Rockhampton Regional Council

Registered Service Provider No. SP493

Drinking Water Quality Management Plan

June 2012

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EXECUTIVE SUMMARY

In accordance with section 94 of the *Water Supply (Safety and Reliability) Act*, the purpose of the Drinking Water Quality Management Plan (DWQMP) is to protect public health through the comprehensive management of drinking water quality. The drinking water quality management provisions in Queensland follow a risk-based management approach and it is intended that this approach is documented in a plan that demonstrates effective management of drinking water services to ensure a safe and reliable supply of drinking water is provided.

The DWQMP is intended to be a living document that reflects the requirements of the water service provider and what needs to be actioned on a day to day basis now and into the future to ensure the supply of safe drinking water. In doing so, the DWQMP will then be used by the water service provider as a means of achieving drinking water quality outcomes in the short and long term through the demonstration that good drinking water quality management measures are in place. A thorough understanding, and effective management of, the drinking water infrastructure, water treatment processes, hazards and hazardous events, and the monitoring of operational processes and the quality of drinking water supplied to customers is therefore essential. This DWQMP, therefore, documents the information required in order to achieve the delivery of safe and reliable drinking water services.

The DWQMP also requires the generation and implementation of a Risk Management Improvement Program (RMIP). The purpose of the RMIP is to describe the management measures proposed for any unacceptable residual risk. The description of these measures must include the proposed measures, actions, strategies or processes, priorities and implementation timeframes. The RMIP included in the DWQMP is based on the following elements:

- Element 1 - Infrastructure Upgrades and Improved Infrastructure Performance
- Element 2 - Optimisation of Information Management and Reporting Capabilities
- Element 3 - Enhanced Engagement with Stakeholders Associated with Drinking Water Infrastructure Management
- Element 4 - Improved Service Through Staff Awareness and Training
- Element 5 - Enhanced Water Quality Performance

These five elements represent high priority action items for which completion is required in order to mitigate risks posed to drinking water quality. The outputs, timeframe for completion and availability of funding for completion of each element is provided.

1 REGISTERED SERVICE DETAILS

1.1 Service Provider Name

Rockhampton Regional Council – Registered Number 493
Ph: 1300 22 55 77| Fax: 1300 22 55 79
Address: PO Box 1860, Rockhampton Q 4700 Web:
www.rockhamptonregion.qld.gov.au

1.2 Drinking Water Service Operator

Fitzroy River Water (a business unit of Rockhampton Regional Council)
Ph: 1300 22 55 77| Fax: 1300 22 55 79
Address: PO Box 1860, (Belmont Road), Rockhampton Q 4700 Web:
www.frw.com.au

1.3 Drinking Water Schemes Covered By This Plan

The following schemes are covered by this DWQMP:

Rockhampton Water Supply Scheme
Capricorn Coast Water Supply Scheme
Mount Morgan Water Supply Scheme
Marlborough Water Supply Scheme.

1.4 Current Details for Location, Size and Demand of Drinking Water Schemes

Figure 1.1 provides an overview of the location of each of the drinking water schemes described in this DWQMP. Table 1.1 lists current information on the names of the communities, the population size, the number of connections and the average daily demand for each drinking water scheme. Table 1.2 provides an indication of the anticipated population, connections and demand for each of the schemes in the year 2021. The population projections for 2021 are based on calculations using the PIFU per annum population growth predictions for each of the pre-amalgamation Council localities.

Data presented for the Marlborough Water Supply Scheme is based on the existing non-potable water supply scheme. This non-potable water supply scheme has recently been converted from a non-potable water supply scheme into a drinking water scheme. This project was undertaken to provide Marlborough residents with a high quality drinking water supply and to take advantage of the relatively abundant supply of good quality bore water that currently serves as the source of the existing non-potable supply. The new drinking water service in Marlborough commenced operation in September 2011.

The Ogmore Water Supply Scheme shown in Figure 1.1 is not a drinking water scheme and is therefore not covered by this DWQMP.

Figure 1.1: Map showing the location of the four drinking water schemes (Rockhampton, Capricorn Coast, Mount Morgan and Marlborough) covered by this plan and the non-potable Ogmore Water Supply Scheme which is not covered by this plan.

Table 1.1: Current information for the communities served, population, number of connections and demand for each drinking water supply scheme

Scheme	Communities Served	Population[a]	Connections[a]	Average Demand (ML/d)
Rockhampton	Rockhampton, Nerimbera, Gracemere, The Caves, Etna Creek, Glenlee, Glendale, Rockyview, Mt Charlton	73,000	28,200	48
Capricorn Coast	Yeppoon, The Causeway, Kinka Beach, Zilzie, Emu Park, Keppel Sands	21,000	10,700	9
Mount Morgan	Mount Morgan, Baree	3,000	1,400	0.9
Marlborough	Marlborough	100	49	0.03
TOTAL		**95,840**	**38,674**	**57.94**

[a]Source: SWIM Reporting 2010.

Table 1.2: Estimated population, number of connections and demand for each drinking water scheme in 2021

Scheme	Population[a]	Connections	Average Demand (ML/d)
Rockhampton	80,637	31,150	53.0
Capricorn Coast	26,621	13,564	11.4
Mount Morgan	3,122	1,457	0.94
Marlborough	104	63	0.04
TOTAL	**110,484**	**46,234**	**65.38**

[a]**Source: PIP ERP projections for Rockhampton, Capricorn Coast and Mount Morgan**

2 DETAILS OF DRINKING WATER SCHEME INFRASTRUCTURE

2.1 Overview of Scheme Infrastructure

Tables 2.1 to 2.4 and Figures 2.1 to 2.4 provide summary information of the infrastructure and scheme layout for each drinking water scheme within Rockhampton Regional Council (RRC). Further specific details of the water source, water treatment and disinfection processes and water distribution infrastructure for each of the drinking water schemes is provided below. In Figure 2.1 due to the size of the scheme and the number of WPS in this scheme, only bulk transfer WPS or those that supply to whole supply zones are shown.

A water grid-style connection exists between the Rockhampton and Capricorn Coast Water Supply Schemes. Figures 1.1, 2.1 and 2.2 show the location of this connection point. Despite this physical connection, these two schemes are described as separate drinking water schemes for the purposes of the DWQMP.

Table 2.1: Summary of Infrastructure for the Rockhampton Water Supply Scheme

Rockhampton Water Supply Scheme		
Source		Fitzroy River 50,383 ML/annum
Source Infrastructure		Fitzroy River Barrage
Treatment Plant		Glenmore Water Treatment Plant coagulation, flocculation, sedimentation, filtration, pH correction and disinfection Treatment Capacity = 120 ML/d
Reservoirs	Number	19
	Capacity	122.3 ML
Pump Stations		31
Length of Mains and Common Services		816.9 km
No. of rechlorination sites		9

Table 2.2: Summary of Infrastructure for the Capricorn Coast Water Supply Scheme

Capricorn Coast Water Supply Scheme		
Source		Waterpark Creek 5,000 ML/annum, Fitzroy River 50,383 ML/annum via the Rockhampton to Yeppoon Water Supply Pipeline.
Source Infrastructure		Waterpark Creek Weir, Fitzroy River Barrage, Kelly's Off-Stream Storage
Treatment Plant		Glenmore Water Treatment Plant (see Table 3) Woodbury Water Treatment Plant Coagulation, flocculation, sedimentation, filtration, pH correction and disinfection Treatment Capacity = 21.6 ML/d
Reservoirs	Number	11
	Capacity	33.7 ML
Pump Stations		15
Length of Mains and Common Services		361 km
No. of rechlorination sites		3

Figure 2.1: Schematic of the Rockhampton Water Supply Scheme (Bulk WPS or WPS to whole supply zones shown only)

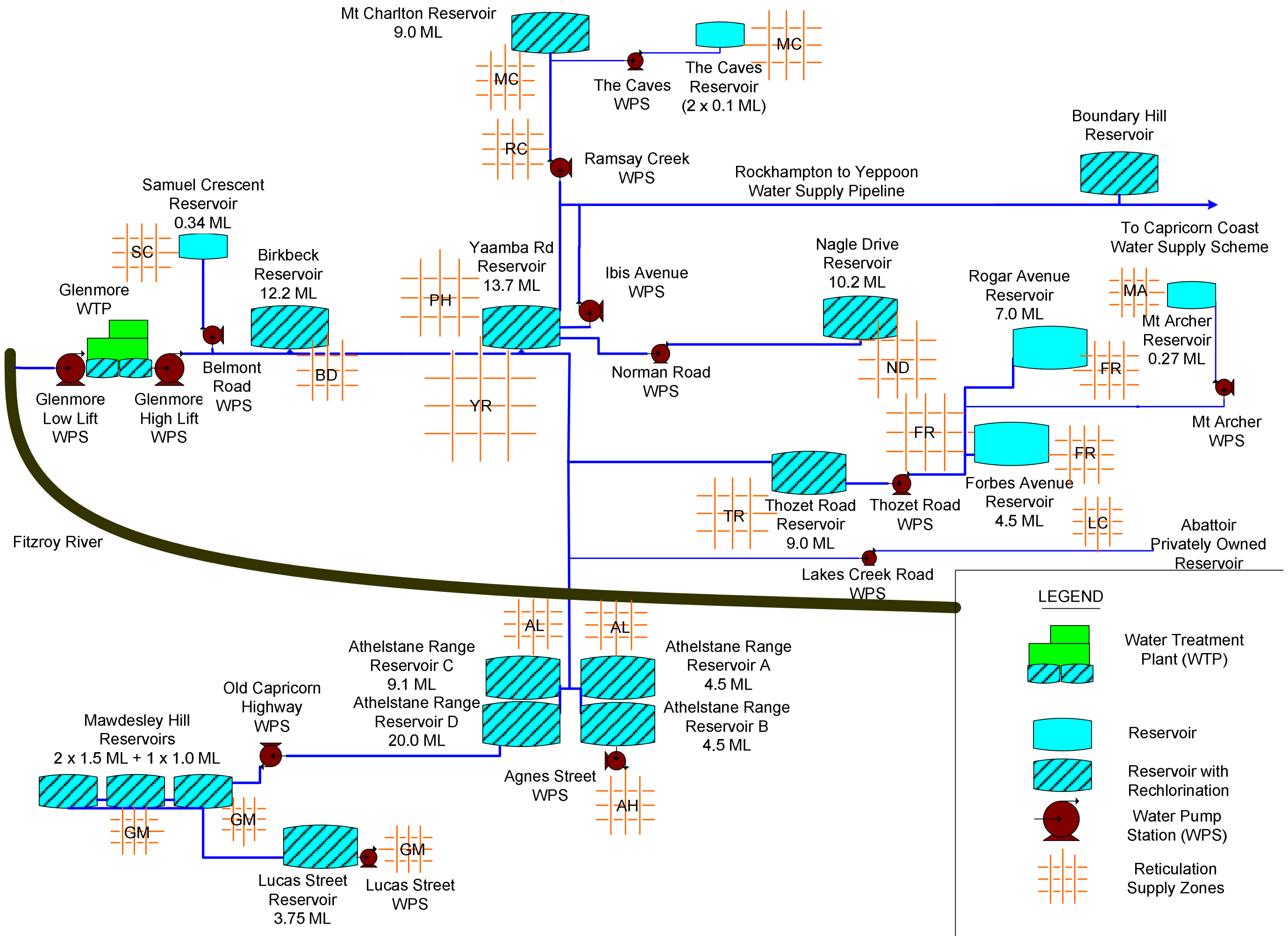


Figure 2.2: Schematic of the Capricorn Coast Water Supply Scheme

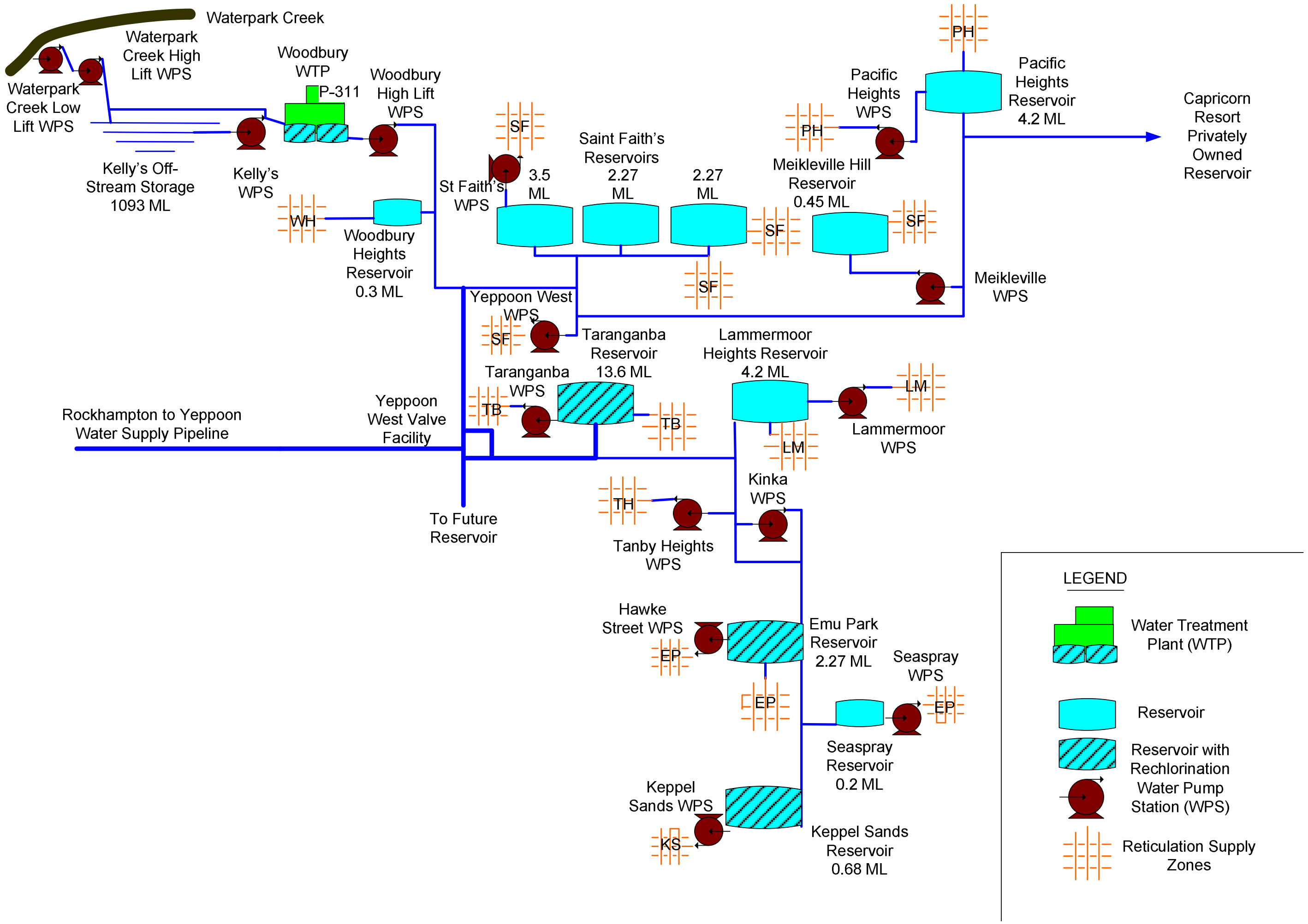


Table 2.3: Summary of Infrastructure for the Mount Morgan Water Supply Scheme

Mount Morgan Water Supply Scheme		
Source		Dee River – Allocation 584 ML/ annum Fletcher Creek Weir – Order in Council (06/02/1986) to take 700 ML/annum
Treatment Plant		Mount Morgan Water Treatment Plant coagulation, sedimentation, filtration, pH correction and disinfection Treatment Capacity = 2.6 ML/d
Reservoirs	No.	2
	Capacity	5.0 ML
Pump Stations		10
Length of Mains and Common Services		66.4 km
No. of rechlorination sites		1

Table 2.4: Summary of Infrastructure for the Marlborough Water Supply Scheme

Marlborough Water Supply Scheme		
Source		Glenprairie Road Bores, Marlborough 16 ML/annum
Treatment Plant		Marlborough Water Treatment Plant filtration, reverse osmosis, disinfection Treatment Capacity = 0.05 ML/d
Reservoirs	No.	1
	Capacity	0.09 ML
Pump Stations		2
Length of Mains and Common Services		4.6 km
No. of rechlorination sites		0

Figure 2.3: Schematic of the Mount Morgan Water Supply Scheme

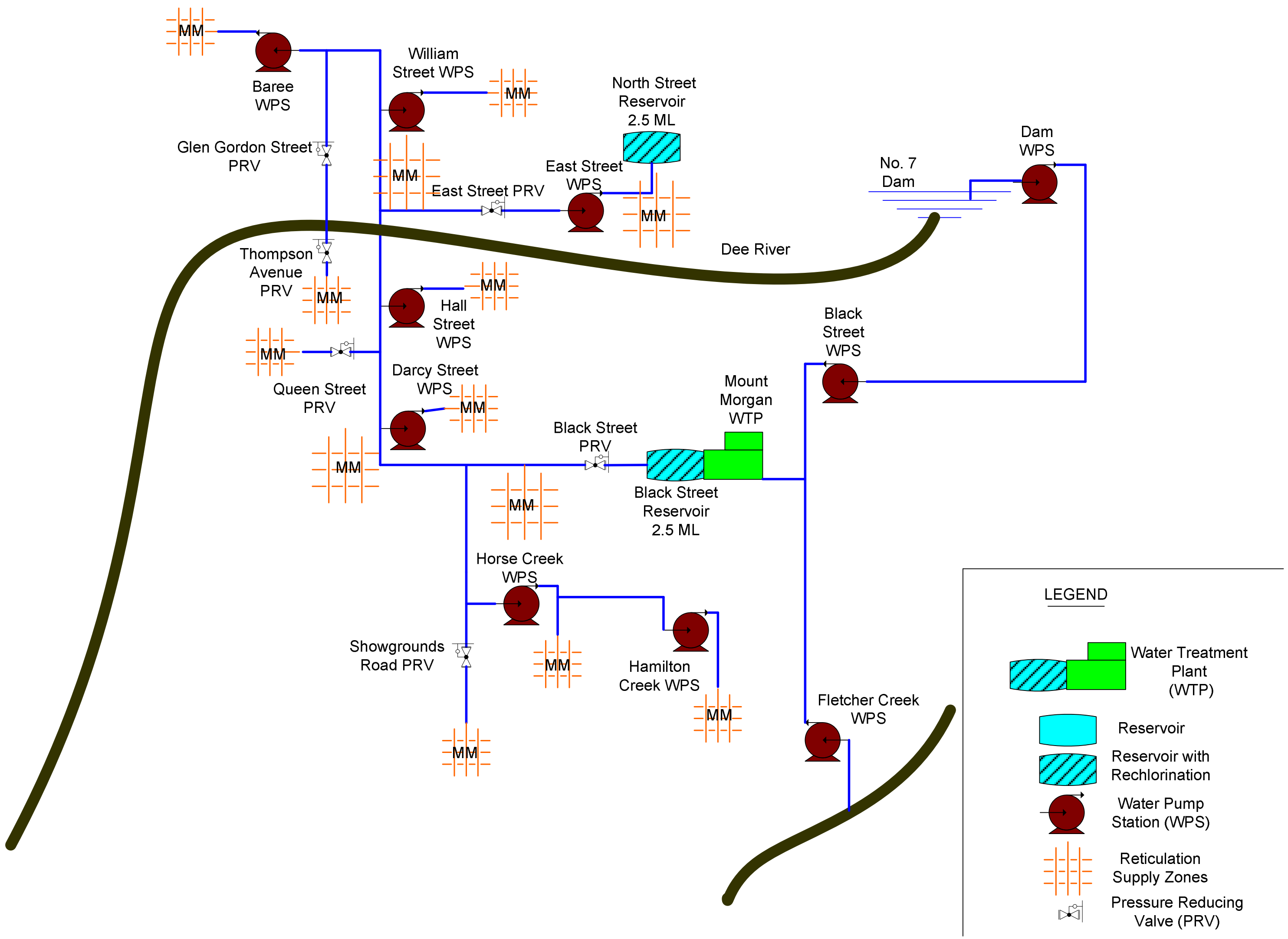
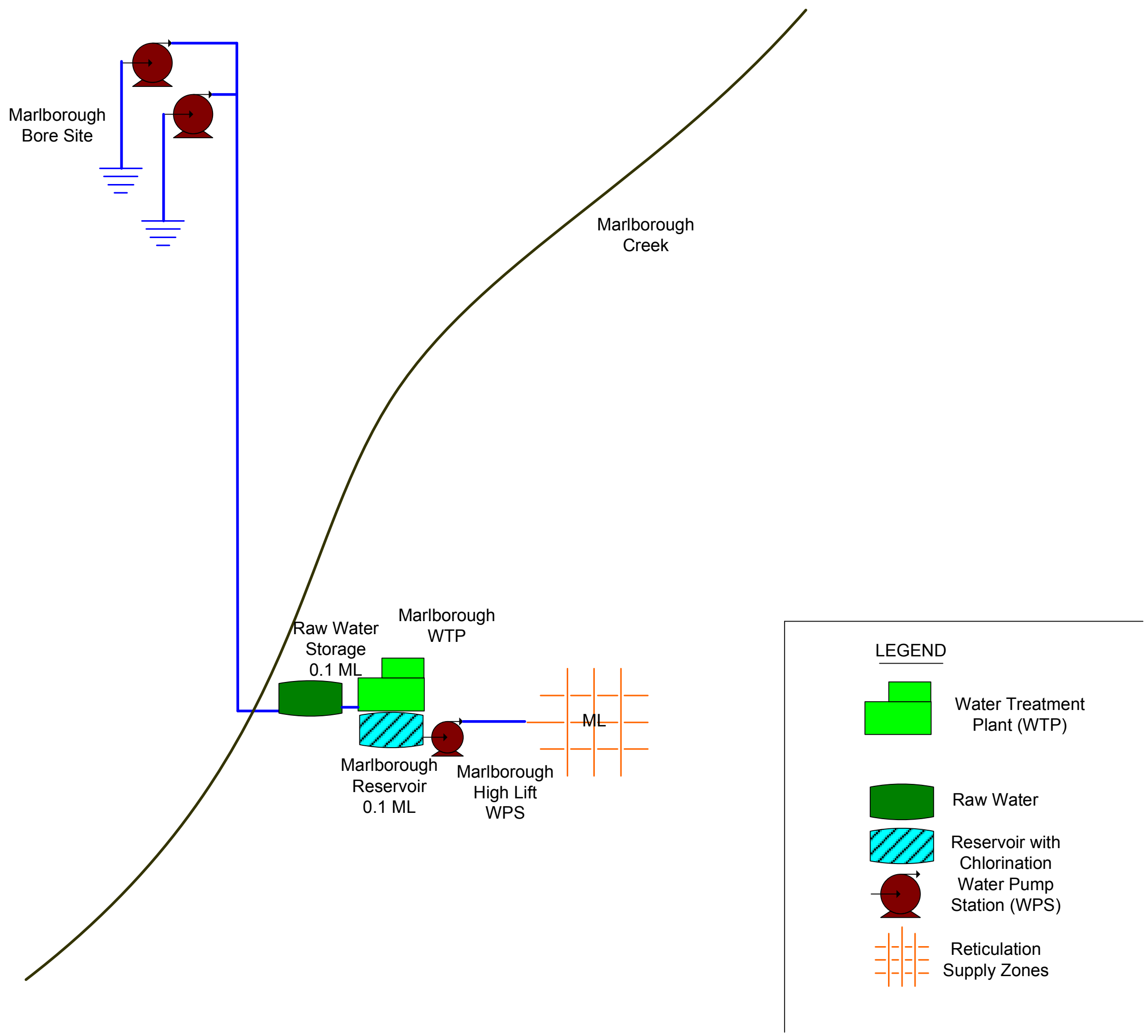


Figure 2.4: Schematic of the Marlborough Water Supply Scheme



2.2 Water Sources for Drinking Water Supply

2.2.1 Fitzroy River Barrage Storage

The Rockhampton and Capricorn Coast Water Supply Schemes are supplied with raw water drawn from RRC's 50,383 ML/year high priority water allocation, which is stored in an impoundment behind the Fitzroy River Barrage.

The Barrage sits at the bottom of the Fitzroy River Catchment which is the second largest in Australia covering in excess of 140,000 km^2. Due to the size of the catchment and the predominantly sub-tropical climate, the system is subject to highly variable but historically reliable flows with an average discharge between 5,000,000 and 6,000,000 ML/year. Fitzroy River Water (FRW) operates the Barrage in accordance with a Resource Operations Plan (ROP) which defines the requirement for storage management, environmental passing flows and water quality as well as other monitoring that is required to be performed. Releases from the Barrage impoundment are made by controlling the operation of 18 vertical lift gates that separate the freshwater from the downstream estuary using a fully automated control system.

FRW manages the storage of 11,583 ML/year of medium priority/high priority water for 189 licensed water allocation holders who draw water from the Barrage impoundment. These allocations are diverted by private infrastructure but FRW, as the delegate of the registered water service provider, oversees the process and ensures the objectives of the *Water Act 2000* are met as they affect the service provider.

The operating rules for the Barrage storage are entwined with the Eden Bann storage which stores a 24,000 ML/year high priority water allocation for the Stanwell Corporation. The Stanwell Corporation draws its water from the Barrage impoundment but water is released from the Eden Bann storage into the Barrage for this purpose.

The Barrage impoundment and upstream catchment are unprotected surface waters that are impacted by a multitude of different land use practices and industrial activities that occur in the various sub-catchments within the Fitzroy Basin. As such the raw water in the Barrage storage is subject to the potential impacts that occur within the catchment. Typical water quality issues that arise include cyanobacterial blooms, mine water discharges that alter water quality aesthetics and high flow or flooding events that lead to highly variable raw water quality e.g. rapid changes in turbidity, fluctuations in Fe and Mn concentration. The raw water contains a low concentration of fluoride at ~0.1 mg/L. A thorough review of the Fitzroy Basin, its characteristics, status and management framework is provided in the Fitzroy Basin Water Quality Improvement Report (2008) prepared by the Fitzroy Basin Association Incorporated.

The Glenmore Water Treatment Plant intake structure is located approximately 5 km upstream of the Fitzroy River Barrage. The intake is designed to provide four different depths from which water is pumped for treatment, from the surface to more than 5 m deep. Multiple high level intake structures provide the ability to pump raw water for treatment during high flow and flooding events. All intake structures are designed to withstand damage from debris and high flows that occur during flooding events.

The Glenmore Low Lift Water Pump Station (WPS) contains four centrifugal pumps ranging in capacity from 270 L/sec to 715 L/sec. This WPS pumps raw water from the river intake into the inlet of the Glenmore WTP which is located about 250 m away from the riverbank. Combinations of these four pumps can be operated to meet the demand requirements and to balance the flow rate of raw water into the Glenmore WTP with the flow rate of drinking water out of the clear water storage reservoirs.

2.2.2 Waterpark Creek

The Waterpark Creek catchment drains an area to the north of Yeppoon that extends along the coastal margin on the southern edge and partially into the Shoalwater Bay military training area. Although much of this area receives some of the highest annual rainfall within Central Queensland (>1500 mm), a $50M water supply pipeline commenced operation in 2010 to enable water to be supplied from the Fitzroy River via the Glenmore WTP to ensure security of supply to the Capricorn Coast.

The Waterpark Creek storage is provided by a small concrete weir which is located immediately upstream of the Waterpark Creek Road crossing of Waterpark Creek at Byfield. The total volume of the weir storage is not well defined as the pondage extends many kilometres upstream through a series of connected or partially disconnected waterholes depending on the flow conditions. A flow in Waterpark Creek is maintained virtually all year round.

The yield from Waterpark Creek is based on just over 100 years of records. The historical no failure yield over this period is 2,020 ML/year. If an event that occurred in 1902 is excluded from the calculation of yield then Waterpark Creek has a safe yield of 4,020 ML/annum (Water Supply Sources Study, Cardno, 2005). Both of the above-mentioned yields include the operation of the existing Kelly's Off-Stream Storage which holds just over 1000 ML at full supply level. An additional 4000 ML/year allocation is also to be made available following the completion of construction of a new storage upstream of the Fitzroy Barrage Storage.

The Waterpark Creek raw water is typical of a densely vegetated coastal catchment area with a high rainfall. The raw water is a low alkalinity, low turbidity, highly coloured surface water. Apart from the high colour content, no significant water quality issues arise from the Waterpark Creek site. The Kelly's Off-Stream Storage is occasionally prone to cyanobacterial blooms and stratification-related water quality issues.

The water intake at Waterpark Creek is located approximately 150 m upstream of the weir and consists of a fixed single intake pipe structure located approximately one metre beneath the normal water level. The opening of the intake pipe is designed with a cylindrical intake strainer that contains bars with a spacing of ~ 80 mm to prevent the large debris from entering the intake pipe. The duty/standby low lift pumps of ~ 150 L/sec capacity pump water a distance of approximately 400 m to the Waterpark Creek High Lift Pump Station (3 pumps of ~150 L/sec capacity each) which then pumps the water about 20 km to the Kelly's Off-Stream Storage (~1200 ML) located in Woodbury which serves as a buffer storage for the Woodbury WTP.

Prior to the commencement of operation of the Rockhampton to Yeppoon Water Supply Pipeline, Kelly's Off-Stream Storage was operated to maintain at least 80% storage capacity so that this volume of water could be relied upon during periods (usually late spring to early summer) when flow in Waterpark Creek decreased to levels beneath an agreed threshold that allows for diversion to continue without risking environmental harm through tidal intrusion into the sensitive high conservation downstream freshwater ecosystem. Following commencement of the Rockhampton to Yeppoon Water Supply Pipeline, Kelly's Off-Stream Storage is maintained at between 80 and 90% capacity. Supply of raw water from this storage to Woodbury WTP is a constant operational arrangement with the bypass of the storage available but not used.

The intake structure at Kelly's Dam consists of nine different 2 m inlets located at different depths with a 150 mm bar screen set at the intake depth to prevent the entry of large objects or debris. The Kelly's WPS contains two duty/standby centrifugal pumps each with a capacity of 500 L/sec. These pumps are used to supply raw water from the Kelly's Off-Stream Storage about 800 m to the Woodbury WTP inlet.

Since the commencement of operation of the Rockhampton to Yeppoon Water Supply Pipeline, the Waterpark Creek source has supplied approximately 30% of the drinking water supplied to the Capricorn Coast Water Supply Scheme with the remainder being supplied from the Fitzroy Barrage Storage via the Glenmore WTP and the new water supply pipeline.

2.2.3 No.7 Dam and Fletcher Creek Weir

The Mount Morgan Water Supply Scheme obtains its water from the No.7 Dam (primary water source) and the Fletcher Creek Weir (alternate source). Currently 100% of the Mount Morgan Water Supply is sourced from the No.7 Dam with the Fletcher Creek source available for use only in the event that water from the No.7 Dam is either unfit for use or unavailable. The No.7 Dam is located on the Dee River which runs through the centre of Mount Morgan. The No.7 Dam was originally constructed in 1900 by the Mount Morgan Gold Mine Company and was later raised an additional 4.5 m in 1999. The total storage capacity of the dam is 2,800 ML.

The Fletcher Creek Weir was originally built in 1966 and was later upgraded to a three row steel piling weir in 1984. The total storage capacity of the Fletcher Creek Weir is approximately 340 ML. Modelling of water storage levels based on current demand suggests that by the time the No.7 Dam level drops to the point where water is unavailable for use, the Fletcher Creek Weir will already be empty and therefore useless as a water source.

For many years long term water security in Mount Morgan has been an area of much attention. The area receives lower annual rainfall than the coastal parts of the region and the Dee River and Fletcher Creek catchments are quite small by comparison. Based on historical data, the 99.9% reliable supply from the No.7 Dam is 1.6 ML/d. Therefore based on current and future demand, the available water supply may be sufficient in 99.9 out of 100 months until at least 2020.

Land use in the Dee River and Fletcher Creek catchments above the two storages is predominantly cattle grazing or undisturbed bushland, with each catchment an unprotected catchment. The two storages are upstream from the extensive gold and copper mining activities associated with Mount Morgan's history. Water quality issues associated with these two storages include problems associated cyanobacterial blooms and occasional increases in the concentrations of iron and manganese in the raw water.

The raw water intake at the No.7 Dam is located approximately 15 m away from dam wall and approximately 20 m from the shore of the dam. An anchored pontoon provides the support for the raw water intake pipe which is supplied via a single submersible pump capable of pumping 25 L/sec located at a fixed depth (600 mm) in water with a maximum depth of 12 m. An identical submersible pump is available for rapid installation as a replacement in the event of a raw water pump failure.

2.2.4 Marlborough Bore Water

The Marlborough Drinking Water Scheme is currently supplied with water from two shallow bores (RN 91861 and RN 91966 on Department Environment and Resource Management (DERM) groundwater database) located 2-3 km to the north of the Marlborough township that draw water from the same two shallow aquifers, the Marlborough Creek Alluvium aquifer (12-15 m depth) and a deeper decomposed granite aquifer (18-20 m depth). The bores were drilled in late 1995 and early 1996, are approximately 20-25 m deep with about 7 m depth to water level and are capable of producing water at about 5 L/sec. Each bore is cased with 160 mm diameter polyvinyl chloride (PVC) pipe with two separate screens located at 13-15 m and 18-20 m depth. The bore heads are located approximately three metres apart and are encased in concrete with the bore heads raised approximately 500 mm above the surface of the ground. The bore heads are sealed to prevent the entry of any contaminating material. The bore site is contained within a fenced enclosure that is locked at all times.

Pump tests conducted in early 1996 following an extended period of drought suggest that a yield of 3.9 L/sec be adopted as the target sustainable pumping rate during drought conditions. At this level of supply, the daily and annual demand targets of 40 kL and approximately 15 ML respectively are highly sustainable into the future. Two bore pumps capable of operating in duty/standby mode and with a capacity of 3.5 L/sec are used to pump raw water from the bore site to the Marlborough WTP.

Land use in the area is predominantly cattle grazing with some fodder production occurring using groundwater irrigation. The bore water is of a moderately good quality low turbidity water with electrical conductivity ranging between 1000 and 1500 µS/cm. Water quality analysis shows that bore water is very close to meeting Australian Drinking Water Guideline (ADWG) standards, however, elevated conductivity and water hardness due to relatively high concentrations of sodium, magnesium and calcium reduce the aesthetic quality of the water.

2.3 Water Treatment Processes

Water treatment for each of the drinking water schemes is performed using slight variations of the same conventional coagulation, flocculation, sedimentation, filtration, pH correction and disinfection process, with the exception of the Marlborough WTP which is comprised of a filtration, reverse osmosis, blending and disinfection process to produce drinking water. The individual treatment processes are described below for each water treatment plant.

2.3.1 Glenmore Water Treatment Plant

The Glenmore WTP in Rockhampton is the source of treated water supplied to residents in Rockhampton, Gracemere, The Caves and also the Capricorn Coast via the Rockhampton to Yeppoon Water Supply Pipeline. Commencing operation in 1971, the Glenmore WTP has a maximum capacity to treat 120 ML/d and the maximum demand recorded on the system was 114 ML/d, which was recorded in 2002/03 prior to the introduction of water meters in Rockhampton. Since consumption-based charging commenced in 2005, maximum consumption has not exceeded 90 ML/d.

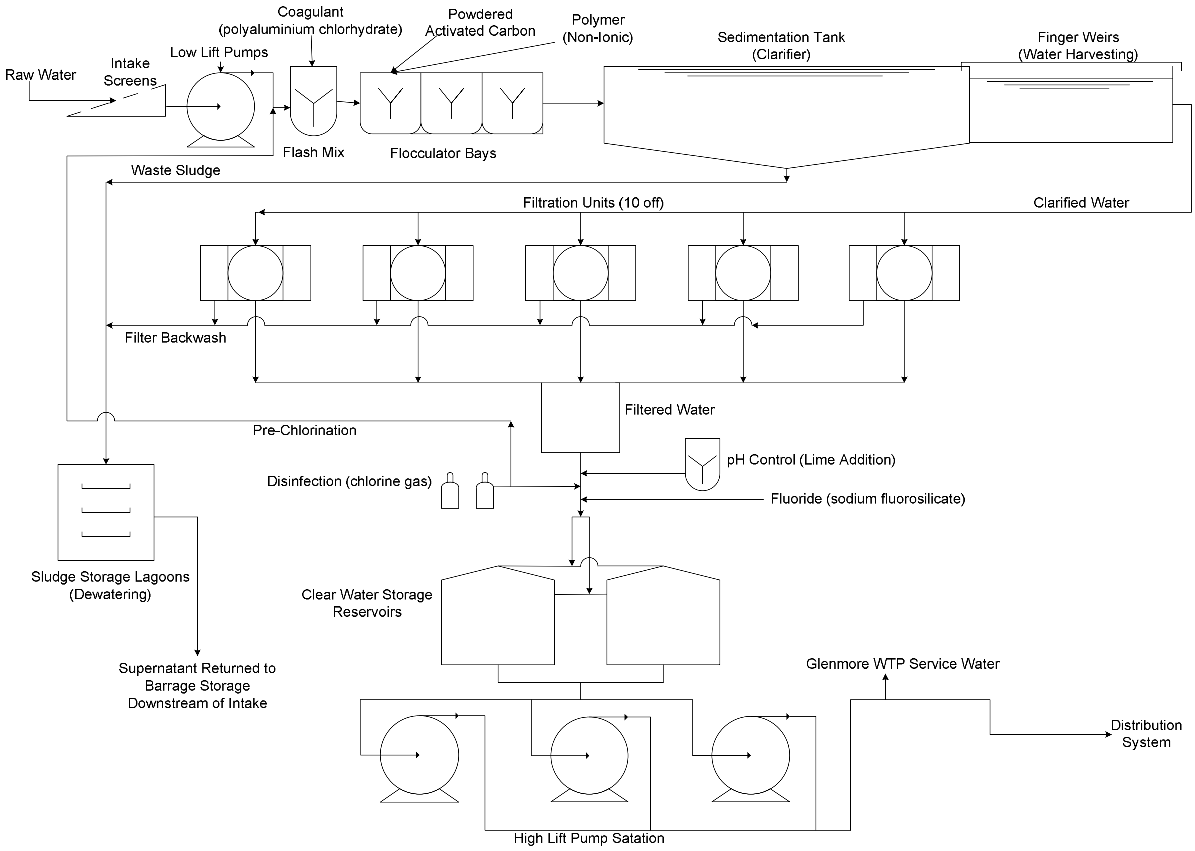
The design of the Glenmore WTP has been maximised to handle very high raw water turbidity and large rapid variations in raw water turbidity. There are no defined raw water turbidity operational limits for the operation of the WTP. The WTP has effectively treated raw water with turbidity in excess of 2000 NTU and is consistently capable of achieving more than 4-log removal of turbidity through its treatment stages. Operational performance is monitored using on-line and manual turbidity to ensure the effectiveness of treatment barriers (see further descriptions below).

Figure 2.5 shows a schematic representation of the treatment processes used at the Glenmore WTP. Water flows through coarse mesh screens into the river inlet structure and gravitates to the low-lift pump station where it is pumped to the inlet of the WTP. Upon entry to the inlet of the WTP, the option exists for pre-chlorination to be used for the oxidation of metals such as iron and manganese, or to assist with the destruction and removal of cyanobacteria. In recent years no pre-chlorination has been conducted and the use of this pre-treatment step is unlikely unless a sever cyanobacterial bloom event occurs in the source water. The WTP inlet is designed to promote rapidly mixing conditions, and at this point the influent raw water is dosed with a coagulant (polyaluminium chlorhydrate, Megapac 23, Omega Chemicals) using a duty/standby two pump set system. The coagulant-dosed raw water is then pumped into two identical parallel train flocculation/sedimentation basins, each with a design capacity of 70 ML/d.

At the entry to the first bay of the flocculation tank powdered activated carbon (Acticarb PS1000, Activated Carbon Technologies) is dosed into the water using a duty/standby activated carbon dosing system when required to remove soluble organics. The flocculation tank is comprised of three bays that contain horizontal paddle mixers to provide gentle mixing to promote flocculation. The direction of flow through each bay is opposite to the previous bay. Upon entry to the second bay of each flocculation tank, the water is dosed with a polyacrylamide (NALCLEAR® 8170 PULV) as a water clarification aid.

Water containing well formed floc particles leaves the flocculation tank and enters the sedimentation tank through a series of slots in the wall of the final flocculation bay. At this point the absence of mixing promotes the settling of the floc particles as the water passes through the sedimentation tank. The majority of the sedimentation process occurs within the first half of the sedimentation tank. A mechanical sludge scraper in each sedimentation tank is used to remove settled sludge through drains in the bottom of the sedimentation tank. Water treatment sludge is collected in on-site sludge holding lagoons. Gravity separation is used to separate the sludge from the supernatant which is then returned to the Barrage impoundment. Strict discharge conditions require that the supernatant is of high quality and therefore poses no risk to the quality of raw water in the Barrage storage. The second half of each sedimentation tank contains a tube settler array to maximise sedimentation of fine floc particles. At this point, clarified top water (target turbidity of 1.0 to 1.5 NTU measured by a pre-filtration on-line turbidity meter) is collected via finger weirs into collection channels which then transfer the clarified water to the filters.

Figure 2.5: Schematic Representation of the Treatment Process at the Glenmore WTP.



Filtration is achieved using 10 rapid gravity sand and garnet filters of 1100 mm total bed depth. Each filter contains three 100 mm deep layers of garnet gravel (effective size = 0.6-1.2 mm, 1.2-2.4 mm and 2.4-4.8 mm) beneath a 200 mm layer of fine garnet (effective size = 0.3-0.4 mm) which is beneath a 600 mm deep layer of top sand (effective size = 0.9-1.0 mm). Filters are automatically backwashed based on time, loss of head or turbidity triggers which are monitored in real-time by the Honeywell Programmable Logic Controller (PLC) and Experion PKS Supervisory Control and Data Acquisition (SCADA) system. Backwashing is achieved using a duty/standby two pump set and duty/standby blowers to air scour and wash each filter. Each filter contains a filter-to-waste function which enables poor quality filtered water to be wasted until the target water quality is achieved. Filters typically produce water with turbidity of <0.1 NTU, with 0.3 NTU used as a setpoint to trigger a backwash (as per the USEPA Long Term 2 Enhanced Surface Water Treatment

Rule). Filter backwash or other waste waters are diverted to the sludge holding lagoons mentioned above and are treated and disposed of accordingly.

Filtered water passes through dual collection pipes which gravity transfers the water to the clear water reservoirs (2 x 2.2 ML reservoirs). Before reaching the clear water reservoirs, the dual collection pipes intersect at a pit designed to provide mixing, a water storage for the filter backwash pumps and also be used as a common dosing point for chlorine. Prior to entry into this pit filtered water is dosed with hydrated lime by one of two duty/standby lime feeding systems to correct pH (pH 7.8 target).

Fluoride (sodium fluorosilicate 1 tonne bulk bag system) is added via dual duty/standby dosing pump skids into each of the dual collection pipes immediately downstream of the intersecting mixing pit. Fluoride dosing to a final concentration of 0.7 mg/L is achieved using flow-paced dosing based on flow readings from meters in the clear water collection pipes. On-line Dulcometer fluoride analysers are installed for each dosing pump set with interlocks with a separate PLC to prevent overdosing and with low, high and high high alarm setpoints to detect excursions outside of the target operating range (0.6 to 0.86 mg/L). The same alarm setup exists on a third final water Dulcometer fluoride analyser to provide redundancy of on-line analysis. This final water on-line analyser is not interlocked with the PLC that controls the two dosing pump sets.

Disinfection is achieved by adding chlorine gas into the pit via one of two duty/standby Wallace & Tiernan gas feed chlorinators. The chlorine gas storage room is designed to allow four cylinders containing 920 kg each to be connected for use at any time. A free chlorine residual setpoint of 1.1 mg/L is used for the final water and this is achieved using flow-paced dosing at rates of more than 8 kg/h of chlorine gas if required to achieve the free chlorine residual setpoint. Water from the clear water reservoirs is then pumped to the distribution system using the High Lift Pump Station on site. Alarm setpoints for low, low low, high and high high alarms for the free chlorine residual are in place to detect excursions outside of a target range (0.5 to 1.5 mg/L of free chlorine) and the Glenmore WTP PLC is programmed to automatically shutdown the WTP and High Lift Pump Station if the free chlorine residual exceeds 1.7 mg/L for more than 30 minutes. If the free chlorine residual triggers a low level alarm urgent action is taken to address the cause of the excursion via the attendance to site of suitably qualified reactive maintenance staff. If required the WTP will be shutdown to prevent the distribution of non-disinfected water to customers.

As indicated above, the Glenmore WTP has a maximum treatment capacity of 120 ML/d. This maximum capacity is based on the recorded peak operating rate used in the early 2000s when demand before the implementation of water meters in Rockhampton was significantly higher than it is currently. Each sedimentation tank is capable of achieving effective clarification of raw water at a rate of 70 ML/d. The 10 rapid sand filters are capable of achieving effective filtration of clarified water at a flow rate of 120 ML/d. The chlorine gas disinfection system is capable of achieving effective disinfection up to at least 120 ML/d.

Despite these stated maximum capacity rates, a safe working maximum treatment capacity of 110 ML has been adopted as the normal maximum flow rate through the Glenmore WTP. Therefore current maximum loadings are well beneath the known effective capacity of the sedimentation tanks, filters and disinfection process steps and no bypasses for any of these steps exists in the WTP process design. This rate has been determined based on its suitability over a range of differing raw water quality conditions. If required to meet high demand or maximise the cost effectiveness of operating during the off-peak electricity period, the Glenmore WTP is operated at the 110 ML/d flow rate, however, much of the time when demand is low, the flow rate through the Glenmore WTP ranges between 60 and 85 ML/d.

The Glenmore WTP is attended by at least one operator all day every day in order to closely monitor and operate (if required) the Glenmore WTP as well as to perform a range of water quality and process performance tests and checks.

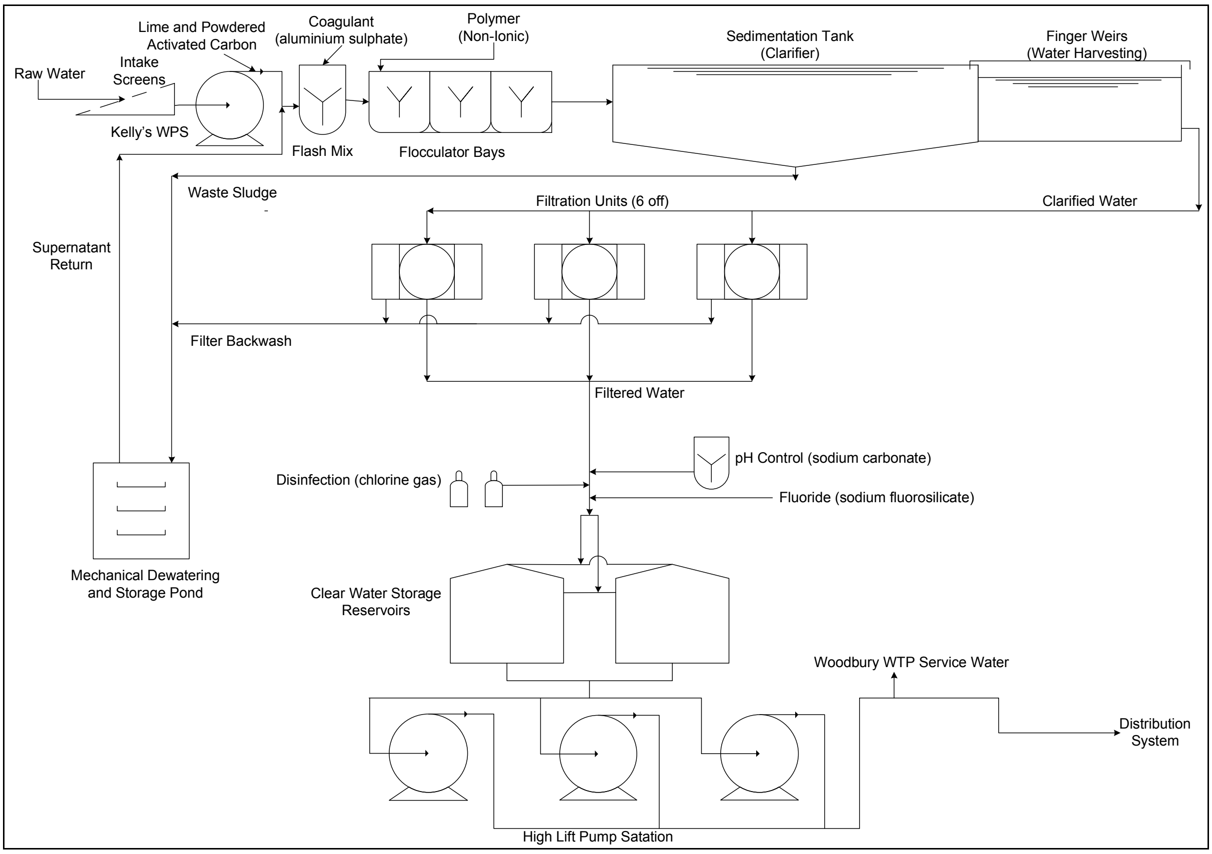
2.3.2 Woodbury Water Treatment Plant

The Woodbury WTP is located in the locality of Woodbury which is 17 km north of Yeppoon on the Capricorn Coast. Commencing operation in 1988, the Woodbury WTP has a design capacity of 21.6 ML/d. Prior to the commencement of operation of the Rockhampton to Yeppoon Water Supply Pipeline, the maximum demand placed on the Woodbury WTP was 18 ML/d. This demand is now significantly offset with approximately 70% of the Capricorn Coast Water Supply Scheme supplied with drinking water produced by the Glenmore WTP in Rockhampton.

Raw water pumped from Waterpark Creek is stored in the Kelly's Off-Stream Storage (~1.2 GL total volume). Although the Woodbury WTP is capable of being supplied directly from Waterpark Creek, for more consistent raw water quality, water is pumped from the Kelly's Off-Stream Storage to the Woodbury WTP. Figure 2.6 shows a schematic representation of the process used at the Woodbury WTP.

The Woodbury WTP has a conventional water treatment plant design. Prior to entering the inlet of the WTP, the raw water is dosed with hydrated lime to increase the pH and alkalinity for the coagulation process. Powdered activated carbon (ACCARB35 FP22) is also added using a duty/standby dosing system to assist with removal of colour and other soluble organic compounds from the low turbidity raw water (< 5 NTU). The raw water is dosed with liquid aluminium sulphate using a duty/standby dosing pump system as it enters the rapid mixing tank to commence coagulation. The use of the Kelly's Off-Stream Storage promotes a highly stable raw water quality which enables coagulant dose to remain constant over time. Water is then pumped into a flocculation tank where reciprocating mixers provide gentle mixing which promotes the formation of floc particles. A water clarification aid (FLOPAM™ FA 920 PWG) is dosed into the water to assist floc formation.

Figure 2.6: Schematic Representation of the Treatment Process at the Woodbury WTP.



The chemically dosed water then passes into a sedimentation tank where floc particles are gravity settled to clarify the water. An array of tube settlers is used to promote the clarification process. The clear top surface of the water is then collected via finger weirs into a clear water channel which transfers the water to the filters. The turbidity target for the water entering the filtration process is 1 NTU.

Filtration is achieved using six rapid gravity sand filters of 1500 mm total bed depth. Each filter contains three 100 mm layers of silica sand gravel (effective size = 3.0-6.0 mm, 6.0-12.0 mm and 12.0-19.0 mm) beneath a 100 mm layer of silica sand (effective size = 1.5-3.0 mm) which is beneath a 400 mm deep layer of top sand (effective size = 0.9-1.0 mm). The layer of top sand is covered by a 600 mm deep layer of filter anthracite (effective size = 1.7-1.9 mm). Filters are automatically backwashed (air scour and wash steps) based on time or turbidity triggers which are monitored in real-time by the Bernecker and Rainer master PLC, some Allen Bradley Micrologix 1500 PLCs and a Citect SCADA system. Filtered water turbidity is typically less than 0.3 NTU.

Following filtration the water is dosed with sodium carbonate using duty/standby dosing pump system to correct pH (target pH = 7.6-7.8), fluoride (sodium fluorosilicate to achieve 0.7 mg/L) and is disinfected using chlorine gas before entering the clear water reservoir (2 ML total storage). The free chlorine residual setpoint for the final water is 1.8 mg/L.

Disinfection is achieved using a single Wallace & Tiernan automatic gas chlorination system (installed in 2009) and flow-paced dosing. The final water is then pumped to the distribution system by the Woodbury high-lift pump station located on the Woodbury WTP site. Alarm setpoints for low, low low, high and high high alarms for the free chlorine residual are in place to detect excursions outside of a target range (0.5 to 1.8 mg/L of free chlorine) and the Woodbury WTP PLC is programmed to automatically shutdown the WTP and High Lift Pump Station if the free chlorine residual exceeds 2.0 mg/L for more than 30 minutes.

Fluoride dosing to 0.7 mg/L is achieved using a sodium fluorosilicate dosing plant installed in accordance with the Fluoridation Code of Practice. This dosing system is controlled by a PLC that operates independently to the main WTP PLC. The same on-line monitoring and alarm setpoints as listed for the Glenmore WTP are in place at the Woodbury WTP.

The maximum treatment capacity of the Woodbury WTP is 21.6 ML/d with peak instantaneous flow through the WTP of ~250 L/sec. Each of the treatment process steps is designed to achieve this maximum capacity, however, the Woodbury WTP is typically operated at 191 L/sec well beneath the maximum treatment capacity to maximise process stability, consistency of chemical dosing and plant performance. No option to bypass any of the treatment steps exists within the WTP design.

Woodbury WTP sludge is collected and dewatered on-site using a thickener and centrifuge. Although it is possible to return the sludge supernatant to the Woodbury WTP inlet, the supernatant is primarily disposed of by irrigating it on site to avoid any chance of negatively impacting the Woodbury WTP treatment process.

The Woodbury WTP is attended by an operator for up to seven hours each day in order to closely monitor and operate (if required) the Woodbury WTP as well as to perform a range of water quality and process performance tests and checks.

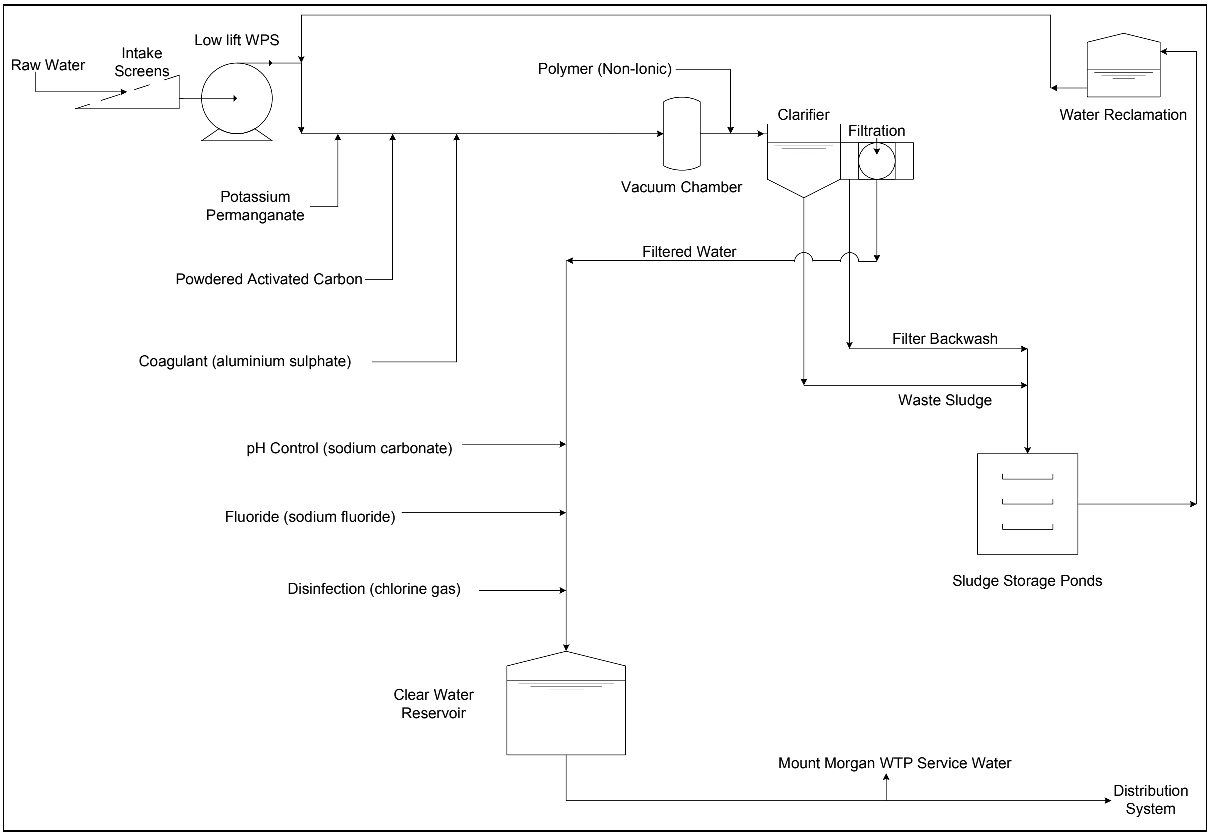
2.3.3 Mount Morgan Water Treatment Plant

The Mount Morgan Water Treatment Plant consists of an AQUAPAC package plant (Aquagenics Pty Ltd) that incorporates coagulation, flocculation, sedimentation and gravity filtration in a single tank system. This plant commenced operation in 1994 and has a design flow capacity of 30 L/sec (~2.6 ML/d).

Figure 7 shows a schematic representation of the treatment process used at the Mount Morgan WTP. The incoming raw water is dosed with powdered activated carbon to assist with the removal of soluble organics and colour. The coagulant aluminium sulphate prepared in a batch mixing tanks is dosed using a duty/standby dual pump system into the inlet pipework. Coagulant dosed water then enters the vacuum chamber which is designed to provide rapid mixing conditions through intermittent high flows into the dosing manifold of the clarifier. The inlet pipework is also equipped with a single pump system and dosing point for the addition of potassium permanganate to pre-oxidise iron and manganese which is often present at elevated concentrations in the raw water sourced from Fletcher Creek. Fletcher Creek is rarely used as the source of raw water since the increase in the storage capacity of No. 7 Dam in 1999.

Clarification is achieved when the ‘pulsed’ intermittent high flows expand the sludge blanket then longer quiescent periods allow the sludge blanket to settle. As the coagulant dosed water passes through the dense sludge blanket, flocs and other particles collide to promote the flocculation and sedimentation process. Clarification also includes the use tube settlers to promote the sedimentation of fine floc particles and reduce carry-over of fine flocs to the filters. The tube settlers are located above the sludge blanket in the clarification tank. The sludge blanket depth is maintained by a sludge hopper which is designed to act as a sludge concentrator to collect excess sludge. Sludge is removed through a manual or automated desludging process to on-site storage ponds where the sludge is gravity settled and the supernatant is either evaporated to avoid any possible impact on Mount Morgan WTP water quality or if required is transferred to a storage tank before being returned to the plant inlet.

Figure 2.7: Schematic Representation of the Treatment Process at the Mount Morgan WTP.



Clarified water is collected into launders through perforated pipes located above the tube settlers and is then transferred to the two rapid gravity sand filters for filtration. Each filter has a total bed depth of 700 mm made up of a 300 mm top layer of anthracite (effective size = 1.6-1.7 mm) above a 300 mm layer of silica sand (effective size = 0.6-0.7 mm) which is above a 100 mm layer of coarse silica sand (effective size = 1.1-1.5 mm). Filters are backwashed automatically or manually using a single backwash pump system and single blower system to air scour and wash each filter every 24-36 hours of plant operation. Backwash water is stored in an on-site lagoon where it is settled and then transferred to a storage tank before being returned to the plant inlet.

Filtered water is dosed with sodium carbonate mixed in a chemical batching tank to correct pH (target pH = 7.8) using a single pump dosing system and is then gravity fed to the on-site clear water reservoir (2.5 ML total storage volume). A sodium fluoride saturator plant doses the filtered water to achieve the 0.7 mg/L target concentration. The filtered water is chlorinated using chlorine gas as it enters the clear water reservoir (Black St Reservoir) which also provides half of the service reservoir storage for the Mount Morgan Water Supply Scheme. The chlorine gas dosing system (installed in 1994) is controlled manually to deliver a free chlorine residual of between 1.5 and 2.0 mg/L.

An upgrade of the disinfection system will be completed by mid 2012 that will see the conversion of the manually controlled dosing system to an automated chorine gas flow-paced dosing system that is controlled by an on-line chlorine analyser. Alarm setpoints for low, low low, high and high high alarms for the free chlorine residual will be put in place to detect excursions outside of a target range (0.5 to 1.2 mg/L of free chlorine). The WTP PLC will also be modified to include a WTP-inhibit step to prevent the WTP from operating if the free chlorine residual exceeds 1.5 mg/L.

Fluoride dosing to 0.7 mg/L is achieved using a sodium fluoride saturator dosing plant installed in accordance with the Fluoridation Code of Practice. This dosing system is controlled by a PLC that operates independently to the main WTP PLC. The same on-line monitoring and alarm setpoints as listed for the Glenmore WTP and Woodbury WTPs are in place at the Mount Morgan WTP.

The plant operation is currently controlled by an Allen Bradley CompactLogix PLC that provides automated operation of plant starting and stopping, filter backwashing and desludging processes. There is currently no on-line monitoring of water quality parameters at the Mount Morgan WTP. Capital upgrades currently in progress will deliver on-line monitoring and control of the Mount Morgan WTP based on analysis of raw, filtered and final water quality parameters including, pH, turbidity, electrical conductivity and free chlorine residual through the installation of new instrumentation and PLC and integration with the Experion SCADA system to allow remote monitoring and operation.

The Mount Morgan WTP is designed with all process steps able to achieve effective operation at a maximum capacity of 2.6 ML/d or a peak instantaneous flow of 30 L/sec with no option to bypass any of the treatment steps. The Mount Morgan WTP is operated at a constant flow rate of approximately 22 L/sec, well beneath the design capacity of the WTP to help ensure stability and consistency of chemical dosing and plant performance. Current water demand is being met easily at this constant flow rate with consumption usually no greater than 1 ML/d.

The Mount Morgan WTP is attended by an operator for at least two hours each day in order to closely monitor and operate (if required) the Mount Morgan WTP as well as to perform a range of water quality and process performance tests and checks.

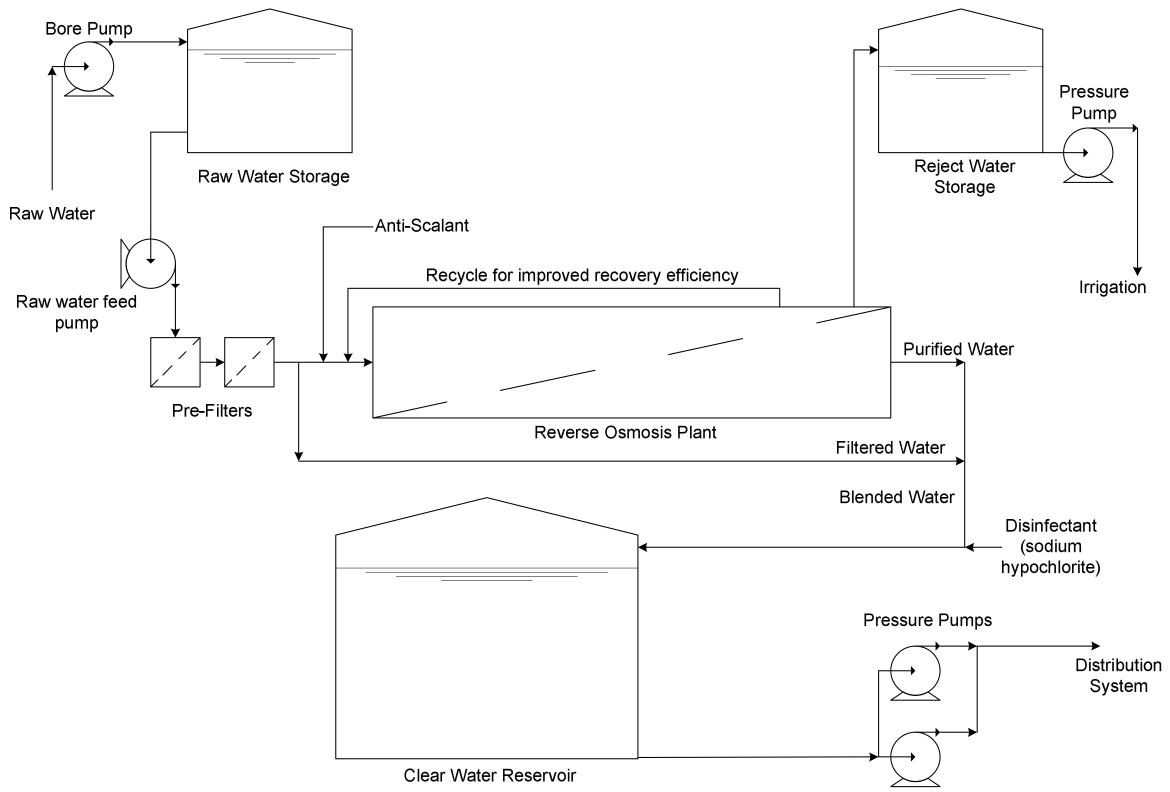
2.3.4 Marlborough Water Treatment Plant

Construction of the Marlborough WTP was completed in September 2011, however, an identical treatment train was added in early 2012 to expand the capacity of the WTP to a total of 100 kL/d. Each WTP treatment train has a maximum treatment capacity of 50 kL/d and treats raw water sourced from the Marlborough bore site located on Glenprairie Road. Treatment to produce drinking water is achieved through a combination of filtration and reverse osmosis. The Marlborough bore water is a moderately good quality low turbidity groundwater that has an elevated concentration of dissolved minerals.

Figure 2.8 shows a schematic representation of one of the duplicate treatment process trains used at the Marlborough WTP. Raw water is pumped from the two duty/standby bore site to a 45 kL raw water storage before entering the Marlborough WTP. A single raw water feed pump then pumps the water through a 5 µm bag filter before entry to the reverse osmosis treatment process. The filtered water is then dosed using a single pump with anti-scalant (Hypersperse MSI410) and filtered through a 5 µm cartridge filter before it is split into two streams. Neither of the filtration steps involve backwashing with the filters units replaced based on time, visual inspection or loss of head indicated by pressure sensors. One of the streams is further treated using reverse osmosis through spiral wound thin film composite reverse osmosis membranes. The reverse osmosis permeate is then blended with the filtered non-reverse osmosis treated stream at a ratio of 3:1 to produce a final drinking water that meets ADWG.

A clean-in-place system is used to clean the reverse osmosis membranes using sodium hydroxide and hydrochloric acid. This system is operated only manually disconnecting the raw water feed pipework and treated water outlet pipework and connecting the clean-in-place system. At start-up of the Marlborough WTP an automatically programmed wash/rinse step is included to flush the system for a fixed period of time with final drinking water before the production of any new drinking water. This step is included to ensure than any residual chemical from the clean-in-place system is removed prior to the production of drinking water.

Figure 2.8: Schematic Representation of one of the Duplicate Treatment Process Trains at the Marlborough WTP.



The final water is disinfected using a single pump sodium hypochlorite flow-paced dosing system with a control loop to produce a free chlorine residual of 0.8 mg/L in the final drinking water. The chlorination is controlled and monitored by a Depolox on-line chlorine analyser. Alarm setpoints for low, low low, high and high high alarms for the free chlorine residual are in place to detect excursions outside of a target range (0.5 to 1.0 mg/L of free chlorine) and the Marlborough WTP PLC is programmed to automatically shutdown the WTP if the free chlorine residual exceeds 1.5 mg/L for more than 30 minutes. The final drinking water is stored in a 90 kL (~2 days supply) clear water storage connected to a three pump WPS that operates in duty/standby mode to supply water at a constant pressure (~380 kPa) to the reticulation system. The Marlborough distribution system does not consist of any other reservoir storages and due to its small size and good penetration of free chlorine, no rechlorination is required.

Reject water produced during the reverse osmosis treatment process is stored in a 25 kL tank that can be accessed by water carriers for non-potable water applications such as road construction. A standpipe dedicated for this purpose is clearly signed to indicate that the reject water is non-potable. The remaining reject water is used to irrigate the park area surrounding the Marlborough WTP.

The Marlborough WTP is controlled automatically by an Allen Bradley MicroLogix 1500 PLC with on-line flow monitoring of permeate, reject, recirculation and blended product as well as final water pH, turbidity and electrical conductivity with two electrical conductivity meters to provide redundancy in the event of one failing. The Marlborough WTP is connected via radio telemetry to the GWTP SCADA system to allow remote monitoring and control from the central control room.

There is no option for any of the treatment steps (filtration, reverse osmosis, disinfection) to be bypassed although the flow of the split treatment streams is adjustable to slightly alter the blend ratio of the two treatment streams to achieve a target final water quality.The Marlborough area often experiences extended power outages. A diesel generator has been installed that is capable of powering the entire Marlborough WTP and the three pump WPS to allow continued treatment and supply of drinking water until mains power is restored.

2.4 Availability of Equipment and Critical Spares

For all WTP and water distribution infrastructure an extensive inventory of equipment and critical spares is kept locally for most of the components of existing water treatment and distribution infrastructure. Table 2.4 provides an indication of the spares kept and provides a description of the type or function of the components.

Standard designs and equipment specifications have been adopted where possible to improve the consistency of processes, and to reduce the number of spares that need to be kept to meet maintenance demands. Critical equipment such as on-line and bench-top water quality monitoring instrumentation, chemical dosing pumps, flow meters, ultrasonic level indicators, PLCs and radio telemetry systems are among the items for which standard design and equipment specifications have been adopted. Future infrastructure upgrades are planned in accordance with these adopted specifications.

A significant amount of redundancy has been designed into the WTPs. Items of equipment such as air compressors, chemical storage tanks, chemical batch tanks, mixers and dosing pumps, flow meters and flow switches have been installed in either duty/standby or in an arrangement which provides a level of backup redundancy to help ensure continuity of operation.

Table 2.5: Critical Spares Kept for Water Treatment and Distribution Infrastructure

Equipment Category	Type of Equipment/Parts in Each Category
Mechanical	Compressor and pneumatic system spares Pumps for process sampling or chemical dosing Backup generator set spares Mixers for chemical batching tanks Valves and valve actuator spares
Electrical	Switching gear and spares for high lift and low lift pump stations Programmable Logic Controller spares Electrical components, contactors, flow switches, circuit breakers Radio telemetry equipment and spares Variable speed drives and spares
Process Control	SCADA servers and spares Flow meters, flow meter head units, flow sensors On-line instrument probes, ultrasonic level indicators

2.5 Water Distribution and Reticulation Infrastructure

A summary of the operation and flow regime through the water distribution system is provided below for each of the four water supply schemes. The four drinking water schemes are comprised of a range of different assets that are used to store, rechlorinate and distribute water to customers. In all four schemes a combination of gravity and pumped distribution mains are used to ensure flow and pressure requirements are met. A detailed description of the below ground pipe infrastructure, the above ground reservoirs and rechlorination facilities, and water pump stations that are required to transport water and pressurise supply zones is also provided. Specific details of these assets in each scheme are provided in Tables 2.6 to 2.9.

2.5.1 Overview of Operation – Rockhampton Water Supply Scheme

The Glenmore high-lift water pump station (WPS) pumps water from the WTP through a network of trunk distribution mains to fill the Birkbeck Avenue, Yaamba Road, Thozet Road and Athelstane Range Reservoirs (see Figure 1). Each of these reservoirs gravity feed water to the surrounding reticulation networks in North Rockhampton. The Belmont Road WPS lifts water to the Samuel Crescent Reservoir which then gravity feeds a small reticulation network near the Glenmore WTP.

The Norman Road WPS is used to fill the Nagle Drive Reservoir which gravity feeds the Norman Gardens reticulation zone in North Rockhampton. The Thozet Road WPS lifts water from the Thozet Road Reservoir to fill the Forbes Avenue and Rogar

Avenue Reservoirs which then gravity feeds water to the surrounding reticulation that serves the Frenchville area of North Rockhampton. A series of three small WPS are used to lift water to the Mt Archer Reservoir (approximately 600 m elevation) which then gravity feeds a small reticulation system on the top of Mt Archer. To the east of the Thozet Rd Reservoir, a trunk main supplies water to a privately owned and operated reservoir used to supply water to two abattoirs.

The Athelstane Range Reservoir Complex gravity feeds water to the South Rockhampton and West Rockhampton reticulation networks as well as supply water along a gravity trunk main to the town of Gracemere where the Old Capricorn Highway WPS lifts the water to fill the Mawdesley Hill Reservoirs. Water is then gravity fed from the Mawdesley Hill Reservoirs to the surrounding reticulation system and also to the Lucas Street Reservoir which supplies the reticulation system on the south-western side of Gracemere.

The Yaamba Road Reservoir gravity feeds water to the Parkhurst area and the Ramsay Creek WPS which lifts water to supply the Glenlee, Glendale, Rockyview and Etna Creek areas as well as filling the Mt Charlton Reservoir and supplying The Caves WPS which fills The Caves Reservoir. The Caves and Mt Charlton Reservoirs also gravity feed the same areas to the north of Parkhurst.

The newly constructed Ibis Avenue WPS pumps water from the Yaamba Road Reservoir along the Rockhampton to Yeppoon Water Supply Pipeline to the Boundary Hill Reservoir located halfway between Rockhampton and Yeppoon. From here, the water is gravity fed through the Yeppoon West Valve Facility to either the St Faith's or Taranganba Reservoirs in the Capricorn Coast Water Supply Scheme.

Details of the material type, age and length of water distribution pipes is provided in Table 2.6 below. The water distribution pipe infrastructure includes a range of different material types and ages. Details of the service reservoirs used to supply the distribution and reticulation systems are provided in Table 2.7.

Drinking water is rechlorinated at a number of locations throughout the distribution system. A list of rechlorination facilities and details of their design is provided in Table 2.8. All rechlorination facilities are monitored using the SCADA system through a radio telemetry network.

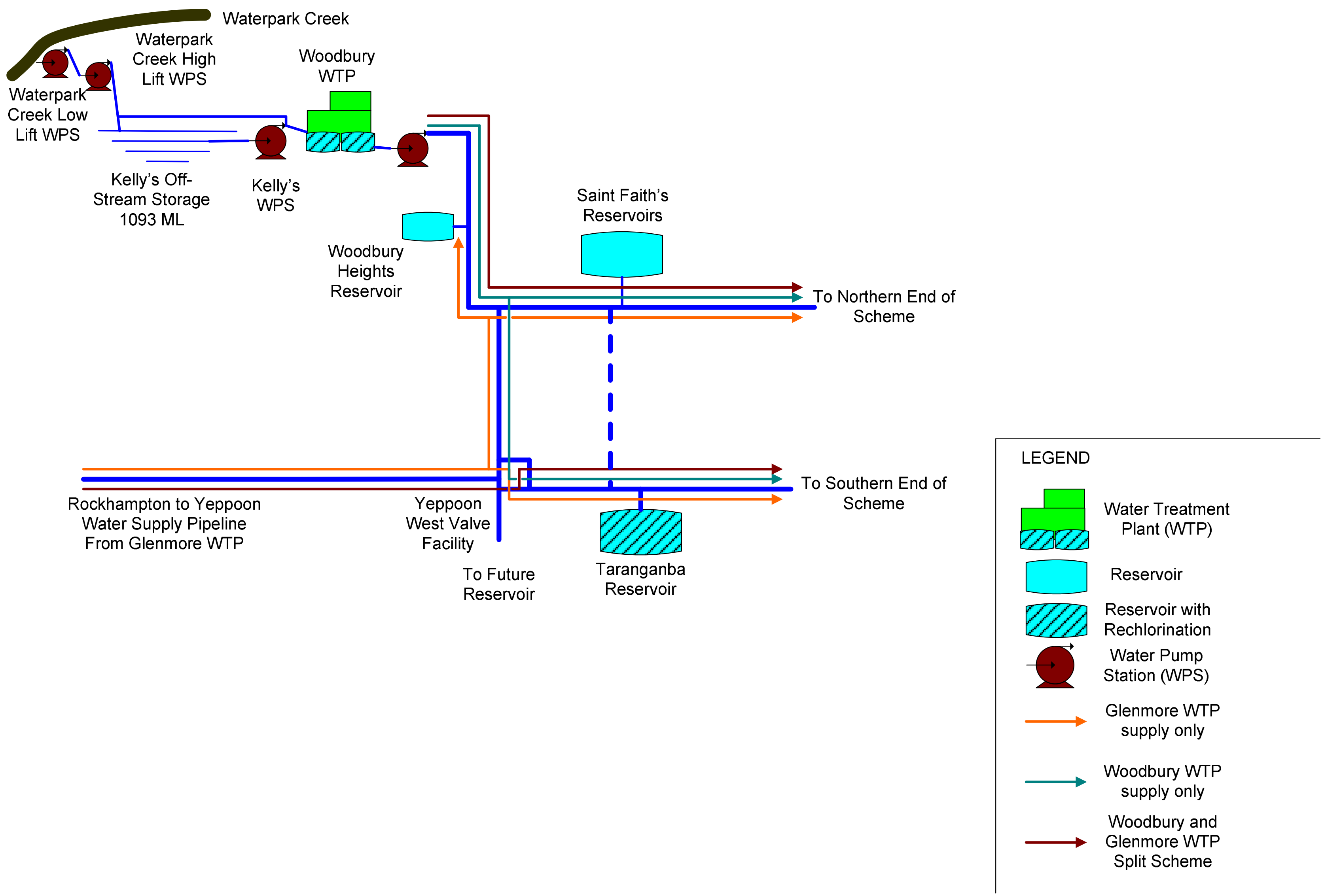
Details of the location, purpose and design of WPS are provided in Table 2.9.

2.5.2 Overview of Operation – Capricorn Coast Water Supply Scheme

Drinking water is supplied to the Capricorn Coast Water Supply Scheme from the Glenmore WTP via the Boundary Hill Reservoir as described in the overview for the Rockhampton Water Supply Scheme above, from the Woodbury WTP or through the combination of supply from each of these two WTPs.

Currently, approximately 25-30% of the Capricorn Coast Water Supply Scheme is supplied with water from the Woodbury WTP with the remaining supply coming from the Glenmore WTP via the Rockhampton to Yeppoon Water Supply Pipeline. The existing infrastructure allows for a number of supply permutations with varied contributions from each source and associated WTP. Figure 2.9 provides a schematic overview of the main options including the current split scheme operating arrangement for supply to the Capricorn Coast Water Supply Scheme.

Figure 2.9: Overview of Supply Scenarios for Supplying Water to the Capricorn Coast Water Supply Scheme.



The existing infrastructure enables the Capricorn Coast Water Supply Scheme to be supplied either wholly by the Glenmore WTP, wholly by the Woodbury WTP or via a split scheme arrangement where the Glenmore WTP and Woodbury WTP supply water to the northern and southern part of the scheme respectively. The supply of water from each WTP can also be done in a time pulsed manner (i.e. Woodbury WTP to northern or southern part of scheme then Glenmore WTP to northern or southern part of the scheme then back to Woodbury WTP and so on) however, this approach is minimised to provide more consistent operation and consistent water quality to the northern and southern parts of the scheme. An existing trunk main (dashed blue line) between the northern and southern parts of the scheme can be used as an additional interconnector between these two parts of the scheme if required.

In the future, the scenarios for supplying water to the Capricorn Coast Water Supply Scheme will largely be dependent on how best to maximise the ability to supply the high quality drinking water from Woodbury WTP to the entire Capricorn Coast Water Supply Scheme, whilst maintaining the Rockhampton to Yeppoon Water Supply Pipeline at fully functioning operational status. The amount of demand met by the Woodbury WTP will also be limited by the current capacity of this WTP and by the volume of the passing flow in Waterpark Creek which has a low passing flow extraction limit of 150 L/s. Current maximum demand days (19 ML/d max demand versus 21.6 ML/d maximum capacity) are approaching the supply capacity of the Woodbury WTP with additional supply from the Glenmore WTP required to meet further demand. Average daily demand for the Capricorn Coast Water Supply Scheme is 9 ML. By 2021, this average daily demand is expected to increase to 11.4 ML and maximum daily demand is expected to be between 25 and 30 ML.

The Woodbury high-lift WPS supplies water along 15-20 km of trunk main to the St Faith's Reservoir complex. Part way along this trunk main water is diverted to fill the small Woodbury Heights Reservoir. It is also possible to pump water from the Woodbury high-lift WPS via the Yeppoon West Valve Facility located on the Rockhampton to Yeppoon Water Supply Pipeline to fill the Taranganba Reservoir, however, this reservoir is predominantly filled with water from the Glenmore WTP gravity fed via the Boundary Hill Reservoir. The Capricorn Coast Water Supply Scheme is therefore operated as if it were two separate water supply schemes. This is done to minimise any mixing of the two waters and avoid aesthetic issues associated with frequently changing water quality.

From the St Faith's Reservoir complex water is gravity fed to the reticulation network in Central Yeppoon and to the Meikleville WPS which pumps water to fill the Meikleville Hill and Pacific Heights Reservoirs which supply the reticulation network to the north of Yeppoon. To the north of the Pacific Heights Reservoir a trunk main supplies water to a privately owned and operated reservoir using to service a coastal resort complex. Water is also pumped from the St Faith's Reservoir complex to supply the reticulation area in West Yeppoon.

The Taranganba Reservoir supplies a local reticulation network and also gravity feeds water to fill the Lammermoor Heights Reservoir and the Emu Park Reservoir which supply local reticulation networks. The reticulation network in the community of Keppel Sands and the Keppel Sands Reservoir are supplied with water that is gravity fed from the Emu Park Reservoir.

Details of the material type, age and length of water distribution pipes is provided in Table 2.6 below. The water distribution pipe infrastructure includes a range of different material types and ages. Details of the service reservoirs used to supply the distribution and reticulation systems are provided in Table 2.7.

Drinking water is rechlorinated at a number of locations throughout the distribution system. A list of rechlorination facilities and details of their design is provided in Table 2.8. All rechlorination facilities are monitored using the SCADA system through a radio telemetry network.

Details of location, purpose and design of WPS are provided in Table 2.9.

2.5.3 Overview of Operation – Mount Morgan Water Supply Scheme

Drinking water produced at the MMWTP is gravity fed into the Black Street Reservoir which also serves as the clear water reservoir for the WTP. From here the water is gravity fed to the reticulation system in the Mount Morgan and Baree areas. Water is pumped by the East Street WPS to fill the North Street Reservoir. These two 2.5 ML reservoirs are used alternately to supply water to the Mount Morgan and Baree reticulation systems. A number of pressure reducing valves and booster WPS are used to maintain appropriate water pressure in low and high elevation areas within the Mount Morgan Water Supply Scheme. The use of pressure reducing valves is needed to cater for the range of changes in elevation throughout the distribution network and also to avoid over-pressuring of some relatively old underground assets to prevent pipe breaks.

Details of the material type, age and length of water distribution pipes is provided in Table 2.6 below. The water distribution pipe infrastructure includes a range of different material types and ages. Details of the service reservoirs used to supply the distribution and reticulation systems are provided in Table 2.7.

Drinking water is rechlorinated at the North Street Reservoir. Details of the design of this rechlorination facility are provided in Table 2.8. This rechlorination facility is monitored using the SCADA system through a radio telemetry network.

Details of location, purpose and design of WPS are provided in Table 2.9.

2.5.4 Overview of Operation – Marlborough Water Supply Scheme

The Marlborough Water Supply Scheme is a small and quite simple distribution system that is supplied directly from a small high-lift WPS located at the MWTP. There are no reservoir storage or rechlorination facilities located within the distribution system. A small diesel generator is used to provide backup power to ensure continuity of water supply in the event of an extended electricity supply outage in Marlborough.

Details of the material type, age and length of water distribution pipes is provided in Table 2.6 below. The water distribution pipe infrastructure includes a range of different material types and ages.

Table 2.6: Details of Pipeline Infrastructure in each Drinking Water Supply Scheme

Material	Length (km)	Year Constructed
Rockhampton Water Supply Scheme		
AC	201	1920-1986
CI	117	1920-1970
PE	33	1970-2009
mPVC	100	2002-2011
uPVC	189	1970-2002
MSCL	30	1950-2007
DICL	9.4	1980-2011
oPVC	5.5	2008-2011
Miscellaneous (unknown)	37	
Capricorn Coast Water Supply Scheme		
AC	196	1950-1986
CI	3	1964-1970
PE	0.5	1984-2011
mPVC	11.9	1972-2011
uPVC	16.6	1972-1993
MSCL	29.8	2003-2011
DICL	6.2	2007-2011
oPVC	112	1972-2003
Miscellaneous (unknown)	7.9	
Mount Morgan Water Supply Scheme		
AC	24.3	1948
CICL	10	1948-1952
uPVC	11.9	1992-2002
MSCL	8.3	1952
Miscellaneous	12	
Marlborough Water Supply Scheme		
AC	2.6	1979
DICL	0.03	1979-1995
uPVC	2.1	1995

AC = asbestos cement, CI = cast iron, PE = polyethylene, mPVC = modified polyvinyl chloride, uPVC = unplasticised polyvinyl chloride, MSCL = mild steel cement lined, DICL = ductile iron cement lined, oPVC = oriented polyvinyl chloride, CICL = cast iron cement lined

Table 2.7: Details of Drinking Water Reservoirs in each Water Supply Scheme

Reservoir Name	Year Built	Capacity (ML)	Type/Design	Roof
Rockhampton Water Supply Scheme				
Birkbeck Ave.	1999	12.2	Concrete circular reservoir	Fully enclosed metal sheet
Samuel Crescent	1993	0.34	Steel panel circular reservoir	Fully enclosed metal sheet
Yaamba Rd	1974	13.7	Concrete circular reservoir	Fully enclosed metal sheet
Mt Charlton	1925	9.0	Concrete rectangular reservoir	Partially enclosed metal sheet
The Caves 1 & 2	1985	2 x 0.1	2 x Concrete circular reservoir	Fully enclosed concrete
Nagle Drv.	1986	10.2	Concrete circular reservoir	Fully enclosed metal sheet
Thozet Rd	1963	9.0	Steel plate circular reservoir	Fully enclosed metal sheet
Forbes Ave.	1976	4.5	Concrete circular reservoir	Fully enclosed metal sheet
Rogar Ave.	2004	7.0	Concrete circular reservoir	Fully enclosed concrete
Mt Archer	1974	0.27	Concrete circular reservoir	Fully enclosed concrete
Athelstane A	1958	4.5	Concrete circular reservoir	Fully enclosed metal sheet
Athelstane B	1958	4.5	Concrete circular reservoir	Fully enclosed metal sheet
Athelstane C	1932	9.1	Concrete rectangular reservoir	Fully enclosed fibro sheet
Athelstane D	1996	20.0	Concrete circular reservoir	Fully enclosed metal sheet
Mawdesley Hill 1	1986	1.5	Concrete circular reservoir	Fully enclosed metal sheet
Mawdesley Hill 2	1993	1.5	Concrete circular reservoir	Fully enclosed metal sheet
Mawdesley Hill 3	1972	1.0	Concrete circular reservoir	Fully enclosed metal sheet
Lucas St	2004	3.75	Concrete circular reservoir	Fully enclosed metal sheet
Boundary Hill	2010	10	Concrete circular reservoir	Fully enclosed concrete
Capricorn Coast Water Supply Scheme				
Woodbury Hts	1995	0.3	Concrete circular reservoir	Fully enclosed concrete
St Faith's 1	1950	2.27	Concrete rectangular reservoir	Fully enclosed metal sheet
St Faith's 2	1958	2.27	Concrete rectangular reservoir	Fully enclosed metal sheet
St Faith's 3	2011	3.5	Concrete circular reservoir	Fully enclosed concrete
Meikleville Hill	1978	0.45	Concrete circular reservoir	Fully enclosed metal sheet
Pacific Hts	2002	4.2	Concrete circular reservoir	Fully enclosed metal sheet
Taranganba	1976	13.6	Concrete circular reservoir	Fully enclosed metal sheet
Lammermoor Hts	2002	4.2	Concrete circular reservoir	Fully enclosed metal sheet
Emu Park	1983	2.27	Concrete circular reservoir	Fully enclosed metal sheet
Seaspray	2005	0.2	Concrete circular reservoir	Fully enclosed concrete
Keppel Sands	1983	0.68	Concrete circular reservoir	Fully enclosed metal sheet
Mount Morgan Water Supply Scheme				
Black St	1955	2.5	Concrete circular reservoir	Fully enclosed metal sheet
North St	1993	2.5	Concrete circular reservoir	Fully enclosed fibro sheet

Table 2.8: Reservoir Rechlorination Facilities and Details of the Disinfection System at each Site

Reservoir Name	Disinfectant Type	Year Installed	Dosing Mode/Design	Target Residual (mg/L)	Monitoring/Alarms	Pump Setup
Rockhampton Water Supply Scheme						
Birkbeck Ave	Sodium hypochlorite	1999	Inlet flow paced, Cl analyser, Overdose auto shut-off, Telemetry to SCADA	0.8	Residual & Hypo tank level Low, Lo Low, High, Hi High,	Single Dosing Pump, Recirculation Pump
Yaamba Rd	Chlorine gas	1993	Inlet flow paced, Cl analyser, High dose auto shut-off, Telemetry to SCADA	0.8	Residual & Gas Weight Low, Lo Low, High, Hi High,	Not applicable
Nagle Drv	Sodium hypochlorite	2011	Inlet flow paced, Cl analyser, High dose auto shut-off, Telemetry to SCADA	0.8	Residual & Hypo tank level Low, Lo Low, High, Hi High	Single Dosing Pump, Recirculation Pump
Mt Charlton	Sodium hypochlorite	2009	Inlet flow paced, Cl analyser, High dose auto shut-off, Telemetry to SCADA	0.8	Residual & Hypo tank level Low, Lo Low, High, Hi High	Single Dosing Pump, Recirculation Pump
Thozet Rd	Sodium hypochlorite	1993	Inlet flow paced, Cl analyser, High dose auto shut-off, Telemetry to SCADA	0.8	Residual & Hypo tank level Low, Lo Low, High, Hi High	Single Dosing Pump, Recirculation Pump
Athelstane	Sodium hypochlorite	1992	Inlet flow paced, Cl analyser, High dose auto shut-off, Telemetry to SCADA	0.8	Residual & Hypo tank level Low, Lo Low, High, Hi High	Single Dosing Pump, Recirculation Pump
Mawdesley Hill	Sodium hypochlorite	2007	Inlet flow paced, Cl analyser, High dose auto shut-off, Telemetry to SCADA	0.8	Residual & Hypo tank level Low, Lo Low, High, Hi High	Single Dosing Pump, Recirculation Pump
Lucas St	Sodium hypochlorite	2004	Inlet flow paced, Cl analyser, High dose auto shut-off, Telemetry to SCADA	0.8	Residual & Hypo tank level Low, Lo Low, High, Hi High	Single Dosing Pump, Recirculation Pump
Boundary Hill	Sodium hypochlorite	2010	Inlet flow paced, Cl analyser, High dose auto shut-off, Telemetry to SCADA	0.8	Residual & Hypo tank level Low, Lo Low, High, Hi High	Duty/Standby Dosing Pump, Recirculation Pump
Capricorn Coast Water Supply Scheme						
Taranganba	Sodium hypochlorite	2011	Inlet flow paced, Cl analyser, High dose auto shut-off, Telemetry to SCADA	0.8	Residual & Hypo tank level Low, Lo Low, High, Hi High	Duty/Standby Dosing Pump, Recirculation Pump
Emu Park	Sodium hypochlorite	2010	Inlet flow paced, Cl analyser, High dose auto shut-off, Telemetry to SCADA	0.8	Residual & Hypo tank level Low, Lo Low, High, Hi High	Single Dosing Pump, Recirculation Pump
Keppel Sands	Sodium hypochlorite	2010	Inlet flow paced, Cl analyser, High dose auto shut-off, Telemetry to SCADA	0.8	Residual & Hypo tank level Low, Lo Low, High, Hi High	Single Dosing Pump, Recirculation Pump
Mount Morgan Water Supply Scheme						
North St	Sodium hypochlorite	2011 in progress	Inlet flow paced, Cl analyser, High dose auto shut-off, Telemetry to SCADA	0.8	Residual & Hypo tank level Low, Lo Low, High, Hi High	Single Dosing Pump, Recirculation Pump

Table 2.9: Details of Water Pump Stations within Drinking Water Supply Schemes

Pump Station Name	Purpose	Pump Capacity L/sec	Pump Station Design[#]
Rockhampton Water Supply Scheme			
Glenmore Low Lift	Supply raw water to the Glenmore WTP	715, 270, 270, 560	4 Centrifugal pumps, SCADA monitored
Glenmore High Lift	Supply potable water to RWSS	270, 270, 270, 560, 560	5 Centrifugal pumps, SCADA monitored
Agnes St	Boost pressure to high zone	270, 110, 190	3 centrifugal pumps, SCADA monitored
Everingham Ave	Boost pressure to high zone	11, 11, 11	3 centrifugal pumps, SCADA monitored
Frenchville Rd	Boost pressure to high zone	1, 1, 1, 1	4 centrifugal pumps, not monitored
Mt Archer 1,2,3,4	Lift water to Mt Archer (~600m elevation)	All 3.4	2 centrifugal pumps, SCADA monitored
Norman Rd	Fill Nagle Drive Reservoir	57, 57	2 centrifugal pumps, SCADA monitored
Ramsay Ck	Fill Mt Charlton Reservoir, Supply to reticulation	60, 60	2 centrifugal pumps, SCADA monitored
Ridgedale Ave	Boost pressure to high zone	4	1 centrifugal pump, not monitored
Samuel Crs.	Boost pressure to high zone	11,11	2 centrifugal pumps, SCADA monitored
Yaamba Rd	Boost pressure to high zone	23, 23	2 centrifugal pumps, not monitored
Belmont Rd	Fill Samuel Crs Reservoir	11, 11, 11	3 centrifugal pumps, SCADA monitored
Bloxsom St	Boost pressure to high zone	7, 7	2 centrifugal pumps, SCADA monitored
Braddy St	Boost pressure to high zone	29, 29	2 centrifugal pumps, SCADA monitored
The Caves	Fill The Caves Reservoir	5, 5	2 centrifugal pumps, SCADA monitored
Forbes Ave	Boost pressure to high zone	0.5, 0.5	2 centrifugal pumps, SCADA monitored
Guymer St	Boost pressure to high zone	10, 10	2 centrifugal pumps, SCADA monitored
Ibis Ave.	Supply water to Boundary Hill Reservoir	250, 250	2 centrifugal pumps, SCADA monitored
Lakes Ck Rd	Fill third party Reservoir, Supply to reticulation	30, 30	2 centrifugal pumps, SCADA monitored
Rockonia Rd	Boost pressure to high zone	25, 25	2 centrifugal pumps, SCADA monitored
Selwyn Crs	Boost pressure to high zone	1, 1	2 centrifugal pumps, not monitored
Sleipner St	Boost pressure to high zone	1.7	1 centrifugal pump, not monitored
Thozet Rd	Fill Forbes and Rogar Reservoirs	120, 120	2 centrifugal pumps, SCADA monitored
Wehmeier Ave	Boost pressure to high zone	20	1 centrifugal pump, SCADA monitored
Whiteley St	Boost pressure to high zone	0.5	1 centrifugal pump, not monitored
Davison St	Boost pressure to high zone	10, 10, 10	3 centrifugal pumps, SCADA monitored
Lucas St	Boost reticulation pressure	45, 45, 45	4 centrifugal pumps, SCADA monitored
Old Capricorn Hwy	Fill Mawdesley Hill Reservoir	115, 115	2 centrifugal pumps, SCADA monitored
Capricorn Coast Water Supply Scheme			
Waterpark Ck Low Lift	Supply raw water to Waterpark Ck High Lift WPS	150, 150	2 centrifugal pumps, SCADA monitored
Waterpark Ck High Lift	Supply raw water to Kelly's Off-Stream Storage	150, 150, 150	3 centrifugal pumps, SCADA monitored
Kelly's	Supply raw water to Woodbury WTP	500, 500	2 centrifugal pumps, SCADA monitored

Pump Station Name	Purpose	Pump Capacity L/sec	Pump Station Design#
Woodbury High Lift	Supply potable water to CCWSS	150, 150, 190	3 centrifugal pumps, SCADA monitored
Hawke St	Boost pressure to high zone	30, 30, 30	3 centrifugal pumps, SCADA monitored
Meikleville	Fill Meikleville Hill Reservoir	28, 28	2 centrifugal pumps, SCADA monitored
St Faith's	Boost pressure to high zone	40, 40	2 centrifugal pumps, SCADA monitored
Tanby Hts	Boost pressure to high zone	5	5 centrifugal pumps, SCADA monitored
Taranganba	Boost pressure to high zone	10, 10, 10	3 centrifugal pumps, SCADA monitored
Yeppoon West	Boost pressure to high zone	30, 30, 30, 30	4 centrifugal pumps, SCADA monitored
Keppel Sands	Boost reticulation pressure	2	1 centrifugal pump, SCADA monitored
Kinka	Fill Emu Park Reservoir, Not yet required	40, 40	2 centrifugal pumps, SCADA monitored
Lammermoor	Boost pressure to high zone	5, 5, 5, 5	4 centrifugal pumps, SCADA monitored
Pacific Hts	Boost pressure to high zone	5, 5, 5, 5	4 centrifugal pumps, SCADA monitored
Seaspray	Boost pressure to high zone	10, 10, 10, 10, 10	5 centrifugal pumps, SCADA monitored
Mount Morgan Water Supply Scheme			
Dam	Supply raw water to Black St WPS	25	1 submersible pump, SCADA monitored
Black St	Supply raw water to MMWTP	24, 24	2 centrifugal pumps, SCADA monitored
Fletcher Ck	Supply raw water to MMWTP	25, 30	2 centrifugal pumps, SCADA monitored
Baree St	Boost pressure to high zone	0.6	1 centrifugal pump, not monitored
Darcy St	Boost pressure to high zone	0.6	1 centrifugal pump, not monitored
East St	Boost pressure to high zone	3	1 centrifugal pump, not monitored
Hall St	Boost pressure to high zone	0.6	1 centrifugal pump, not monitored
Horse Ck	Boost pressure to high zone	0.6	1 centrifugal pump, not monitored
Hamilton Ck	Boost pressure to high zone	0.6	1 centrifugal pump, not monitored
William St	Boost pressure to high zone	0.6	1 centrifugal pump, not monitored
Marlborough Water Supply Scheme			
Glenprairie Rd Bores	Supply raw water to MWTP	3.5, 3.5	2 bore pumps, SCADA monitored
Marlborough High Lift	Supply water to reticulation	2.5, 2.5, 2.5	3 centrifugal pumps, SCADA monitored

#All pump stations with multiple pumps operate as Duty/Standby pumps except the Low Lift and High Lift WPS in the Capricorn Coast Water Supply Scheme and the Rockhampton Drinking Water Supply Scheme

2.5.5 Known Areas of Low Pressure within Distribution Systems

There are two locations within the existing drinking water schemes where a number of properties are known to receive less than the standard minimum water supply pressure of 220 kPa. Neither of these sites experience water supply pressure low enough to create the risk of entry of contaminating material through pipe joints.

One location is Cliff St within the Capricorn Coast Water Supply Scheme. Approximately fifteen properties in this area have always experienced low pressure due to their relative elevation to the St Faith's supply reservoir. A booster pump was installed at the beginning of 2011 to service the adjacent Freeman St and this eliminated the low pressure problems for eleven of these properties. A similar solution is now proposed for Cliff St to eliminate the low pressure problems experienced by the remaining four properties in this street.

The second location is Old Rifle Range Rd in the Mt Morgan Water Supply Scheme. There are several properties in this locality where low pressure problems are regularly experienced due to their relative elevation to the North St Reservoir. Ultimately a booster pump is required to eliminate the low pressure problem and this upgrade will be brought about through further development in the area

2.5.6 Known Areas of Long Detention Time within Distribution Systems

There are two locations within the existing drinking water schemes where the size and length of water supply pipelines leads to long detention times that result in a drinking water age in excess of 5 days.

The most significant of these is the Rockhampton to Yeppoon Water Supply Pipeline which is comprised of approximately 40 km of 600 mm or 750 mm diameter water trunk infrastructure. The Boundary Hill Reservoir (10 ML) is located at close to the mid-point of this length of pipeline. The combined storage capacity of the pipeline and the reservoir is approximately 24 ML. The daily volume of supply from the Glenmore WTP along the pipeline to the Capricorn Coast Water Supply Scheme is usually between 5 and 10 ML. Based on this rate of supply the water may take in excess of 5 days before it travels from the WTP to the first customer's tap. Another 3 to 5 days is required for the water to travel to the end of the Capricorn Coast Water Supply Scheme in Keppel Sands. The potential impact of this long detention time on water quality is currently being investigated with respect to the formation of disinfection by-products and changes to water aesthetics.

To a lesser degree the supply trunk mains from Woodbury WTP to the St Faith's Reservoir is a location which also leads to long detention times for drinking water. This section of the distribution system is approximately 18 km of dual pipelines with combined diameter of close to 900 mm. The total storage capacity of this pipe infrastructure is about 11.5 ML. As consumption varies, the detention time of drinking water in this section of pipe varies from 2 to 5 days. Once the water reaches the St Faith's Reservoir complex it typically takes another 3 to 5 days for the water to reach the extremities of the system. The option of isolating one of the duplicate trunk supply mains is being investigated as a means of reducing the water age in this part of the Capricorn Coast Water Supply Scheme.

2.6 Stakeholders Involved in Managing Drinking Water Infrastructure

Apart from FRW staff, other groups, companies or organisations are involved in the management of the infrastructure and water quality associated with drinking water services provided by RRC. Table 2.10 contains a list of these stakeholders, the infrastructure they are involved in managing and their contribution as a stakeholder.

Table 2.10: Stakeholders Involved in the Management of Drinking Water Quality and Infrastructure

Name of Stakeholder	Infrastructure Involved	Stakeholder Contribution
All Water Supply Schemes		
Department of Natural Resources and Mining	Water sources and catchments	Water quality and quantity monitoring and management
Department of Environment and Heritage Protection	Water sources and receiving environments and associated catchments	Regulator for protection of the environment.
Office of the Water Supply Regulator	All of scheme infrastructure	Regulator of drinking and recycled water schemes, incident management
Queensland Health	All of scheme infrastructure	Primary responsibility for public health, incident management
Rockhampton Water Supply Scheme		
Fitzroy Basin Association Incorporated	Fitzroy Basin upstream catchment	Catchment management and water quality monitoring
Fitzroy Water Quality Advisory Group	Fitzroy Basin upstream catchment	Advisory function for monitoring and environmental management
Fitzroy Partnership for River Health	Water sources and catchments	Water quality monitoring and reporting.
Teys Brothers Pty Ltd	Reticulation supply to abattoir	Major commercial customer
SunWater	Eden Bann Weir and other upstream storages	Management of catchment and storage releases
Capricorn Coast Water Supply Scheme		
Byfield Community Reference Panel	Waterpark Creek raw water source	Waterpark Creek waterways health management
Mercure Capricorn Resort	Reticulation supply to resort	Major commercial customer
Mount Morgan Water Supply Scheme		
Smalls Egg Farm	Reticulation to Egg Farm	Major commercial customer
External Contractors/Suppliers		
Orica	WTPs and Reservoir Disinfection	Chlorine gas supplier
Omega Chemicals	WTPs	Coagulant chemical supplier
Redox	WTPs	Treatment chemical supplier
Elite Chemicals	WTPs and Reservoir Disinfection	Sodium hypochlorite supplier
Nalco	WTPs	Treatment chemical supplier
Activated Carbon Technologies	WTPs	Activated carbon supplier
Internal Contractors/Suppliers		
Procurement and Logistics	All infrastructure	Assisting with procurement and logistics for all water operations
Business Services Team	All infrastructure	Assist with business management
Records Management	All infrastructure	Assist with data archiving
Customer Service Team	All infrastructure	Assist with customer interactions
Corporate Compliance	All infrastructure	Assist with Corporate reporting.

3 CATCHMENT AND WATER QUALITY INFORMATION

3.1 Catchment Characteristics

The four drinking water supply schemes are supplied by a total of five separate surface water catchment systems and one groundwater system. The surface catchments differ considerably with respect to size, volume of flow, topography, geology, vegetation, climate and land use. A detailed description of each surface water catchment is provided below. A description of the Marlborough groundwater system is provided above in the section on source waters for drinking water supply.

3.1.1 Fitzroy River Basin

The Fitzroy River Basin is an extensive and diverse catchment. It covers an area of Queensland of approximately 142,000 km^2 and consists of six major sub-catchments: Isaac/Connors, Nogoa, Comet, Mackenzie, Dawson and Fitzroy. A very detailed description of the Fitzroy River Basin is provided in the Fitzroy Basin Water Quality Improvement Report published by the Fitzroy Basin Association in 2008. In brief, the topography, geology, vegetation, climate and land use within the Fitzroy River Basin vary considerably.

Based on area, the predominant vegetation type is brigalow scrub (28%) which is characterised by a range of different softwood species which thrive on a variety of clay or loam soil types. Next most abundant (24%) is mountain and range topography which consists of medium to tall hardwood forests on the rocky more elevated terrain. Eucalypt woodlands (22%) are the next most abundant vegetation type and exist on a mix of sandy or loamy tableland or clay areas dominated by ironbark or related eucalypt species. Alluvial deposits covered by ‘true gum’ species such as blue gums and red gums as well as some poplar box and brigalow scrub cover 16% of the catchment. The remaining 10% is covered by bluegrass downs with open woodlands (7%), sandy areas dominated by cypress, shrubby and heath species (2%), and the coastal sandy margins that include eucalypt, teatree, sand dune and marine vegetation types (1%).

Average annual rainfall across the catchment ranges between 600 mm in the west, 800 mm in the east and 1000 mm in the north. Despite these rainfall averages, seasons are highly variable with long dry periods usually punctuated by short periods of high rainfall (usually in the summer months) which lead to high flows and flooding events. In some parts of the basin drought occurs on average every three years. As a result, 29 dams and weirs have been constructed throughout the basin to improve water availability for agriculture, industrial and urban uses. Isolated bushfires are common during dry periods and occur especially during late winter and early spring before the onset of summer rainfall.

Land use across the basin includes livestock grazing (81%), cropping (6%), conservation (6%), forestry (5%), urban (1%), mining (0.5%) and irrigation (0.5%). Grazing activities are widespread throughout the catchment including within a few kilometres of the Glenmore WTP along the banks of the Fitzroy River. Mining activities include the activities throughout the Bowen Basin to the west and north of the basin as well as in the lower parts of the Dawson River valley. Currently at least 43 coal mine operations exist within the basin. Mining activities are expected to increase over time with the establishment of new coal mines or coal seam gas operations within the basin. The increased mining activities will inevitably lead to increased impacts on water quality in the basin. The extreme example of this impact was the release of mine-associated water from the Ensham Mine during 2008 under an emergency release arrangement. This emergency release led to sodium concentrations in excess of 100 mg/L in the Fitzroy Barrage Storage. It is estimated that coal mine water discharges contributed to between 18 and 25% of salinity loadings into the Fitzroy Basin at different times during 2011. Increased levels of total dissolved solids (TDS) such as sodium have the potential to negatively impact water aesthetics.

Rockhampton is the largest urban development in the basin. The towns of Emerald and Blackwater to the west of Rockhampton and the townships along the Dawson River and Isaac River are amongst the more developed areas of the basin. Urban development is expected to grow in response to increased mining activities in the region and the future construction of additional water storage on the Connors, Dawson and Fitzroy Rivers. Currently there is minimal impact from urban development, industrial activities or recreational activities on the located adjacent to Rockhampton on the water quality in the Fitzroy River Barrage storage. Urban development includes low level residential development, industrial activities include sand dredging and livestock grazing, and recreational activities are mainly limited to rowing and water skiing. These development activities have the potential to cause slight increases in turbidity (e.g. dredging) or microbial pathogen loads (e.g. from livestock) although there is no evidence to date that these activities are significantly impacting water quality in the Barrage storage.

3.1.2 Waterpark Creek and Kelly's Off-Stream Storage

Waterpark Creek drains the Byfield and adjacent areas within the Shoalwater Bay Military Training Area located along the coastal margin to the north of Yeppoon. This area to the north of Yeppoon receives higher rainfall than other parts of the region with average annual rainfall above 1500 mm. Most of this rainfall is received during the summer months. The heavy summer rainfalls and consistent rainfall throughout the year means that Waterpark Creek usually maintains a flow all year round.

The catchment area is dominated by largely uncleared lowland and mountain areas to the north of the catchment, a line of sand dune areas along the coast to the east and exotic pine forest plantations to the south. The heavily forested catchment and limited rural or urban development in the area helps to ensure a high quality of water in Waterpark Creek. In the more mountainous areas, stands of tall eucalypt and other forest hardwoods dominate the ridge lines with softwood and rainforest vegetation types abundant around gorges and other watercourses. At lower elevations the uncleared areas consist of a mix of either hardwood forests on clay or loam soils and teatree and heath areas on the sandy soils nearer to the coast. Extensive areas of exotic pine forest plantations can be found throughout parts of the lowland areas away from the more sandy soils.

Apart from the pine plantation activities, the catchment area is largely undeveloped with low level agriculture and grazing activities occurring at lower elevations. The staging of military training activities in the upper parts of the catchment does not appear to have any negative impact on Waterpark Creek and its water quality. The potential for significant further development in the catchment area is unlikely due to the high conservation values of the area and the ongoing future use of the military training area.

The Kelly's Off-Stream Storage (~1200 ML) is used as a storage for raw water pumped from Waterpark Creek. Kelly's Off-Stream Storage has its own very small catchment which is dominated by moderately thick eucalypt forest on rocky hillsides. This storage is fully fenced and is not accessible by livestock.

3.1.3 Dee River and Fletcher Creek

The township of Mount Morgan and surrounding areas receive approximately 800 mm rainfall per year on average. The Dee River passes through the township of Mount Morgan. Although more famous for its highly coloured waters due to impacts caused by acid and metal pollution from the Mount Morgan mine site, the No. 7 Dam constructed on the Dee River just upstream of the town by the Mount Morgan Gold Mining Company is by contrast a relatively clean and undisturbed catchment. It is still however, an unprotected surface water with cattle grazing activities conducted upstream of the No. 7 Dam site in what is largely open eucalypt woodland on rocky soils through hilly terrain. The upper catchment of the Dee River contains minimal other urban, rural or industrial development or land use activities. It is possible that agricultural or grazing activities could impact the water quality in No. 7 Dam through the release of nutrients or microbial pathogens to the catchment. There is currently no evidence that these activities are having a negative impact on the quality of raw water in No. 7 Dam.

Fletcher Creek is located approximately 15 km to the south of Mount Morgan and is comprised of a small catchment that winds its way through a series of low hills that consist of open dry eucalypt woodlands and grasslands. The area is used predominantly for cattle grazing purposes with minimal other urban, rural or industrial development in the catchment area. The southern edge of the copper- and gold-bearing sulphide ore body that extends through to just north of Mount Morgan is located within a few kilometres of the Fletcher Creek weir. The sulphide ore body has no direct impact on the Fletcher Creek system, however, the slightly acidic soils create highly corrosive conditions for acid-sensitive metallic pipe materials.

The Mount Morgan area has not experienced significant levels of growth and development in recent years. The potential exists for the Mount Morgan mine to again become an active operation. Although this has the potential to lead to increased development and population growth in the township, this type of development does not appear likely to impact on either the upper Dee River or Fletcher Creek catchment areas.

3.2 Raw Water and Drinking Water Quality

Prior to the amalgamation of four Councils to form RRC, the analysis of raw water and drinking water quality was performed to varying degrees using a range of different approaches. In early 2009 a standardised approach to water quality monitoring was commenced across the existing drinking water schemes to ensure monitoring of raw water and drinking water quality was conducted appropriately. Since then, the operational and verification monitoring programs have been refined towards ensuring safe and reliable water supplies. These monitoring programs are defined in more detail in a later section.

The raw water sources and the treatment processes used to produce drinking water vary significantly among the four schemes included in the DWQMP. The following information provides a summary of the raw water quality in each raw water source and a summary of the quality of the drinking water produced by each of the associated WTPs. Aspects of water quality of specific relevance to each drinking water scheme are discussed including comments on the variability and range of values over which some water quality parameters are recorded.

Due to the paucity of data for some of the drinking water schemes prior to 2009 only data collected in the 2009 and 2010 years and a small selection of 2011 data is presented. As the extreme drought of 2009 was followed closely by a period of above average rainfall and stream flows in 2010, these two years of data probably provide a good representation of the likely variations in raw water and drinking water quality. The presented data are from samples collected by FRW Water Quality Officers or WTP Operators and analysed by Ecoscope Environmental, ALS or Queensland Health Forensic and Scientific Services.

3.2.1 Rockhampton Water Supply Scheme

As described above, the Fitzroy Basin is a very large and complex catchment system. The Fitzroy River raw water quality data presented in Table 3.1 reflects the size and complexity of the catchment. Of particular note is the massive range over which raw turbidity measurements have been recorded. High raw water turbidity occurs due to flow events in the river. The Dawson River catchment has historically been the greatest source of high turbidity raw water with values in excess of 2000 NTU recorded during flood events that occurred late last century.

The raw water also contains low background concentrations of fluoride. The specific source of the fluoride is unknown. Relatively high concentrations of iron have also been observed in the raw water. During a flood event that occurred in early 2010 raw water total iron concentrations of up to 14 mg/L were recorded.

Low levels of the cyanobacterial toxin cylindrospermopsin were detected during a bloom of *Cylindrospermopsis raciborskii* which occurred in 2009. This toxin-producing species of cyanobacteria is usually detected during prolonged periods of low raw water turbidity in late winter or early spring.

Testing for more than 20 different pesticides (see Appendix B) revealed the presence of many pesticides at or less than the limits of detection in the raw water. None of the pesticides were detected at concentrations above ADWG values.

Drinking water produced by the GWTP is typically of a very high quality and consistently meets ADWG. The value for final water turbidity (average = 0.41 NTU) is slightly higher than expected compared to the individual filter outlet turbidity measurements which rarely exceed 0.3 NTU. It is thought that the slightly higher turbidity readings are due to the addition of lime post-filtration. The installation of a final water turbidity meter in late 2011 is expected to help confirm whether the addition of lime contributes to this turbidity increase.

Disinfection by-product formation (e.g. trihalomethanes (THM)) in the Rockhampton Water Supply Scheme has been profiled. The results of the samples analysed show maximum THM concentrations of 150 µg/L at the extremities of the scheme.

Table 3.1: Raw and Potable Water Quality Data for the Rockhampton Water Supply Scheme (average value shown with range shown in brackets)

Parameter	Unit	Fitzroy River Raw Water	Glenmore WTP Final Water
Nitrate	mg/L	0.38 (0.03-2.2)	0.29 (0.02-2.3)
Sulphate	mg/L	14.53 (0.32-96)	4.27 (0.32-10.3)
Fluoride	mg/L	0.10 (0.07-0.20)	0.23 (0.06-0.7)
Aluminium (acid-soluble)	mg/L	0.32 (<0.02-0.88)	0.03 (<0.01-0.05)
Boron	mg/L	0.05 (<0.03-0.05)	0.04 (0.03-0.07)
Copper	µg/L	1.20 (<0.002-13)	5.27 (0.002-24)
Iron	mg/L	1.17 (<0.01-14)	0.03 (<0.01-0.07)
Lead	µg/L	0.93 (<0.001-4.7)	0.461 (<0.001-2.8)
Manganese	mg/L	0.04 (<0.01-0.18)	0.005 (<0.001-0.001)
Zinc	mg/L	0.01 (<0.005-0.06)	0.01 (<0.005-0.06)
pH	pH units	7.77 (6.8-8.3)	7.93 (7.43-8.5)
Turbidity	NTU	150.61 (3.2-877)	0.41 (0.1-2.2)
Trihalomethanes	µg/L	NT	45.08 (0-110)
Total Dissolved Solids	mg/L	156.55 (38-244)	138.3 (76-188)
Total Alkalinity	mg/L	65.05 (28-91)	65.85 (31-93)
Chloride	mg/L	23.92 (9.5-38)	29 (15-43)
Electrical Conductivity	µS/cm	218 (114-316)	239.2 (148-330)
Calcium	mg/L	11.7 (6-17)	14.9 (9.9-20)
Magnesium	mg/L	6.98 (3-11)	7 (2.9-11)
Potassium	mg/L	3.49 (1.8-5)	3.57 (2.6-5)
Sodium	mg/L	19.45 (12-25)	18.92 (9.4-25)
Total Hardness	mg/L	58.2 (28-90)	65.75 (40-95)
True Colour	Pt-Co	39.85 (11-91)	3.5 (<1-7)
Silica	mg/L	18.78 (14-22)	17 (12-20)
Total Organic Carbon	mg/L	5.8 (5-6)	4.0
E. coli	MPN/100ml	NT	<1 (<1-1)
A. circinalis	cells/ml	690 (340-1180)	0
C. raciborskii	cells/ml	2815 (0-46700)	40 (40-40)
Cylindrospermopsin	µg/L	0.2	<0.2
Giardia sp.	cysts/10L	0	0
Cryptosporidium sp.	oocysts/10L	0	0

Data obtained from 24 monthly sampling events during 2009 and 2010 except for trihalomethanes (8 sampling events), turbidity (daily sampling events), total organic carbon (4 sampling events for raw, 1 sampling event for final), *Giardia* and *Cryptosporidium* (1 sampling event), cylindrospermopsin (1 sampling event), *E. coli* (102 sampling events), *A. circinalis* and *C. raciborskii* (23 sampling events)
MPN = most probable number, NTU = nephelometric turbidity units, NT = not tested

Raw water quality in the Fitzroy River typically varies seasonally. This variation is usually flow dependent and is perhaps best illustrated by the changes in turbidity as flow events occur and then gradually decline over subsequent months. Figure 3.1 shows data for raw water turbidity at the Glenmore WTP between August 2010 and August 2011. During this period, the Fitzroy River changed from having no flow and low turbidity to and extended period of flow events and associated high turbidity from September 2010 onwards until the middle of 2011 before flows gradually reduced. The high and rapidly changing turbidity seen during this period is typical of these flow events which usually occur at least once a year. The Glenmore WTP effectively treats raw water with high turbidity due to its design and the use of the Megapac 23 coagulant. When raw water turbidity decreases to levels less than 20 NTU or an extended period of time, the river can experience algal blooms which have the potential to affect water quality. The coagulant and polymer dosing rates are adjusted during algal bloom events to treat the water and filter operation is managed closely in order to optimise filter run time and performance during these events.

Figure 3.1: Changes in Fitzroy River raw water turbidity based on flow conditions from August 2010 to August 2011.

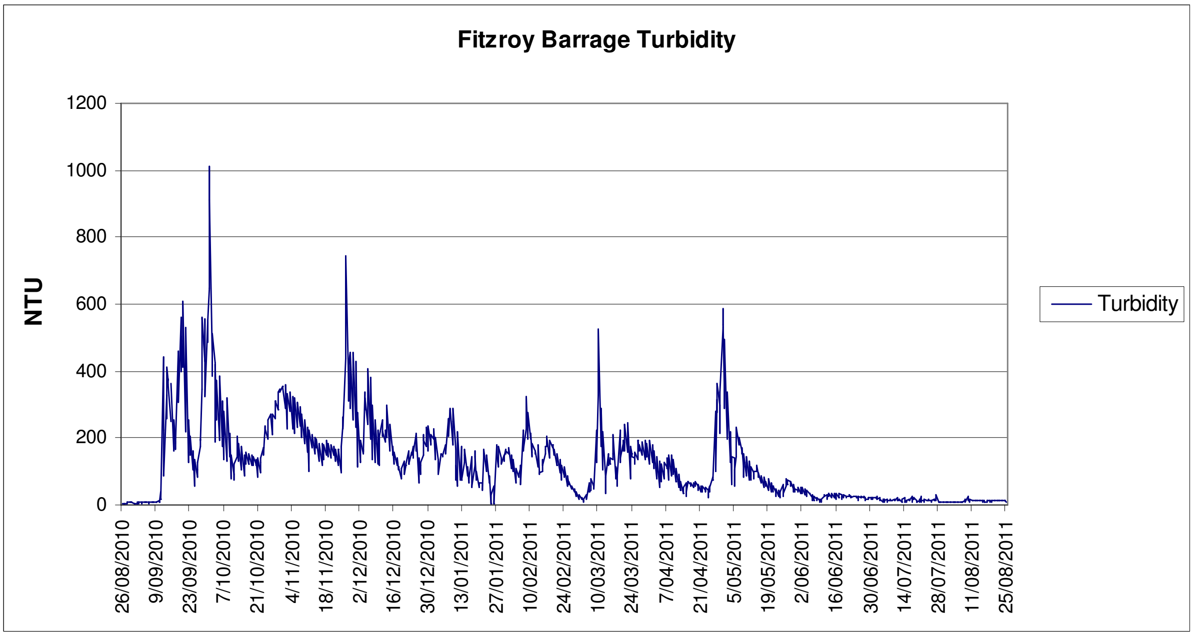
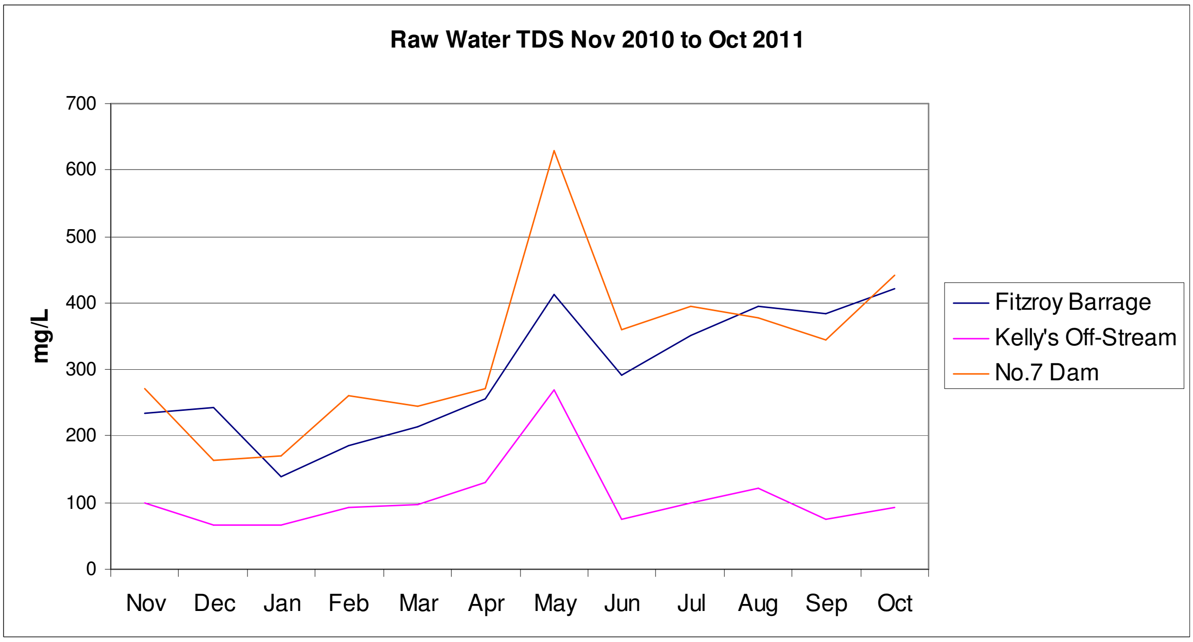


Figure 3.2: Raw Water TDS for raw water in the Fitzroy Barrage Storage, No. 7 Dam and Kelly's Off-Stream Storage from November 2010 to October 2011.



The Fitzroy Barrage raw water TDS also changes significantly due to events that occur upstream in the catchment. Figure 3.2 shows the changes in TDS that occurred during the 12 month period from November 2010 to October 2011. Record rainfall in parts of the catchment saw the input of high levels of TDS into the Fitzroy Basin from rising groundwater with high electrical conductivity. After the peak of the flood in the early 2011, high TDS waters continued to flow downstream leading to a gradual increase in TDS in the Fitzroy Barrage Storage. The same effect was observed in raw water collected from the No. 7 Dam in Mount Morgan. In contrast, the Waterpark Creek raw water TDS remained at relatively constant levels. The unusually high TDS values in each of the raw water samples collected in May appear to be a laboratory artefact.

3.2.2 Capricorn Coast Water Supply Scheme

Raw water from Waterpark Creek (sampled at Kelly's Off-Stream Storage) is a low turbidity, low alkalinity, high colour surface water. The water quality data presented in Table 3.2 reflect this fact. The raw water pH is usually less than pH 7.0 and has been measured at pH <6.5. Low levels of algal growth usually occur in Kelly's Off-Stream Storage, however, there are no recent reports of *Anabaena* or *Cylindrospermopsis*.

Drinking water produced by the Woodbury WTP is typically of a very high quality and consistently meets ADWG. The final water turbidity is consistently very low. The final water pH and alkalinity have historically been very low, however, changes made to the WTP operation in 2009 have increased the final pH to >7.5. The increased concentration of sulphate in the final water compared to the raw water reflects the use of aluminium sulphate as the primary coagulant. Higher TDS in the final water is due to the addition of treatment chemicals to raw water with low TDS.

The quality of raw water in Kelly's Off-Stream Storage does not vary significantly according to seasonal changes or other events. This is due mainly to the fact that the Waterpark Creek system usually sustains a base flow all year round. High flow events in Waterpark Creek during the wet season have minimal impact on the quality of water in the Kelly's Off-Stream Storage due to its size. As raw water turbidity is usually always quite low, algal blooms can occur on a seasonal basis but not to the extent that they have a large impact on water quality.

The formation of disinfection by-products such as THM throughout the Capricorn Coast Water Supply Scheme has been profiled. The results of the samples analysed showed a maximum THM concentration of 98 µg/L at the extremities of the scheme. Further profiling of THM formation will be conducted following commencement of supply via the Rockhampton to Yeppoon Water Supply Pipeline to assess any impacts due to additional rechlorination and water age.

Capricorn Coast drinking water is supplied from two different WTP (Glenmore and Woodbury). These two WTP treat raw water from very different water sources. As described earlier, the Capricorn Coast is predominantly operated as two separate water supply schemes to minimise any need to mix water from these two sources. This way the quality of the drinking water supplied to each of the two parts of the scheme is maintained at a consistent standard. On the few occasions where some mixing of the two source waters has occurred at the St Faith's Reservoir there have not been any observed problems due to water mixing.

Table 3.2: Raw and Potable Water Quality Data for the Capricorn Coast Water Supply Scheme (average value with range shown in brackets)

Parameter	Unit	Kelly's Off-Stream Raw Water	Woodbury WTP Final Water
Nitrate	mg/L	0.13 (<0.01-0.06)	0.19 (<0.01-0.7)
Sulphate	mg/L	3.46 (2-4.4)	27.85 (23-49)
Fluoride	mg/L	0.09 (<0.01-0.1)	0.06 (<0.01-0.1)
Aluminium (acid-soluble)	mg/L	0.07 (<0.05-0.12)	0.03 (<0.01-0.05)
Boron	mg/L	0.11 (0.02-0.2)	0.02 (0.02-0.02)
Copper	µg/L	62.31 (0.029-420)	4.89 (0-90)
Iron	mg/L	0.72 (0.25-1.5)	0.03 (<0.01-0.05)
Lead	µg/L	0.51 (<0.001-3.6)	1.5 (0-1.6)
Manganese	mg/L	0.05 (<0.01-0.31)	0.01 (0-0.02)
Zinc	mg/L	0.04 (<0.005-0.2)	0.01 (<0.005-0.04)
pH	pH units	6.79 (6.28-7.40)	7.25 (6.90-7.60)
Turbidity	NTU	3.23 (1.3-11.9)	0.15 (0.05-0.80)
Trihalomethanes	µg/L	NT	47 (9-74)
Total Dissolved Solids	mg/L	83.94 (66-120)	123.25 (111-140)
Total Alkalinity	mg/L	9.81 (4-23)	20.12 (12-33)
Chloride	mg/L	31.19 (26-37)	32.31 (8.9-40.0)
Electrical Conductivity	µS/cm	138.25 (121-152)	219.12 (200-244)
Calcium	mg/L	2.27 (1.2-4.9)	9.26 (1.4-14.0)
Magnesium	mg/L	2.46 (2-3.1)	2.48 (2.0-3.0)
Potassium	mg/L	0.76 (0.5-1.1)	0.73 (0.5-1.0)
Sodium	mg/L	18.06 (16-21)	27.83 (19-41)
Total Hardness	mg/L	15.94 (13-25)	33.69 (13-46)
True Colour	Pt-Co	59.38 (31-100)	2.23 (1-5)
Silica	mg/L	8.4 (8-9)	7.6 (7-8)
Total Organic Carbon	mg/L	4.5 (3-7)	2.0
E. coli	MPN/100ml	NT	<1 (<1-<1)
A. circinalis	cells/ml	0	NT
C. raciborskii	cells/ml	0	NT
Cylindrospermopsin	µg/L	NT	NT
Giardia sp.	cysts/10L	0	0
Cryptosporidium sp.	oocysts/10L	0	0

Data obtained from 24 monthly sampling events during 2009 and 2010 except for trihalomethanes (8 sampling events), turbidity (daily sampling events), total organic carbon (4 sampling events for raw, 1 sampling event for final), *Giardia* and *Cryptosporidium* (1 sampling event), *E. coli* (102 sampling events), *A. circinalis* and *C. raciborskii* (12 sampling events)
MPN = most probable number, NTU = nephelometric turbidity units, NT = not tested

3.2.3 Mount Morgan Water Supply Scheme

Raw water quality in the two available water sources No. 7 Dam and Fletcher Creek varies considerably. The water quality data presented in Table 3.3 show the contrasts between these two source waters. The No. 7 Dam raw water is typically of better quality than that available in the Fletcher Creek storage. A comparison of values for electrical conductivity for each source shows elevated values for Fletcher Creek due to the higher concentrations of calcium, magnesium and sodium in this raw water. The Fletcher Creek raw water also contains significantly higher concentrations of iron and manganese. Elevated concentrations of iron and manganese have previously challenged the performance of the Mount Morgan WTP.

Because of the generally lower quality of its water and its relatively small storage size, the Fletcher Creek source is rarely used as a raw water for the supply of drinking water to the Mount Morgan Water Supply Scheme.

Table 3.3: Raw and Potable Water Quality Data for the Mt Morgan Water Supply Scheme (average value with range shown in brackets)

Parameter	Unit	No. 7 Dam Raw Water	Fletcher Creek Raw Water	Mount Morgan WTP Final Water
Nitrate	mg/L	0.32 (<0.01-2.1)	0.21 (0.01-0.64)	0.31 (0.03-1.7)
Sulphate	mg/L	5.83 (3-23)	15.42 (7-45)	40 (33-52)
Fluoride	mg/L	0.08 (<0.01-0.1)	0.3 (<0.1-2.7)	0.07 (0.05-0.1)
Aluminium (acid-soluble)	mg/L	0.17 (<0.01-0.66)	0.12 (<0.01-0.56)	0.21 (0.04-0.83)
Boron	mg/L	0.06 (0.05-0.06)	0.06 (0.05-0.06)	0.05 (0.05-0.06)
Copper	µg/L	15.44 (0.006-84)	1.01 (<0.001-4)	1.58 (0.001-5)
Iron	mg/L	0.35 (0.02-1.08)	2.05 (<0.01-20)	0.03 (<0.005-0.08)
Lead	µg/L	1.5 (<0.001-5.3)	0.38 (<0.001-2)	0.08 (<0.001-0.3)
Manganese	mg/L	0.05 (<0.01-0.18)	0.88 (0-5.2)	0.01 (<0.001-0.047)
Zinc	mg/L	0.08 (<0.01-0.46)	0.03 (<0.005-0.13)	0.007 (<0.005-0.014)
pH	pH units	7.63 (7.1-8.0)	7.85 (7.0-8.6)	7.53 (7.2-7.8)
Turbidity	NTU	8.4 (1.0-40)	16.0 (0.60-50)	1.07 (0.4-1.9)
Trihalomethanes	µg/L	NT	NT	94.3 (65-160)
Total Dissolved Solids	mg/L	271 (171-260)	325 (140-770)	182.81 (149-208)
Total Alkalinity	mg/L	63.67 (37-88)	205.6 (45-596)	66.81 (46-90)
Chloride	mg/L	21.87 (12-34)	44.4 (19-66)	25.25 (17-30)
Electrical Conductivity	µS/cm	227.93 (130-528)	553.6 (180-1300)	311.19 (262-349)
Calcium	mg/L	13.8 (7.4-18)	40.12 (8.8-120)	13.94 (7.5-18)
Magnesium	mg/L	7.16 (3.8-10)	23.77 (4.6-60)	7.18 (3.7-9)
Potassium	mg/L	1.8 (0.9-2.8)	1.4 (0.6-1.7)	1.91 (1-2.7)
Sodium	mg/L	16.13 (12-21)	38 (16-47)	36.44 (28-45)
Total Hardness	mg/L	64 (34-83)	198.53 (41-550)	64.31 (34-80)
True Colour	Pt-Co	44 (12-100)	26.87 (2-100)	2.54 (<1-4)
Silica	mg/L	17 (16-18)	24.25 (21-29)	13.8 (13-14)
Total Organic Carbon	mg/L	8.3 (6-10)	10 (7-13)	7.0
E. coli	MPN/100ml	NT	NT	<1 (<1-<1)
A. circinalis	cells/ml	NT	NT	NT
C. raciborskii	cells/ml	NT	NT	NT
Cylindrospermopsin	µg/L	NT	NT	NT
Giardia sp.	cysts/10L	0	0	0
Cryptosporidium sp.	oocysts/10L	0	0	0

Data obtained from 24 monthly sampling events during 2009 and 2010 except for trihalomethanes (8 sampling events), total organic carbon (4 sampling events for raw, 1 sampling event for final), *Giardia* and *Cryptosporidium* (1 sampling event), *E. coli* (102 sampling events)
MPN = most probable number, NTU = nephelometric turbidity units, NT = not tested

Historically, very little data has been obtained for type and number of cyanobacteria in either of the raw water sources. The commencement of regular sampling in early 2011 has detected low levels of the potentially toxic species *Planktolyngbya subtilis*.

The No. 7 Dam raw water quality is influenced by the flow patterns of the Dee River. Flows in the Dee River lead to increases in raw water turbidity and TDS (see Figure

3.2). Installation of on-line turbidity, pH and electrical conductivity meters will provide a better indication of how raw water changes over time. This will enable a better understanding of seasonal or other trends in raw water quality.

Drinking water produced by the MMWTP consistently meets ADWG, however, improvements to the quality of this drinking water are currently being targeted through upgrades and improvements to the operation of the WTP. The installation of on-line analysis of key water quality parameters at different stages throughout the plant will enable improvements to be made in the operation and performance of the WTP. The increased concentration of sulphate in the final water compared to the No. 7 Dam raw water reflects the use of aluminium sulphate as the primary coagulant.

The formation of disinfection by-products such as THM throughout the Mount Morgan Water Supply Scheme has been profiled. The highest concentration of THM in the distribution system was 79 µg/L, although a THM concentration of 160 µg/L has previously been measured in the final treated water produced by the MMWTP.

3.2.4 Marlborough Water Supply Scheme

The Marlborough bore water has elevated levels of iron and other cations such as sodium, calcium and magnesium. Chloride and silica are also present at relatively high concentrations. The values for total dissolved solids and electrical conductivity listed in Table 3.4 reflect this. Other than this the bore water is generally of a high quality as it has very low turbidity, colour and heavy metals, and has a suitable pH.

Table 3.4: Raw Water Quality Data for the Marlborough Water Supply Scheme (average value with range shown in brackets)

Parameter	Unit	Marlborough Bore Raw Water	Marlborough WTP Final Water
Nitrate	mg/L	1.32 (0.5-2.6)	0.18 (0.17-0.19)
Sulphate	mg/L	25.67 (23-30)	7.0 (5.0-9.0)
Fluoride	mg/L	0.14 (0.1-0.2)	<0.1
Aluminium (acid-soluble)	mg/L	0.04 (<0.02-<0.05)	<0.010
Boron	mg/L	0.07 (0.07-0.07)	<0.010
Copper	µg/L	3.52 (<0.03-7)	16
Iron	mg/L	145.35 (<0.02-436)	<0.05
Lead	µg/L	0.3 (0.30-0.30)	<1
Manganese	mg/L	<0.01 (<0.001-<0.01)	<0.001
Zinc	mg/L	0.01 (<0.005-0.1)	0.007
pH	pH units	7.67 (7.52-7.8)	7.81 (7.36-8.26)
Turbidity	NTU	0.5 (0.2-1)	0.75 (0.7-0.8)
Total Dissolved Solids	mg/L	713.67 (600-838)	205.5 (150-261)
Total Alkalinity	mg/L	411.50 (366-457)	123.5 (91-156)
Chloride	mg/L	169.67 (120-205)	50.5 (35-66)
Electrical Conductivity	µS/cm	1310 (1100-1490)	412 (313-511)
Calcium	mg/L	22.67 (18-26)	6 (4-8)
Magnesium	mg/L	94.67 (75-109)	24.5 (18-31)
Potassium	mg/L	1.2 (1-1.6)	3 (<1-6)
Sodium	mg/L	116.67 (100-130)	34 (21-47)
Total Hardness	mg/L	445.67 (350-514)	116 (84-148)
True Colour	Pt-Co	1.33 (1-2)	3.5 (2-5)
Silica	mg/L	60 (60-60)	NT

Raw water data obtained from 3 sampling events. Final water data obtained from 3 sampling events although not all parameters tested for on each occasion. NT = not tested.

Data describing the quality of the final water produced by the Marlborough WTP are also provided in Table 3.4. The drinking water produced is of good quality with moderate levels of Total Hardness and low levels of Total Dissolved Solids. Most water quality parameters have been significantly reduced in concentration following the combined filtration/reverse osmosis treatment process. The current average values for the drinking water quality sampled to date represent the typical target values for the quality of the final water supplied to Marlborough residents. Further monitoring of water quality over the coming months will confirm the performance of the new WTP.

3.3 Drinking Water Quality Incidents

A number of drinking water quality incidents have occurred since the commencement of mandatory reporting of these events in accordance with the *Water Supply (Safety and Reliability) Act*. Table 3.5 contains a description of the events that have occurred, the nature of the incident and actions taken to manage or resolve the hazard.

Table 3.5: Drinking Water Quality Incidents within the Drinking Water Supply Schemes

Date	Scheme	Incident Type	Location	Action Taken
20 Feb 2009	Rockhampton	*E. coli* detected	Reticulation	Rechlorination upgraded
27 Aug 2009	Rockhampton	Cyanobacteria	Source water	Normal WTP processes
15 Oct 2009	Rockhampton	*E. coli* detected	Reticulation	Rechlorination installed
23 Nov 2009	Rockhampton	High chlorine	Reticulation	Rechlorination upgraded
27 Nov 2009	Rockhampton	Cyanobacteria	Final water	WTP processes upgraded
03 Feb 2010	Rockhampton	*E. coli* detected	Reticulation	Reviewed rechlorination
24 Feb 2010	Capricorn Coast	*E. coli* detected	Reticulation	Rechlorination upgraded
28 Sep 2010	Rockhampton	*E. coli* detected	Reticulation	Manual rechlorination started
24 Nov 2010	Capricorn Coast	*E. coli* detected	Reticulation	Frog-proofed reservoir, Manual rechlorination started
06 Dec 2010	Capricorn Coast	*E. coli* detected	Reticulation	Frog-proofed reservoir, Manual rechlorination started
03 Jan 2011	Mount Morgan	Failed alum dose	WTP	Pump repair, WTP process upgrade commenced
01 Mar 2011	Rockhampton	*E. coli* detected	Reticulation	Frog-proofed reservoir, Reviewed rechlorination
08 Mar 2011	Rockhampton, Capricorn Coast	*E. coli* detected	Reticulation	Chlorine residual setpoints increased, Frog-proofed reservoir

All of the *E. coli* detections recorded in the drinking water quality incidents described in Table 3.5 except for the event on 24 Feb 2010 were attributed to green tree frogs gaining access to the inside of service reservoirs at a number of locations across the region. The 24 Feb 2010 incident was attributed to a significant trunk main break event that led to minor contamination of the drinking water in the distribution system.

A range of follow-up actions have been taken to reduce the risk of recurrence of these drinking water quality incidents. More information on these actions and other current or planned projects is provided in the Risk Management Improvement Program below.

3.4 Drinking Water Quality Complaints

Drinking water quality complaints have been received from customers in all three existing drinking water schemes. In most cases these complaints have been due to discoloured water or water containing entrained air bubbles. Table 3.6 shows the number of drinking water quality complaints received during the 2009-2010 reporting year and the 2010-2011 year as at 31 December 2010 for each drinking water scheme.

Table 3.6: Number of Water Quality Complaints for Each Drinking Water Scheme

Period	Rockhampton (per 1000 connections)	Capricorn Coast (per 1000 connections)	Mount Morgan (per 1000 connections)
2009-2010	55 (1.93)	52 (5.96)	24 (17.4)
2010-2011 (at 31/12/10)	17 (0.60)	61 (5.70)	12 (8.57)

The high number of water quality complaints for the Capricorn Coast Water Supply Scheme in 2010-2011 was due to a multiple pipe break event that occurred due to a failure of a pressure reducing valve at the Taranganba Reservoir. All the water quality complaints received during this event were due to discoloured water which was produced when a pressure surge mobilised sediment and other material within the distribution pipe network.

The high number of water quality complaints for the Mount Morgan Water Supply Scheme was due to discoloured complaints associated with iron and manganese in the distributed water. Follow up investigations have identified some ‘hot-spots’ for discoloured water within this scheme.

4 HAZARD IDENTIFICATION

The identification of hazards and hazardous events that have the potential to impact water quality is an ongoing process that continues to be conducted by technical, operational and managerial staff within FRW and RRC. See Section 5 below for a more detailed description of the roles of each of the participants in this process.

Table 4.1 contains a list of the specific hazards and hazardous events that have occurred or have the potential to impact water quality across the four drinking water schemes and provides an indication of the frequency of each event. A more detailed assessment of these hazards for each scheme including an assessment of the level of risk with and without existing or proposed controls is provided below in the section on Assessment of Risks.

Table 4.1: Hazards and Hazardous Events That Have or May Impact Drinking Water Quality

Hazards	Hazardous Events	Has Occurred? (Frequency)	Critical Controls
Catchment/Raw Water Storages			
Bacterial Pathogens	Unrestricted livestock	Yes (ongoing)	Monitoring, Multiple barriers
Protozoan Pathogens	Unrestricted livestock	Yes (ongoing)	Monitoring. Multiple barriers
Toxic cyanobacteria	Stratification, eutrophication	Yes (>1/year)	Monitoring, Multiple barriers
Viral Pathogens	Unrestricted livestock	Unknown	Multiple barriers
Toxic/Radioactive metals	Industrial Spill/Release	No	Monitoring, Multiple barriers
Toxic Pesticides/organics	Agriculture	Yes (ongoing)	Monitoring
High Iron and Manganese	Flow event iron and manganese rich water	Yes (ongoing)	Monitoring, Pre-treatment oxidation
High E.C. or TDS	Industrial Spill/Release	Yes (>1/year)	Monitoring
Excessive Turbidity	Flood Events/Bushfire	No (>1/year)	Monitoring, Multiple barriers
Treatment			
Bacterial Pathogens	Failure of treatment barrier	Yes (<1/year)	Operator training, Operational monitoring and alarms
Protozoan Pathogens	Failure of treatment barrier	No	Operator training, Operational monitoring and alarms
Toxic cyanobacteria	Failure of treatment barrier	Yes (<1/year)	Operator training, Operational monitoring and alarms
Viral Pathogens	Failure of treatment barrier	Unknown	Operator training, Operational monitoring and alarms
Toxic Pesticide/organics	No effective treatment	Yes (ongoing)	Monitoring
High E.C. or TDS	No effective treatment	Yes (>1/year)	Monitoring
Excessive Turbidity	Failure of treatment barrier	Yes (<1/year)	Operator training, Operational monitoring and alarms
Coagulant Underdose	Equipment/process control failure	Yes (<1/year)	Maintenance, Operational monitoring and alarms
Chlorine Underdose	Equipment/process control failure	Yes (<1/year)	Maintenance, Operational monitoring and alarms
Chemical Contamination	Unapproved chemicals	No	Supply contracts, specified QA
Coagulant Overdose	Equipment/process control failure	No	Operator training, Operational monitoring, Daily chemical usage reporting
Fluoride Overdose	Equipment/process control failure	No	Operator training, Operational monitoring and alarms
Chlorine Overdose	Equipment/process control failure	Yes (<1/year)	Maintenance, Operational monitoring and alarms
Distribution			
Bacterial Pathogens	Animal access to reservoirs	Yes (>1/year)	Inspections/ Operational monitoring and alarms for chlorine residual
Protozoan Pathogens	Animal access to reservoirs	Yes (>1/year)	Inspections/ Operational monitoring and alarms for chlorine residual
Viral Pathogens	Animal access to reservoirs	Yes (>1/year)	Inspections/ Operational monitoring and alarms for chlorine residual
Microbial pathogens	Water mains break	Yes (<1/year)	Mains break repair procedure
Discoloured water	Pipewall biofilm and sediment mobilisation	Yes (>1/year)	Chlorine residual penetration, reticulation air scouring program
No chlorine residual	Long detention time	Yes (ongoing)	Increase chlorination, operate scheme to reduce water age.

Hazards	Hazardous Events	Has Occurred? (Frequency)	Critical Controls
Disinfection by-products	High TOC, rechlorination, long detention time	Yes (ongoing)	Effective Treatment/Monitoring
Chemical contamination	Sabotage, terrorism	No	Physical Security/Site Inspection
Excessive chlorination	Equipment/process control failure at rechlorination site	No	Remote monitoring with alarms, Calibration/Site Inspection
Customers Tap			
Contamination	Inappropriate plumbing	No	Compliance inspections
Contamination	Inappropriate use	No	Education Programs

5 ASSESSMENT OF RISKS

The risk assessment presented in this section has been prepared in a two stage approach. A broader more general risk assessment was prepared in accordance with the AS/NZS:4360 Risk Management Standard through a series of five workshops and meetings involving key FRW management, technical and operational staff working in association with the RRC Risk Management Coordinator. The following personnel attended some or all of the workshops that were held:

- Neil Hanschen (previous General Manager FRW)
- Robert Holmes (then Executive Manager Business Services)
- Nimish Chand (Strategic Manager FRW)
- Tracy Sweeney (Strategic Manager Commercial Governance)
- Jason Plumb (Manager Treatment and Supply)
- Bill Van Wees (Coordinator Treatment)
- Barry Harper (Risk Management Coordinator)

The previous General Manager of FRW has almost 40 years experience in water treatment working at the Glenmore WTP. The Manager Treatment and Supply and the Coordinator Treatment are responsible for the day-to-day operation of WTPs and other distribution infrastructure. Each of these officers has over 15 years experience in water and sewerage operations and associated process technologies. The Coordinator Treatment is a dual ticketed Treatment Plant Operator and the Manager Treatment and Supply has a PhD in microbiology. The Strategic Manager FRW, Strategic Manager Commercial Governance have extensive experience in Risk Management in the water industry and the Risk Management Coordinator has extensive experience in Corporate Risk Management. This risk assessment is not shown in the DWQMP.

The second stage of the process involved revising and reformatting the risk assessment to focus more specifically on the risks that have the greatest potential to impact public health through their potential to impact drinking water quality either directly or indirectly. This risk assessment was prepared by the Manager Treatment and Supply in consultation with representatives from the Office of the Water Supply Regulator via a part-day workshop and through follow-up correspondence. The methodology used follows a generic risk assessment framework. Appendix A contains the Likelihood and Consequence Ratings tables, the Risk Rating Matrix and an Uncertainty Ratings table that were used in to prepare this Risk Assessment.

This more public health-specific risk assessment is presented in Tables 5.1 to 5.5. These risk assessments provide a description of the key risks that have the potential to impact each drinking water scheme at the catchment, treatment plant and distribution system stages of each scheme, including, some whole of service risks that are more broadly applicable across all schemes. All risks with a Residual Risk Rating above Low are considered unacceptable. In each case Proposed Actions are listed to further mitigate these unacceptable risks. These Proposed Actions are captured in the Risk Management Improvement Program (see Section 12).

Table 5.1: Assessment of Risks with the Potential to Impact Drinking Water Quality in the Rockhampton Water Supply Scheme

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
Source, Raw Water Intake	No, low or high flow conditions in Fitzroy Barrage Storage, contamination via discharge release or access e.g. grazing livestock, industry water discharge (unprotected surface water catchment)	Bacterial pathogens	5	5	E25	• Catchment monitoring and regular inspection of river intake structure for obvious contaminating material • Stakeholder engagement towards preventing any high risk activities that might pose a threat.	3	1	L3	Confident	• Alarms in place for monitoring of raw water turbidity to alert operator of any significant changes. • No apparent change in risk during no, low or high flow events.	R01
		Protozoan pathogens	5	3	H15	• Catchment monitoring and regular inspection of river intake structure for obvious contaminating material • Stakeholder engagement towards preventing any high risk activities that might pose a threat.	3	1	L3	Reliable	• Alarms in place for monitoring of raw water turbidity to alert operator of any significant changes. • No Cryptosporidium or Giardia detected in GWTP raw or final water in the last 3 years. • No apparent change in risk during no, low or high flow events.	R02
		Toxic cyanobacteria	5	3	H15	• Catchment monitoring to detect toxic blooms. • Variable depth intake to avoid surface scum during bloom events. • Pre-treatment chlorination available to destroy toxic cyanobacteria. • Powdered activated carbon dosing if required to remove toxins.	3	1	L3	Reliable	• Cyanobacteria season highly dependent on river flow season and origin of flows in the upper catchments. • Good engagement with local university to keep up to date with latest local research on cyanobacteria in the catchment.	R03
		Viral pathogens	5	4	E20	• Catchment monitoring and regular inspection of river intake structure for obvious contaminating material • Stakeholder engagement towards preventing any high risk activities that might pose a threat.	3	1	L3	Reliable (based on chlorination performance)	• Alarms in place for monitoring of raw water turbidity to alert operator of any significant changes. • No apparent change in risk during no, low or high flow events.	R04
		Toxic or Radioactive Metals	5	1	M6	• Catchment monitoring and regular inspection of river intake structure for obvious contaminating material • Stakeholder engagement towards preventing any high risk activities that might pose	3	1	L3	Reliable	• Constant engagement with other Fitzroy Basin stakeholders about water quality. • No metals or radioisotopes detected at concentrations close to ADWG in last 3 years.	R05

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
						a threat. • Pre-treatment oxidation available if required						
		High Iron and Manganese	3	2	M6	• Catchment and raw water monitoring • Pre-treatment oxidation available if required	3	1	L3	Reliable	• Fitzroy River raw water does not usually contain high iron and manganese. • This event only occurs during major flooding events • Pre-treatment oxidation is rarely used due to event usually being very short-lived.	R06
		Toxic Pesticides or Organics	5	1	M6	• Pre-treatment chlorination available to oxidise organics and pesticides if required. • Powdered activated carbon dosing if required to remove soluble compounds	3	1	L3	Reliable	• Constant discussion with other Fitzroy Basin stakeholders about water quality. • No pesticides detected at concentrations close to ADWG in last 3 years.	R07
		Excessive E.C. or TDS	3	4	H12	• Stakeholder engagement and catchment monitoring. • No additional controls and no effective treatment process	3	3	M9	Confident	• The combination of natural and artificial inputs of E.C. and sodium has led to the possibility that raw water will become unacceptable quality for treatment using conventional processes. • **Proposed action: continue to lobby regulator for tighter water quality limits on mine water discharges.**	R08
		Excessive Turbidity	3	2	M6	• On-line analysis of raw water turbidity with alarms in place to alert operator of significant changes in turbidity. • Robust treatment plant and treatment process design. • Stakeholder engagement and upstream monitoring of flow events.	2	1	L2	Confident	• GWTP capable of 4-log removal of turbidity and can handle raw water >2000 NTU.	R09
Treatment, Multiple Barriers, Process Control	Failure of Treatment Barrier, Lack of effective treatment, Process control failure	Bacterial pathogens	5	5	E25	• Coagulation/sedimentation barrier with on-line monitoring of turbidity pre-filtration to assess effectiveness. • Filtration performance closely monitored to backwash at >0.2 NTU. • Filter to waste valves used for	3	1	L3	Confident	• Alarms in place for monitoring of turbidity pre- and post-filtration to ensure process effectiveness. • Alarms also in place to ensure effective chlorine residual achieved in clear water reservoirs. • Individual filter turbidity rarely above 0.3 NTU.	R10

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
						ripening of filters after backwash to ensure turbidity <0.2 NTU. • Gas chlorination closely monitored to ensure effective disinfection.					• No E. coli detected in GWTP final water in the last 5 years. • No difference in performance during no, low or high flow events.	
		Protozoan pathogens	5	3	H15	• Coagulation/sedimentation barrier with on-line monitoring of turbidity pre-filtration to assess effectiveness. • Filtration performance closely monitored to backwash at >0.2 NTU. • Filter to waste valves used for ripening of filters after backwash to ensure turbidity <0.2 NTU.	3	1	L3	Reliable	• Alarms in place for monitoring of turbidity pre and post filtration to ensure process effectiveness. • Filter to waste valves prevent turbidity spikes following backwash. • Individual filter turbidities rarely above 0.3 NTU. • No Cryptosporidium or Giardia detected in GWTP raw or final water in the last 3 years. • No difference in performance during no, low or high flow events.	R11
		Toxic cyanobacteria	5	3	H15	• Coagulation/sedimentation barrier with on-line monitoring of turbidity pre-filtration to assess effectiveness. • Pre-coagulation chlorination available to destroy toxic cyanobacteria. • Powdered activated carbon dosing if required to remove toxins.	3	1	L3	Reliable	• Effective removal of Cylindrospermopsis raciborskii using sedimentation and filtration validated at GWTP. • Increased coagulant dose very effective under high bloom conditions. • Very little if any penetration of cyanobacteria through to final water during blooms events over the last 3 years.	R12
		Viral pathogens	5	4	E20	• Coagulation/sedimentation barrier with on-line monitoring of turbidity pre-filtration to assess effectiveness. • Filtration performance closely monitored to backwash at >0.2 NTU. • Filter to waste valves used for ripening of filters after backwash to ensure turbidity <0.2 NTU. • Gas chlorination closely monitored to ensure effective disinfection.	4	1	M5	Reliable (based on chlorination performance)	• Alarms in place for monitoring of turbidity pre- and post-filtration to ensure process effectiveness. • Alarms also in place to ensure effective chlorine residual achieved in clear water reservoirs. • Individual filter turbidities rarely above 0.3 NTU. • No difference in performance during no, low or high flow events. • **Proposed action: perform testing for viruses for further confirmation of process effectiveness.**	R13
		Toxic or	5	1	M6	• Coagulation/sedimentation	3	1	L3	Reliable	• Constant discussion with other	R14

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
		Radioactive Metals				barrier with on-line monitoring of turbidity pre-filtration to assess effectiveness.					Fitzroy Basin stakeholders about water quality. • No metals or radioisotopes detected at concentrations close to ADWG in last 3 years. • Very effective sedimentation process with 4-log turbidity removal.	
		Toxic Pesticides or Organics	5	1	M6	• Pre-coagulation chlorination available to oxidise organics and pesticides if required. • Powdered activated carbon dosing if required to remove soluble compounds.	3	1	L3	Reliable	• Constant discussion with other Fitzroy Basin stakeholders about water quality. • No pesticides detected at concentrations close to ADWG in last 3 years.	R15
		Excessive E.C. or TDS	3	4	H12	• Stakeholder engagement and catchment monitoring. • No additional controls and no effective treatment process	3	3	M9	Confident	• The combination of natural and artificial inputs of E.C. and sodium has led to the possibility that raw water will become unacceptable quality for treatment using conventional processes. • **Proposed action: determine feasibility of installing reverse osmosis treatment to reduce E.C. in drinking water.**	R16
		Excessive Turbidity	3	2	M6	• Robust treatment plant and treatment process design. • Coagulation/sedimentation barrier with on-line monitoring of turbidity pre-filtration to assess effectiveness. • Filtration performance closely monitored to backwash at >0.2 NTU. • Filter to waste valves used for ripening of filters after backwash to ensure turbidity <0.2 NTU.	2	1	L2	Confident	• GWTP capable of 4-log removal of turbidity and can handle raw water >2000 NTU. • In addition, the sedimentation and filtration processes and their controls are reliable and robust.	R17
	Equipment or Process control failure, Chemical underdosing	Coagulant Underdose	4	3	H12	• Coagulation/sedimentation barrier with on-line monitoring of turbidity pre-filtration to assess effectiveness. • Filtration performance closely monitored to backwash at >0.2 NTU.	2	2	L4	Reliable	• The on-line turbidity analysis has alarms set to alert operator to any problems with effectiveness of sedimentation process and possible coagulant underdosing. • The PACL coagulant is a very effective product and not readily	R18

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
						• Duty/Standby dosing pumps available					susceptible to underdosing issues	
		Chlorine Underdose	5	3	H15	• Duplicate on-line chlorine analysers used to monitor effectiveness of chlorine dosing with low and low low alarms to alert of possible underdosing • Duty/Standby chlorinators in place	3	1	L3	Confident	• The robust design and good performance of the filtration and disinfection systems at the GWTP as well as the relevant SCADA alarms being in place provide good management of this risk	R19
	Contaminated chemicals, Use of unapproved treatment chemical	Toxic Metals, Toxic Chemicals	5	1	M6	• Chemical supply contracts in place with stringent quality assurance and chemical analysis specifications required.	3	1	L3	Reliable	• Low chemical dose rates and the associated monitoring and daily checking of chemical usage generally prevents any inadvertent overdosing of chemicals that may lead to water quality problems.	R20
	Equipment or Process control failure, Chemical overdosing	Coagulant Overdose	3	3	M9	• Trained operators and on-line monitoring of process performance alerts operator of possible overdose • Daily reporting of chemical consumption helps operator to identify potential overdosing • Verification monitoring used to check for any overdosing of coagulant leading to high aluminium in potable water	3	1	L3	Confident	• The PACL coagulant used at GWTP allows for effective treatment at lower aluminium concentrations than alum sulphate helping to avoid any possible impacts from overdosing. • Verification monitoring data shows no evidence of any significant overdosing events leading to high aluminium in potable water.	R21
		Fluoride Overdose	4	2	M8	• PLC interlocks to shutdown fluoride dosing prior to achieving harmful dose. • High concentration alarms to warn operator of potential problem. • Redundancy of flow metering and on-line analysis for fluoride.	3	1	L3	Reliable	• Fluoride dosing system PLC separate to main WTP PLC and operates independently. • High concentration alarms and daily manual testing and instrument calibration help to reduce the risk of any problems associated with high dosing or incorrect fluoride concentration measurements.	R22
		Chlorine Overdose	4	2	M8	• PLC interlocks to shutdown chlorine dosing and highlift pump station prior to achieving harmful dose. • High concentration alarms to warn operator of potential problem.	3	1	L3	Confident	• GWTP high chlorine interlock shuts the WTP highlift pumps down before free chlorine residual exceeds 2.0 mg/L. • High concentration alarms and daily manual testing and instrument calibration help to reduce the risk of	R23

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
						• Redundancy of on-line analysis for chlorine.					any problems associated with high dosing or incorrect chlorine concentration measurements.	
Distribution system, trunk infrastructure, reservoirs, reticulation.	Contamination due to animals accessing reservoirs.	Bacterial Pathogens	5	3	H15	• Automated rechlorination or manual rechlorination at all reservoirs. • Appropriate roof design to prevent animal access or contaminant entry via roof run-off (except Mt Charlton Reservoir). • Regular inspection program to check reservoir integrity and measure free chlorine residual. • Reliable rechlorination with alarms to indicate dosing faults.	4	2	M8	Reliable	• Automated rechlorination maintains >0.5 mg/L free chlorine with a setpoint target of 1.0 mg/L. • Remote monitoring and low level alarms used to indentify and rectify any dosing faults. • Standard roof design being specified for all new reservoirs to prevent animal ingress. • **Proposed action: repair and/or replace Mt Charlton Reservoir roof to prevent any entry into the reservoir by roof run-off.**	R24
		Protozoan Pathogens	5	3	H15	• Appropriate roof design to prevent animal access or contaminant entry via roof run-off (except Mt Charlton Reservoir). • Regular inspection program to check reservoir integrity	4	2	M8	Reliable	• Standard roof design being specified for all new reservoirs to prevent animal ingress. • **Proposed action: repair and/or replace Mt Charlton Reservoir roof to prevent any entry into the reservoir by roof run-off.**	R25
		Viral Pathogen	5	3	H15	• Automated rechlorination or manual rechlorination at all reservoirs. • Appropriate roof design to prevent animal access or contaminant entry via roof run-off (except Mt Charlton Reservoir). • Regular inspection program, Reliable rechlorination with alarms to indicate dosing faults.	4	2	M8	Reliable	• Automated rechlorination maintains >0.5 mg/L free chlorine with a setpoint target of 1.0 mg/L. • Remote monitoring and low level alarms used to indentify and rectify any dosing faults. • Standard roof design being specified for all new reservoirs to prevent animal ingress. • **Proposed action: repair and/or replace Mt Charlton Reservoir roof to prevent any entry into the reservoir by roof run-off.**	R26
	Contamination via water mains break or reservoir maintenance activity	Microbial Pathogens	5	4	E20	• Procedures in place to minimise the entry of contaminating material into broken water mains or reservoirs during reactive or planned maintenance	4	2	M8	Reliable	• Procedures are based on AWWA methods for chlorination of water mains and reservoirs to ensure effective disinfection. • **Proposed action: Provide training to maintenance and**	R27

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
						activities. • Chlorination and flushing carried out as part of these procedures.					**construction staff to increase level of awareness of risks of microbial pathogens to drinking water quality and human health.**	
	Increased water age, multiple rechlorination and high total organic carbon	Excessive disinfection by-products	3	3	M9	• Effective treatment processes to remove organic carbon, reticulation monitoring for disinfection by-product formation. • Use of modelling to manage water age.	3	1	L3	Reliable	• This hazard is somewhat subject to the prevailing scientific literature or the perception of risk based on health guideline values which vary significantly around the world. • Efforts are continuing to keep up to date with changes in strategies to prevent or manage disinfection by-product formation.	R28
	Increased water age due to long pipelines and lack of nearby rechlorination	No chlorine residual leads to unsafe water	4	4	H16	• Increased chlorination where required to boost penetration of residual • System operation optimised to reduce water age and aid in residual penetration	3	1	L3	Reliable	• Most of the reticulation consistently receives water with free chlorine residual >0.2 mg/L, however, this level of protection is not likely to provide an effective barrier against significant quantities of contaminating material.	R29
	Act of sabotage or terrorism	Toxic agent	5	2	M6	• Adequate physical security and regular site inspection program. • Internal tracking of security keys. • Some CCTV at sites with higher risk of unauthorised access.	4	1	M5	Reliable	• Signage, physical security and CCTV help to prevent unauthorised access, but are unlikely to be effective against a deliberate act of sabotage or terrorism. • **Proposed action: identify high risk sites and install CCTV at these sites.**	R30
	Equipment or Process control failure at reservoir rechlorination site	Chlorine Underdose	4	3	H12	• Remote monitoring using on-line chlorine analysers with low and low low alarms to trigger rectification action • Duty/Standby dosing pumps and critical spares kept • Regular equipment servicing and regular monitoring and calibration of chlorine on-line analysers.	3	1	L3	Reliable	• These measures listed here as well as the focus placed on regular inspection of reservoirs to prevent animal access and contamination provides good management of this risk.	R31
		Chlorine Overdose	4	2	M8	• High alarms on chlorine residual concentrations to trigger rectification action, • Regular equipment servicing and regular monitoring and	3	1	L3	Reliable	• Maintaining a regular inspection and calibration program is an essential part of ensuring that the on-line analysers read correctly and prevent any over-dosing of chlorine.	R32

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
						calibration of chlorine on-line analysers.						
Customers Tap	Contamination via backflow or cross connection	Microbial pathogens	5	2	**H10**	• Good penetration of free chlorine residual to most parts of the reticulation, • Plumbing Inspection team to ensure plumbing and network assets are constructed to meet legislative and standard requirements.	4	1	**M5**	Reliable	• Most of the reticulation consistently receives water with free chlorine residual >0.2 mg/L, however, this level of protection is not likely to provide an effective barrier against significant quantities of contaminating material. • Prevention using backflow prevention devices or good regulation is the preferred approach. • **Proposed action: create a website Fact Sheet warning of risks of contamination at customer tap**	R33

Table 5.2: Assessment of Risks with the Potential to Impact Drinking Water Quality in the Capricorn Coast Water Supply Scheme

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
Source, Raw Water Intake	No, low or high flow conditions in Waterpark Creek or Kelly's Off-Stream Storage, contamination via discharge release or access e.g. grazing livestock, industry water discharge or excessive run-off from forestry plantations (unprotected surface water catchment)	Bacterial pathogens	5	5	E25	• Waterpark Creek water very high quality raw water due to relatively pristine environment and minimal sources of contamination. • Filtration performance closely monitored to backwash at >0.2 NTU. • Gas chlorination closely monitored to ensure effective disinfection.	3	1	L3	Reliable	• Alarms in place for monitoring of turbidity pre and post filtration to ensure process effectiveness. • Alarms also in place to ensure effective chlorine residual achieved in clear water reservoir. • Raw water turbidity rarely above 5 NTU due to Kelly's Off-Stream Storage operating as a buffer against flow events in Waterpark Creek. • Individual filter turbidities rarely above 0.3 NTU. • No E. coli detected in WWTP final water in the last 3 years.	CC01
		Protozoan pathogens	5	3	H15	• Waterpark Creek water very high quality raw water due to relatively pristine environment and minimal sources of contamination. • Reasonable protection at Kelly's Off-Stream Storage against access by livestock. • Filtration performance closely monitored to backwash at >0.2 NTU.	3	1	L3	Reliable	• Alarms in place for monitoring of turbidity pre and post filtration to ensure process effectiveness. • Individual filter turbidity rarely above 0.3 NTU. • No Cryptosporidium or Giardia detected in WWTP raw or final water in the last 3 years. • Raw water turbidity rarely above 5 NTU due to Kelly's Off-Stream Storage operating as a buffer against flow events in Waterpark Creek.	CC02
		Toxic cyanobacteria	5	3	H15	• Catchment monitoring to detect toxic blooms. • Variable depth intake to avoid surface scum during bloom events. • Coagulation/sedimentation and filtration barriers effective at removal cyanobacteria. • Pre-coagulation chlorination if required to destroy toxic cyanobacteria. • Powdered activated carbon dosing if required to remove toxins.	3	1	L3	Reliable	• Effective removal of cyanobacteria using sedimentation and filtration validated at WWTP. • Very little if any penetration of cyanobacteria through to final water during bloom events over the last 3 years.	CC03

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
		Viral pathogens	5	4	E20	• Coagulation/sedimentation barrier consistently very effective. • Filtration performance closely monitored to backwash at >0.2 NTU. • Gas chlorination closely monitored to ensure effective disinfection.	3	1	L3	Reliable (based on chlorination performance)	• Alarms also in place to ensure effective chlorine residual achieved in clear water reservoirs. • Individual filter turbidity rarely above 0.3 NTU. • Raw water turbidity rarely above 5 NTU due to Kelly's Off-Stream Storage operating as a buffer against flow events in Waterpark Creek.	CC04
		Toxic or Radioactive Metals	5	1	M6	• Waterpark Creek water very high quality raw water due to relatively pristine environment and minimal sources of contamination. • Stakeholder engagement and catchment monitoring. • Coagulation/sedimentation barrier very effective	3	1	L3	Reliable	• No metals or radioisotopes detected at concentrations close to ADWG in last 3 years.	CC05
		High Iron and Manganese	3	2	M6	• Kelly's Off-Stream Storage provides buffer against events in Waterpark Creek. • Catchment and raw water monitoring • Pre-treatment oxidation available if required	3	1	L3	Reliable	• WWTP potable water has consistently very low concentrations of iron and manganese.	CC06
		Toxic Pesticides or Organics	5	1	M6	• Waterpark Creek water very high quality raw water due to relatively pristine environment and minimal sources of contamination. • Kelly's Off-Stream Storage provides buffer against events in Waterpark Creek. • Pre-treatment chlorination available to oxidise organics and pesticides if required. • Powdered activated carbon dosing if required to remove soluble compounds	3	1	L3	Reliable	• No pesticides detected at concentrations close to ADWG in last 3 years.	CC07
		Excessive E.C. or TDS	3	3	M9	• Small catchment with high rainfall reduces the risk of large increases in E.C. or TDS • Monitoring to detect changes	3	1	L3	Confident	• Raw water E.C. and TDS rarely increase above 150 µS/cm and 120 mg/L respectively.	CC08

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
						in raw water quality.						
		Excessive Turbidity	3	2	M6	• Robust treatment plant and treatment process design. • Kelly's Off-Stream Storage provides buffer against events in Waterpark Creek. • On-line monitoring of raw water turbidity with alarms to alert of any large increases in turbidity	2	1	L2	Confident	• Raw water turbidity rarely above 5 NTU due to Kelly's Off-Stream Storage operating as a buffer against flow events in Waterpark Creek. • In addition, the sedimentation and filtration processes and their controls are reliable and robust. • Individual filter turbidity rarely above 0.3 NTU.	CC09
Treatment, Multiple Barriers, Process Control	Failure of Treatment Barrier, Lack of effective treatment, Process control failure	Bacterial pathogens	5	5	E25	• Coagulation/sedimentation and filtration barriers very effective. • Filtration performance closely monitored to backwash at >0.2 NTU. • Waterpark Creek water very high quality raw water due to relatively pristine environment and minimal sources of contamination. • Gas chlorination closely monitored to ensure effective disinfection.	3	1	L3	Reliable	• Alarms in place for monitoring of turbidity post-filtration to ensure process effectiveness. • Alarms also in place to ensure effective chlorine residual achieved in clear water reservoirs. • Individual filter turbidity rarely above 0.3 NTU. • No E. coli detected in WWTP final water in the last 3 years. • No difference in performance during no, low or high flow events.	CC10
		Protozoan pathogens	5	3	H15	• Coagulation/sedimentation and filtration barriers very effective. • Filtration performance closely monitored to backwash at >0.2 NTU. • Waterpark Creek water very high quality raw water due to relatively pristine environment and minimal sources of contamination.	3	1	L3	Reliable	• Alarms in place for monitoring of turbidity post filtration to ensure process effectiveness. • Individual filter turbidities rarely above 0.3 NTU. • No Cryptosporidium or Giardia detected in WWTP raw or final water in the last 3 years.	CC11
		Toxic cyanobacteria	5	3	H15	• Coagulation/sedimentation and filtration barriers effective at removing cyanobacteria. • Pre-coagulation chlorination available to destroy toxic cyanobacteria. • Powdered activated carbon dosing if required to remove	3	1	L3	Reliable	• Effective removal of cyanobacteria using sedimentation and filtration validated at WWTP. • Very little if any penetration of cyanobacteria through to final water during bloom events over the last 3 years.	CC12

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
						toxins.						
		Viral pathogens	5	4	E20	• Coagulation/sedimentation and filtration barriers very effective • Filtration performance closely monitored to backwash at >0.2 NTU. • Gas chlorination closely monitored to ensure effective disinfection.	4	1	M5	Reliable (based on chlorination performance)	• Alarms in place for monitoring of turbidity post-filtration to ensure process effectiveness. • Alarms also in place to ensure effective chlorine residual achieved in clear water reservoirs. • Individual filter turbidities rarely above 0.3 NTU. • **Proposed action: perform testing for viruses for further confirmation of process effectiveness.**	CC13
		Toxic or Radioactive Metals	5	1	M6	• Coagulation/sedimentation and filtration barriers very effective.	3	1	L3	Reliable	• Waterpark Creek water very high quality raw water due to relatively pristine environment and minimal sources of contamination. • No metals or radioisotopes detected at concentrations close to ADWG in last 3 years.	CC14
		Toxic Pesticides or Organics	5	1	M6	• Pre-coagulation chlorination available to oxidise organics and pesticides if required. • Powdered activated carbon dosing if required to remove soluble compounds.	3	1	L3	Reliable	• Waterpark Creek water very high quality raw water due to relatively pristine environment and minimal sources of contamination. • No pesticides detected at concentrations close to ADWG in last 3 years.	CC15
		Excessive E.C. or TDS	3	2	M6	• Small catchment with high rainfall reduces the risk of large increases in E.C. or TDS • Monitoring to detect changes in raw water quality.	3	1	L3	Confident	• Raw water E.C. and TDS rarely increase above 150 µS/cm and 120 mg/L respectively.	CC16
		Excessive Turbidity	3	2	M6	• Robust treatment plant and treatment process design. • Coagulation/sedimentation and filtration barriers very effective. • Filtration performance closely monitored to backwash at >0.2 NTU.	2	1	L2	Confident	• On-line monitoring of filtration performance and filtered water turbidity with alarms to alert operator or any reduced performance • Individual filter turbidities rarely above 0.3 NTU.	CC17
	Process failure leads to sludge return to inlet of	Excessive Turbidity	4	2	M8	• Return of supernatant from sludge lagoons is a fully manual process that is	4	1	M5	Reliable	• Manual process reliable but further risk mitigation possible. • **Proposed action: Install level**	CC18

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
	WTP from sludge lagoons					monitored visually to prevent sludge draw-off					**sensor to provide automated shut-off of supernatant return.**	
	Equipment or Process control failure, Chemical underdosing	Coagulant Underdose	4	3	H12	• Coagulation/sedimentation barrier with on-line monitoring and manual sampling to assess effectiveness of dosing. • Filtration performance closely monitored to backwash at >0.2 NTU. • Duty/Standby dosing pumps available	2	2	L4	Reliable	• The on-line turbidity analysis has alarms set to alert operator to any problems with effectiveness of sedimentation process and possible coagulant underdosing. • Consistently very low raw water turbidity helps to minimise the risk of coagulant underdosing on final water quality	CC19
		Chlorine Underdose	5	3	H15	• On-line chlorine analysers used to monitor effectiveness of chlorine dosing with low and low low alarms to alert of possible underdosing	3	1	L3	Confident	• The robust design and good performance of the filtration and disinfection systems at the WWTP as well as the relevant SCADA alarms being in place provide good management of this risk	CC20
	Contaminated chemicals, Use of unapproved treatment chemical	Toxic Metals, Toxic Chemicals	5	1	M6	• Chemical supply contracts in place with stringent quality assurance and chemical analysis specifications required.	3	1	L3	Reliable	• Low chemical dose rates and the associated monitoring and daily checking of chemical usage generally prevents any inadvertent overdosing of chemicals that may lead to water quality problems.	CC21
	Equipment or Process control failure, Chemical overdosing	Coagulant Overdose	3	3	M9	• Trained operators and on-line monitoring of process parameters such as pH alerts operator to possible overdose • Daily reporting of chemical consumption helps operator to identify potential overdosing • Verification monitoring used to check for any overdosing of coagulant leading to high aluminium in potable water	3	1	L3	Confident	• Verification monitoring data shows no evidence of any significant overdosing events leading to high aluminium in potable water.	CC22
		Fluoride Overdose	4	2	M8	• PLC interlocks to shutdown fluoride dosing prior to achieving harmful dose. • High concentration alarms to warn operator of potential problem. • Redundancy of flow metering and on-line analysis for	3	1	L3	Reliable	• Fluoride dosing system PLC separate to main WTP PLC and operates independently. • High concentration alarms and daily manual testing and instrument calibration help to reduce the risk of any problems associated with high dosing or incorrect fluoride	CC23

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
						fluoride.					concentration measurements.	
		Chlorine Overdose	4	2	M8	• PLC interlocks to shutdown chlorine dosing and highlift pump station prior to achieving harmful dose. • High concentration alarms to warn operator of potential problem.	3	1	L3	Confident	• Woodbury WTP high chlorine interlock shuts the WTP high lift pumps down before free chlorine residual exceeds 2.5 mg/L. • High concentration alarms and daily manual testing and instrument calibration help to reduce the risk of any problems associated with high dosing or incorrect chlorine concentration measurements.	CC24
Distribution system, trunk infrastructure, reservoirs, reticulation.	Contamination due to animals accessing reservoirs.	Bacterial Pathogens	5	3	H15	• Automated rechlorination or manual rechlorination at reservoirs if required. • Appropriate roof design to prevent animal access or contaminant entry via roof run-off. • Regular inspection program to check reservoir integrity and measure free chlorine residual. • Reliable rechlorination with alarms to indicate dosing faults.	3	2	M6	Reliable	• Automated rechlorination maintains >0.5 mg/L free chlorine with a setpoint target of 1.0 mg/L. • Remote monitoring and low level alarms used to indentify and rectify any dosing faults. • Standard roof design being specified for all new reservoirs to prevent animal ingress. • **Proposed action: install additional automated rechlorination at Pacific Heights Reservoir to avoid need for manual dosing at this site.**	CC25
		Protozoan Pathogens	5	3	H15	• Appropriate roof design to prevent animal access or contaminant entry via roof run-off. • Regular inspection program to check reservoir integrity	3	1	L3	Reliable	• Standard roof design being specified for all new reservoirs to prevent animal ingress.	CC26
		Viral Pathogen	5	3	H15	• Automated rechlorination or manual rechlorination at all reservoirs. • Appropriate roof design to prevent animal access or contaminant entry via roof run-off. • Regular inspection program, Reliable rechlorination with alarms to indicate dosing faults.	3	2	M6	Reliable	• Automated rechlorination maintains >0.5 mg/L free chlorine with a setpoint target of 1.0 mg/L. • Remote monitoring and low level alarms used to indentify and rectify any dosing faults. • Standard roof design being specified for all new reservoirs to prevent animal ingress. • **Proposed action: install additional automated rechlorination at Pacific Heights**	CC27

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
											manual dosing at this site.	
	Contamination via water mains break or reservoir maintenance activity	Microbial Pathogens	5	4	E20	• Procedures in place to minimise the entry of contaminating material into broken water mains or reservoirs during reactive or planned maintenance activities. • Chlorination and flushing carried out as part of these procedures.	4	2	M8	Reliable	• Procedures are based on AWWA methods for chlorination of water mains and reservoirs to ensure effective disinfection. • **Proposed action: Provide training to maintenance and construction staff to increase level of awareness of risks of microbial pathogens to drinking water quality and human health.**	CC28
	Increased water age, multiple rechlorination and high total organic carbon	Excessive disinfection by-products	3	3	M9	• Effective treatment processes to remove organic carbon, reticulation monitoring for disinfection by-product formation. • Use of modelling to manage water age.	3	1	L3	Reliable	• This hazard is somewhat subject to the prevailing scientific literature or the perception of risk based on health guideline values which vary significantly around the world. • Efforts are continuing to keep up to date with changes in strategies to prevent or manage disinfection by-product formation.	CC29
	Increased water age due to long pipelines and lack of nearby rechlorination	No chlorine residual leads to unsafe water	4	4	H16	• Increased chlorination where required to boost penetration of residual • System operation optimised to reduce water age and aid in residual penetration	3	1	L3	Reliable	• Most of the reticulation consistently receives water with free chlorine residual >0.2 mg/L, however, this level of protection is not likely to provide an effective barrier against significant quantities of contaminating material.	CC30
	Act of sabotage or terrorism	Toxic agent	5	2	M6	• Adequate physical security and regular site inspection program. • Internal tracking of security keys. • Some CCTV at sites with higher risk of unauthorised access.	4	1	M5	Reliable	• Signage, physical security and CCTV help to prevent unauthorised access, but are unlikely to be effective against a deliberate act of sabotage or terrorism. • **Proposed action: identify high risk sites and install CCTV at these sites.**	CC31
	Equipment or Process control failure at reservoir rechlorination site	Chlorine Underdose	4	3	H12	• Remote monitoring using on-line chlorine analysers with low and low low alarms to trigger rectification action • Duty/Standby dosing pumps and critical spares kept • Regular equipment servicing and regular monitoring and calibration of chlorine on-line	3	1	L3	Reliable	• These measures listed here as well as the focus placed on regular inspection of reservoirs to prevent animal access and contamination provides good management of this risk.	CC32

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
						analysers.						
		Chlorine Overdose	4	2	M8	• High alarms on chlorine residual concentrations to trigger rectification action, • Regular equipment servicing and regular monitoring and calibration of chlorine on-line analysers.	3	1	L3	Reliable	• Maintaining a regular inspection and calibration program is an essential part of ensuring that the on-line analysers read correctly and prevent any over-dosing of chlorine.	CC33
	Mobilisation of Pipewall Biofilm or Sediments	Discoloured Water	3	4	H12	• Increased free chlorine residual penetration through distribution system • Air scouring program to clear reticulation 'hot spots'	2	2	L4	Reliable	• The air scouring program has been shown to be effective where applied to date. This work will continue as required.	CC34
Customers Tap	Contamination via backflow or cross connection	Microbial pathogens	5	2	H10	• Good penetration of free chlorine residual to most parts of the reticulation, • Plumbing Inspection team to ensure plumbing and network assets are constructed to meet legislative and standard requirements.	5	1	M6	Reliable	• Most of the reticulation consistently receives water with free chlorine residual >0.2 mg/L, however, this level of protection is not likely to provide an effective barrier against significant quantities of contaminating material. • Prevention using backflow prevention devices or good regulation is the preferred approach. • **Proposed action: create a website Fact Sheet warning of risks of contamination at customer tap**	CC35

Table 5.3: Assessment of Risks with the Potential to Impact Drinking Water Quality in the Mount Morgan Water Supply Scheme

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
Source, Raw Water Intake	No, low or high flow conditions in No.7 Dam, contamination via discharge release or access e.g. grazing livestock, (unprotected surface water catchment)	Bacterial pathogens	5	5	E25	• Catchment for No.7 Dam relatively undisturbed and well forested, however, still technically an unprotected surface water storage • Catchment monitoring and on-line raw water turbidity monitoring alerts operator to changes in turbidity. • Gas chlorination closely monitored manually to ensure effective disinfection.	3	1	L3	Reliable	• Raw water turbidity rarely above 10 NTU throughout periods with no flow in the Dee River. • No E. coli detected in WWTP final water in the last 3 years.	MM01
		Protozoan pathogens	5	3	H15	• Catchment for No.7 Dam relatively undisturbed and well forested, however, still technically an unprotected surface water storage. • Catchment monitoring and on-line raw water turbidity monitoring alerts operator to changes in turbidity.	3	1	L3	Reliable	• Raw water turbidity rarely above 10 NTU throughout periods with no flow in the Dee River. • No Cryptosporidium or Giardia detected in MMWTP raw or final water in the last 3 years.	MM02
		Toxic cyanobacteria	5	3	H15	• Catchment monitoring to detect toxic blooms. • Pre-treatment chlorination possible if required to destroy cyanobacteria • Some ability to vary the intake depth at No.7 Dam to avoid surface scums.	3	1	L3	Reliable	• Cyanobacteria have not posed a significant issue in No. 7 Dam during the last 3 years. Data prior to that is relatively limited.	MM03
		Viral pathogens	5	4	E20	• Catchment for No.7 Dam relatively undisturbed and well forested, however, still technically an unprotected surface water storage. • Catchment monitoring and on-line raw water turbidity monitoring alerts operator to changes in turbidity. • Sedimentation and filtration barriers are generally quite reliable although improved performance is being targeted.	3	1	L3	Estimate (newly installed on-line monitoring is increasing the level of certainty)	• Raw water turbidity rarely above 10 NTU throughout periods with no flow in the Dee River.	MM04

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
		Toxic or Radioactive Metals	5	1	M6	• Catchment for No.7 Dam relatively undisturbed and well forested, however, still technically an unprotected surface water storage. • Catchment monitoring program provides indication of changes to raw water quality	3	1	L3	Reliable	• No metals or radioisotopes detected at concentrations close to ADWG in last 3 years.	MM05
		High Iron and Manganese	3	2	M6	• Catchment monitoring program provides indication of changes to raw water quality • Pre-treatment oxidation available if required	3	1	L3	Reliable	• Although No. 7 Dam raw water can have periodic increases in levels of iron and manganese, MMWTP potable water has consistently concentrations of iron and manganese beneath ADWG aesthetic guidelines.	MM06
		Toxic Pesticides or Organics	5	1	M6	• Catchment for No.7 Dam relatively undisturbed and well forested, however, still technically an unprotected surface water storage. • Catchment monitoring program provides indication of changes to raw water quality • Pre-treatment chlorination available to oxidise organics and pesticides if required. • Powdered activated carbon dosing if required to remove soluble compounds	3	1	L3	Reliable	• No pesticides detected at concentrations close to ADWG in last 3 years.	MM07
		Excessive E.C. or TDS	3	3	M9	• Catchment monitoring program provides indication of changes to raw water quality • Naturally high background E.C. and TDS in raw water means that customers are used to this water quality.	3	1	L3	Confident	• Raw water E.C. and TDS average 227 µS/cm and 271 mg/L respectively.	MM08
		Excessive Turbidity	3	2	M6	• Catchment monitoring program provides indication of changes to raw water quality • On-line monitoring of raw water turbidity with alarms to alert of any large increases in turbidity	2	1	L2	Estimate (newly installed on-line monitoring is increasing the level of certainty)	• Raw water turbidity rarely above 10 NTU throughout periods with no flow in the Dee River. • Newly installed on-line monitoring providing a better understanding of raw water turbidity changes during flow and no flow periods.	MM09
Fletcher Creek	No, low or	High Iron and	3	4	H12	• Catchment monitoring	3	1	L3	Estimate	• With the storage capacity in No.7	MM10

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
Emergency Source, Raw Water Intake (all hazards except for Iron and Manganese as per above for No.7 Dam)	high flow conditions in No.7 Dam, contamination via discharge release or access e.g. grazing livestock, (unprotected surface water catchment)	Manganese				program provides indication of current raw water quality • Source water only used in an emergency which is very unlikely • Pre-treatment oxidation available to assist with iron and manganese removal					much greater than in previous years when Fletcher Creek was more commonly used, it is unlikely that this water source will be used again. • Nevertheless monitoring and infrastructure maintenance continues should the need arise to use this water source.	
Treatment, Multiple Barriers, Process Control	Failure of Treatment Barrier, Lack of effective treatment, Process control failure	Bacterial pathogens	5	5	E25	• Coagulation/sedimentation and filtration barriers reasonably reliable and effective. • Gas chlorination closely monitored manually to ensure effective disinfection.	4	2	M8	Estimate (newly installed on-line monitoring is increasing the level of certainty)	• Alarms in place for monitoring of turbidity post-filtration to ensure process effectiveness. • No E. coli detected in MMWTP final water in the last 3 years. • **Proposed action: complete installation of automated chlorination and on-line chlorine analysis** • **Proposed action: use newly installed on-line analysis to drive further process optimisation**	MM11
		Protozoan pathogens	5	3	H15	• Coagulation/sedimentation and filtration barriers reasonably reliable and effective. • Newly installed on-line analysis of filtered water turbidity with alarms in place to alert operator of poor performance.	4	2	M8	Estimate (newly installed on-line monitoring is increasing the level of certainty)	• Alarms in place for monitoring of turbidity post filtration to help optimise sedimentation and filtration performance. • No Cryptosporidium or Giardia detected in MMWTP raw or final water in the last 3 years. • **Proposed action: use newly installed on-line analysis to drive further process optimisation**	MM12
		Toxic cyanobacteria	5	3	H15	• Coagulation/sedimentation and filtration barriers reasonably reliable and effective. • Newly installed on-line analysis of filtered water turbidity with alarms in place to alert operator of poor performance. • Pre-coagulation chlorination	4	2	M8	Estimate (newly installed on-line monitoring is increasing the level of certainty)	• **Proposed action: use newly installed on-line analysis to drive further process optimisation** • **Proposed action: conduct more analysis to determine effectiveness of each treatment barrier for removal of cyanobacteria**	MM13

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
						available if required to destroy toxic cyanobacteria. • Powdered activated carbon dosing if required to remove toxins.						
		Viral pathogens	5	4	E20	• Coagulation/sedimentation and filtration barriers reasonably reliable and effective. • Newly installed on-line analysis of filtered water turbidity with alarms in place to alert operator of poor performance. • Gas chlorination monitored manually to ensure effective disinfection.	4	2	M8	Estimate (newly installed on-line monitoring is increasing the level of certainty)	• Alarms in place for monitoring of turbidity post-filtration to ensure process effectiveness. • **Proposed action: complete installation of automated chlorination and on-line chlorine analysis** • **Proposed action: perform testing for viruses for further confirmation of process effectiveness.**	MM14
		Toxic or Radioactive Metals	5	1	M6	• Coagulation/sedimentation and filtration barriers reasonably reliable and effective. • Catchment for No.7 Dam relatively undisturbed and well forested, however, still technically an unprotected surface water storage.	3	1	L3	Reliable	• No metals or radioisotopes detected at concentrations close to ADWG in last 3 years.	MM15
		Toxic Pesticides or Organics	5	1	M6	• Pre-coagulation chlorination available to oxidise organics and pesticides if required. • Powdered activated carbon dosing if required to remove soluble compounds. • Catchment for No.7 Dam relatively undisturbed and well forested, however, still technically an unprotected surface water storage.	3	1	L3	Reliable	• No pesticides detected at concentrations close to ADWG in last 3 years.	MM16
		Excessive E.C. or TDS	3	2	M6	• On-line monitoring of raw water and final water E.C. used to alert operator of changes to water quality.	3	1	L3	Estimate (newly installed on-line monitoring is increasing the level of certainty)	• Customers are historically adapted to periods of potable water having elevated E.C. and TDS. • There does not appear to be any need to further reduce this risk.	MM17

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
		Excessive Turbidity	4	2	M8	• Coagulation/sedimentation and filtration barriers reasonably reliable and effective. • On-line water quality analysis of raw and filtered water provides operational monitoring of barrier effectiveness	4	1	M5	Estimate (newly installed on-line monitoring is increasing the level of certainty)	• On-line monitoring of filtration performance and filtered water turbidity with alarms to alert operator or any reduced performance • **Proposed action: use newly installed on-line analysis to drive further process optimisation**	MM18
	Process failure leads to sludge return to inlet of WTP from sludge lagoons	Excessive Turbidity	4	2	M8	• Return of supernatant from sludge lagoons is a fully manual process that is monitored visually to prevent sludge draw-off	4	1	M5	Estimate (newly installed on-line monitoring is increasing the level of certainty)	• Manual process reliable but further risk mitigation possible. • **Proposed action: Install level sensor to provide automated shut-off of supernatant return.**	MM19
	Equipment or Process control failure, Chemical underdosing	Coagulant Underdose	4	3	H12	• On-line water quality analysis of raw and filtered water provides operational monitoring of barrier effectiveness • Duty/Standby dosing pumps available	3	2	M6	Estimate (newly installed on-line monitoring is increasing the level of certainty)	• The on-line turbidity analysis has alarms set to alert operator to any problems with effectiveness of sedimentation process and possible coagulant underdosing. • **Proposed action: convert coagulant dosing to liquid alum to allow for on-line flow metering and better measurement of chemical usage.**	MM20
		Chlorine Underdose	5	3	H15	• Currently only manually adjusted chlorination in use with no on-line chlorine analysis • At least daily manual testing used to check effectiveness of dosing	3	2	M6	Estimate (newly installed on-line monitoring is increasing the level of certainty)	• Although manual daily testing is proving adequate further action is being taken to further mitigate this risk • **Proposed action: complete the installation of automated chlorination with on-line chlorine analyser to allow for continuous monitoring and alarming to alert operator of underdosing.**	MM21
	Contaminated chemicals, Use of unapproved treatment chemical	Toxic Metals, Toxic Chemicals	5	1	M6	• Chemical supply contracts in place with stringent quality assurance and chemical analysis specifications required.	3	1	L3	Reliable	• Verification monitoring data shows no evidence of any overdosing events leading to reduce quality potable water.	MM22
	Equipment or Process	Coagulant Overdose	3	3	M9	• Trained operators and on-line monitoring of process	3	1	L3	Confident	• Verification monitoring data shows no evidence of any significant	MM23

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
						parameters such as pH alerts operator to possible overdose • Daily reporting of chemical consumption helps operator to identify potential overdosing • Verification monitoring used to check for any overdosing of coagulant leading to high aluminium in potable water					overdosing events leading to high aluminium in potable water.	
	control failure, Chemical overdosing	Fluoride Overdose	4	2	M8	• PLC interlocks to shutdown fluoride dosing prior to achieving harmful dose. • High concentration alarms to warn operator of potential problem. • Redundancy of flow metering and on-line analysis for fluoride.	3	1	L3	Reliable	• Fluoride dosing system PLC separate to main WTP PLC and operates independently. • High concentration alarms and daily manual testing and instrument calibration help to reduce the risk of any problems associated with high dosing or incorrect fluoride concentration measurements.	MM24
		Chlorine Overdose	4	2	M8	• Currently only manually adjusted chlorination in use with no on-line chlorine analysis • At least daily manual testing used to check chlorine concentration	3	2	M6	Estimate (newly installed on-line monitoring is increasing the level of certainty)	• Although manual daily testing is proving adequate further action is being taken to further mitigate this risk • **Proposed action: complete the installation of automated chlorination with on-line chlorine analyser to allow for continuous monitoring and alarming to alert operator of overdosing.**	MM25
Distribution system, trunk infrastructure, reservoirs, reticulation.	Contamination due to animals accessing reservoirs.	Bacterial Pathogens	5	3	H15	• Manual rechlorination at only other reservoirs as required. • Appropriate roof design to prevent animal access or contaminant entry via roof run-off. • Regular inspection program to check reservoir integrity and measure free chlorine residual.	3	2	M6	Estimate	• Standard roof design being specified for all new reservoirs to prevent animal ingress. • Regular manual testing of free chlorine residual to determine if manual chlorination is effective but further action is being taken to further mitigate risk. • **Proposed action: complete the installation of automated chlorination at the North St Reservoir site to allow for continuous monitoring and alarming to alert operator of incorrect dosing.**	MM26
		Protozoan	5	3	H15	• Appropriate roof design to	3	1	L3	Estimate	• Standard roof design being	MM27

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
		Pathogens				prevent animal access or contaminant entry via roof run-off. • Regular inspection program to check reservoir integrity					specified for all new reservoirs to prevent animal ingress.	
		Viral Pathogen	5	3	H15	• Manual rechlorination at only other reservoir as required. • Appropriate roof design to prevent animal access or contaminant entry via roof run-off. • Regular inspection program to check reservoir integrity and measure free chlorine residual.	3	2	M6	Estimate	• Standard roof design being specified for all new reservoirs to prevent animal ingress. • Regular manual testing of free chlorine residual to determine if manual chlorination is effective but further action is being taken to further mitigate risk. • **Proposed action: complete the installation of automated chlorination at the North St Reservoir site to allow for continuous monitoring and alarming to alert operator of incorrect dosing.**	MM28
	Contamination via water mains break or reservoir maintenance activity	Microbial Pathogens	5	4	E20	• Procedures in place to minimise the entry of contaminating material into broken water mains or reservoirs during reactive or planned maintenance activities. • Chlorination and flushing carried out as part of these procedures.	4	2	M8	Reliable	• Procedures are based on AWWA methods for chlorination of water mains and reservoirs to ensure effective disinfection. • **Proposed action: Provide training to maintenance and construction staff to increase level of awareness of risks of microbial pathogens to drinking water quality and human health.**	MM29
	Increased water age, multiple rechlorination and high total organic carbon	Excessive disinfection by-products	3	3	M9	• Effective treatment processes to remove organic carbon, reticulation monitoring for disinfection by-product formation. • Use of modelling to manage water age.	3	1	L3	Reliable	• This hazard is somewhat subject to the prevailing scientific literature or the perception of risk based on health guideline values which vary significantly around the world. • Efforts are continuing to keep up to date with changes in strategies to prevent or manage disinfection by-product formation.	MM30
	Increased water age due to long pipelines and lack of nearby	No chlorine residual leads to unsafe water	4	4	H16	• Increased chlorination where required to boost penetration of residual • System operation optimised to reduce water age and aid in	3	1	L3	Reliable	• Most of the reticulation consistently receives water with free chlorine residual >0.2 mg/L, however, this level of protection is not likely to provide an effective barrier against	MM31

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
	rechlorination					residual penetration					significant quantities of contaminating material.	
	Act of sabotage or terrorism	Toxic agent	5	2	M6	• Adequate physical security and regular site inspection program. • Internal tracking of security keys.	4	1	M5	Reliable	• Signage, physical security and CCTV help to prevent unauthorised access, but are unlikely to be effective against a deliberate act of sabotage or terrorism. • **Proposed action: identify high risk sites and install CCTV at these sites.**	MM32
	Equipment or Process control failure at reservoir rechlorination site	Chlorine Underdose	4	3	H12	• Manual rechlorination at only other reservoir as required. • Underdose is currently dependent on regular inspection and chlorine testing program	3	2	M6	Estimate	• Regular manual testing of free chlorine residual to determine if manual chlorination is effective but further action is being taken to further mitigate risk. • **Proposed action: complete the installation of automated chlorination at the North St Reservoir site to allow for continuous monitoring and alarming to alert operator of incorrect dosing.**	MM33
		Chlorine Overdose	4	2	M8	• Manual rechlorination at only other reservoir as required. • Overdosing is almost impossible given current practice of manual rechlorination, although instructions followed to determine hypochlorite tablet dose added.	3	2	M6	Estimate	• Regular manual testing of free chlorine residual to determine if manual chlorination is effective but further action is being taken to further mitigate risk. • **Proposed action: complete the installation of automated chlorination at the North St Reservoir site to allow for continuous monitoring and alarming to alert operator of incorrect dosing.**	MM34
	Mobilisation of Pipewall Biofilm or Sediments	Discoloured Water	3	4	H12	• Increased free chlorine residual penetration through distribution system • Air scouring program to clear reticulation 'hot spots'	2	2	L4	Reliable	• The air scouring program has been shown to be effective where applied to date. This work will continue as required.	MM35
Customers Tap	Contamination via backflow or cross connection	Microbial pathogens	5	2	H10	• Good penetration of free chlorine residual to most parts of the reticulation, • Plumbing Inspection team to ensure plumbing and network	5	1	M6	Reliable	• Most of the reticulation consistently receives water with free chlorine residual >0.2 mg/L, however, this level of protection is not likely to provide an effective barrier against	MM36

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
						assets are constructed to meet legislative and standard requirements.					significant quantities of contaminating material. • Prevention using backflow prevention devices or good regulation is the preferred approach. • **Proposed action: create a website Fact Sheet warning of risks of contamination at customer tap**	

Table 5.4: Assessment of Risks with the Potential to Impact Drinking Water Quality in the Marlborough Water Supply Scheme

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
Source, Raw Water Intake	Groundwater source and associated bores for raw water intake, contamination via release or access e.g. grazing livestock, industry water release to groundwater (protected groundwater catchment)	Bacterial pathogens	5	5	E25	• Minimal impact from natural or human activities on groundwater to cause contamination • Well designed sealed bores • Raw water monitoring program and catchment inspections conducted.	3	1	L3	Estimate (scheme less than one year old)	• Marlborough Bores raw water is consistently <1 NTU • No evidence of any activities that pose a risk to groundwater quality.	M01
		Protozoan pathogens	5	3	H15	• Minimal impact from natural or human activities on groundwater to cause contamination • Well designed sealed bores • Raw water monitoring program and catchment inspections conducted.	3	1	L3	Estimate (scheme less than one year old)	• Marlborough Bores raw water is consistently <1 NTU • No evidence of any activities that pose a risk to groundwater quality.	M02
		Toxic cyanobacteria	5	3	H15	• Not applicable as no impact of surface events expected to occur on groundwater and all other raw water in closed pipes or tank storages.	3	1	L3	Reliable	• Not expected to ever be an issue.	M03
		Viral pathogens	5	4	E20	• Minimal impact from natural or human activities on groundwater to cause contamination • Well designed sealed bores • Raw water monitoring program and catchment inspections conducted.	3	1	L3	Estimate (scheme less than one year old)	• Marlborough Bores raw water is consistently <1 NTU • No evidence of any activities that pose a risk to groundwater quality.	M04
		Toxic or Radioactive Metals	5	1	M6	• No evidence of toxic or radioactive metals in groundwater • Minimal impact from natural or human activities on groundwater to cause contamination • Well designed sealed bores.	3	1	L3	Estimate (scheme less than one year old)	• Further testing over time will determine if there is any variation during drought periods.	M05
		High Iron and Manganese	3	2	M6	• Groundwater contains high concentrations of iron • Pre-treatment oxidation occurs passively in raw water storage tank.	3	1	L3	Estimate (scheme less than one year old)	• No evidence that raw water iron content poses a problem for water quality due to the passive aeration.	M06

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
		Toxic Pesticides or Organics	5	2	H10	• Minimal impact from natural or human activities on groundwater to cause contamination • Well designed sealed bores • Raw water monitoring program and catchment inspections conducted	4	1	M5	Estimate (scheme less than one year old)	• **Proposed action: engage further with landholders to educate about the potential for pesticides to impact groundwater.**	M07
		Excessive E.C. or TDS	3	5	H15	• WTP designed to desalinate the raw water using reverse osmosis. • Adjustable reverse osmosis and blend ratio provides flexibility to enable targeted final water E.C.	3	1	L3	Estimate (scheme less than one year old)	• Current E.C. and TDS of raw water is almost of a standard suitable for direct consumption. • Treatment is used to reduce E.C. and TDS to aesthetically acceptable levels	M08
		Excessive Turbidity	3	2	M6	• Minimal impact from natural or human activities on groundwater to cause contamination • Well designed sealed bores	2	1	L2	Estimate (scheme less than one year old)	• Marlborough Bores raw water is consistently <1 NTU • No evidence of any activities that pose a risk to groundwater quality.	M09
Treatment, Multiple Barriers, Process Control	Failure of Treatment Barrier, Lack of effective treatment, Process control failure	Bacterial pathogens	5	5	E25	• Dual filtration using 5 µm filters in series prior to reverse osmosis treatment • Automated chlorination closely monitored to ensure effective disinfection.	3	1	L3	Estimate (scheme less than one year old)	• Alarms in place for monitoring of turbidity post-filtration to ensure process effectiveness. • Alarms also in place to ensure effective chlorine residual achieved in clear water reservoirs. • No E. coli detected in MWTP since commencement in September 2011.	M10
		Protozoan pathogens	5	3	H15	• Dual filtration using 5 µm filters in series prior to reverse osmosis treatment	3	1	L3	Estimate (scheme less than one year old)	• Final water turbidity usually less than 0.3 NTU. • No Cryptosporidium or Giardia detected in MWTP raw or final water since commencement in September 2011. • No difference in performance during no, low or high flow events.	M11
		Toxic cyanobacteria	5	3	H15	• Not likely to be applicable given comments above about expected lack of impact from cyanobacteria.	3	1	L3	Estimate (scheme less than one year old)	• Not expected to ever be an issue for this WTP.	M12
		Viral pathogens	5	4	E20	• Dual filtration using 5 µm filters in series prior to reverse	3	1	L3	Estimate (scheme less	• Not expected to ever be an issue for this WTP.	M13

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
						osmosis treatment • Automated chlorination closely monitored to ensure effective disinfection.				than one year old)		
		Toxic or Radioactive Metals	5	1	M6	• Passive aeration of raw water serves to oxidise and precipitate metals prior to them entering WTP.	3	1	L3	Estimate (scheme less than one year old)	• No metals or radioisotopes detected at concentrations close to ADWG since commencement in September 2011.	M14
		Toxic Pesticides or Organics	5	2	H10	• Limited impact from pesticides or organics on groundwater • All pipes and storage tanks for raw water sealed • Reverse osmosis treatment would provide effective barrier for majority of treated water but not for non-reverse osmosis treated stream.	4	1	M5	Estimate (scheme less than one year old)	• **Proposed action: engage further with landholders to educate about the potential for pesticides to impact groundwater.**	M15
		Excessive E.C. or TDS	3	5	H15	• WTP designed to desalinate the raw water using reverse osmosis. • Adjustable reverse osmosis and blend ratio provides flexibility to enable targeted final water E.C.	3	1	L3	Estimate (scheme less than one year old)	• Current E.C. and TDS of raw water is almost of a standard suitable for direct consumption. • Treatment is used to reduce E.C. and TDS to aesthetically acceptable levels	M16
		Excessive Turbidity	3	2	M6	• Dual filtration using 5 µm filters in series prior to reverse osmosis treatment	2	1	L2	Estimate (scheme less than one year old)	• Marlborough Bores raw water is consistently <1 NTU • Final water turbidity usually less than 0.3 NTU.	M17
	Equipment or Process control failure, Chemical underdosing	Antiscalant Underdose	3	3	M9	• Antiscalant not toxic and approved for water treatment • Does not specifically impact water quality if not dosed.	2	2	L4	Estimate (scheme less than one year old)	• Lack of antiscalant dosing would only impact the longevity of the reverse osmosis membranes.	M18
		Hypochlorite Underdose	5	3	H15	• Automated hypochlorite dosing system with on-line analysis to allow control and monitoring of dose rate. • Low and Low Low alarms alert operator of any underdosing that needs to be rectified.	3	1	L3	Estimate (scheme less than one year old)	• Minimal chlorine demand in final water which means that chlorine residual is quite stable.	M19
	Contaminated chemicals, Use of unapproved	Toxic Metals, Toxic Chemicals	5	1	M6	• Chemical supply contracts in place with stringent quality assurance and chemical analysis specifications	3	1	L3	Estimate (scheme less than one year old)	• Low chemical dose rates and the following of set procedures for chemical use prevents any inadvertent overdosing of	M20

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
	treatment chemical					required. • Sodium hydroxide and hydrochloric acid used for membrane cleaning according to well defined procedure.					chemicals that may lead to water quality problems.	
	Equipment or Process control failure, Chemical overdosing	Antiscalant Overdose	3	3	M9	• Very low concentration of chemical used in batch tank poses minimal risk to water quality. • Dosing pump not capable of delivering sufficient dose rate to pose a risk. • Set procedures used to prepare and operate dosing system and staff trained accordingly.	3	1	L3	Estimate (scheme less than one year old)	• It is very unlikely that antiscalant overdosing is possible to the extent that would cause a water quality problem.	M21
		Fluoride Overdose	4	1	M5	• No fluoridation at the MWTP	3	1	L3	Certain	• This is not expected to ever be an issue at this WTP.	M22
		Chlorine Overdose	4	2	M8	• Capacity of dosing system designed to prevent any chance of significant hypochlorite overdosing. • High concentration alarms to warn operator of potential problem.	3	1	L3	Estimate (scheme less than one year old)	• High concentration alarms and regular equipment checking and instrument calibration help to reduce the risk of any problems associated with high dosing or incorrect chlorine concentration measurements.	M23
Distribution system, trunk infrastructure, reservoirs, reticulation.	Contamination due to animals accessing reservoirs.	Bacterial Pathogens	5	3	H15	• No potable water storage reservoirs other than the clear water tanks at the MWTP. • Clear water storage tank design prevents animal access. • Regular inspections conducted to ensure integrity of clear water storages.	3	1	L3	Estimate (scheme less than one year old)	• There are virtually no other possible access points for animal entry to cause recontamination of the drinking water.	M24
		Protozoan Pathogens	5	3	H15	• No potable water storage reservoirs other than the clear water tanks at the MWTP. • Clear water storage tank design prevents animal access. • Regular inspections conducted to ensure integrity of clear water storages.	3	1	L3	Estimate (scheme less than one year old)	• There are virtually no other possible access points for animal entry to cause recontamination of the drinking water.	M25

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
		Viral Pathogen	5	3	H15	• No potable water storage reservoirs other than the clear water tanks at the MWTP. • Clear water storage tank design prevents animal access. • Regular inspections conducted to ensure integrity of clear water storages.	3	1	L3	Estimate (scheme less than one year old)	• There are virtually no other possible access points for animal entry to cause recontamination of the drinking water.	M26
	Contamination via water mains break or reservoir maintenance activity	Microbial Pathogens	5	4	E20	• Procedures in place to minimise the entry of contaminating material into broken water mains or reservoirs during reactive or planned maintenance activities. • Chlorination and flushing carried out as part of these procedures.	4	2	M8	Estimate (scheme less than one year old)	• Procedures are based on AWWA methods for chlorination of water mains and reservoirs to ensure effective disinfection. • **Proposed action: Provide training to maintenance and construction staff to increase level of awareness of risks of microbial pathogens to drinking water quality and human health.**	M27
	Increased water age, multiple rechlorination and high total organic carbon	Excessive disinfection by-products	3	3	M9	• Very short reticulation system and low water age prevents this from being an issue.	3	1	L3	Estimate (scheme less than one year old)	• This is not expected to ever be an issue in this scheme.	M28
	Increased water age due to long pipelines and lack of nearby rechlorination	No chlorine residual leads to unsafe water	4	4	H16	• Very short reticulation system and low water age prevents this from being an issue.	3	1	L3	Estimate (scheme less than one year old)	• The entire system consistently receives water with a free chlorine residual of >0.2 mg/L. • This is not expected to ever be an issue in this scheme.	M29
	Act of sabotage or terrorism	Toxic agent	5	2	M6	• Adequate physical security and regular site inspection program. • Internal tracking of security keys. • Some CCTV at sites with higher risk of unauthorised access.	4	1	M5	Estimate (scheme less than one year old)	• Signage, physical security and CCTV help to prevent unauthorised access, but are unlikely to be effective against a deliberate act of sabotage or terrorism. • **Proposed action: identify high risk sites and install CCTV at these sites.**	M30
	Equipment or Process control failure at reservoir	Chlorine Underdose	4	3	H12	• No rechlorination sites in this scheme due to small scale and design of the distribution system.	3	1	L3	Estimate (scheme less than one year old)	• This is not expected to be a significant issue in this scheme.	M31

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
	rechlorination site	Chlorine Overdose	4	2	M8	• No rechlorination sites in this scheme due to small scale and design of the distribution system.	3	1	L3	Estimate (scheme less than one year old)	• This is not expected to be a significant issue in this scheme.	M32
Customers Tap	Contamination via backflow or cross connection	Microbial pathogens	5	2	H10	• Good penetration of free chlorine residual to most parts of the reticulation, • Plumbing Inspection team to ensure plumbing and network assets are constructed to meet legislative and standard requirements.	5	1	M6	Reliable	• Most of the reticulation consistently receives water with free chlorine residual >0.2 mg/L, however, this level of protection is not likely to provide an effective barrier against significant quantities of contaminating material. • Prevention using backflow prevention devices or good regulation is the preferred approach. • **Proposed action: create a website Fact Sheet warning of risks of contamination at customer tap**	M33

Table 5.5: Assessment of Whole of Service Risks with the Potential to Impact Drinking Water Quality in Each Drinking Water Scheme

Scheme Component	Hazardous Event	Hazard	CR	LH	IRR	Existing Preventative Measure/Barrier	CR	LH	RRR	Uncertainty	Comment/Proposed Further Risk Mitigation	Risk No.
Whole of Service	Extended Loss of Power to Infrastructure	No chlorine dosing at Reservoir Rechlorination Sites	4	3	H12	• Hypochlorite kept in stock for manual dosing if required • Portable pumping systems able to be used to pump hypochlorite	3	1	L3	Reliable	• In an extended power outage scenario, mobile gensets would be used if required to assist with operation of rechlorination sites	W01
		Inability to Treat Water to Potable Standard	4	3	H12	• Soon to be Emergency Genset at GWTP. • Significant storage in reservoirs for emergency supplies for a short period	3	1	L3	Reliable	• In a power outage all electrical systems would stop including pumps which means that untreated water would not enter distribution system	W02
	Loss of Radio Telemetry	Unsafe exceedances not detected	4	3	H12	• Rapid response to reinstate radio telemetry or other communications links as soon as possible • Most critical systems have localised control to avoid failure during communications outage • Critical spares kept for all communications systems	3	1	L3	Reliable	• Highly trained competent staff available internally to attend to communications faults	W03
	Lack of qualified and competent staff	Poor decision making and low competency leads to unsafe practices	4	3	H12	• Training provided as appropriate to operations and maintenance staff • Exposure of staff to industry events and technical developments	3	1		Reliable	• Attracting suitably qualified staff during the mining boom will always prove to be somewhat of a challenge	W04
	Lack of availability of chemical supplies	Critical chemical processes cease leading to unsafe water	4	3	H12	• Backup stocks and additional storage of critical treatment chemicals • Alarms on most storage vessels to indicate when they need to be restocked • Good chemical supply contracts	3	1	L3	Reliable	• Regular checking of chemical inventories done to ensure chemical availability.	W05
	No information management system	Loss of important information	4	3	H12	• Manual document system in place • Electronic archiving in use					• Continuous improvement is undertaken through revision of critical information	W06

6 MANAGING RISKS

The assessment of risks for each drinking water scheme and the whole of service risks outlined above also provide a description of the existing risk treatments that are in place to minimise the risk posed by each hazard or hazardous event. The various existing risk treatments include (but are not limited to), Operation and Maintenance Manuals (O&M) and procedures, water quality monitoring programs, preventative maintenance programs, redundancy in design, critical spares inventory, chemical supply contracts, physical security, inspection programs, staff training and awareness, on-line monitoring and SCADA alarming, multiple treatment barriers, stakeholder engagement and asset management planning. These risk treatments are described in more detail in the following sections of the DWQMP. Despite the application of existing risk treatments, a number of risks have an unacceptable Residual Risk Rating. These lists and the proposed additional treatments are listed in Table 6.1.

6.1 Unacceptable Risks to Drinking Water Quality

Of the 143 individual risks that were rated 37 of the risks were considered to be unacceptable levels of risk as they have a moderate Residual Risk Rating (see Table 6.1). Proposed Actions has been identified to further mitigate the risk. The Proposed Actions being taken to mitigate these unacceptable risks form part of the Risk Management Improvement Program (see Section 12).

Table 6.1: Unacceptable Risks Identified from Risk Assessments and Proposed Treatments

Risk No.	Component-Event-Hazard	RRR	Proposed Action
Rockhampton Water Supply Scheme			
R08	Source – Contamination of raw water Excessive E.C. or TDS	M9	Continue to lobby regulator for tighter water quality limits on mine water discharges.
R13	Treatment – Lack of effective treatment Viral Pathogens	M5	Perform testing for viruses for further confirmation of process effectiveness.
R16	Treatment – Lack of effective treatment Excessive E.C or TDS	M9	Determine feasibility of installing reverse osmosis treatment to reduce E.C. and TDS.
R24	Distribution – Reservoir Contamination Bacterial Pathogens	M8	Repair or replace Mt Charlton Reservoir roof to prevent entry into the reservoir by roof run-off.
R25	Distribution – Reservoir Contamination Protozoan Pathogens	M8	Repair or replace Mt Charlton Reservoir roof to prevent entry into the reservoir by roof run-off.
R26	Distribution – Reservoir Contamination Viral Pathogens	M8	Repair or replace Mt Charlton Reservoir roof to prevent entry into the reservoir by roof run-off.
R27	Distribution – Broken Water Pipes Microbial Pathogens	M8	Provide training to maintenance and construction staff to increase level of awareness of risks of microbial pathogens to drinking water quality and human health.
R30	Distribution – Sabotage or Terrorism Toxic agent	M5	Identify high risk sites and install CCTV at these sites.
R33	Customers Tap – Contamination Microbial Pathogens	M5	Create a website Fact Sheet warning of risks of contamination at customer tap

Risk No.	Component-Event-Hazard	RRR	Proposed Action
Capricorn Coast Water Supply Scheme			
CC13	Treatment – Lack of effective treatment Viral Pathogens	M5	Perform testing for viruses for further confirmation of process effectiveness.
CC18	Treatment – Sludge return to inlet Excessive Turbidity	M5	Install level sensor to provide automated shut-off of supernatant return.
CC25	Distribution – Reservoir Contamination Bacterial Pathogens	M6	Install additional automated rechlorination at Pacific Heights Reservoir to avoid need for manual dosing at this site.
CC27	Distribution – Reservoir Contamination Viral Pathogens	M6	Install additional automated rechlorination at Pacific Heights Reservoir to avoid need for manual dosing at this site.
CC28	Distribution – Broken Water Pipes Microbial Pathogens	M8	Provide training to maintenance and construction staff to increase level of awareness of risks of microbial pathogens to drinking water quality and human health.
CC31	Distribution – Sabotage or Terrorism Toxic agent	M5	Identify high risk sites and install CCTV at these sites.
CC35	Customers Tap – Contamination Microbial Pathogens	M5	Create a website Fact Sheet warning of risks of contamination at customer tap
Mount Morgan Water Supply Scheme			
MM11	Treatment – Lack of effective treatment Bacterial Pathogens	M8	Complete installation of automated chlorination and on-line chlorine analysis. Use newly installed on-line analysis to drive further process optimisation.
MM12	Treatment – Lack of effective treatment Protozoan Pathogens	M8	Use newly installed on-line analysis to drive further process optimisation.
MM13	Treatment – Lack of effective treatment Toxic Cyanobacteria	M8	Use newly installed on-line analysis to drive further process optimisation. Conduct more analysis to determine effectiveness of each treatment barrier for removal of cyanobacteria.
MM14	Treatment – Lack of effective treatment Viral Pathogens	M8	Complete installation of automated chlorination and on-line chlorine analysis. Perform testing for viruses for further confirmation of process effectiveness.
MM18	Treatment – Lack of effective treatment Excessive Turbidity	M5	Use newly installed on-line analysis to drive further process optimisation.
MM19	Treatment – Sludge return to inlet Excessive Turbidity	M5	Install level sensor to provide automated shut-off of supernatant return.
MM20	Treatment – Process control failure Coagulant Underdose	M6	Convert coagulant dosing to liquid alum to allow for on-line flow metering and better measurement of chemical usage.
MM21	Treatment – Process control failure Chlorine Underdose	M6	Complete the installation of automation chlorination with on-line chlorine analyser to allow for continuous monitoring and alarming to alert operator of underdosing.
MM25	Treatment – Process control failure Chlorine Overdose	M6	Complete the installation of automation chlorination with on-line chlorine analyser to allow for continuous monitoring and alarming to alert operator of underdosing.
MM26	Distribution – Reservoir contamination Bacterial Pathogens	M6	Complete the installation of automated chlorination at the North St Reservoir site to allow for continuous monitoring and alarming to alert operator of incorrect dosing.
MM28	Distribution – Reservoir contamination Viral Pathogens	M6	Complete the installation of automated chlorination at the North St Reservoir site to

Risk No.	Component-Event-Hazard	RRR	Proposed Action
			allow for continuous monitoring and alarming to alert operator of incorrect dosing.
MM29	Distribution – Broken Water Pipes Microbial Pathogens	M8	Provide training to maintenance and construction staff to increase level of awareness of risks of microbial pathogens to drinking water quality and human health.
MM32	Distribution – Sabotage or Terrorism Toxic agent	M5	Identify high risk sites and install CCTV at these sites.
MM33	Distribution – Process control failure Chlorine Underdose	M6	Complete the installation of automated chlorination at the North St Reservoir site to allow for continuous monitoring and alarming to alert operator of incorrect dosing.
MM34	Distribution – Process control failure Chlorine Overdose	M6	Complete the installation of automated chlorination at the North St Reservoir site to allow for continuous monitoring and alarming to alert operator of incorrect dosing.
MM36	Customers Tap – Contamination Microbial Pathogens	M6	Create a website Fact Sheet warning of risks of contamination at customer tap
Marlborough Water Supply Scheme			
M07	Source – Contamination of raw water Toxic Pesticides or Organics	M5	Engage further with landholders to educate about the potential for pesticides to impact groundwater.
M15	Treatment – Lack of effective treatment Toxic Pesticides or Organics	M5	Engage further with landholders to educate about the potential for pesticides to impact groundwater.
M27	Distribution – Broken Water Pipes Microbial Pathogens	M8	Provide training to maintenance and construction staff to increase level of awareness of risks of microbial pathogens to drinking water quality and human health.
M30	Distribution – Sabotage or Terrorism Toxic agent	M5	Identify high risk sites and install CCTV at these sites.
M33	Customers Tap – Contamination Microbial Pathogens	M6	Create a website Fact Sheet warning of risks of contamination at customer tap

7 OPERATION AND MAINTENANCE PROCEDURES

7.1 Manuals and Procedures for Drinking Water Schemes

Operation and Maintenance (O&M) Manuals exist for all WTP and many of their unit processes (e.g. chemical dosing systems) although most of these are not fully up to date due to changes since amalgamation. Table 7.1 contains a list of relevant manuals and procedures, the date they were prepared, the date for their next revision (if applicable) and the responsible officer. FRW is currently in the process of reviewing and renewing all WTP manuals and converting them into a standard O&M format (WTP template document released by the Queensland Water Directorate (QWD)) to allow for consistency of process description and to facilitate the ongoing updating of these manuals as changes are made to infrastructure or operating procedures. Once updated in electronic form manuals will be added to the Honeywell Experion SCADA system with active links to the manuals via the click of a button on the relevant SCADA screens.

Table 7.1: Operation and Maintenance Manuals and Relevant Procedures for Managing Drinking Water Infrastructure

Document	Date Prepared	Last Reviewed	Date For Revision	Responsible Officer
Fitzroy Basin Resource Operations Plan	2006	N/A	2011	N/A
Glenmore WTP Operating Instructions (Original)	1971	1971	Not planned	Manager Treatment and Supply
Glenmore WTP O&M Manual (QWD template)	In preparation	N/A	Ongoing, part of WTP Upgrade	Manager Treatment and Supply
Woodbury WTP O&M Manual (Original)	1988	1988	Not planned	Manager Treatment and Supply
Woodbury WTP O&M Manual (QWD template)	In preparation	N/A	Ongoing, part of WTP Upgrade	Manager Treatment and Supply
Mount Morgan WTP O&M Manual (Original)	1993	1993	Not planned	Manager Treatment and Supply
Mount Morgan WTP O&M Manual (QWD template)	In preparation	N/A	Ongoing, part of WTP Upgrade	Manager Treatment and Supply
Marlborough WTP O&M Manual (QWD template)	In preparation	N/A	Ongoing, part of WTP Upgrade	Manager Treatment and Supply
Rockhampton to Yeppoon Pipeline O&M Manual	2010	2010	Not planned	Manager Treatment and Supply
Lucas St Reservoir, Pump Station O&M Manual	2003	2003	Not planned	M&E Services Engineer
Rechlorination O&M Manual	In preparation	In progress	Ongoing as part of Upgrades	M&E Services Engineer
Glenmore WTP Fluoridation O&M Manual	2010	2010	Not planned	M&E Services Engineer
Woodbury WTP Fluoridation O&M Manual	2011	2011	Not planned	M&E Services Engineer
Mount Morgan WTP Fluoridation O&M Manual	2011	2011	Not planned	M&E Services Engineer
Activated Carbon Loading Procedure	2010	2010	As required	Coordinator Treatment
Mains Break Repair Procedure	Unknown	In progress	As required	Manager Network Services
Reservoir Disinfection and Inspection Procedure	Unknown	In progress	As required	Manager Treatment and Supply
Water Mains Air-Scouring Procedure	2010	In progress	As required	Manager Network Services
Cyanobacteria Monitoring and Management Procedure	2009	In progress	As required	Manager Treatment and Supply

N/A = not applicable

Standard operating procedures are used for the operation of unit processes or associated equipment (e.g. powdered activated carbon bulk bag unloading system) to ensure that are operated according to manufacturer's specifications. Similarly, procedures for the operation and calibration of on-line and bench top analytical instrumentation are also in place. In most cases these procedures are as supplied by the manufacturer but in some instances the procedures are reproduced in a format that allows co-location next to the equipment being operated to help ensure correct operation occurs. Procedures are also in place for the disinfection of reservoirs, new water mains and broken water mains and for the regular reservoir inspection program and reticulation network air-scouring. Often these procedures are prepared in checklist format to document the completion of tasks for archiving purposes. FRW is currently reviewing and allocating numbers to all procedures to ensure that a register of current procedures is kept up to date.

The WTP O&M Manuals listed in Table 7.1 form the basis of the operating parameters coded into PLC codes or SCADA control setpoints used to control key all key process treatment steps. The reviewing of these manuals is being done to ensure that there is consistency of information between the manuals and all the current operational settings used in PLC programs and SCADA settings. Since amalgamation, a large amount of capital upgrade work has been completed in all schemes and work is currently underway to ensure that all these infrastructure changes are captured in the relevant O&M manuals and procedures.

7.2 Preventative Maintenance Program

A preventative maintenance program is currently in place for drinking infrastructure within each supply scheme. The Conquest asset and maintenance management system is used to manage planned and reactive maintenance activities. More than 130 planned maintenance tasks are conducted by FRW staff to ensure the continued reliable operation of a range of mechanical, electrical and process control system components. Table 7.2 provides an overview summary of the main types of preventative maintenance activities that are conducted and their frequency.

Table 7.2: Overview of Preventative Maintenance Program for Drinking Water Infrastructure

Equipment Category	Specific Task	Frequency
Electrical	Backup generator servicing	yearly
	Switchboard thermography testing	yearly
	Chlorine gas sensor testing and servicing	monthly
	Uninterruptible Power Supply servicing	6 monthly
Mechanical	WPS pump servicing and greasing	3 monthly
	WTP Air compressor servicing	3 monthly
	Backwash blower servicing	3 monthly
	WTP coagulant dose pump servicing	3 monthly
	Chlorinator and vacuum regulator servicing	6 monthly
	Low lift and High lift pump hydraulic oil checking	3 monthly
	Low lift pump intake screen cleaning	2 weekly
	Flocculator gearbox and compressor greasing	weekly
Process Control	pH, Electrical conductivity and turbidity meter calibrations	monthly
	Chlorine analysers servicing	2 monthly
	Chlorine analysers calibration	monthly
	On-line fluoride analysers calibration	weekly

7.3 Reactive Maintenance Management

All reactive maintenance requirements are managed using a standard approach. Upon discovery of a process or component fault or an excursion from normal operational performance, a maintenance request is raised using the Conquest software system by the WTP Operator or staff member who discovers the issue. The nature and location of the issue is described in the request together with an indication of the urgency of the maintenance request. This request is then circulated automatically to key supervisors and managers involved in the operation and maintenance of drinking water infrastructure to provide the opportunity for comment on the fault or its urgency rating to optimise the prioritisation of reactive maintenance activities. Reporting of the progress made against the preventative and reactive maintenance tasks is conducted to ensure tasks are completed in a timely manner.

8 MANAGEMENT OF EMERGENCIES, INCIDENTS, OR EXCURSIONS FROM NORMAL PERFORMANCE

8.1 Emergency Response Plan

FRW has in place an Emergency Response Plan (ERP) that details the approach for managing the response to, and recovery from, emergency situations e.g. natural disasters. The ERP has recently been reviewed and updated following the prolonged major flooding event that occurred during the 2010-2011 summer season. Mock emergency scenarios and desktop exercise alert workshops are held to provide training to key staff involved in the management of emergency situations.

8.2 Managing Drinking Water Incidents or Excursions from Normal Operational Performance

Drinking water incidents including reportable drinking water quality incidents or excursions from normal operational performance are rated and managed using the information provided Table 8.1 and Figure 8.1. An additional flow charted procedure is in place for the management of microbiological water quality incidents following the detection of non-compliances within the drinking water schemes. Table 8.1 also provides information about the response and rectification time targets to return to normal safe operating status.

Members of the Treatment and Supply team within FRW together with other key stakeholders play different roles in the management of drinking water quality incidents or any excursion from normal operational performance. For example an excursion from normal operating range is usually identified by a Treatment Plant Operator through a SCADA alarm whereas a non-compliance detected through verification monitoring (e.g. *E. coli* detection) is normally identified by the Water Quality Officer or Water Quality Coordinator through the receipt of a non-compliant test result from an external laboratory. Depending on the nature of the excursion or non-compliance, each of these team members will attempt to take any action possible to immediately resolve the matter or alternatively, a reactive maintenance action request will be submitted electronically for dispatch to maintenance staff according to the Priority Ratings given in Table 8.1.

The Maintenance Planner and Supervisor Operations are responsible for confirming the Priority Rating and dispatching the reactive request to the maintenance staff. This tasking is currently done using the Conquest maintenance management software. In either case, the matter will be reported immediately to either the Coordinator Treatment, Coordinator Water Quality or Manager Treatment and Supply. These three officers are responsible for assessing any action taken or for formulating a plan of further action (e.g. resampling) if required to address or investigate the non-compliance and for directing staff to complete these actions.

Table 8.1: Priority Ratings of Possible Drinking Water Incidents or Events and the associated Response and Rectification Time Targets

Consequences (always rate using consequence with greatest potential impact)			
Generic Description	Negative public perception Prevention of normal operations Increased reactive maintenance Disruption to normal staff duties Loss of critical spares or supplies	Public complaint or environmental spill Reduction in service level Loss of normal design operating status Loss of preventative maintenance Unacceptable civil or site condition	Possible public health impact Loss of service or non-compliance Loss of SCADA control or monitoring Loss of whole treatment barrier Security or structural breach
Examples	*Site left untidy or poorly signed* *Process shutdown required* *Increased need for fault resetting* *Normal planned tasks disrupted* *No spare parts or store chemicals*	*Widespread drinking water complaint* *Significant drop in reticulation pressure* *Low or high alarm, loss of duty standby* *On-line instrumentation not calibrated* *Reservoir roof structure damaged*	*Reservoir contamination detected* *Exceedance of ADWG health value* *No radio telemetry or local comms* *Chlorine dosing failure* *Unauthorised access to WTP*
Likelihood			
Within 1 to 7 days	**P2 – Moderate Impact/Risk**	**P1 – High Impact/Risk**	**P1 – High Impact/Risk**
Within 7 to 28 days	**P3 – Low Impact/Risk**	**P2 – Moderate Impact/Risk**	**P1 – High Impact/Risk**
Not within 28 days	**P3 – Low Impact/Risk**	**P3 – Low Impact/Risk**	**P2 – Moderate Impact/Risk**

Response and Rectification Time Targets			
Priority Rating	**Response Time to Site**	**Rectification Time**	**Maximum Tolerable Outage**
P1	**1 hour**	**5 hour**	**5 hour**
P2	**2 hours**	**24 hours**	**24 hours**
P3	**24 hours**	**5 days**	**5 days**

In the event of a notifiable water quality incident, the incident will be reported to the Office of the Water Supply Regulator and simultaneously to Queensland Health and then investigated by either the Coordinator Water Quality or the Manager Treatment and Supply. Upon completion of the investigation the incidents are reported in writing to the Office of the Water Supply Regulator and to Queensland Health. Once fully resolved, the incident reporting is completed and any long term actions or preventative measures are incorporated into O&M Manuals or procedures or incorporated into future Capital Works Programs in order to prevent further incidents or excursions from normal operational performance targets.

Examples of specific actions that may be taken for events with different ratings are:

P1 Rating

- Resampling for further chemical or microbiological testing
- Manual dosing of sodium hypochlorite to boost disinfection
- Draining reservoirs or issuing boil water alerts to avoid impact on public health
- sourcing water from alternative supplies
- Install critical spare for chemical dosing pump

P2 Rating

- flushing of mains to clear a discoloured water event,
- changes made to treatment chemical dosing rates (e.g. coagulant dose),
- process control settings (e.g. changes to PID loops on chlorination systems)

P3 Rating

- air-scouring of water mains to remove sediment or biofilm

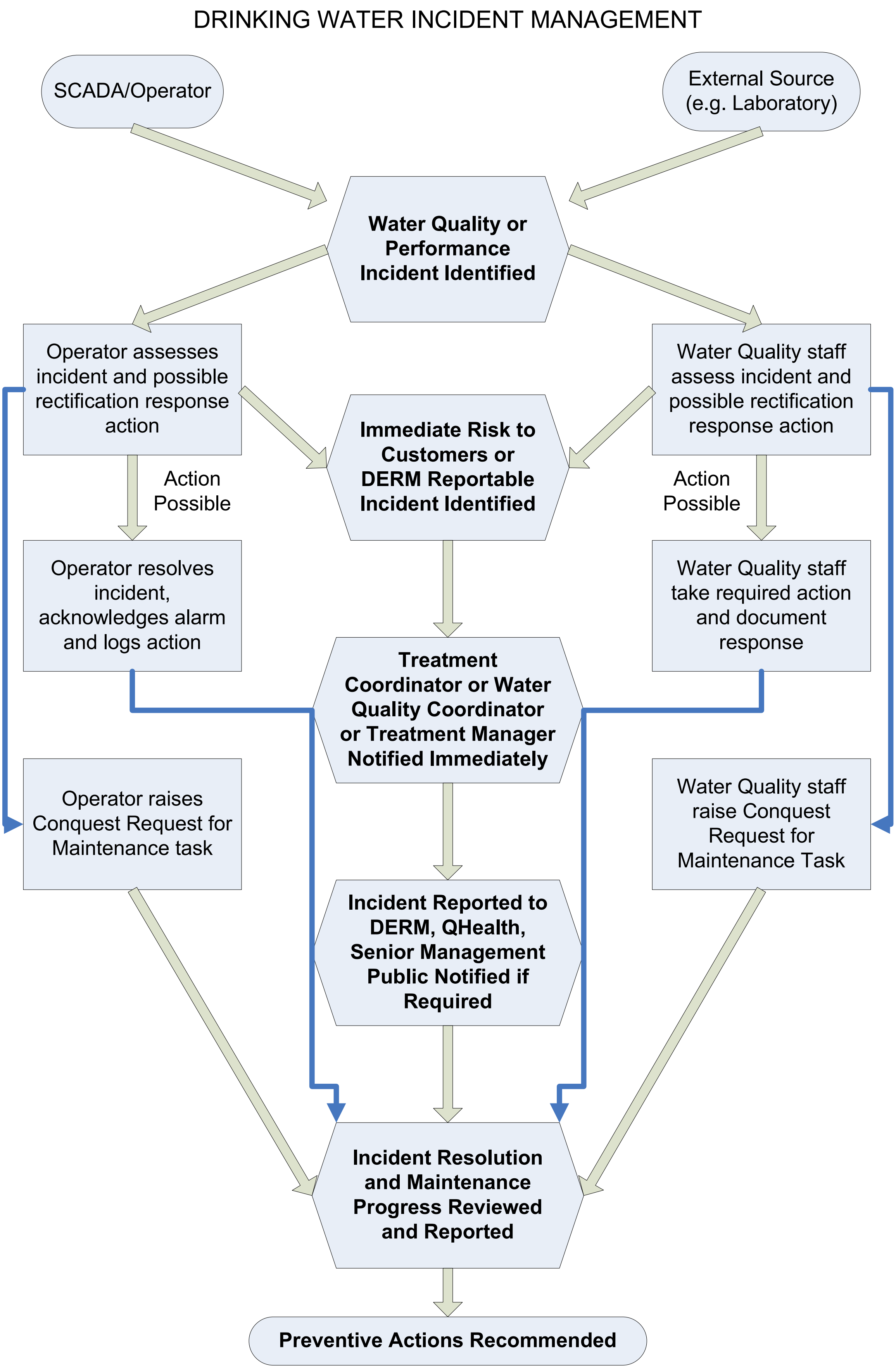
8.3 Emergency Contact Information

Table 8.2 identifies key personnel or stakeholders involved in managing drinking water incidents including FRW staff and officers within the Office of the Water Supply Regulator and Queensland Health. The positions in bold have in-depth knowledge of water treatment processes and/or water quality biology and chemistry and will engage with State Government officers if required to manage drinking water quality incidents.

Table 8.2: FRW or other Personnel Involved in Managing Drinking Water Incidents

Name	Position	Role	Phone Numbers
Nimish Chand	Strategic Manager FRW	Overall FRW Responsibility	1300 22 55 77
Jason Plumb	**Manager Treatment & Supply**	Reporting, Investigating, Managing Responses	1300 22 55 77
Bill Van Wees	**Coordinator Treatment**	Reporting, Investigating, Managing Responses	1300 22 55 77
Michael Dalton	**Coordinator Water Quality**	Sampling, Reporting	1300 22 55 77
Ariane Acuna	**Water Quality Officer**	Sampling, Reporting	1300 22 55 77
Dean Kreiser	M&E Services Engineer	Rectification Actions	1300 22 55 77
Tammy Zerner	Maintenance Planner	Rectification Actions	1300 22 55 77
Jeff Schneider	Supervisor Operations	Rectification Actions	1300 22 55 77
Office of the Water Supply Regulator	Regulator for Drinking Water	Regulator, Management of Incident Response	1300 59 67 09
Queensland Health	Regulator for Public Health	Management of Incident Response	4920 6895

Figure 8.1: Flow Chart Showing Approach to Drinking Water Incident Management



9 SERVICE WIDE SUPPORT – INFORMATION MANAGEMENT

Record keeping, information management and reporting activities are currently performed in a number of different ways depending on the type and source of the information and its intended use. The overarching approach to record keeping and record retention requirements is prescribed in Council's Recordkeeping Policy (Policy No. POL.F4.7).

9.1 Information Management Systems

A number of different software systems are used to capture, manipulate and archive information relating to drinking water. These systems are accessible to all relevant staff through Council's online IT services. Table 9.1 provides a listing of the software systems that are currently in use and provides an indication of how current or up-to-date the information is in each system. O&M Manuals and procedure documents are also stored in hardcopy. The group responsible for maintaining and updating each software system is also indicated.

Information is made available or distributed to all staff via Toolbox Meetings held each month or through specially organised meetings or training workshops as required. In addition, information is presented on noticeboards and important safety information provided to team members in document wallets that accompany each of the work vehicles used by staff. If required email or is used to distribute important information about drinking water operations and performance data.

Table 9.1: Software Systems Used for Management of Drinking Water Associated Information

System	Function	Group Responsible	Currency
DataWorks	Archiving of all business critical documents including internal and external correspondence	RRC Records Management	Current
Conquest	Management of all asset inventory, maintenance management information and all O&M Manuals	FRW Asset Management	Current
Pathways	Management of all customer engagements including complaints and information requests	RRC and FRW Admin	Current
Geko	Management of Council-wide GIS and asset location information	RRC and FRW Asset Management	95% current
Experion SCADA	Archiving of all on-line monitored operational data for drinking water infrastructure	FRW Treatment and Supply Team	Current
Microsoft Excel	Management of all water quality monitoring information	FRW Treatment and Supply Team	Current

9.2 Reporting Activities

Currently all reporting activities are managed by a number of teams within FRW although predominantly members of the Treatment and Supply Team are responsible for all reporting related to drinking water quality. Information for reporting purposes is obtained from Microsoft Excel files (e.g. drinking water quality testing results), SCADA archives (e.g. WTP performance metrics, flow measurements and on-line drinking water quality results), Pathways archives (e.g. customer complaints) and Conquest archives (e.g. operating and maintenance activities).

Reports are prepared by key members of the Treatment and Supply Team (e.g. Water Quality Officer, Coordinator Water Quality, Coordinator Treatment, Manager Treatment and Supply) and are reviewed by other members of the team and the Strategic Manager FRW prior to submission. In this manner, the many different internal and external reporting requirements associated with drinking water (e.g. Council reports, internal team performance reports, FRW Website reports for customers, drinking water quality compliance reports and drinking water quality incident reports) are generated to meet business and legislative obligations.

As outlined in the RMIP a Reporting Capability Enhancement Project has been commenced to streamline all reporting activities through the review and development of a well structured, robust and repeatable process for the management of all reportable information and reportable activities to ensure statutory and internal business reporting requirements are met. The changes identified through this project will be implemented by 30 June 2011. In addition, a Microsoft Outlook-based Corporate Calendar will be implemented to ensure the timely completion of all reporting activities.

10 OPERATIONAL AND VERIFICATION MONITORING PROGRAMS

A comprehensive water quality monitoring program is in place to ensure that operational performance is maintained to a sufficiently high level in order to consistently produce drinking water that meets ADWG. Table 10.1 provides an overview of the water quality monitoring program in its entirety. The same monitoring program is applied across all drinking water schemes. The ADWG values for health and aesthetics are used as the compliance targets for the water quality monitoring program. The sampling locations and frequency recommended in the ADWG serve as the basis for the locations and sampling frequency applied for each water quality parameter in the monitoring program. Raw water sources are monitored in accordance with a Cyanobacteria Monitoring and Management Procedure based on best industry practice recommendations.

Unless specified, samples are collected by grab sample and transported by express courier to external laboratories where required. Trained water quality staff apply standard methods for sampling and sample handling with specialised containers and instructions supplied by analytical service providers incorporated in the sampling program. Additional detail on the operational monitoring conducted at each WTP and the detailed program for microbiological sampling across the drinking water schemes is provided below.

Excursions detected during operational or verification monitoring are managed according to the information outlined in the Section 8.

10.1 Operational Monitoring Within Drinking Water Scheme

Operational monitoring is performed at different stages in each drinking water scheme from catchment through to the distribution system. In particular, monitoring of the performance of key treatment barriers is a key focus of the operational monitoring conducted at each WTP. Table 10.2 provides a breakdown of the operational monitoring that is conducted within each drinking water scheme including information on how the sampling is performed, its frequency and where defined, the operational targets or ranges (if applicable) for each parameter tested. Where stated in Table 10.2, ranges reflect the values between the high and low alarms around the SCADA setpoint for a given on-line operating parameter or water quality parameter. Values outside of this range therefore trigger an alarm which is responded to as described in Section 8.

Manual sampling listed as daily is also conducted more frequently on an event-related basis as required. The information provided for the Mount Morgan WTP is inclusive of the planned upgrade to install on-line monitoring of pH, electrical conductivity, turbidity and free chlorine at appropriate locations throughout the WTP; work which is currently nearing completion.

10.2 Verification Monitoring within Drinking Water Schemes

In addition to the verification monitoring program described in Table 10.1, drinking water is sampled weekly throughout each drinking water scheme for *E. coli,* free chlorine residual testing and other physico-chemical testing described below. Each week 15 drinking water samplings are tested for *E. coli*. A sample is collected from each WTP and 12 samples (Rockhampton 7, Capricorn Coast 4, Mount Morgan 1) are collected from 69 possible sampling sites located throughout the three distribution systems. Table 10.3 provides a list of all the sampling sites that the weekly sampling schedule is rotated through. For example, each week a sample is collected from each of seven different supply zones within the Rockhampton Water Supply. The following week another seven supply zones, with some overlap with the preceding week, are sampled in order to rotate through all the different individual sampling sites over an extended period of time. A breakdown of the sampling locations based on supply zones and scheme is provided in Table 10.3. These supply zones are also identified in the water supply scheme schematics shown in Figures 2.1 to 2.4. Selection of the number and location of sampling sites was done in accordance with recommendations in the ADWG.

Table 10.1: Overview of Water Quality Monitoring Program for Each Drinking Water Scheme

Water Quality Parameter	ADWG Health Guideline	ADWG Aesthetic Guideline	Location Sampled*	Sampling Frequency# (ADWG Guide)
E. coli	0 cfu	No value	P, T, R	W, E (W)
Cryptosporidium	No value	No value	S, P	Y, E, (E)
Giardia	No value	No value	S, P	Y, E, (E)
Cyanobacteria	No value	No value	S, P	M, E, (M)
pH	No value	6.5-8.5	S, P	C, D, (D, W)
Chlorine	5 mg/L	0.6 mg/L	P, T, R	C, D, (D,W)
Electrical Conductivity	No value	No value	S, P, R	C, D, M, (W,M)
Total Dissolved Solids	No value	600 mg/L	S, P	M, (Q)
Colour	No value	15 HU	S, P	D, M, (W, M)
Turbidity	<1 NTU&	5 NTU	S, P, R	C, D, M, (D, W)
Total Hardness	No value	200 mg/L	S, P	M, (M)
Total Alkalinity	No value	No value	S, P	M, (W, M)
Sulphate	500 mg/L	250 mg/L	S, P	M, (Q)
Chloride	No value	250 mg/L	S, P	M, (Q)
Calcium	No value	No value	S, P	M, (Q)
Magnesium	No value	No value	S, P	M, (Q)
Sodium	No value	180 mg/L	S, P	M, (Q)
Potassium	No value	No value	S, P	M, (Q)
Aluminium	No value	0.2 mg/L	S, P	M, (D, W)
Copper	2 mg/L	1 mg/L	S, P	M, (M)
Lead	0.01 mg/L	No value	S, P	M, (M)
Manganese	0.5 mg/L	0.1 mg/L	S, P	M, (F)
Zinc	No value	3 mg/L	S, P	M, (M)
Iron	No value	0.3 mg/L	S, P	M, (M)
Fluoride	1.5 mg/L	No value	S, P, R	C, D, (C, W)
Nitrite	3 mg/L	No value	S, P	M, (M)
Nitrate	50 mg/L	No value	S, P	M, (M)
Total Organic Carbon	No value	No value	S, P	Q, (M,Q)
Trihalomethanes	0.25 mg/L	No value	P, R	Q, (M)
Taste/odour compounds	No value	No value	S, P	E, (W, M)
Heavy Metals>	Various	No values	S, P	E, Y
Pesticides>	Various	No value	S	E, Y (M, E)
Radionuclides	Various	No value	S	E, Y (5 years)

cfu = colony forming unit, HU = Hazen units, NTU = nephelometric turbidity units
* S = raw water source, P = treatment plant, T = transmission, R = reticulation
\# C = continuous (online), D = daily, W = weekly, F = fortnightly, M = monthly, Q = quarterly, Y = yearly, E = event related, >See Appendix B for details of the heavy metals and pesticide testing, & <1 NTU target is for effective disinfection only with <0.2 NTU the target for filtration of protozoan pathogens

Table 10.2: Operational Monitoring Conducted within Each Drinking Water Scheme

Parameter	Location[a]	Frequency[b]	Target Values or Range
Rockhampton Water Supply Scheme			
Turbidity	RW, PS, PF, DW	D, On-line	PS (<1.5 NTU), PF (<0.3 NTU)
pH	RW, PF, PC, DW	D, On-line	PC & DW (pH 7.6-8.2)
Colour	RW, DW	D	DW (<5 HU)
Alkalinity	RW, DW	D	RW & DW (30-80 mg/L)
Dissolved Oxygen	DW	D	Not defined
Electrical Conductivity	PF, DW	D, On-line	<400 µS/cm
Total Dissolved Solids	DW	D	Not defined
Temperature	RW	D, On-line	Not defined
Taste and Odour	RW, DW	D	Not objectionable
Fluoride	FD, DW	D, On-line	0.6-0.8 mg/L
Streaming Current	CD	On-line	Deviation monitoring
Free Chlorine	CW, DW, SR	D, On-line	DW (0.5-1.5mg/L), SR (0.5 - 1.5mg/L)
Capricorn Coast Water Supply Scheme			
Turbidity	RW, PS, PF, DW	D(RW), On-line	PF & DW (<0.3 NTU)
pH	RW, CD, PS, DW	D, On-line	CD (6.5-7.0), PC & DW (pH 7-8.2)
Colour (apparent, true)	RW, PF, DW	D	DW (<5 HU)
Alkalinity	RW, DW	D	DW (30 mg/L)
Temperature	RW	D	Not defined
Taste and Odour	RW, DW	D	Not objectionable
Fluoride	FD, DW	D, On-line	0.6-0.8 mg/L
Free Chlorine	CW, DW, SR	D, On-line	DW (0.5-2.0 mg/L), SR (0.5 – 1.5mg/L)
Mount Morgan Water Supply Scheme (on-line analysis except fluoride currently being installed)			
Turbidity	RW, PF, DW	D(RW), On-line	DW (<1.0 NTU)
pH	RW, PF, DW	D, On-line	CD (6.5-7.0), DW (pH 7.8)
Colour (apparent, true)	RW, DW	D	DW (<5 HU)
Alkalinity	RW, DW	TW	DW (30 mg/L)
Electrical Conductivity	RW, PF, DW	D, On-line	<400 µS/cm
Temperature	RW	D	Not defined
Taste and Odour	RW, DW	D	Not objectionable
Fluoride	FD, DW	D, On-line	0.7 mg/L
Free Chlorine	CW, DW, SR	D, On-line	DW (1.5 mg/L), SR (0.5-1.5mg/L)
Marlborough Water Supply Scheme			
Turbidity	DW	On-line	<0.3 NTU
pH	DW	On-line	pH 7-7.8
Electrical Conductivity	RW, DW	On-line	<400 µS/cm
Free chlorine	DW	On-line	0.5-1.5 mg/L

[a]RW = raw water, PS = post-sedimentation, PF = post-filtration, DW = final drinking water from outlet of clear water reservoir, CD = pre-filtration coagulant-dosed water, FD = fluoride dosed filtered water, CW = clear water inlet, SR = service reservoir, PC = post-pH correction
[b]D = daily manual sampling, TW = twice weekly

Care has been taken to select a range of different sampling points so that there is good coverage of areas with different attributes. For example, points towards the extremity of reticulation supply zones have been chosen in some instances due to long water age, or known areas of limited free chlorine residual penetration. Examples of these sites include site EP3 in Emu Park on the Capricorn Coast Water Supply Scheme, site LC1 on Lakes Creek Rd in Rockhampton or site MA1 at Sleipner St on Mt Archer in Rockhampton. One site in Mount Morgan was chosen as the area occasionally experiences low pressure as well as being at the extremity of the reticulation system. This MM4 site on Smalls Rd provides a good indication of the penetration of free chlorine residuals in the Mount Morgan Water Supply Scheme. In contrast, areas of known good free chlorine residual have also been selected so that the maximum levels of free chlorine reaching the customer's tap are able to be monitored in some instance.

Each week a eight samples are collected randomly from the designated reticulation sampling sites in each scheme and pH, colour, turbidity and electrical conductivity is measured to determine any gross changes in water quality at different locations in the distribution system. In this way, areas where water quality changes significantly due to events that occur in the distribution system will be identified and an investigation of possible causes commenced.

FRW spends a significant amount of time and effort responding to customer water quality complaints or comments about changes in water quality. This is done in order to provide the best means of addressing the root cause of the water quality issue rather than only addressing the nature of the complaint. FRW receives a relatively low number of drinking water quality complaints from customers but understands the importance of using this information to help understand events or changes that occur in water quality and within the water distribution infrastructure.

The verification monitoring program in place is commensurate with the level of risk that exists within each of the water supply schemes based on the recent records of drinking water quality incidents or the frequency of drinking water quality complaints. Despite this, FRW intend to keep reviewing this monitoring program following some revision of the sections in the ADWG 2011 relevant to monitoring and also to further maximise the quality of drinking water supplied to customers. As with operational monitoring, if non-compliances or exceedances are detected during the verification monitoring program action is taken as described in Section 8.

Table 10.3: Drinking Water Distribution System Sampling Sites for Weekly Verification Monitoring (Supply Zone codes are labelled on reticulation areas in Figures 2.1 to 2.4)

Site Code	Reservoir Supply Zone	Address
Rockhampton Water Supply Scheme		
AL1	Agnes St Low Pressure System	O'Connell St
AL2		Cambridge St
AL3		Exhibition Rd
AL4		Ann St
AL5		Prospect St
AL6		Hunter St
AL7		Wandal Rd
AL8		Port Curtis Rd
AL9		Derby St
AL10		Denham St
AH1	Agnes St High Pressure System	Nathan St
AH2		North St
AH3		Herbert St
AH4		Jessie St
YR1	Yaamba Road Reservoir System	Bruigom St
YR2		Main St
YR3		Macallister St
YR4		Beaney St
YR5		Norman Rd
YR6		Maloney St
YR7		Rachel Drv
YR8		Robison St
TR1	Thozet Road Reservoir System	Earl St
TR2		Lucas St
TR3		Joiner St
TR4		Berserker St
TR5		Oshanesy St
GM1	Gracemere	O'Shanesy St
GM2		Lilly Pilly Ave
GM3		Johnson Rd
GM4		Donovan Crs
GM5		Old Capricorn Hwy
MC1	Mount Charlton	Rossmoya Rd
MC2		Glendale Rd
MC3		Bruce Hwy
MC4		Emmerson Drv
FR1	Forbes Ave Reservoir System	Eichelberger St
FR2		Aldridge Ave
FR3		Frenchville Rd
ND1	Nagle Drv Reservoir System	Norman Rd
ND2		Selwyn Crs
ND3		Alyssa Court
PH1	Parkhurst Trunk Main System	McMillan Ave
PH2		Brosnan Crs
LC1	Lakes Ck Main	Lakes Creek Rd
MA1	Mount Archer	Sleipner St
SC1	Samuel Cres	Samuel Crs
BD1	Parkhurst Industrial Estate	Bush Crs
RC1	Ramsay Creek Pumped Main	Bruce Hwy
Capricorn Coast Water Supply Scheme		
SF1	St Faith's System	Anzac Parade
SF2		Pacific Heights Rd

Site Code	Reservoir Supply Zone	Address
SF3		Arthur St
SF4		Adelaide Park Rd
SF5		Rockhampton Rd
TB1	Taranganba System	Matthew Flinders Drv
TB2		Poinciana Ave
LM1	Lammermoor	Scenic Highway
LM2		Vin E Jones Memorial Drv
LM3		Scenic Hwy
LM4		Scenic Hwy
EP1	Emu Park	Pattison St
EP2		Haven Rd
EP3		Svendsen Rd
KS1	Keppel Sands	Schofield Pde North
KS2		Schofield Pde South
Mount Morgan Water Supply Scheme		
MM1	Mount Morgan	Dee St
MM2		Creek St
MM3		River St
MM4		Smalls Rd
Marlborough Water Supply Scheme		
ML1	Marlborough Reticulation	Railway St
ML2	Marlborough Reticulation	Magog Rd

11 BEST PRACTICE INITIATIVES

FRW is actively engaged in a number of activities and initiatives which demonstrate an approach consistent with industry best practice for drinking water quality management. These activities include an ongoing commitment to drinking water quality management through stakeholder engagement towards improved catchment management, initiation and sponsoring of research and development projects and staff awareness and training activities. A commitment to the implementation of an approach that includes ongoing review and continual improvement is outlined in the RMIP detailed above.

11.1 Commitment to Drinking Water Quality Management

FRW is involved in a number of key stakeholder initiatives designed to provide guidance to the overall management and monitoring of water quality and environmental health in the Fitzroy Basin. This Fitzroy River Basin is a very important part of Central Queensland with the vast majority of residents within RRC now dependent on the provision of safe drinking water sourced from the Fitzroy River. Management of the health of the catchment and the minimisation of the impact of catchment land use activities is therefore a key priority. FRW's ongoing involvement in the Fitzroy Water Quality Advisory Group established following the Ensham Mine discharge event in 2008, and its active participation in the Strategic Working Group at the embryonic stages of the Fitzroy Partnership for River Health underpins this commitment.

11.2 Research and Development Activities

Over the last three years FRW has strengthened its collaborative ties with researchers at Central Queensland University. FRW has been involved in the initiation and funding of two research projects. The first project focused on developing an understanding of the diversity and abundance of micro-fungi within parts of the Rockhampton Water Supply Scheme. This PhD project generated very useful data related to the prevalence of micro-fungi and the role of frogs and aerosols in the contamination of service reservoirs.

The second project focused on the optimisation of treatment chemicals and associated processes for the optimisation of the removal of toxic species of cyanobacteria from the Fitzroy River raw water. Through this project FRW gained an insight into the effectiveness of different treatment options for the removal of the known toxin producer *Cylindrospermopsis raciborskii* – one of the more abundant population members during cyanobacterial blooms in the Fitzroy River.

11.3 Staff Awareness and Training

The importance of drinking water quality and the role of team members at FRW in the delivery of safe and reliable drinking water to the community is a topic that is emphasised regularly at staff Toolbox Meetings and during day to day activities. As continual improvements are made to operating procedures or infrastructure upgrades are completed, the significance of these changes with respect to improvements in water quality and levels of service are discussed and relevant training is provided. Equally, the importance of delivering a high quality drinking water service is emphasised to promote a culture of proactive behaviour, innovation and ownership of service delivery.

12 RISK MANAGEMENT IMPROVEMENT PROGRAM

FRW and RRC are committed to delivering safe and reliable drinking water services to the community. To ensure that this is achieved, and to minimise the risks posed to the current drinking water services, a Risk Management Improvement Program has been prepared that comprises five elements. These are:

- Element 1 - Infrastructure Upgrades and Improved Infrastructure Performance
- Element 2 - Optimisation of Information Management and Reporting Capabilities
- Element 3 - Enhanced Engagement with Stakeholders Associated with Drinking Water Infrastructure Management
- Element 4 - Improved Service Through Staff Awareness and Training
- Element 5 - Enhanced Water Quality Performance

Table 12.1 provides an overview of the outputs, priority level, timeframe for completion and availability of funding for each of the five Elements identified in the Risk Improvement Management Program. Table 12.2 provides a specific detail for each action identified as being required to mitigate the unacceptable residual risk ratings listed in Table 6.1 and also other areas where further actions have been identified as being required. The current status and timeframes and person responsible for the completion of these actions are also listed.

Table 12.1: Risk Management Improvement Program for Drinking Water Services

Element	Outputs	Priority Level	Timeframe for Completion	Funding Availability
Element1 Infrastructure Upgrades and Improved Infrastructure Performance	Complete all capital upgrades to water supply infrastructure to mitigate unacceptable risks identified in Table 6.1	High	June 2013	Yes
Element 2 Information Management and Reporting Capability Enhancement	Consolidated and streamlined information management and reporting processes	High	September 2012	Yes
Element 3 Enhanced Stakeholder Engagement	Influence on stakeholders delivers improved management of catchments and other water infrastructure	High	Ongoing	Yes
Element 4 Improved Service through Staff Awareness and Training	Deliver the DWQMP to staff and develop culture of awareness of drinking water quality management. Deliver appropriate training	High	September 2012	Yes
Element 5 Enhanced Water Quality Performance	Develop and implement a Drinking Water Quality Policy. Develop, implement and achieve enhanced water quality performance targets.	High	June 2013	Yes

Table 12.1: Specific Actions Identified to Mitigate Unacceptable Risks to Drinking Water Quality and Information Describing Path to Completion of Actions.

Risk No.	Component-Event-Hazard	RRR	Proposed Action	Responsible Officer	Status	Completion Date
Rockhampton Water Supply Scheme						
R08	Source – Contamination of raw water Excessive E.C. or TDS	M9	Continue to lobby regulator for tighter water quality limits on mine water discharges.	Manager Treatment and Supply	Ongoing	N/A
R13	Treatment – Lack of effective treatment Viral Pathogens	M5	Perform testing for viruses for further confirmation of process effectiveness.	Coordinator Water Quality	Planning	30/09/2012
R16	Treatment – Lack of effective treatment Excessive E.C or TDS	M9	Determine feasibility of installing reverse osmosis treatment to reduce E.C. and TDS.	Manager Treatment and Supply	Complete	30/06/2012
R24	Distribution – Reservoir Contamination Bacterial Pathogens	M8	Repair or replace Mt Charlton Reservoir roof to prevent entry into the reservoir by roof run-off.	Manager Treatment and Supply	Procurement	30/06/2013
R25	Distribution – Reservoir Contamination Protozoan Pathogens	M8	Repair or replace Mt Charlton Reservoir roof to prevent entry into the reservoir by roof run-off.	Manager Treatment and Supply	Procurement	30/06/2013
R26	Distribution – Reservoir Contamination Viral Pathogens	M8	Repair or replace Mt Charlton Reservoir roof to prevent entry into the reservoir by roof run-off.	Manager Treatment and Supply	Procurement	30/06/2012
R27	Distribution – Broken Water Pipes Microbial Pathogens	M8	Provide training to maintenance and construction staff to increase level of awareness of risks of microbial pathogens to drinking water quality and human health.	Manager Treatment and Supply, Manager Network Services	Planning	30/09/2012
R30	Distribution – Sabotage or Terrorism Toxic agent	M5	Identify high risk sites and install CCTV at these sites.	Manager Treatment and Supply	Planning	30/06/2013
R33	Customers Tap – Contamination Microbial Pathogens	M5	Create a website Fact Sheet warning of risks of contamination at customer tap	Coordinator Water Quality	Planning	30/09/2012
Capricorn Coast Water Supply Scheme						
CC13	Treatment – Lack of effective treatment Viral Pathogens	M5	Perform testing for viruses for further confirmation of process effectiveness.	Coordinator Water Quality	Planning	30/09/2012
CC18	Treatment – Sludge return to inlet Excessive Turbidity	M5	Install level sensor to provide automated shut-off of supernatant return.	Coordinator Treatment	Planning	31/12/2012
CC25	Distribution – Reservoir Contamination	M6	Install additional automated	Manager	Planning	31/12/2012

Risk No.	Component-Event-Hazard	RRR	Proposed Action	Responsible Officer	Status	Completion Date
	Bacterial Pathogens		rechlorination at Pacific Heights Reservoir to avoid need for manual dosing at this site.	Treatment and Supply		
CC27	Distribution – Reservoir Contamination Viral Pathogens	M6	Install additional automated rechlorination at Pacific Heights Reservoir to avoid need for manual dosing at this site.	Manager Treatment and Supply	Planning	31/12/2012
CC28	Distribution – Broken Water Pipes Microbial Pathogens	M8	Provide training to maintenance and construction staff to increase level of awareness of risks of microbial pathogens to drinking water quality and human health.	Manager Treatment and Supply, Manager Network Services	Planning	30/09/2012
CC31	Distribution – Sabotage or Terrorism Toxic agent	M5	Identify high risk sites and install CCTV at these sites.	Manager Treatment and Supply	Planning	30/06/2013
CC35	Customers Tap – Contamination Microbial Pathogens	M5	Create a website Fact Sheet warning of risks of contamination at customer tap	Coordinator Water Quality	Planning	30/09/2012
Mount Morgan Water Supply Scheme						
MM11	Treatment – Lack of effective treatment Bacterial Pathogens	M8	Complete installation of automated chlorination and on-line chlorine analysis. Use newly installed on-line analysis to drive further process optimisation.	Manager Treatment and Supply	80% complete	30/09/2012
MM12	Treatment – Lack of effective treatment Protozoan Pathogens	M8	Use newly installed on-line analysis to drive further process optimisation.	Manager Treatment and Supply	In progress	31/12/2012
MM13	Treatment – Lack of effective treatment Toxic Cyanobacteria	M8	Use newly installed on-line analysis to drive further process optimisation. Conduct more analysis to determine effectiveness of each treatment barrier for removal of cyanobacteria.	Manager Treatment and Supply	In progress	31/12/2012
MM14	Treatment – Lack of effective treatment Viral Pathogens	M8	Complete installation of automated chlorination and on-line chlorine analysis. Perform testing for viruses for further confirmation of process effectiveness.	Manager Treatment and Supply, Coordinator Water Quality	80% complete, Planning	30/09/2012

Risk No.	Component-Event-Hazard	RRR	Proposed Action	Responsible Officer	Status	Completion Date
MM18	Treatment – Lack of effective treatment Excessive Turbidity	M5	Use newly installed on-line analysis to drive further process optimisation.	Manager Treatment and Supply	In progress	31/12/2012
MM19	Treatment – Sludge return to inlet Excessive Turbidity	M5	Install level sensor to provide automated shut-off of supernatant return.	Coordinator Treatment	Planning	31/12/2012
MM20	Treatment – Process control failure Coagulant Underdose	M6	Convert coagulant dosing to liquid alum to allow for on-line flow metering and better measurement of chemical usage.	Manager Treatment and Supply	Planning	31/12/2012
MM21	Treatment – Process control failure Chlorine Underdose	M6	Complete the installation of automation chlorination with on-line chlorine analyser to allow for continuous monitoring and alarming to alert operator of underdosing.	Manager Treatment and Supply	80% complete	30/09/2012
MM25	Treatment – Process control failure Chlorine Overdose	M6	Complete the installation of automation chlorination with on-line chlorine analyser to allow for continuous monitoring and alarming to alert operator of underdosing.	Manager Treatment and Supply	80% complete	30/09/2012
MM26	Distribution – Reservoir contamination Bacterial Pathogens	M6	Complete the installation of automated chlorination at the North St Reservoir site to allow for continuous monitoring and alarming to alert operator of incorrect dosing.	Manager Treatment and Supply	80% complete	30/09/2012
MM28	Distribution – Reservoir contamination Viral Pathogens	M6	Complete the installation of automated chlorination at the North St Reservoir site to allow for continuous monitoring and alarming to alert operator of incorrect dosing.	Manager Treatment and Supply	80% complete	30/09/2012
MM29	Distribution – Broken Water Pipes Microbial Pathogens	M8	Provide training to maintenance and construction staff to increase level of awareness of risks of microbial pathogens to drinking water quality and human health.	Manager Treatment and Supply, Manager Network Services	Planning	30/09/2012
MM32	Distribution – Sabotage or Terrorism Toxic agent	M5	Identify high risk sites and install CCTV at these sites.	Manager Treatment and Supply	Planning	30/06/2013

Risk No.	Component-Event-Hazard	RRR	Proposed Action	Responsible Officer	Status	Completion Date
MM33	Distribution – Process control failure Chlorine Underdose	M6	Complete the installation of automated chlorination at the North St Reservoir site to allow for continuous monitoring and alarming to alert operator of incorrect dosing.	Manager Treatment and Supply	80% complete	30/09/2012
MM34	Distribution – Process control failure Chlorine Overdose	M6	Complete the installation of automated chlorination at the North St Reservoir site to allow for continuous monitoring and alarming to alert operator of incorrect dosing.	Manager Treatment and Supply	80% complete	30/09/2012
MM36	Customers Tap – Contamination Microbial Pathogens	M6	Create a website Fact Sheet warning of risks of contamination at customer tap	Coordinator Water Quality	Planning	30/09/2012
Marlborough Water Supply Scheme						
M07	Source – Contamination of raw water Toxic Pesticides or Organics	M5	Engage further with landholders to educate about the potential for pesticides to impact groundwater.	Manager Treatment and Supply	Planning	31/12/2012
M15	Treatment – Lack of effective treatment Toxic Pesticides or Organics	M5	Engage further with landholders to educate about the potential for pesticides to impact groundwater.	Manager Treatment and Supply	Planning	31/12/2012
M27	Distribution – Broken Water Pipes Microbial Pathogens	M8	Provide training to maintenance and construction staff to increase level of awareness of risks of microbial pathogens to drinking water quality and human health.	Manager Treatment and Supply, Manager Network Services	Planning	30/09/2012
M30	Distribution – Sabotage or Terrorism Toxic agent	M5	Identify high risk sites and install CCTV at these sites.	Manager Treatment and Supply	Planning	30/06/2013
M33	Customers Tap – Contamination Microbial Pathogens	M6	Create a website Fact Sheet warning of risks of contamination at customer tap	Coordinator Water Quality	Planning	30/09/2012

N/A = Not applicable

APPENDIX A

Likelihood Rating Table

Likelihood	Description
5. Almost Certain	Occurs more often than once per week (52/yr)
4. Likely	Occurs more often than once per month (12/yr) and up to once per week (52/yr)
3. Possible	Occurs more often than once per year and up to once per month (12/yr)
2. Unlikely	Occurs more often than once every five years and up to once per year
1. Rare	Occurs less than or equal to once every five years

Consequence Rating Table

Consequence	Description
5. Catastrophic	Potential acute health impact, declared outbreak expected
4. Major	Potential acute health impact, no declared outbreak expected
3. Moderate	Potential widespread aesthetic impact or repeated breach of chronic health parameter
2. Minor	Potential local aesthetic, isolated exceedance of chronic health parameter
1. Insignificant	Isolated exceedance of aesthetic parameter with little or no disruption to normal operation

Risk Rating Matrix

	Consequence				
Likelihood	1. Insignificant	2. Minor	3. Moderate	4. Major	5. Catastrophic
5. Almost Certain	Medium 6	High 10	High 15	Extreme 20	Extreme 25
4. Likely	Medium 5	Medium 8	High 12	High 16	Extreme 20
3. Possible	Low 3	Medium 6	Medium 9	High 12	High 15
2. Unlikely	Low 2	Low 4	Medium 6	Medium 8	High 10
1. Rare	Low 1	Low 2	Low 3	Medium 5	Medium 6

Uncertainty Ratings

Uncertainty	Description
Certain	There is 5 years of continuous monitoring data which has been trended and assessed with at least daily monitoring. The processes involved are thoroughly understood.
Confident	There is 5 years of continuous monitoring data which has been trended and assessed with at least weekly monitoring or for the duration of seasonal events. There is good understanding of the processes involved.
Reliable	There is at least a year of continuous monitoring data available which has been assessed. There is a good understanding of the processes involved.
Estimate	There is limited monitoring data available. There is a reasonable understanding of the processes involved.
Uncertain	There is limited or no monitoring data available. Processes are not well understood.

APPENDIX B

Example Heavy Metal and Pesticide Test Results

Page : 3 of 8
Work Order : EB1120053
Client : ROCKHAMPTON REGIONAL COUNCIL
Project : Monthly Water Quality Physical Anions Cations

Analytical Results

Sub-Matrix: WATER			Client sample ID	Glenmore Potable	Glenmore Raw	Woodbury Potable	Woodbury Raw	Mt Morgan Potable
			Client sampling date / time	28-SEP-2011 15:00	28-SEP-2011 15:00	28-SEP-2011 15:00	28-SEP-2011 15:00	27-SEP-2011 15:00
Compound	CAS Number	LOR	Unit	EB1120053-001	EB1120053-002	EB1120053-003	EB1120053-004	EB1120053-005
EG020T: Total Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	<0.001	0.001	<0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	0.002	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Analytical Results

Sub-Matrix: WATER			Client sample ID	No 7 Dam Raw	Fletchers Ck	Glenmore Raw	Woodbury Raw	No 7 Dam Raw
			Client sampling date / time	27-SEP-2011 15:00	27-SEP-2011 15:00	28-SEP-2011 15:00	28-SEP-2011 15:00	27-SEP-2011 15:00
Compound	CAS Number	LOR	Unit	EB1120053-006	EB1120053-007	EB1120053-008	EB1120053-009	EB1120053-010
EG020T: Total Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----
EP130A: Organophosphorus Pesticides (Ultra-trace)								
Bromophos-ethyl	4824-78-6	0.10	µg/L	----	----	<0.10	<0.10	<0.10
Carbophenothion	786-19-6	0.10	µg/L	----	----	<0.10	<0.10	<0.10
Chlorfenvinphos (Z)	18708-87-7	0.10	µg/L	----	----	<0.10	<0.10	<0.10
Chlorpyrifos	2921-88-2	0.050	µg/L	----	----	<0.050	<0.050	<0.050
Chlorpyrifos-methyl	5598-13-0	0.10	µg/L	----	----	<0.10	<0.10	<0.10
Demeton-S-methyl	919-86-8	0.10	µg/L	----	----	<0.10	<0.10	<0.10
Diazinon	333-41-5	0.10	µg/L	----	----	<0.10	<0.10	<0.10
Dichlorvos	62-73-7	0.10	µg/L	----	----	<0.10	<0.10	<0.10
Dimethoate	60-51-5	0.10	µg/L	----	----	<0.10	<0.10	<0.10
Ethion	563-12-2	0.10	µg/L	----	----	<0.10	<0.10	<0.10
Fenamiphos	22224-92-6	0.10	µg/L	----	----	<0.10	<0.10	<0.10
Fenthion	55-38-9	0.10	µg/L	----	----	<0.10	<0.10	<0.10
Malathion	121-75-5	0.10	µg/L	----	----	<0.10	<0.10	<0.10
Azinphos Methyl	86-50-0	0.10	µg/L	----	----	<0.10	<0.10	<0.10
Monocrotophos	6923-22-4	0.10	µg/L	----	----	<0.10	<0.10	<0.10
Parathion	56-38-2	0.10	µg/L	----	----	<0.10	<0.10	<0.10
Parathion-methyl	298-00-0	0.10	µg/L	----	----	<0.10	<0.10	<0.10
Pirimphos-ethyl	23505-41-1	0.10	µg/L	----	----	<0.10	<0.10	<0.10
Prothiofos	34643-46-4	0.10	µg/L	----	----	<0.10	<0.10	<0.10
EP131A: Organochlorine Pesticides								
Aldrin	309-00-2	0.010	µg/L	----	----	<0.010	<0.010	<0.010
alpha-BHC	319-84-6	0.010	µg/L	----	----	<0.010	<0.010	<0.010
beta-BHC	319-85-7	0.010	µg/L	----	----	<0.010	<0.010	<0.010
delta-BHC	319-86-8	0.010	µg/L	----	----	<0.010	<0.010	<0.010
4.4`-DDD	72-54-8	0.010	µg/L	----	----	<0.010	<0.010	<0.010
4.4`-DDE	72-55-9	0.010	µg/L	----	----	<0.010	<0.010	<0.010
4.4`-DDT	50-29-3	0.010	µg/L	----	----	<0.010	<0.010	<0.010
^ Sum of DDD + DDE + DDT	----	0.010	µg/L	----	----	<0.010	<0.010	<0.010
Dieldrin	60-57-1	0.010	µg/L	----	----	<0.010	<0.010	<0.010
alpha-Endosulfan	959-98-8	0.010	µg/L	----	----	<0.010	<0.010	<0.010

Analytical Results

Sub-Matrix: WATER			Client sample ID	No 7 Dam Raw	Fletchers Ck	Glenmore Raw	Woodbury Raw	No 7 Dam Raw
			Client sampling date / time	27-SEP-2011 15:00	27-SEP-2011 15:00	28-SEP-2011 15:00	28-SEP-2011 15:00	27-SEP-2011 15:00
Compound	CAS Number	LOR	Unit	EB1120053-006	EB1120053-007	EB1120053-008	EB1120053-009	EB1120053-010
EP131A: Organochlorine Pesticides - Continued								
beta-Endosulfan	33213-65-9	0.010	µg/L	—	—	<0.010	<0.010	<0.010
Endosulfan sulfate	1031-07-8	0.010	µg/L	—	—	<0.010	<0.010	<0.010
Endosulfan (sum)	115-29-7	0.010	µg/L	—	—	<0.010	<0.010	<0.010
Endrin	72-20-8	0.010	µg/L	—	—	<0.010	<0.010	<0.010
Endrin aldehyde	7421-93-4	0.010	µg/L	—	—	<0.010	<0.010	<0.010
Endrin ketone	53494-70-5	0.010	µg/L	—	—	<0.010	<0.010	<0.010
Heptachlor	76-44-8	0.005	µg/L	—	—	<0.005	<0.005	<0.005
Heptachlor epoxide	1024-57-3	0.010	µg/L	—	—	<0.010	<0.010	<0.010
Hexachlorobenzene (HCB)	118-74-1	0.010	µg/L	—	—	<0.010	<0.010	<0.010
gamma-BHC	58-89-9	0.010	µg/L	—	—	<0.010	<0.010	<0.010
Methoxychlor	72-43-5	0.010	µg/L	—	—	<0.010	<0.010	<0.010
cis-Chlordane	5103-71-9	0.010	µg/L	—	—	<0.010	<0.010	<0.010
trans-Chlordane	5103-74-2	0.010	µg/L	—	—	<0.010	<0.010	<0.010
Total Chlordane (sum)	—	0.010	µg/L	—	—	<0.010	<0.010	<0.010
Oxychlordane	27304-13-8	0.010	µg/L	—	—	<0.010	<0.010	<0.010
EP130S: Organophosphorus Pesticide Surrogate								
DEF	78-48-8	0.1	%	—	—	63.2	103	105
EP131S: OC Pesticide Surrogate								
Dibromo-DDE	21655-73-2	0.1	%	—	—	40.4	76.9	80.8