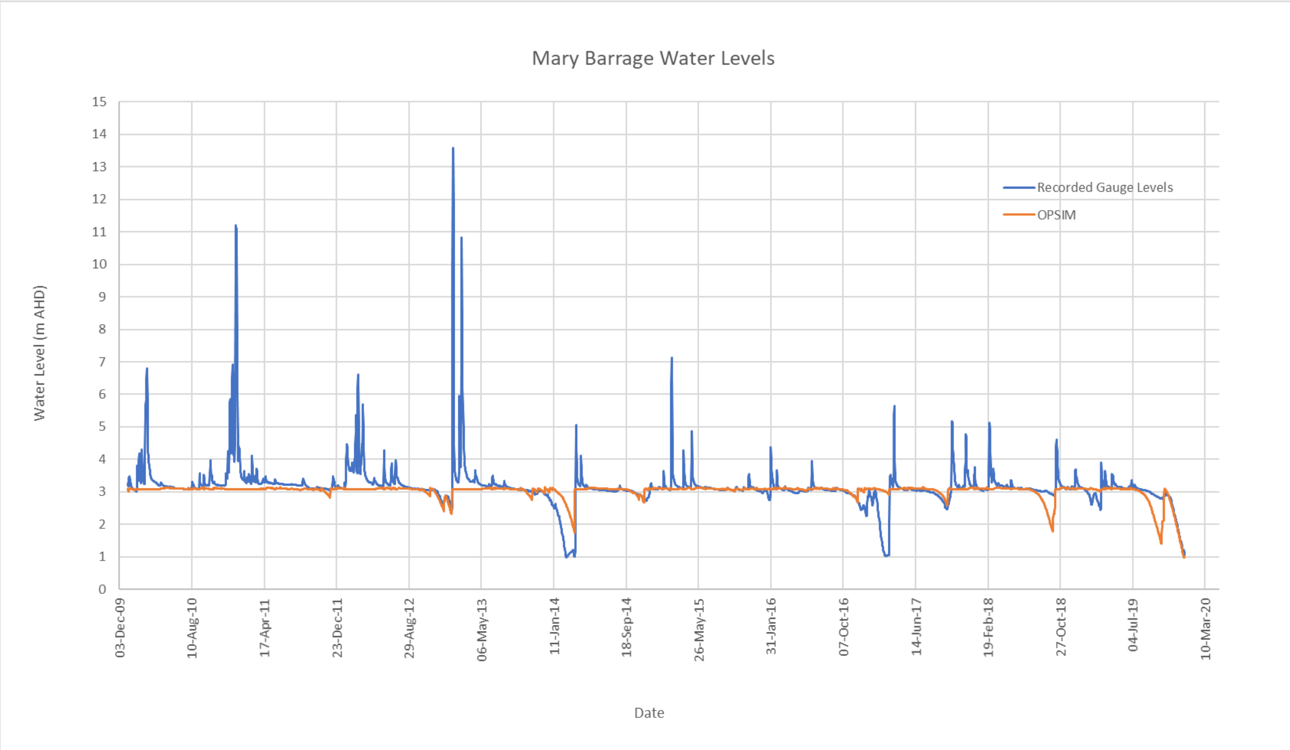

Figure 3-9 Mary Barrage Calibration Results (OPSIM)

The historic water levels within the Mary Barrage for the 2009 -2020 timeframe are illustrated in Figure 3-9. Situated along the Mary River, the Barrage generally remains near full supply capacity (RL 3m AHD) with wet season inflows well exceeding the spillway level. The strong base flow component of the Mary River results in a reliable water supply source for the scheme. There have been three (3) major drawdown events resulting in water restrictions being triggered in the past 10 years (2013, 2016, 2019) which have corresponded to a reduced/delayed wet season inflow. Although water restrictions have historically been triggered within the storage, the duration of these occurrences are relatively brief, due to the reactive nature of the catchment to rainfall events.

An accurate calibration of the Mary Barrage was difficult to carry out due to the lack of stage storage data, uncertainty around the high/medium demands on the system and the absence of reliable long term recorded water levels within the Barrage. In general, the draw down in most occurrences was reflective of the recorded gauge data.

The largest variability in the results for the calibration are in the timing/magnitude of drawdowns. It is noted that the Mary Barrage supplies mainly to medium priority allocations holders, which are not consistent demands on the system. This is demonstrated by occurrences of sharp reduction in water levels as seen in January 2014 and November 2016. As the OPSIM model simulates an average removal of allocations throughout the year, the simulated results do not capture this. The OPSIM simulated results provided replication the performance of the Mary Barrage, providing confidence that the model is fit for purpose to carry out the system review and assessment.

3.5.2 System Review and Assessment

The historic performance of the storages replicated in the calibration model provides an insight into water supply reliability of the systems based on previous climatic data and demands. However, the historical performance cannot predict the system response to future climatic data which has not yet been experienced. To predict the system performance in the future, both changing demands and a wider range of climatic data has been incorporated into the modelling.

3.5.2.1 Stochastic Modelling for Climatic Data

The long-term climatic data sets publicly available span for a time frame of 130 years. Using the stochastic modelling platform within eWater's Stochastic Climate Library (SCL), the 130 year data set was utilised to generate climatic data for a 1,000 year time frame. The climatic data sets where generated for the centroid location of all Fraser Coast Schemes.

Stochastically generated data sets provide alternative realisations that are likely to occur based on the historic data sets characteristics (in terms of mean, variance, skew, and long-term persistency) to predict future climatic variability. To capture sampling variability, 100 replicates of the 1,000 year dataset were generated. The replicate that was deemed to present the median data set of the 1,000 years was utilised in the OPSIM modelling as it represents the centre of the data. The median data set was selected from sorting parameters of average annual rainfall conditions and further refined by reviewing dry days within the data set.

3.5.2.2 Model Overview

The model operates by analysing the system for each five year cohort from 2021-2051 (e.g. 2021, 2026, 2031) for the entire long term stochastically generated climatic data set. For each time cohort, the model generates the predicted system behaviour if the forecast 1,000 years of climatic data where to occur.

The current system performance will be defined by determining the frequency and duration of Level 1 – 4 water restrictions, dead volume, and supply shortfall, using Average Recurrence Intervals (ARI). ARI's provide the frequency of occurrence (1 in X years) of when a particular event is to occur.

Due to the 1,000 year climatic dataset, the model performance is limited to ARI estimates of 1 in 1,000 years. It is noted that to generate data sets to account for a large ranger in probabilities, i.e. a 1 in 10,000 year drought event would require stochastic modelling outside of the current extrapolation range capable within the eWater platform. As with the 1,000 year data set, the results are artificially generated and provide estimates of future climatic variability only. As such, the 1,000 year data set is deemed to provide an adequate risk profile to define current and future LOS for the Fraser Coast Scheme.

3.5.2.3 Model Results

Each system was simulated for the predicted increasing demands from 2021- 2051 using a long-term climatic data set. For each five year cohort representing an increase in demand, the following information about the scheme performance was ascertained;

- The average recurrence interval (ARI) at which Levels 2-4 water restrictions could be expected to be triggered based on stochastic generated climatic data.
- The average recurrence interval (ARI) the storage might fall to minimum operating level (dead storage).
- The average recurrence interval (ARI) each scheme might experience water supply shortfalls.

ARI's are calculated based from the number of occurrences of an event within the simulation period. For each system, an occurrence has been defined as when a trigger level is engaged for more than a day.

3.5.2.4 Hervey Bay

The storage volume of Lake Lenthall throughout the 1,000yr simulation period, for the current (2021) scenario, is illustrated in Figure 3-10 and represents the current performance of the storage with current demands.

The forecast performance of the Hervey Bay system for the 2021 – 2051 timeframe is shown in Figure 3-11. Table 3-10 summarized the current LOS for the Hervey Bay system when compared to the predicted 2051 LOS.

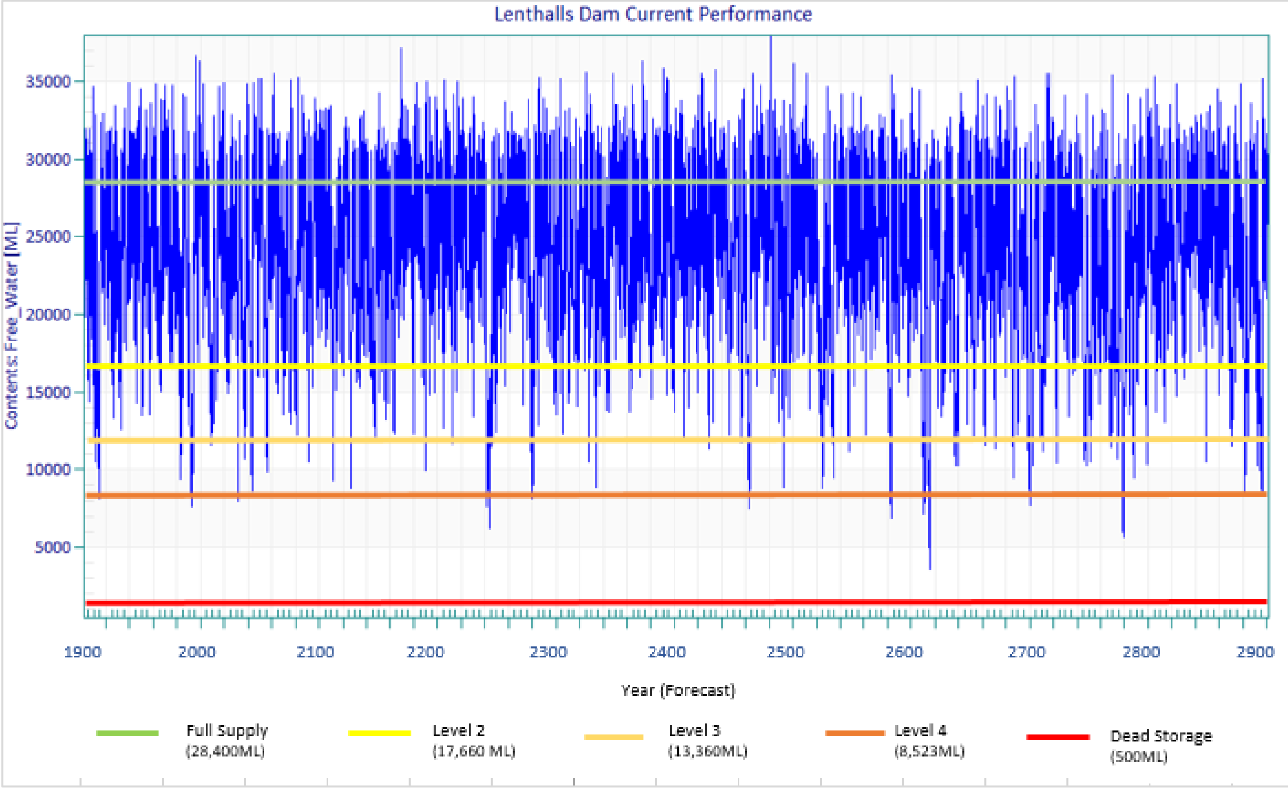

Figure 3-10 Storage volume of Lake Lenthall over 1,000yr simulation period (current scenario)

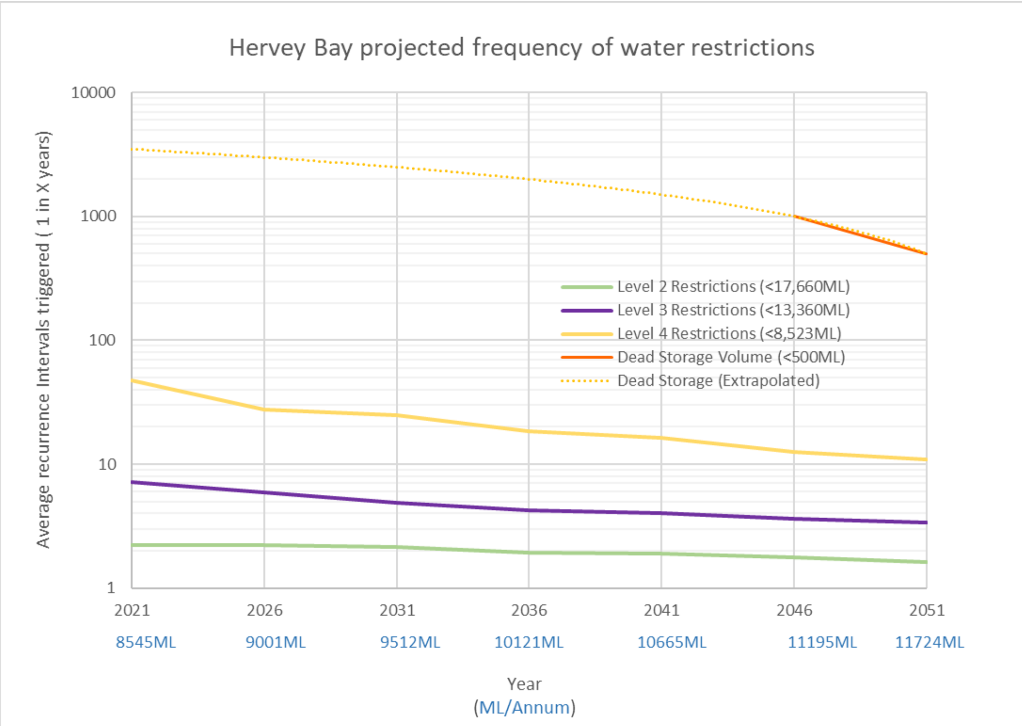

Figure 3-11 Frequency of water restriction and supply shortfall compared to total annual demand

Table 3-10 Summary of current and 2051 LOS for Hervey Bay

	Level 2 (ARI)	Level 3 (ARI)	Level 4 (ARI)	Dead Volume (ARI)	Supply Shortfall (ARI)
Current LOS	3	7	48	4,000	>1,000
2051 LOS	2	4	11	500	>1,000

The number of occurrences in which Level 1-4 water restrictions where triggered in the current system (as shown in Figure 3-10) where converted to ARI's. This same process was conducted for each 5 year time cohort to 2051.

The results in Figure 3-11 illustrates that as the demands within the system increase, there is a consequent reduction in ARI, indicating an increased frequency of water restrictions. The results predict that by 2051 the frequency of Level 2 water restrictions will increase to 1 in 2 years, when compared to the current (2021) frequency of 1 in 3 years. Level 4 water restrictions are anticipated to increase to a 1 in 11 year frequency by 2051, when compared to the current 1 in 50 year occurrence.

It is noted that based on the long-term climatic data set, Lake Lenthall does not reach the dead storage volume until 2046, with results prior to this being extrapolated. The likelihood of Lake Lenthall experiencing a water supply shortfall was not encountered in the modelling, indicating a recurrence interval greater than 1 in 1,000 years.

In addition to the frequency of water restriction occurrences, the duration of time spent in water restrictions comprises another aspect that contributes to determining the level of service for a system.

Figure 3-12 displays the simulated numbed of occurrences over the 1,000 period in which Hervey Bay is anticipated to experience Level 2 water restrictions. The results indicate that as the demands on the system increase, the duration of time spent in water restrictions also increases for periods of 1 month, 3 months and 6 months. A comparison between the 2021 (current) and 2051 results are summarized in Table 3-11. The same information is displayed in Figure 3-13 and Table 3-12 for Level 4 water restrictions.

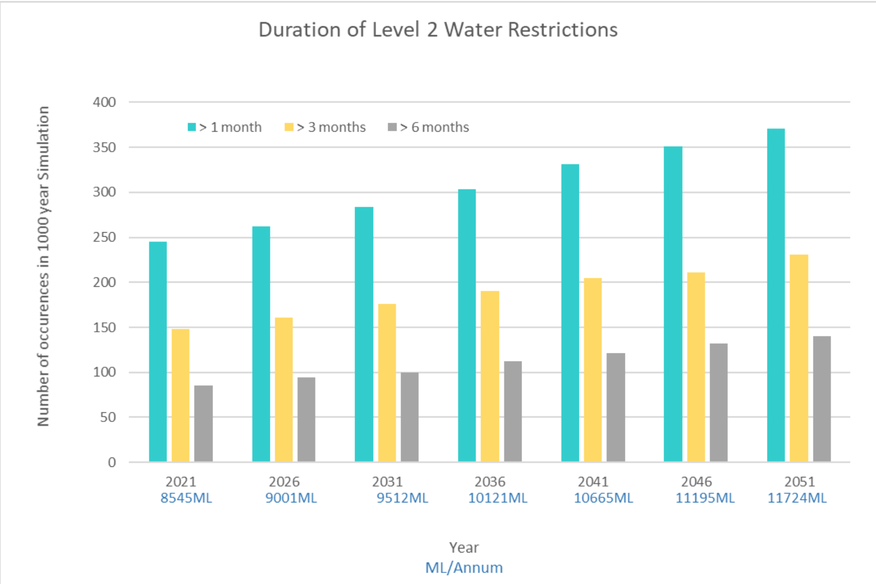

Figure 3-12 Number and duration of level 2 water restrictions

Table 3-11 Summary of current and 2051 LOS for Hervey Bay Scheme (Level 2 Restrictions)

	>1 month	>3 months	>6 months
Current LOS	245 occurrences	148 occurrences	85 occurrences
2051 LOS	371 occurrences	234 occurrences	140 occurrences

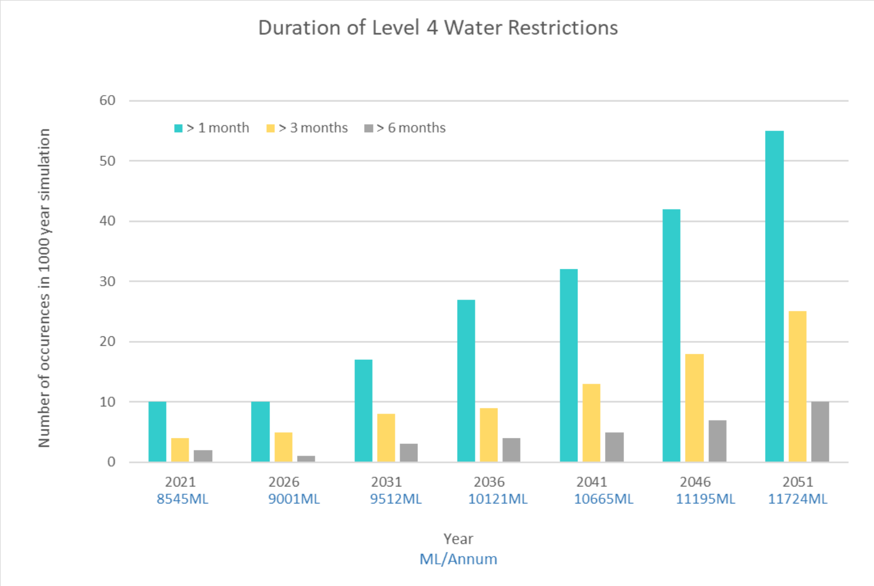

Figure 3-13 Number and duration of level 4 water restrictions

Table 3-12 Summary of current and 2051 LOS for Hervey Bay Scheme (Level 4 Restrictions)

	>1 month	>3 months	>6 months
Current LOS	10 occurrences	4 occurrences	2 occurrences
2051 LOS	55 occurrences	25 occurrences	10 occurrences

Similar observations exist for the duration of Level 4 water restrictions, with an increase in occurrences observed from the current to 2051 time cohort. The results in Figure 3-13 indicate that although Level 4 water restriction are anticipated to occur in the future, the duration of restrictions will generally be for duration of less than 6 months.

3.5.2.5 Maryborough

The water levels within Teddington Weir throughout the 1,000yr simulation period, for the current (2021) scenario is illustrated in Figure 3-14 and represents the current performance of the storage with current demands.

The forecast performance of the Maryborough system for the 2021 – 2051 timeframe is shown in Figure 3-15. Table 3-13 summarized the current LOS for the Maryborough system when compared to the predicted 2051 LOS.

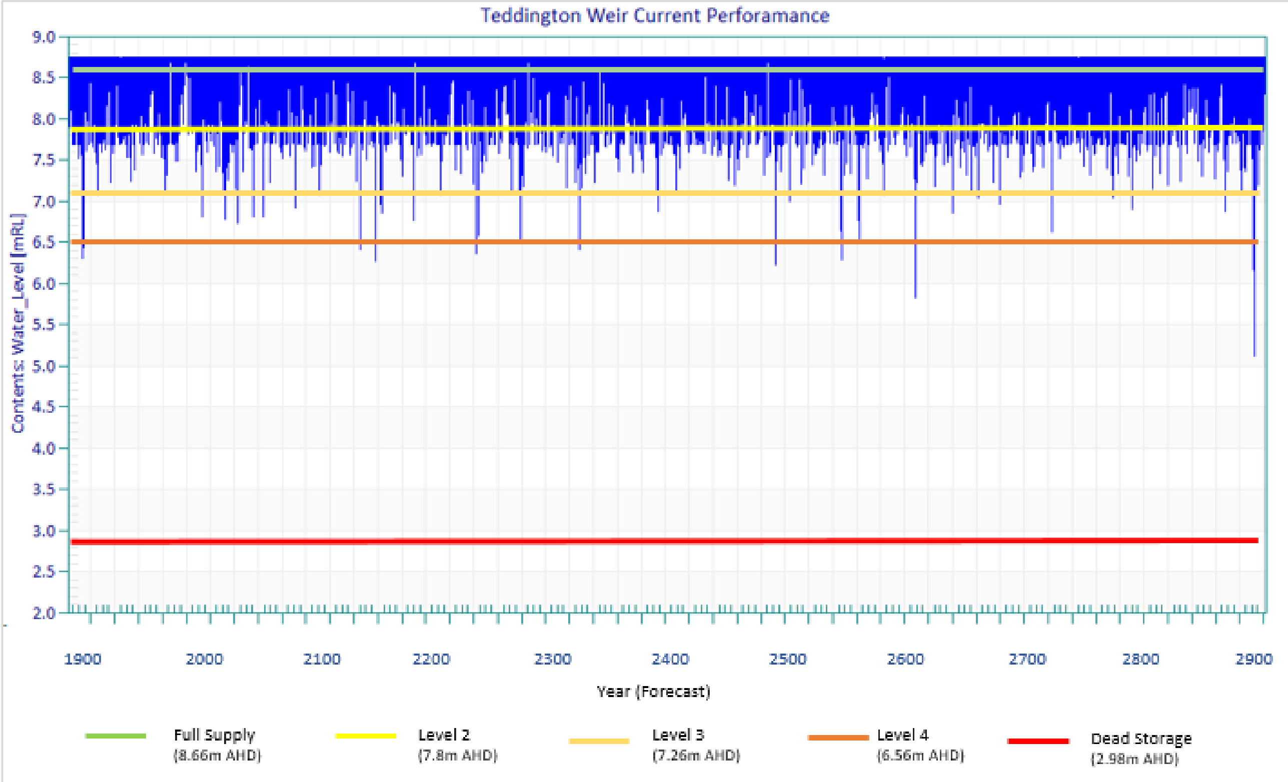

Figure 3-14 Water levels within Teddington Weir over 1,000yr simulation period (current scenario)

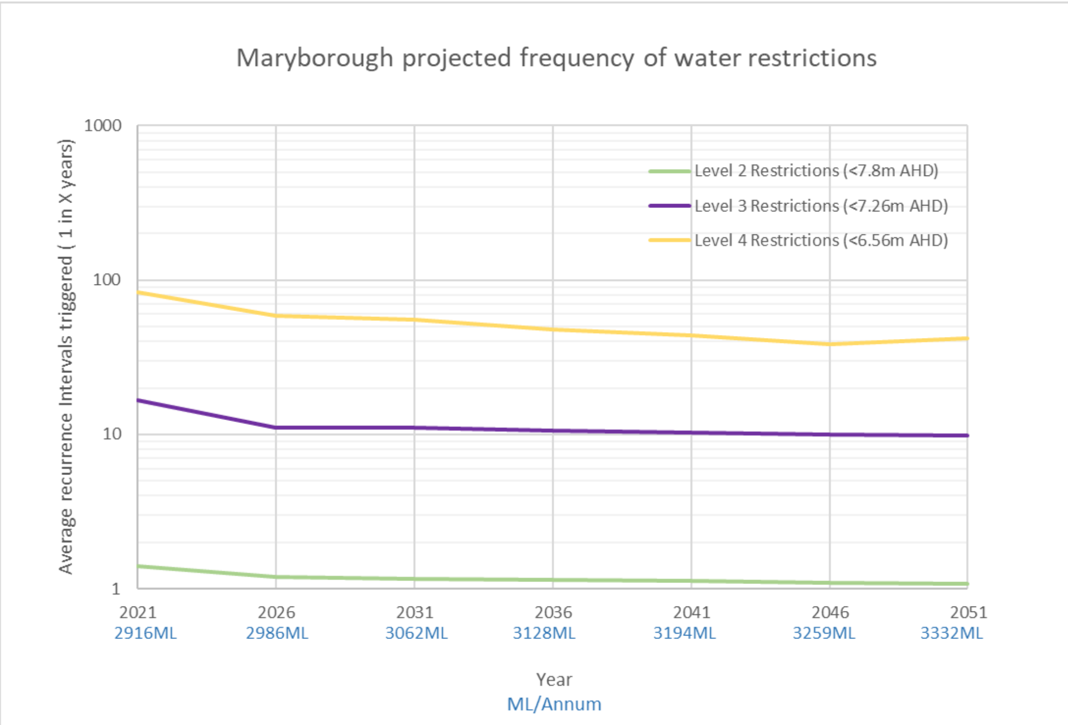

Figure 3-15 Frequency of water restriction and supply shortfall compared to total annual demand

Table 3-13 Summary of current and 2051 LOS for Maryborough

	Level 2 (ARI)	Level 3 (ARI)	Level 4 (ARI)	Dead Volume (ARI)	Supply Shortfall (ARI)
Current LOS	2	17	83	>1,000	>1,000
2051 LOS	1	10	42	>1,000	>1,000

The results predict that by 2051 the frequency of Level 2 water restrictions will increase to 1 in 1 year (i.e. every year), when compared to the current (2021) frequency of 1 in 2 years. Level 4 water restrictions are anticipated to increase from 1 in 83 years to 1 in 42 years.

The simulated results predicted that Teddington Weir would not reach the dead storage volume, or experience a water supply shortfall for a duration based on the current demands. The likelihood of these events occurring are greater than the 1 in 1,000 year event.

Figure 3-16 displays the simulated numbed of occurrences over the 1,000 period in which Maryborough is anticipated to experience Level 2 water restrictions. The results indicate that as the demands on the system increase, the duration of time spent in water restrictions also increases for periods of 1 month, 3 months and 6 months. A comparison between the 2021 (current) and 2051 results are summarized in Table 3-14. The same information is displayed in and Figure 3-17 and Table 3-15 for Level 4 water restrictions.

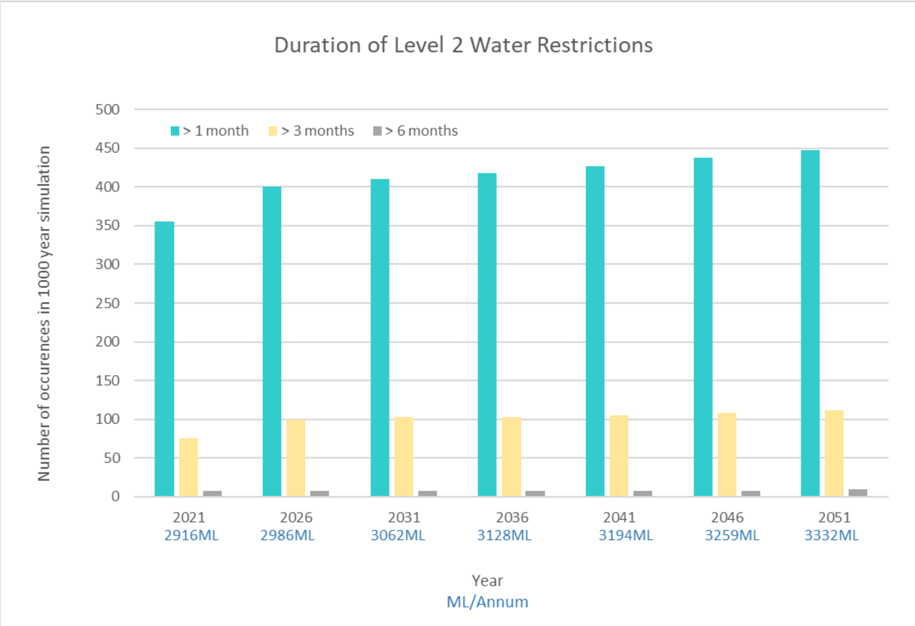

Figure 3-16 Number and duration of level 4 water restrictions

Table 3-14 Summary of current and 2051 LOS for Maryborough Scheme (Level 2 Restrictions)

	>1 month	>3 months	>6 months
Current LOS	355 occurrences	76 occurrences	7 occurrences
2051 LOS	448 occurrences	112 occurrences	10 occurrences

The number of occurrences spent in Level 2 water restriction for durations greater than 6 months are infrequent, indicating that Teddington Weir is generally recharged in a short time frame after water restrictions are implemented.

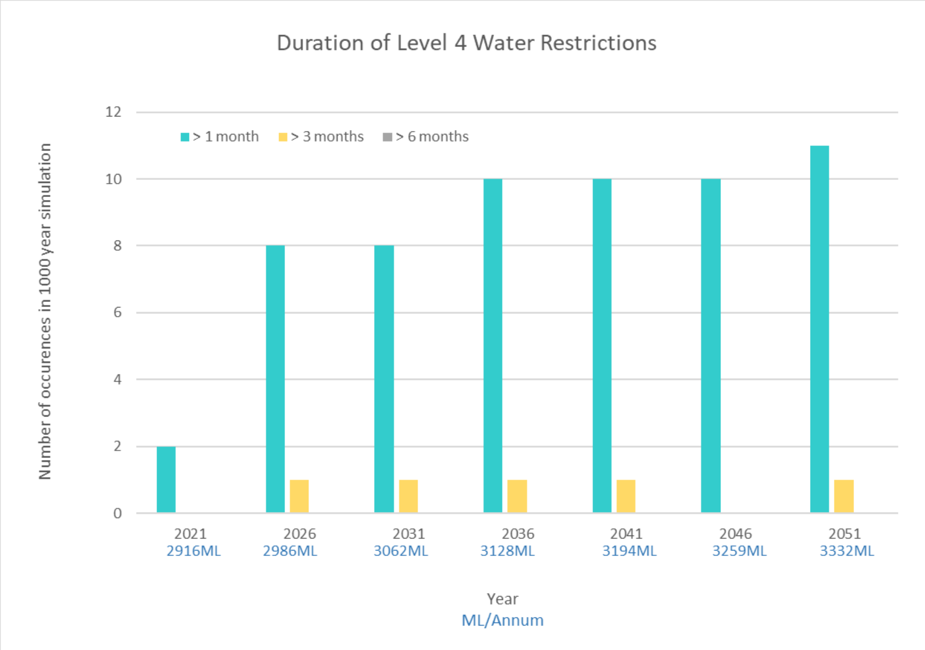

Figure 3-17 Number and duration of level 4 water restrictions

Table 3-15 Summary of current and 2051 LOS for Maryborough Scheme (Level 4 Restrictions)

	>1 month	>3 months	>6 months
Current LOS	2 occurrences	0 occurrences	0 occurrences
2051 LOS	11 occurrences	1 occurrence	0 occurrences

Teddington Weir is currently anticipated to trigger Level 4 water restriction once in every 83 years. When Level 4 restrictions are entered, the duration of occurrence is only for 30 days, indicating that the system recovers to Level 3 restrictions or better in a short time frame. In 2051, there is only anticipated to be one occurrence of Level 4 water restrictions for greater than 3 months.

3.5.2.6 Tiaro

The water levels within the Mary Barrage throughout the 1,000yr simulation period, for the current (2021) scenario is illustrated in Figure 3-18and represents the current performance of the storage with current demands. The forecast performance of the Tiaro system for the 2021 – 2051 timeframe is shown in Figure 3-19. Table 3-16 summarized the current LOS for the Tiaro system when compared to the predicted 2051 LOS.

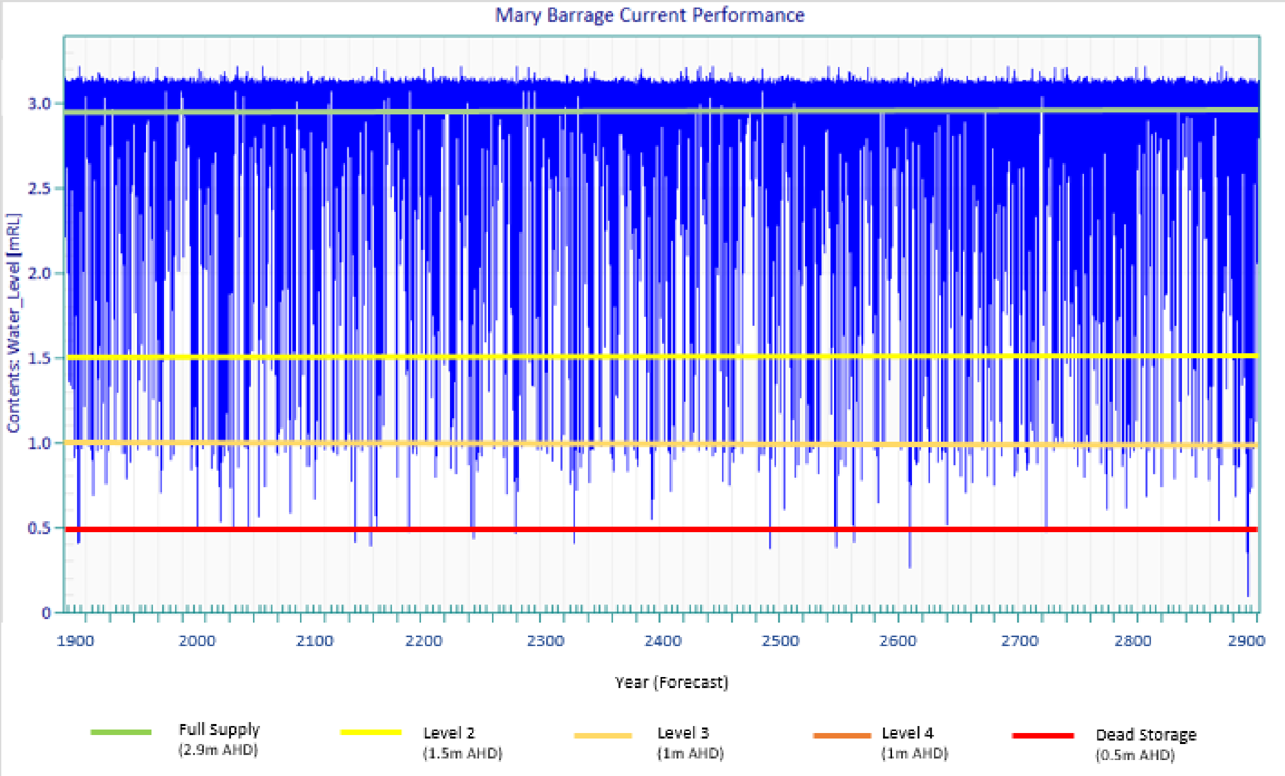

Figure 3-18 Water levels within Mary Barrage over 1,000yr simulation period (current scenario)

Refer to Figure 3-18 for the summary of results for the performance of the scheme from 2021- 2051. The results illustrate that there is no change in frequency of water restrictions from now to 2051, based on the predicted demands on the system. In comparison to the volume allocation held by SunWater customers for the Mary River, the demands of the Tiaro townships are relatively insignificant for the system. As such, the current performance of the Mary River is not anticipated to be impacted by the increasing demands projected for Tiaro.

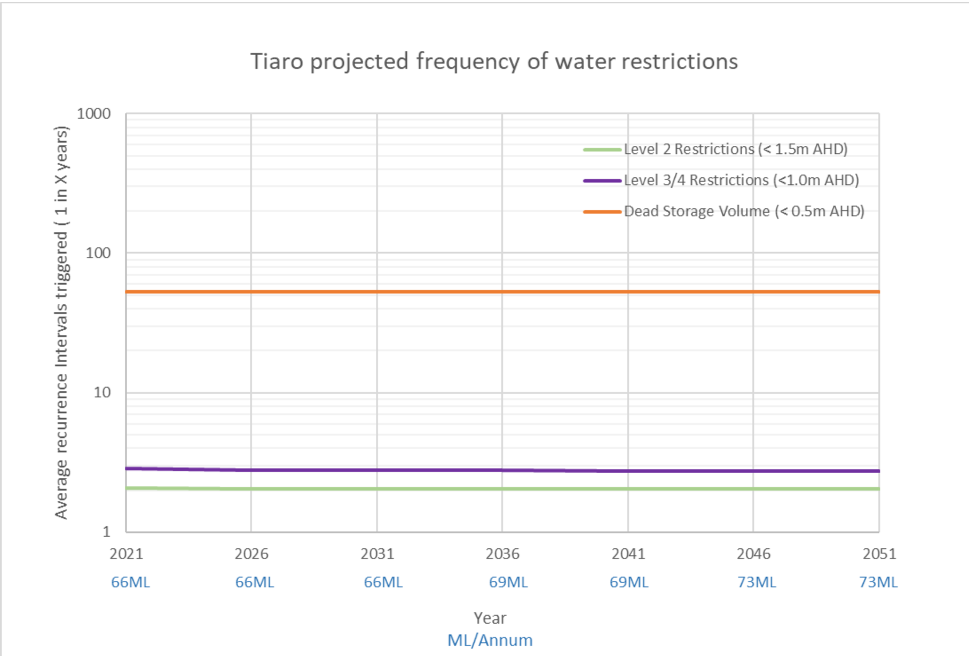

Figure 3-19 Frequency of water restriction and supply shortfall compared to total annual demand

Table 3-16 Summary of current and 2051 LOS for Tiaro

	Level 2 (ARI)	Level 3/4 (ARI)	Dead Volume (ARI)	Supply Shortfall (ARI)
Current LOS	2	3	52	>1,000
2051 LOS	2	3	52	>1,000

Modelling indicates that the Mary Barrage enters Level 2 water restrictions once in every 2 years and Level 3/4 water restrictions once in every 3 years. Although the occurrence of restrictions appear relatively frequent, this is largely influenced by the timing of when third party irrigators harvest water from the system. Based on historic behaviour, when allocations are taken from the system, this generally corresponds with entering both level 2 and 3 water restrictions, based on the small volume difference between the current triggers levels. Once allocations have been drawn from the system, the Mary Barrage generally recovers to levels of near fully supply capacity.

Based on the long-term climatic data set, the Mary Barrage is predicted to reach the dead storage volume once in every 50 years. This does not correspond to a water supply shortfall for the Tiaro scheme due to the adequate informal storage volume available at the offtake location.

Refer to Figure 3-20 for the number and duration of Level 2 water restrictions within the Mary Barrage from 2021 – 2051. A comparison between the 2021 (current) and 2051 results are summarized in Table 3-17. The same information is displayed in and Figure 3-21 and Table 3-18 for Level 4 water restrictions.

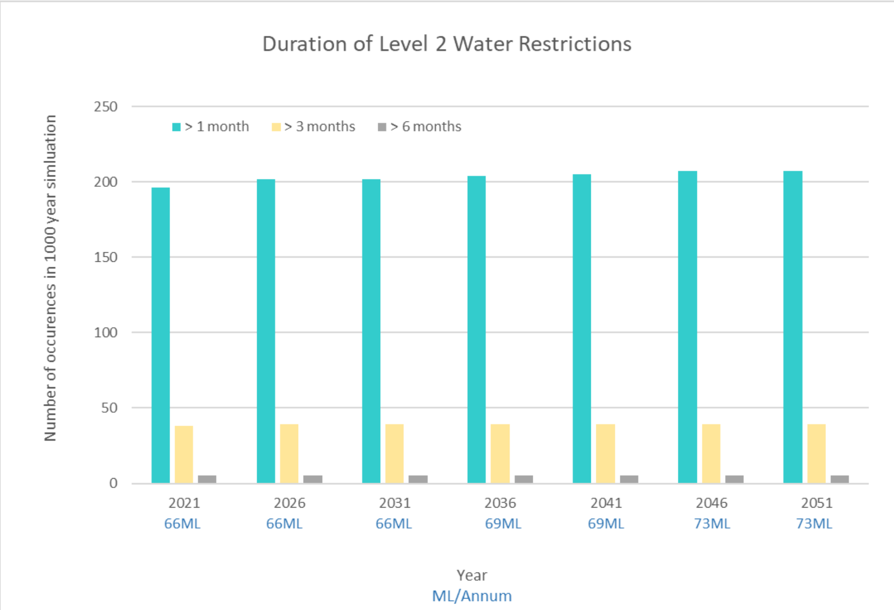

Figure 3-20 Number and duration of level 2 water restrictions

Table 3-17 Summary of current and 2051 LOS for Tiaro Scheme (Level 2 Restrictions)

	>1 month	>3 months	>6 months
Current LOS	2 occurrences	0 occurrences	0 occurrences
2051 LOS	11 occurrences	1 occurrence	0 occurrences

Figure 3-20 displays the simulated numbed of occurrences over the 1,000 period in which Tiaro is anticipated to experience Level 2 water restrictions. The results indicate there is minimal to no change in the number of occurrences for durations greater than 1 month - 6 months from now to 2051. As mentioned previously, this is due to the Tiaro township demands being relatively insignificant for the Mary River.

There is five (5) occurrence of Level 2 water restriction being entered for greater than 6 months, indicating that the Mary Barrage is generally recharged in a short time frame after water restrictions are implemented.

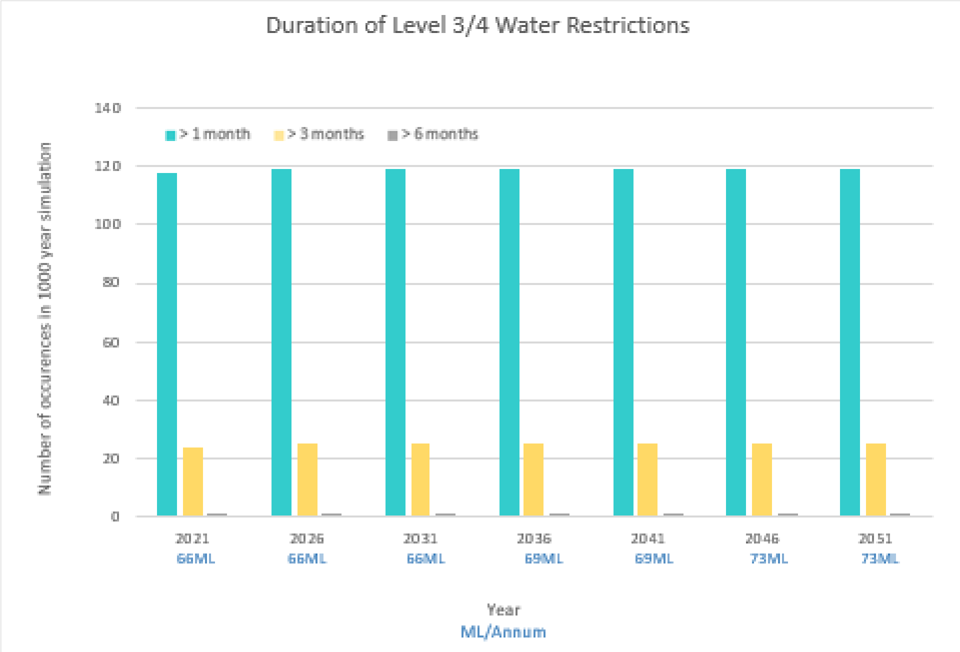

Figure 3-21 Number and duration of level 4 water restrictions

Table 3-18 Summary of current and 2051 LOS for Tiaro Scheme (Level 4 Restrictions)

	>1 month	>3 months	>6 months
Current LOS	2 occurrences	0 occurrences	0 occurrences
2051 LOS	11 occurrences	1 occurrence	0 occurrences

Although the Mary Barrage enters Level 4 water restrictions once in every 3 years, the duration of time spent in Level 4 restrictions is generally only for periods of 1 month. The current POT for third part allocation holders coincides with the trigger level for of Level 4 water restrictions. As such, when Level 4 restrictions are entered, the major demand on the system (third priority water) is removed, and the system rapidly recovers to Level 2 restrictions or better in a short time frame.

Based on the frequency and duration of water restrictions currently exhibited for the Mary Barrage, the system is not impacted by the current of future demands for Tiaro township and is largely influenced by the regime of harvest from SunWater allocation holders.

4 Sensitivity Analysis

The initial assessment of the existing system was carried out using population growth rates that were provided from FCRC. It is understood that the growth rates generated by FCRC, and applied in the hydrodynamic modelling, were adapted from the published data within *Queensland Government population projections 2018.*

It noted that there were minor changes applied by FCRC in determining the growth rates used to calculate the forecast population for the 2021-2046 time cohorts.

4.1 Revised Growth Rates

Since the release of the predicted growth rates published by QGISO in 2018, there has been a spike in growth within the Fraser Coast Region. As such, it was deemed necessary to carry out a sensitivity check on the original model by simulating a revised high growth scenario (HGS) and comparing the impact it has on forecasted LOS for the 2021-2051 time cohorts.

As future augmentation options will be developed from the LOS results generated from the existing model, it is important that the most accurate representation of growth/demand data is captured within the base case model.

The high growth rates adopted within the HGS scenario were determined as follows;

> The medium series growth rates for the Hervey Bay and Maryborough regions were calculated using the Projected population (medium series), by statistical area level 2 (SA2), SA3 and SA4, Queensland, 2016 to 2041.

> The medium and high growth series for the Fraser Coast Municipality was calculated using the Projected population (high & medium series), by local government area, Queensland, 2016 to 2041.

> The medium growth rates predicted for Fraser Coast, Hervey Bay and Maryborough were analysed to developed a ratio to define the Maryborough to Fraser Coast growth rate and Hervey Bay to Fraser Coast growth rate.

> As no high growth rates were published for Hervey Bay and Maryborough, the high growth rates were estimated by using the ratio determined for the medium growth scenario, and applying that to the high growth rate predictions for the Fraser Coast Region.

The results of the high growth rate analysis are presented in Table 4-1. Note as no data was published for 2041 onwards, the same growth rate as per 2036 was applied for proceeding years.

Table 4-1 QGISO Medium and High Growth Rates Review

	2016	2021	2026	2031	2036	2041	2046	2051
Medium Growth								
Fraser Coast	4.72%	5.44%	5.70%	4.56%	3.98%	3.98%	3.98%	3.98%
Hervey Bay (HB)	5.75%	5.90%	6.18%	5.08%	4.58%	4.58%	4.58%	4.58%
Maryborough (MB)	4.45%	4.11%	3.63%	2.98%	2.71%	2.71%	2.71%	2.71%
Ratio HB to Fraser Coast	1.217	1.085	1.083	1.114	1.152	1.152	1.152	1.152
Ration MB to Fraser Coast	0.941	0.757	0.637	0.655	0.681	0.681	0.681	0.681
High Growth								
Fraser Coast	6.24%	7.87%	8.24%	6.81%	6.28%	6.28%	6.28%	6.28%
Ratioed Hervey Bay (HB)	7.59%	8.54%	8.92%	7.59%	7.24%	7.24%	7.24%	7.24%
Ratioed Maryborough (MB)	5.87%	5.96%	5.25%	4.46%	4.28%	4.28%	4.28%	4.28%

The existing system was simulated for the revised high growth rates for time cohorts from 2021 to 2051. The results for each scheme are presented in the following tables.

4.1.2 Hervey Bay High Growth Rates Results

Table 4-2 Summary of current and 2051 LOS for Hervey Bay (High Growth Rates)

	Level 2 (ARI)	Level 3 (ARI)	Level 4 (ARI)	Dead Volume (ARI)	Supply Shortfall (ARI)
Current LOS	3	7	37	1,000	>1,000
2051 LOS	1	3	8	250	>1,000

Table 4-3 Summary of current and 2051 LOS for Hervey Bay Scheme (Level 2 Restrictions)

	>1 month	> 3 months	> 6 months
Current LOS	258 occurrences	154 occurrences	91 occurrences
2051 LOS	431 occurrences	267 occurrences	174 occurrences

Table 4-4 Summary of current and 2051 LOS for Hervey Bay Scheme (Level 4 Restrictions)

	>1 month	> 3 months	> 6 months
Current LOS	10 occurrences	5 occurrences	1 occurrence
2051 LOS	77 occurrences	40 occurrences	18 occurrences

4.1.3 Maryborough High Growth Rates Results

Table 4-5 Summary of current and 2051 LOS for Maryborough (High Growth Rates)

	Level 2 (ARI)	Level 3 (ARI)	Level 4 (ARI)	Dead Volume (ARI)	Supply Shortfall (ARI)
Current LOS	1	11	56	>1,000	>1,000
2051 LOS	1	8	28	1,000	>1,000

Table 4-6 Summary of current and 2051 LOS for Maryborough Scheme (Level 2 Restrictions)

	>1 month	> 3 months	> 6 months
Current LOS	411 occurrences	101 occurrences	8 occurrences
2051 LOS	533 occurrences	129 occurrences	14 occurrences

Table 4-7 Summary of current and 2051 LOS for Maryborough (Level 4 Restrictions)

	>1 month	> 3 months	> 6 months
Current LOS	8 occurrences	1 occurrence	0 occurrences
2051 LOS	18 occurrences	2 occurrences	0 occurrences

4.1.4 Tiaro High Growth Rates Results

Table 4-8 Summary of current and 2051 LOS for Tiaro (High Growth Rates)

	Level 2 (ARI)	Level 3 (ARI)	Level 4 (ARI)	Dead Volume (ARI)	Supply Shortfall (ARI)
Current LOS	2	3	3	50	>1,000
2051 LOS	2	3	3	50	>1,000

Table 4-9 Summary of current and 2051 LOS for Tiaro Scheme (Level 2 Restrictions)

	>1 month	> 3 months	> 6 months
Current LOS	202 occurrences	39 occurrences	5 occurrences
2051 LOS	214 occurrences	40 occurrences	5 occurrences

Table 4-10 Summary of current and 2051 LOS for Tiaro (Level 4 Restrictions)

	>1 month	> 3 months	> 6 months
Current LOS	119 occurrences	25 occurrences	1 occurrence
2051 LOS	123 occurrences	25 occurrences	1 occurrence

The LOS results obtained from the high growth rates were compared to the original results within section 3.5.2.3. There are notable differences in the LOS results obtained in the Level 3 and Level 4 trigger levels ARI's, however no change in ARI was encountered for supply shortfall.

Upon consultation with FCRC, it was decided that the original results using the supplied growth rates, would be adopted to progress with augmentation design.

5 Augmentation Options

System augmentation is the process of altering the operation of a current water supply scheme via changes to infrastructure within the scheme or modifications to non-infrastructure aspects that have an impact on the performance of the system. This study has considered both infrastructure and non-infrastructure options when investigating potential system augmentations for the Fraser Coast systems.

Based on the community consultation survey that was undertaken, the recommended desired LOS for the Fraser Coast systems is detailed in Table 5-1. The current LOS for the Hervey Bay, Maryborough and Tiaro system are documented within Table 5-2, Table 5-3 and Table 5-4 respectively.

Table 5-1 Target Level of Service

Restriction	Community Desired LOS
Level 2 Frequency	Every year
Level 2 Duration	< 3 months
Level 3 Frequency	5 years
Level 3 Duration	1- 3 months
Level 4 Frequency	40 years
Level 4 Duration	< 1 month

Table 5-2 Current Level of Service – Hervey Bay

Restriction	2026	2031	2036	2041	2046	2051
Level 2 Frequency (ARI)	2	2	2	2	2	2
Level 3 Frequency (ARI)	6	5	4	4	4	3
Level 4 Frequency (ARI)	28	25	19	16	13	11

Table 5-3 Current Level of Service – Maryborough

Restriction	2026	2031	2036	2041	2046	2051
Level 2 Frequency (ARI)	1	1	1	1	1	1
Level 3 Frequency (ARI)	11	11	11	10	10	10
Level 4 Frequency (ARI)	59	56	48	43	38	42

Table 5-4 Current Level of Service – Tiaro

Restriction	2026	2031	2036	2041	2046	2051
Level 2 Frequency (ARI)	2	2	2	2	2	2
Level 3 Frequency (ARI)	3	3	3	3	3	3
Level 4 Frequency (ARI)	3	3	3	3	3	3

As detailed within the tables above, there are occurrences where all systems are underperforming when compared to the target LOS in Table 5-1.

For the Hervey Bay and Tiaro systems, the forecast LOS is consistently below the desired LOS, with the Maryborough system only under-performing in the Level 2 LOS criteria.

The methods for improving the performance of each system via system augmentation are outlined in the following sections. It is noted that where infrastructure augmentations options are recommended, the proposed upgrades have been designed to cater for at least the 2051 growth/demand scenarios.

5.2 Non-Infrastructure Options

5.2.1 Option 1 – Tiaro Revised Trigger Levels

At present, the water restrictions for the Tiaro township are governed by the water levels within the Mary Barrage. As a result, the model results for the Tiaro Scheme showed frequently occurring Level 2, 3 and 4 water restrictions due to the fluctuating levels within the Barrage.

The Tiaro offtake location, which comprises of an informal storage of approximately 860ML, is an online system of the Mary River. The informal storage is understood to provide adequate volume to service the Tiaro township in dry conditions even when the Mary River is not flowing. Due to the relatively small demands of the Tiaro township when compared to the volume available within the informal storage, it was deemed appropriate to determine a set of trigger levels relative to the offtake location.

The trigger levels for water restrictions were set to achieve the desired level of service by the community as detailed within Table 5-5.

Table 5-5 Tiaro Offtake Trigger Levels

Water restriction level/ % of full supply volume	Level in Tiaro Offtake (ML)	% of Full Supply Volume (860.25ML)	Target reduction in demand
Level 1 (permanent)	> 860.10	Nil	Nil
Level 2	860.07 – 860.10	99.9%	5%
Level 3	857.00 – 860.07	99.9%	20%
Level 4	< 857.00	94.3%	40%

As detailed in Table 5-5, the trigger levels show minimal volumetric difference between Level 1-4 water restrictions. This is as the Tiaro offtake storage is generally at full capacity, as it is situated along the Mary River, which is flowing the majority of the time. As the water levels within the formal offtake rarely recede lower than the designated spillway (the spillway indicates when the Mary River is flowing) the triggers are set to nearly 100% capacity of the Tiaro offtake as capacities below this occur less frequently than the target LOS triggers.

The resulting trigger levels depend significantly on the stage storage curve developed for Tiaro offtake location. It is noted that this was largely developed from LiDAR data, with survey bathymetry only available for a portion of the area. Assumptions were also made for the downstream spillway which currently models when the Mary River is flowing. It is recommended that before these trigger levels are enforced, that additional survey is carried out to better define the stage storage of the Tiaro offtake location.

As such, it is difficult to set realistic trigger levels for the informal storage with the data currently on hand. In the interim, it is recommended that the water restrictions for the Tiaro Township are based off the Maryborough and Hervey Bay systems, similar to what is currently implemented for the Wide Bay Region.

5.2.2 Option 2 – Maryborough System Loss Reduction

Currently, the existing representation of the Maryborough system exceeded the desired LOS for the Fraser Coast Region for Level 3 and Level 4 Water restriction criteria. As such, the Maryborough system has been flagged to subsidise the Hervey Bay system through the implementation of a water grid system.

In order to maximise the volume of water that can be transferred from the Maryborough to the Hervey Bay system, without resulting in a reduction in LOS below the desired community target, the Maryborough system has been optimised via the reduction of system Losses. The system losses (currently at 20%) were reduced to 10%, which is in-line with the system losses recorded for the Hervey Bay and Tiaro systems. The results for the 10% system loss reduction scenario are presented below.

Table 5-6 Summary of forecast LOS for Maryborough (10% system losses)

Restriction	2026	2031	2036	2041	2046	2051
Level 2 Frequency (ARI)	1	1	1	1	1	1
Level 3 Frequency (ARI)	15	14	14	13	12	11
Level 4 Frequency (ARI)	71	71	71	71	67	63

As detailed in Table 5-6, there is improvement in the LOS for Level 3 and Level 4 criteria when system losses are reduced from 20% to 10%. There was no notable change for the frequency of Level 2 water restrictions.

5.3 Infrastructure Options

5.3.1 Option 3 – Hervey Bay Additional Source

According hydrodynamic modelling, the predicted performance of the Hervey Bay system does not achieve the target LOS criteria from 2026 onwards. As such, augmentation to the system is deemed necessary from 2026 in order to achieve the target LOS. This option has been developed to predominantly address the Level 4 LOS criteria and involves supplementing the Hervey Bay system with an additional water source. A key assumption that has been adopted when investigating this solution is that the additional source will always have adequate capacity to subsidise the Hervey Bay system.

The previous model developed to assess the 2051 Hervey Bay system performance was adapted for the analysis of this option. The 2051 demands were utilised in order to conservatively size any infrastructure. The model was simulated by extracting water from the additional source (kL/Day) when Lake Lenthall reached a certain trigger level. A constant daily transfer between the additional source and Lake Lenthall was also investigated to determine whether the target LOS could be achieved.

An iterative process was carried out between the daily transfer volume and the trigger level within Lake Lenthall in order to achieve the desired Level 4 LOS of 1 in 40 years.

Table 5-7 Additional Source to Hervey Bay Transfer LOS

Time Cohort	Transfer Volume	Transfer Trigger Level (Lenthalls Dam)	Hervey Bay Level 4 LOS
2051	18 ML/Day	21.33m AHD	1 in 40yrs
2051	7.5 ML/Day	NA – always transferring	1 in 40yrs

Hydrodynamic modelling indicated that two (2) different approaches could be adopted to achieve the desired Level 4 LOS, a daily transfer of 7.5ML/Day or a 18ML/Day transfer when Lenthalls Dam reached RL 21.33m AHD.

5.3.2 Option 4 – Maryborough to Hervey Bay Connection

This system augmentation option involved sourcing water from the Teddington Weir via a raw water pipeline and forming a water grid between the Hervey Bay and Maryborough systems. Factors which have been considered in determining the optimum volume of water to be transferred from the Maryborough to the Hervey Bay system include the safe yield volume for Teddington Weir and maintaining an acceptable LOS for the Maryborough system.

According to the Mary River Basin Operational Plan, the safe yield volume for Teddington Weir is 8,179ML/annum. Based on the projected 2051 demand rates of 3,285ML/Day for the Maryborough system, this results in a maximum safe volume of 4,894ML/annum (8,179ML – 3,285ML) available to transfer to the Hervey Bay system.

The previous model developed to assess the 2051 Hervey Bay and Maryborough systems performance was adapted for the analysis of this option. The model was modified by adding a transfer function between the two schemes. The maximum available volume (13ML/Day) was trialled with a range of different trigger levels to determine the maximum LOS that could be achieved for the Hervey Bay system, while having the least impact on the Maryborough system.

It is noted that the Maryborough system was modelled with 10% system losses in this scenario.

Table 5-8 details the results of transfer volumes and trigger levels that were carried out for the water interconnection for each time cohort.

Table 5-8 Maryborough to Hervey Bay Connection LOS

Time Cohort	Transfer Volume	Transfer Trigger Level (Lenthalls Dam)	Hervey Bay Level 4 LOS	Maryborough Level 4 LOS
2026	5 ML/Day	21.33m AHD	1 in 47yrs	1 in 47yrs
2031	7 ML/Day	21.33m AHD	1 in 40yrs	1 in 41yrs
2036	11 ML/Day	21.33m AHD	1 in 43yrs	1 in 28yrs
2041	13 ML/Day	21.33m AHD	1 in 38yrs	1 in 24yrs
2046	13 ML/Day	21.33m AHD	1 in 28yrs	1 in 21yrs
2051	13 ML/Day	21.33m AHD	1 in 21yrs	1 in 19yrs
2051	7.5ML/Day	NA – always transferring	1 in 40yrs	1 in 8yrs

Results indicate that up to the 2031 cohort, the Maryborough system can supplement the Hervey Bay Scheme to achieve the target LOS, while still achieving the desired 1 in 40yr LOS.

From 2036 onwards, the LOS for the Maryborough system will be reduced below the target level if a transfer between the two schemes continues.

5.3.3 Option 5 – Maryborough to Hervey Bay Connection with Additional Source

The Maryborough to Hervey Bay connection was modelled with the incorporation of the additional source supplementing the Hervey Bay system. The additional source is anticipated to provide the extra volume to ensure that the Maryborough system's LOS did not reduce below the target LOS.

Table 5-9 Maryborough to Hervey Bay Connection LOS

Time cohort	2051
Transfer from Teddington Weir when Lenthalls Dam < 21.33m AHD	7ML/Day
Transfer from Additional Source, always occurring	5.5ML/Day
Hervey Bay Level 4 LOS	43
Maryborough Level 4 LOS	40

5.3.4 Option 5 – Maryborough to Hervey Bay Connection with Teddington Offtake

Previous studies carried out by SunWater have investigated the viability of constructing an offline storage near the existing Teddington Weir structure. The Teddington offline storage would be a flood harvesting device, with water being transferred from Teddington Weir to the offline storage when the weir was overflowing.

The original feasibility study was intended to increase the supply yield for the Maryborough system, however for the purpose of this investigation, the offline storage is acting in supplementing the Maryborough to Hervey Bay Transfer.

The arrangement has been modelled to operate by transferring water from Teddington Weir to the offline storage when the weir was overflowing. The transfer from Maryborough to Hervey Bay would then occur from the offline storage first, with any additional water being sourced from Teddington weir, if required. It is noted that the total transfer capacity between the schemes has still been limited to 13ML/Day.

The Teddington offline storage was modelled with parameters as detailed in Table 5-10, based on the information contained within SunWater report *G-81211-02-01-04.* The LOS results achieved when utilised the off-stream storage for the 2051 cohort are presented in Table 5-11.

Table 5-10 Teddington Offtake Stage Storage

Stage (m)	Area (ha)	Volume (ML)
0	62.5	0
8	90.0	6100

*Note that a pumping rate of 259,200KL/Day has been applied to transfer water from Teddington Weir to the offline storage, as defined within the SunWater report.

Table 5-11 Maryborough to Hervey Bay Connection with Teddington Offtake

Time Cohort	Transfer Volume	Transfer Trigger Level (Lenthalls Dam)	Hervey Bay Level 4 LOS	Maryborough Level 4 LOS
2051	13 ML/Day	21.33m AHD	1 in 21yrs	1 in 62yrs
2051	7.5ML/Day	NA – always transferring	1 in 40yrs	1 in 62yrs

Results indicate that the incorporation of the Teddington offline storage improves the performance of the Maryborough Scheme and allows the target LOS to be achieved even when transferring water to the Hervey Bay Scheme. Review of the Teddington offtake storage throughout the 1,000 year simulation indicates that the storage provides the required volume to service the Hervey Bay Scheme, without requiring Teddington Weir as a supplementary source.

5.3.5 Option 6 – Maryborough to Hervey Bay Connection with Mary River Offtake

Investigating the viability of constructing an offline storage near the Mary Barrage has been considered as a potential option for system augmentation. The Mary Barrage offline storage would be a flood harvesting device, with water being transferred from the Marry Barrage Spillway to the offline storage when the weir was overflowing. Water would then be transferred via the existing Owanyilla channel/pipelines system to Teddington Weir.

For this investigation, the offline storage is acting in supplementing the Maryborough to Hervey Bay Transfer.

The arrangement has been modelled to operate by transferring water from the Mary Barrage to the offline storage when the weir was overflowing. The transfer to Teddington Weir would then occur to supplement the transfer from Maryborough to Hervey Bay. It is noted that the total transfer capacity between the schemes has still been limited to 13ML/Day.

The Mary River offline storage was modelled with parameters as detailed in Table 5-12, and have been assumed for modelling purposes only. The LOS results achieved when utilising the off-steam storage for the 2051 cohort are presented in Table 5-13.

Table 5-12 Mary River Offtake Stage Storage

Stage (m)	Area (ha)	Volume (ML)
0	62.5	0
8	90	6100

*Note that the existing pumping rate of 92,000kL/Day for the Owanyilla pipelines has been applied to transfer water from the offline storage to the Teddington Weir.

Table 5-13 Maryborough to Hervey Bay Connection -With Mary River Offtake

Time Cohort	Transfer Volume from offline storage	Transfer Volume from MB - HB	Transfer Trigger Level (Lenthalls Dam)	Hervey Bay Level 4 LOS	Maryborough Level 4 LOS
2051	5 ML/Day	7.5ML/Day	NA – always transferring	1 in 40yrs	1 in 40yrs

Results indicate that the incorporation of the Mary River offline storage improves the performance of the Maryborough system and allows the target LOS to be achieved even when transferring water to the Hervey Bay system. Review of the Mary River offtake storage throughout the 1,000 year simulation indicates that the storage provides the required volume to service the Hervey Bay system, with an average daily transfer of 5ML/Day to Teddington Weir.

6 Conclusion

Hydrodynamic modelling was carried out to determine the current performance of the Hervey Bay, Maryborough, and Tiaro systems under increasing demands from 2021-2051. The existing (2021) performance of the system was assessed to establish a level of service to benchmark future augmentation options against.

The current LOS established for the existing systems are summarised below.

Table 6-1 Summary of current and 2051 LOS for Hervey Bay

	Level 2 (ARI)	Level 3 (ARI)	Level 4 (ARI)	Dead Volume (ARI)	Supply Shortfall (ARI)
Current LOS	3	7	48	4,000	>1,000
2051 LOS	2	4	11	500	>1,000

Table 6-2 Summary of current and 2051 LOS for Maryborough

	Level 2 (ARI)	Level 3 (ARI)	Level 4 (ARI)	Dead Volume (ARI)	Supply Shortfall (ARI)
Current LOS	2	17	83	>1,000	>1,000
2051 LOS	1	10	42	>1,000	>1,000

Table 6-3 Summary of current and 2051 LOS for Tiaro

	Level 2 (ARI)	Level 3/4 (ARI)	Dead Volume (ARI)	Supply Shortfall (ARI)
Current LOS	2	3	52	>1,000
2051 LOS	2	3	52	>1,000

The current LOS results were presented to the community and key stakeholders, and from these consultations, a desired LOS was established and is presented in Table 6-4.

Table 6-4 Target Level of Service

Restriction	Community Desired LOS
Level 2 Frequency	Every year
Level 2 Duration	< 3 months
Level 3 Frequency	5 years
Level 3 Duration	1- 3 months
Level 4 Frequency	40 years
Level 4 Duration	< 1 month

Review of current system performance against target LOS indicated that the Hervey Bay system was most in need of requiring system augmentation that involved infrastructure upgrades. For the Maryborough and Tiaro systems, non-infrastructure options such as modifying trigger levels and addressing system losses were deemed appropriate measures to improve system performance to achieve to the target LOS.

A range of system augmentation options were investigated to achieve the target Level 4 LOS for the Hervey Bay system. From a modelling perspective only, the options which were deemed to satisfy the target LOS requirements for Hervey Bay and not result in the reduction in the performance of other systems are outlined below.

- Additional Source Supplementing Hervey Bay System
- Maryborough to Hervey Bay Interconnection, with additional source
- Maryborough to Hervey Bay Interconnection, with Teddington offline storage
- Maryborough to Hervey Bay Interconnection, with Mary River offline storage

Each of the options outlined above were further assessed under a Multi-Criteria-Analysis (MCA) to determine the most viable option for the region and is discussed in the Planning Report.

The modelling carried out to inform the recommendations for future system augmentation have been conducted on a conceptual basis only, based on the information available at the time of the study. Prior to progressing any proposed augmentation options highlighted in this study to detailed design, it is highly recommended that additional data is sourced and validated to enable further investigate and refinement of modelling to be undertaken.

APPENDIX

A

STAGE STORAGE DATA

Lenthalls Dam Stage Storage Information		
RL (m AHD)	**Area (ha)**	**Volume (ML)**
12.00	35	0
14.00	40	500
16.00	70	1798
18.00	120	4039
20.00	180	7332
21.00	210	9257
21.50	230	10383
22.00	250	11628
22.50	300	12958
23.00	350	14429
23.50	370	16009
24.00	420	17797
24.50	450	20015
25.00	500	22453
26.00	720	28410
27.00	1061	37328
28.00	1292	49092
29.00	1633	63720
30.00	1898	81375
31.00	2306	102394
32.00	2630	127076
33.00	3086	155657
34.00	3441	188294

Burrum Weir 2 Stage Storage Information		
R (m AHD)	**Area (ha)**	**Volume (ML)**
1.85	5	0
4.00	6	105
6.00	12	245
7.00	32	530
8.00	32	830
9.00	44	1210
10.00	53	1700
10.97	58	2242
12.30	58.5	2915
14.50	120	5039
16.70	133	7761

Burrum Weir 1 Stage Storage Information		
RL (m AHD)	**Area (ha)**	**Volume (ML)**
-2.00	15.0	0
0.50	18.0	410
1.00	22.0	520
2.00	29.5	770
3.00	30.5	1070
4.00.	33.5	1390
4.87	41.2	1715
6.38	62.8	2500
8.00	62.8	3000
10.33	63.0	5000
13.00	63.5	6667

Cassava Dam 1 Stage Storage Information		
RL (m AHD)	**Area (ha)**	**Volume (ML)**
16.00	1.80	0
16.50	1.80	9
17.00	1.80	18
17.50	1.80	27
18.00	1.80	36
18.50	2.20	46
19.00	2.20	57
19.50	9.00	85
20.00	21.00	160
20.50	29.00	285
21.00	37.00	450
21.50	53.00	675
22.00	59.00	955
22.50	83.00	1315
23.00	83.00	1725
23.50	103.00	2190
24.00	105.40	2750
30.00	120.90	9500

Cassava Dam 2 Stage Storage Information		
RL (m AHD)	**Area (ha)**	**Volume (ML)**
12.00	1.2	0
12.50	1.2	6
13.00	1.2	12
13.50	1.2	18
14.00	1.4	25
14.50	1.4	32
15.00	3.7	44
15.50	6.6	70
16.00	9.0	110
16.50	13.0	168
17.00	14.0	242
17.50	15.0	325
18.00	35.1	427
24.00	35.1	1650

Teddington Weir Stage Storage Information		
RL (m AHD)	**Area (ha)**	**Volume (ML)**
0.00	1.29	0
0.20	1.30	11
0.40	3.00	27
0.60	5.60	61
0.70	6.70	74
1.00	12.10	149
2.00	17.00	235
2.50	20.90	310
2.99	25.40	402
3.50	32.20	575
4.00	37.00	712
4.50	44.40	956
5.00	48.90	1143
6.00	59.70	1686
7.00	71.20	2340
8.00	84.80	3125
8.66	92.00	3710
9.05	98.60	4104
10.10	107.60	5214
12.10	123.60	7524
13.60	156.60	9584

Talegalla Stage Storage Information		
RL (m AHD)	**Area (ha)**	**Volume (ML)**
10.31	0.256	0
14.49	2.000	385
16.00	99,999	99,999

Tiaro Stage Storage Information		
RL (m AHD)	**Area (ha)**	**Volume (ML)**
0.00	18.10	236
0.25	18.82	282
0.50	19.02	329
0.75	19.16	377
1.00	19.27	425
1.25	19.32	473
1.50	19.33	522
1.75	19.34	570
2.00	19.34	618
2.25	19.34	667
2.50	19.34	715
2.75	19.34	764
3.00	19.34	812
3.25	19.35	860
3.50	19.48	909
3.75	20.03	958
4.00	21.09	1009

Mary Barrage Stage Storage Information		
RL (m AHD)	**Area (ha)**	**Volume (ML)**
-4.60	0	0
0.15	212	5050
0.50	230	5935
1.00	235	7198
2.90	299	12000
3.25	314	13095
4.25	350	16418
5.00	375	19127

APPENDIX

B

COMMUNITY ENGAGEMENT REPORT

DECEMBER 2021

Fraser Coast Region
Water Supply Security Strategy
Community engagement report

Prepared by Articulous for Cardno & Wide Bay Water and Waste Services

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Contents

1. Executive Summary

Articulous was part of the consultant team, led by Cardno and including Marsden Jacobs, that supported Wide Bay Water and Waste Services and Fraser Coast Regional Council to develop the draft Water Supply Security Strategy throughout 2021. Articulous lead the community engagement aspects of the project.

The purpose of this project was to determine the community's future desired Level of Service (LOS) including the duration and frequency of water restrictions and identify suitable water supply options that fit with the community's willingness to pay for water into the future.

Articulous designed and facilitated three sessions with an engagement panel of up to 40 people between January and December 2021. These sessions featured presentations from Cardo and Wide Bay Water and Waste Services detailing the technical information relating to existing and future water supply in the Fraser Coast region and allowed panellists to ask questions.

Between sessions Articulous managed technical questions from the panel and responses from Wide Bay Water and Waste Services with the consultant team providing information to panellists via Council's online portal.

Fraser Coast Regional Council and Wide Bay Water and Waste Services also hosted a survey on their website, via Engagement Hub with the consultant team providing advice on question design and analysis of the survey results.

This report outlines the community engagement methods implemented as part of this project as well as the key findings of the community engagement throughout 2021.

Engagement topics and community attitudes

The main topics explored with the community were:

- frequency and duration of water restrictions
- future water supply options
- water values, attitudes, and knowledge (panel only)
- proposed infrastructure strategy (panel only)

Frequency and duration of water restrictions

57% of community members who completed the survey were willing to support **Level 2 water restrictions every year.**

63% of panel members who completed the online survey were willing to have **Level 2 water restrictions every year.**

Future water supply options

The water supply options that received the most community support were:

- maintain the pressure reduction and leak detection programmes (85%)
- water efficiency in irrigation (85%)
- water saving devices in the home (80%) and
- a new source of water (80%).

Of the water supply options presented to the panel, the most favourable were purified recycled water, followed by surface water storage then desalination.

The most favoured demand management options by the panel were household/business reduction, customer metering and community wide awareness campaigns.

Proposed infrastructure strategy

- 80% of panellists agreed with the preferred infrastructure options presented by the engagement panel and consensus was reached about the willingness to pay for them

2. Project background

Water supply security is a contemporary topic, particularly in areas of Australia where droughts pose threat to the security of water sources.

In accordance with the Local Government Act 2009 and Sustainable Planning Act 2009, Fraser Coast Regional Council and Wide Bay Water and Waste Services committed to consider the security of water sources in the Fraser Coast Region including Hervey Bay, Maryborough and Tiaro. A collaborative approach to community consultation throughout this project was supported by Council.

The purpose of this project was to consider the Level of Service (LOS) that these water sources offer currently and the desired LOS into the future.

3. Engagement overview

This section of the report provides details about the most relevant parts of the communication and engagement strategy for this project: engagement objectives, key engagement questions and engagement methods.

3.1 Engagement objectives

- determine from the community, through release of information and feedback, the desired level of service for our water sources. That is, what frequency and / or duration would water restrictions (at various severity levels) be acceptable to the community?
- how much is the community willing to pay for the desired Level of Service?
- determine the specific impacts to businesses and the community when water restrictions are applied
- send a message that efficient water usage can prolong our water sources without necessarily compromising lifestyle.

3.2 Key engagement questions

- what impact do water restrictions have on you, your business, or your group?
- what frequency and/or duration of water restrictions would ideally be desirable (for all different restriction levels 1-4)? And why?
- how much are you willing to pay for this level of water availability (level of service) into the future? And why?

  Note: the engagement panel needed to understand the why of each of the last two engagement question so they can do the trade off
- what actions can you take to reduce your water usage and save water during restrictions, when water sources are low?
- what are the commonly recommended water saving actions you can't take and why?
- increasing the availability of water (level of service) generally means higher cost water source infrastructure will be needed, is this affordable (given the impact of restrictions)?

3.3 Engagement methods

The following engagement methods were used during the engagement to gauge the community's desired frequency, duration and level of water restrictions and willingness to pay for water in the future.

Engagement panel

In November 2020 , Fraser Coast Regional Council promoted an expression of interest for up to 45 community members of the community to self-nominate to participate in an engagement panel for the project.

Targeted Facebook advertising was used by Council to promote this opportunity to residents and businesses and more specifically young people.

The community was provided with a factsheet outlining the objectives of the project, terms of reference for the engagement panel. The factsheet also included a series of questions for interested participants to answer relating to their demographics, connection to town water and interest in the panel.

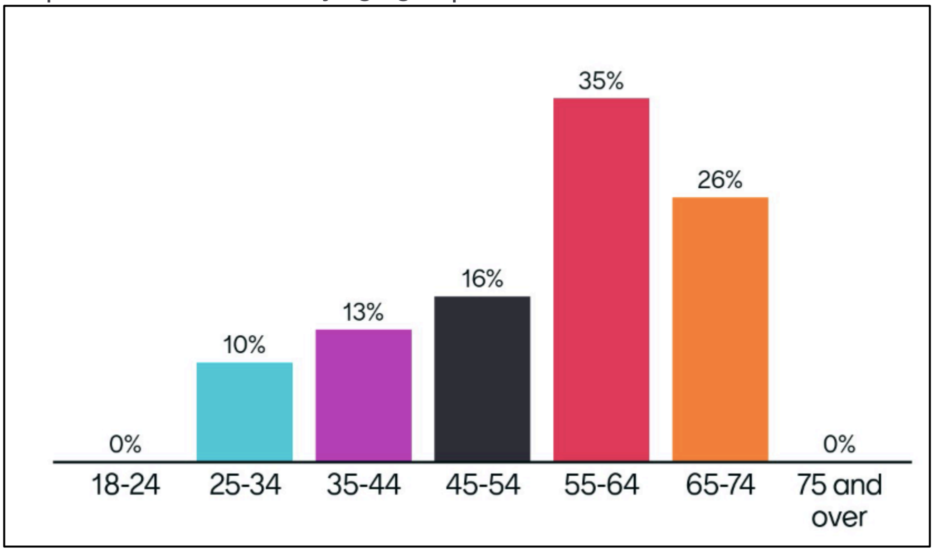
Articulous blindly selected a representative panel of 42 panel members. Council contacted both successful and unsuccessful community applicants. One panel member withdrew before the first workshop.

Demographics

Of the 31 panel members who attended the first workshop, 55% identified as male and 45% identified as female.

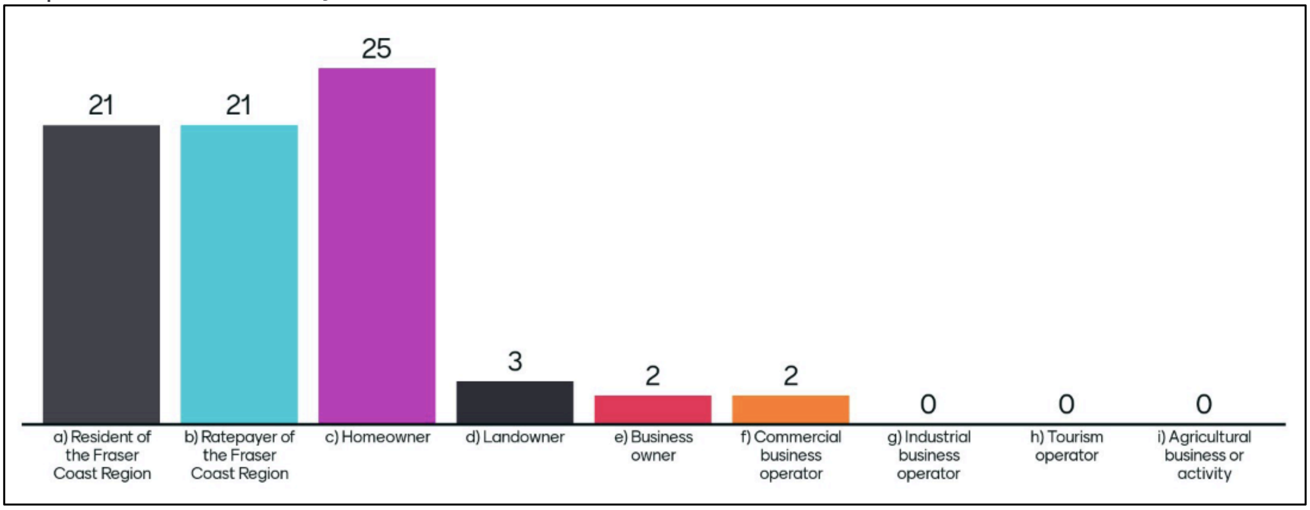
The following graph shows the ages of the panel members who attended the first workshop. Considerable effort, through targeted Facebook advertising, was made by Council to recruit young people (aged 18-24) during the expression of interest process and although some responded to the expression of interest they didn't participate in the panel.

Graph 1: Panel members by age group (n=31)



The following graph shows the interests of panel members at the first workshop. Panel members were able to select more than one interest.

Graph 2: Panel members by interests (n=31)



Workshop 1

The first workshop was held in Hervey Bay on Tuesday 19th January 2021 from 6-8pm at The Beach House and was attended by 31 panel members. Three panel members provided apologies and one panel member withdrew.

The purpose of Workshop 1 was to:

- provide relevant project information to the panel;
- allow panellists to ask questions about the project and the information presented; and
- use interactive engagement activities such as table discussions and live polling to find out their perceptions on the impacts of water restrictions on residents and businesses.

A combination of round table discussions and live polling were used to engage and gather feedback from panel members during this session.

Online portal

Following Workshop 1, Council invited panel members to join a private online portal where they could view the information presented at the workshops and ask questions of the project team.

Workshop 2

Workshop 2 was held online via Zoom on Tuesday 26th July 2021 from 6-8pm and attended by 14 panel members. Four panel members provided apologies with eight withdrawing before the meeting. 15 panel members were absent without apologies.

The attrition rate of 55% was most likely due to the unexpected delay between the first two workshops due to changes in project scope.

The purpose of this workshop was to present and discuss future water supply options for the region including indicative costs for each option.

Workshop 3

Workshop 3 was held online via Zoom on Tuesday 7 December 2021 from 6-8pm and was attended by 10 panel members. No apologies were provided.

The purpose of this workshop was to present and explain the preferred infrastructure options and gain the panel's feedback on the preferred infrastructure options including willingness to pay.

Online survey

To verify whether responses provided by the panel were representative of the entire community, an online survey was created to seek feedback from local residents on their desired LOS for water supply security.

The survey asked about the community's water use habits as well as specific questions on how often and long they would be willing to accept each level of restriction.

The consultant team, including Articulous, provided advice on question design to Wide Bay Water and Waste Services and Fraser Coast Regional Council. Survey results were analysed by Cardno with a report prepared for Wide Bay Water and Waste Services for consideration.

The survey was open for a month from mid-February to mid-March in 2021 and was promoted via Council's online engagement hub, website, social media and four drop in stalls hosted by Wide Bay Water and Waste Services at the local markets in Hervey Bay and Maryborough. It was also promoted at the Tiaro Library.

The survey attracted 186 responses, with 125 coming from residents of the Hervey Bay area. No survey responses were received from residents of Tiaro.

As the Fraser Coast region has a population of around 80,000 people, the survey results were considered statistically significant. Based on the response rate and population, the survey has a margin of error of 7% and a 95% confidence level.

4. Key community engagement findings

The main topics that were tested in the survey were about frequency and duration of water restrictions and future water supply options. More in-depth water values, attitudes, and knowledge as well as water supply options and the proposed infrastructure strategy were tested with the panel. The following section provides more detail about each of these topics.

4.1 Water values, attitudes, and knowledge

During Workshop 1, the panel were asked questions via live polling about their water values and attitudes.

The most common words panellists used to describe how water relates to their everyday life were '**life**' and '**essential**'. The most common ways the panel used water at home were **drinking** (20 responses), **washing** (18 responses) and **gardening** (14 responses).

47% of the panel rated their water efficiency at home as a 3 out of 5, where 5 is the most efficient, and 33% of the panel rated their water efficiency at home as 4 or 5.

The most common reasons the panel gave when asked **what motivates them to save water** were

1. because water is a scarce resource (20%)
2. save money (18%)
3. save the environment, because it's the right thing to do and so we don't run out of water (17% for each of these three responses)

70% of panellists indicated **dam levels of 40-60% would indicate a drought**.

81% of panel members identified that **dam levels of 50-70% indicate they should reduce their water usage**.

81% of panel members identified that **dam levels of 40-70% indicate that Council should do more.**

The impacts of water restrictions on residents and businesses were discussed during Workshop 1. Most comments and questions raised by the panel were generally about water restrictions and only a few comments were about specific restriction levels. Community awareness and enforcement were recurring themes in the discussions.

4.2 Frequency of water restrictions

Level 2

During Workshop 1, 67% of panellists said they would be willing to accept level 2 water restrictions **less than every 3 years** with 27% agreeing to **every 3 to 5 years**. These responses represent the highest frequency answers presented to the panel. The responses were then adjusted for the community and online panel surveys to include more frequent options.

57% of community members who answered the survey were willing to have Level 2 water restrictions **every year**. This compares to 63% of panel members who completed the survey willing to have Level 2 water restrictions **every year.**

Level 3
During Workshop 1, 58% of panellists indicated they would be willing to accept Level 3 restrictions every 3-5 years. This compares to 41% of community members who were willing to accepts Level 3 water restrictions every 2 years.

46% of the panel responded that they would be willing to have Level 3 water restrictions **every 2 years,** followed by 36% **every 5 years.**

Level 4
In the first panel workshop almost a third of the panel were willing to accept Level 4 restrictions every **21-50 years**, with 21% were willing to accept level 3 restrictions **every 6-10 years**. These results are reflected in the community survey results and online survey of panel members after the first session.

51% of the community members who responded to the survey were willing to have Level 4 water restrictions **every 30 years**, with 34% willing to have Level 4 restrictions **every 100 year**s. 55% of the panel members were willing to have Level 4 water restrictions **every 30 years**, followed by 27% **every 40 year**s.

4.3 Duration of water restrictions

Level 2
During Workshop 1, 40% of the panel suggested they would be willing to accept Level 2 water restrictions for **more than 6 months**, followed by 37% accepting **1-3 months**.

24% of the community members were willing to have Level 2 water restrictions for **less than one month** with 39% accepted a duration of between **1to 3 months**. Similarly, 37% of panel members advised they were willing to accept Level 2 water restrictions **between 1-3 months** with 36% suggesting they would accept a duration of **more than 6 months.**

Level 3

42% of Workshop 1 participants were willing to accept Level 3 water restrictions for a shorter duration, with 42% of the panel option for 1-3months, 26% accepting 3-6 months and 23% less than one month. Only 10% accepted a duration of more than 6 months.

42% of the community were willing to have Level 3 water restrictions for **1-3 months** duration with 38% supporting less than one month. 54% were willing to have Level 3 water restrictions for 1-3 months.

Prior to the final panel workshop, Council introduced Level 3 water restrictions for the first time in more than 10 years. During the final workshop, 90% of panel members were overwhelmingly in agreement about whether they considered more frequent Level 2 and 3 restrictions appropriate to meet the proposed level of service (based on community survey results).

Respondents said they accepted the logic and rationale of the proposed strategy and acknowledged the need for more community education about water conservation.

Level 4
55% of panellists in Workshop 1 said they were willing to accept Level 4 restrictions for less than a month, with 26% accepting of a period of 1-3 months.

These results were reflected in the community survey results.

68% of community members and 59% of panellists were willing to support Level 4 water restrictions for less than one month.

4.4 Future water supply options

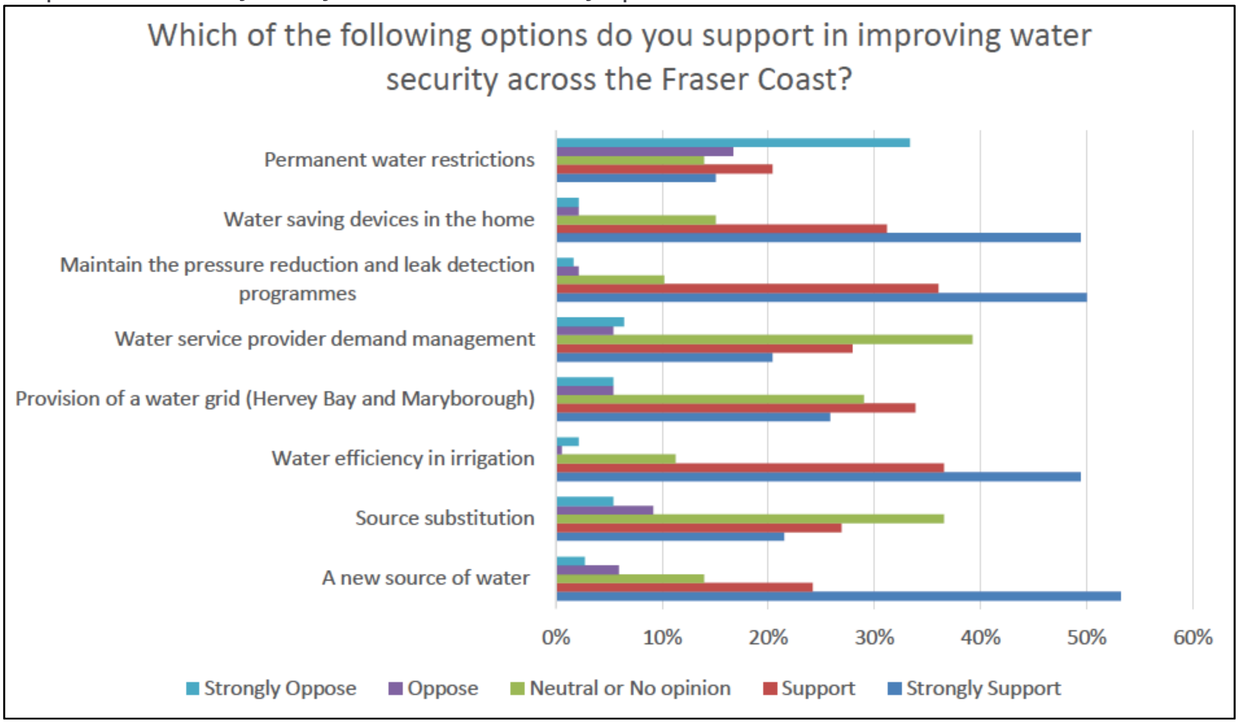
The survey provided an opportunity to test the favourability of future water supply options with the community.

The water supply options that received the most community support were:

- maintain the pressure reduction and leak detection programmes (85%)
- water efficiency in irrigation (85%)
- water saving devices in the home (80%) and
- a new source of water (80%).

This is shown in the graph below.

Graph 3: Community survey results, water security options



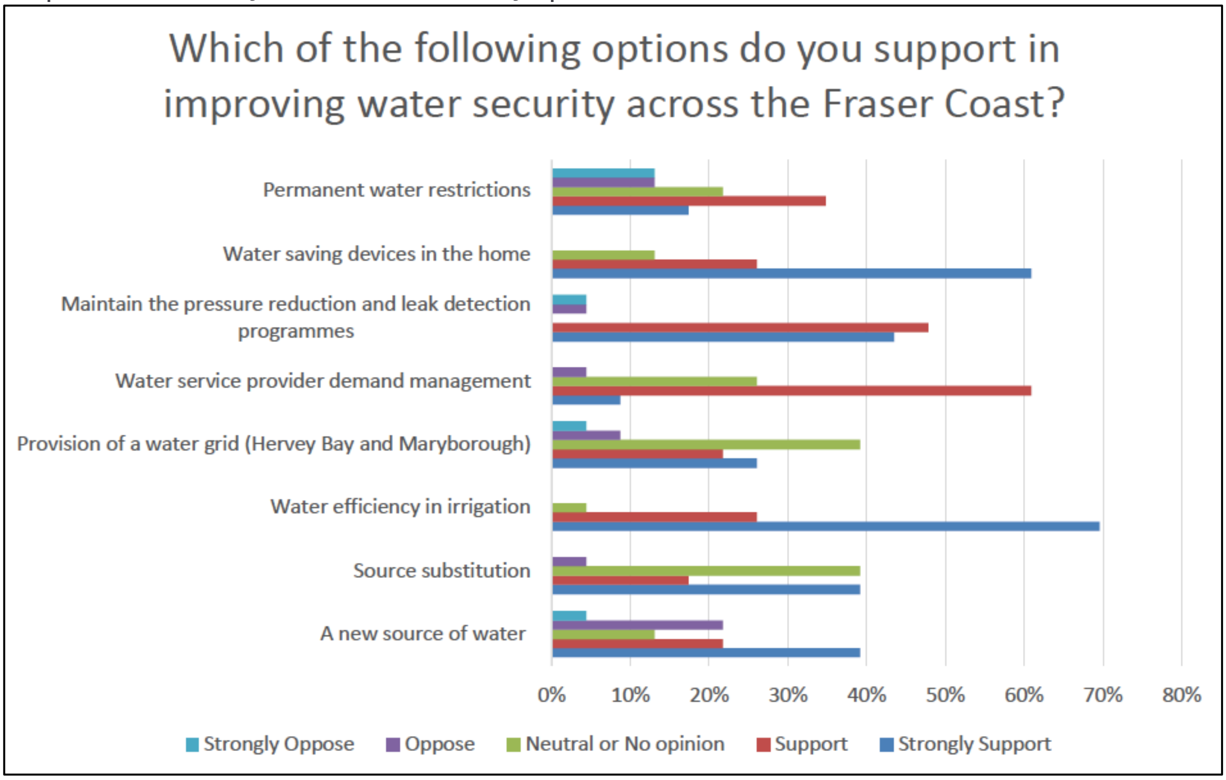
Source: Cardno

Among panel members, the most supported water supply options were:

- efforts to increase water efficiency in irrigation (95%)
- maintain the pressure reduction and leak detection programmes (90%)
- water saving devices in the home (85%)

This is shown in the following graph.

Graph 4: Panel survey results, water security options



Source: Cardno

In Workshop 2, a range of future water supply options were presented to the panel to test their favourability with a rating for each provided below. The most favourable option was **water grids** (average favourability of 8.7). Support for this option was mostly due to agreement that sharing water between towns made sense.

Purified recycled water received an average favourability of 7.5. Most people supported the quality and science behind this option, while some people were concerned about contamination and association with effluent.

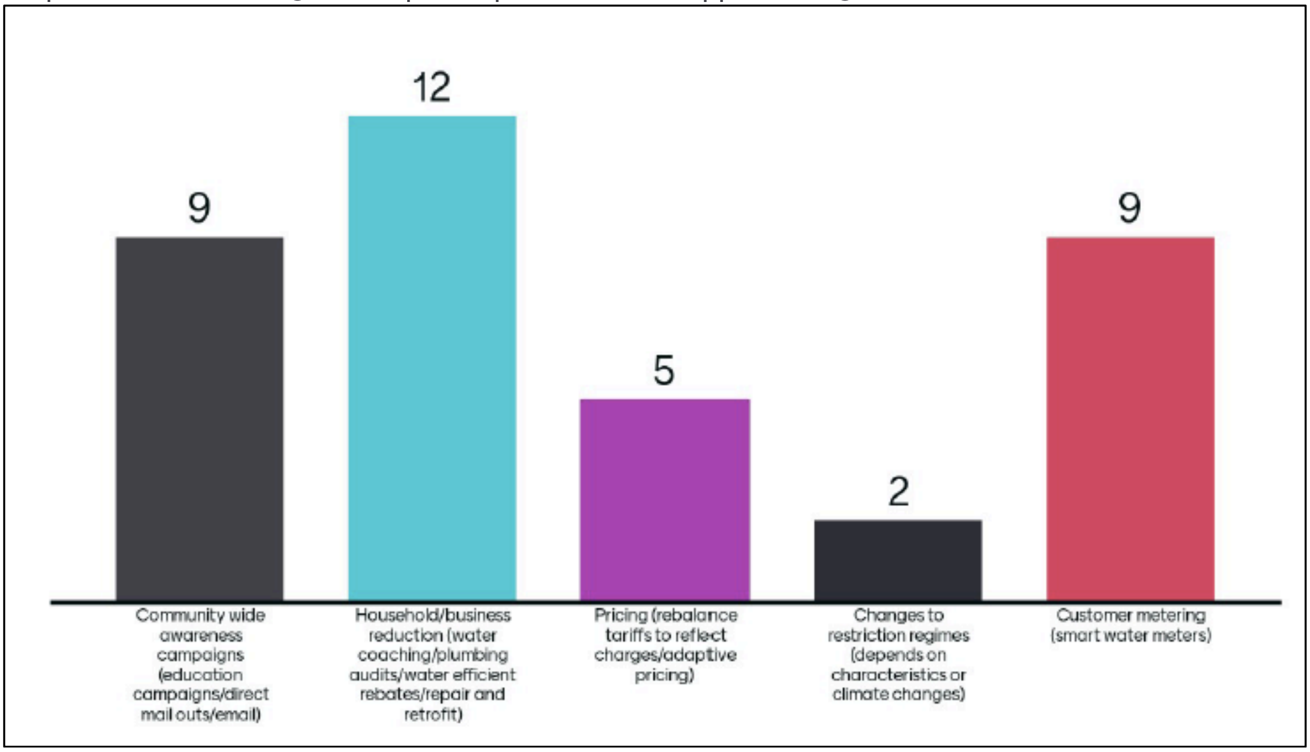
Surface water storage was less supported (average favourability of 6.2). Concerns were raised about environmental impacts and evaporation. Reasons for support were cost and previous success of existing dams.

Desalination received an average favourability of 4.9. Concerns were raised about high energy use, building and maintenance costs as well as environmental impacts on the ocean.

Demand management options

Panellists were asked about which of the following demand management options were acceptable to them with household/business reduction, customer metering and community wide awareness campaigns being the most acceptable options as shown in the following graph.

Graph 5: Demand management options, panel member support during session 2



4.5 Proposed infrastructure strategy

Cardno presented the proposed infrastructure strategy during the third and final Workshop in December 2021. This included providing the rationale for each water supply option and as well as the indicative costs to build and maintain. **80% of panellists supported the proposed infrastructure strategy**, although there were some concerns about desalination and associated environmental impacts.

When asked about K'gari (Fraser Island) being considered as a source of water for the mainland during the final workshop, 55% of the panellists said they were against such a move stating environmental and cultural heritage concerns.

4.6 Willingness to pay

52% of the community said they were **opposed to additional any costs associated with improved level of service**, with 27% saying they were supportive and 21% being neutral on new charges. The reason for this could be that the need to consider investing in water infrastructure options is not understood by the community.

52% of panellists **opposed any additional costs associated with an improved level of service**, with 31% agreeing supporting new charges and 17% being neutral. At this point in time the panel had some understanding of the need to consider investing in water infrastructure from the first workshop.

In the third and final Workshop, **all** panel members indicated they were **supportive of the indicative cost to maintain the acceptable Level of Service in the future**. The most common reasons given were about water security and the importance of water. By this point in time the panel had an excellent understanding of water security options and their need from the information provided in the three workshops.

5. Engagement evaluation

After the first two workshops and during the third, an online survey was completed by panel members to seek their feedback on the session.

The responses were overwhelmingly positive which has been demonstrated by the many constructive ideas received from panel members on ways to improve water conservation in the community. Panellists also confirmed their preference for in person events.

The high dropout rate (75%) of panel members was most likely due to the longer than anticipated duration of the project due to technical scope changes. At the time of seeking expressions of interest from the community, the three sessions were expected to conclude by April 2021. Due to unexpected technical project delays the second panel session was held in July 2021 and the final panel session was held in December 2021.

6. Conclusion

The level of community participation in the both the engagement panel and survey, as well as the strong engagement panel support for the preferred infrastructure options should provide Wide Bay Water and Waste Services and Fraser Coast Regional Council with the confidence to proceed with the endorsement and approval of the draft Water Supply Security Strategy.

The detailed findings from the engagement activities, especially from the engagement panel, also provide Council and Wide Bay Water and Waste Services with a strong platform on which it can build a water conservation campaign for the region.

A communication and engagement strategy to support the delivery of the Water Supply Security Strategy, including key messages, can also be crafted using the information about community concerns, questions and benefits of the water supply options discussed by the panel.

About Cardno

Cardno is a professional infrastructure and environmental services company, with expertise in the development and improvement of physical and social infrastructure for communities around the world. Cardno's team includes leading professionals who plan, design, manage and deliver sustainable projects and community programs. Cardno is an international company listed on the Australian Securities Exchange [ASX:CDD].

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