RICHMOND SHIRE COUNCIL

ABN 47 039 843 844

65 Goldring Street, Richmond, Qld 4822

P.O. Box 18, Richmond, Qld 4822

T (+61) (07) 4719 3377 F (+61) (07) 4719 3372

Email: enquiries@richmond.qld.gov.au

Web: www.richmond.qld.gov.au

DRINKING WATER QUALITY MANAGEMENT PLAN SERVICE PROVIDER NO. 111

Document Status

This document must be reviewed routinely in accordance with the general guidance notes listed below;

1. Improvement plan – should be reviewed and updated quarterly to maintain continual improvement and ensure validity and actions are being addressed within the specified timeframes.
2. Risk Assessment tables should be reviewed quarterly and updated specifically relating to the quarterly review of the improvement plan, this review need only be associated to specific risks that have been addressed through completion of actions identified in the improvement plan.
3. Operational documents register should be reviewed quarterly in accordance with the above to ensure as new documents, record sheets and or maintenance programs are recorded and identified as complete providing document reference and location details for ease of access by all RSC staff required to monitor and maintain the system.
4. Up-on any significant change to raw water supply (e.g. new bore) or treatment process the document and system description flow charts must be updated to reflect any significant change.

Revision No.	Details	Author	Reviewer	Approved for Issue Name	Signature	Date
A	Submission to DEWS			G. Potter	G. Potter	1/09/13
B	Update containing additional information requested by DEWS	D. Hillman	P. Fullwood			
C	Full update	M. Wanrooy		P. Bennett	P. Bennett	8/02/17
D	Review and update for DEWS	M. Samblebe J. Busch				17/7/17
E	Review for assessment by DEWS		M. Wanrooy			
F	Full update in response to DEWS request for further information.	M. Samblebe J. Busch				
G	Biannual Update – Review Amendment	M. Samblebe J. Busch				28-8-19
H	Amendment Review and Approval			P. Bennett	P. Bennett	
I	Updated Ammendment following feedback from DNRME	M.Samblebe J. Busch		P.Bennett	P. Bennett	30-4-20

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1 EXECUTIVE SUMMARY

Richmond Shire Council updated its Drinking Water Quality Management Plan (DWQMP) following construction of a water treatment plant in 2015. The plan was approved in 2017 and in line with requirements reviewed in June 2019 and amended to reflect progress against the Risk management Improvement Plan (RMIP) and recommendations following the scheduled audit in September 2018.

This document and the supporting systems demonstrate Richmond Shire Council's compliance with the requirement of the Public Health Act 2010 to develop a Quality Assurance Plan in line with the "Framework for Drinking Water Quality Management" in the Australian Drinking Water Guidelines. This document acts as a roadmap of the activities that Council undertakes to ensure the provision of safe drinking water to its customers.

This report documents the development of this DWQMP, describes Councils' existing management systems and contains an improvement plan to ensure that the system can be updated to comply with all the requirements of the ADWG and that risk are appropriately managed and adequate records are kept to demonstrate compliance.

Part of the DWQMP development process, as specified by the ADWG, requires water utilities to identify Critical Control Points (CCP) in the water supply systems to allow effective management of deviations from recommended water parameter guidelines. A summary of the CCPs identified for Council's water supply systems is provided. These have been reviewed and updated in 2019 to reflect current operating procedures.

The DWQMP is a working system document and requires council to action RMIP items within the recommended time frames. Continued development, implementation and review of this system is critical to the effective management of water quality in the drinking water supply systems.

2 REGISTERED SERVICE DETAILS

2.1 Purpose

The purpose of the Drinking Water Quality Management Plan (DWQMP) is to protect public health and document a risk-based system for managing the supply of drinking water under the control of Richmond Shire Council for the Richmond Water Supply Scheme.

The DWQMP is viewed as a means of achieving drinking water quality outcomes (in the short and long-term) and demonstrating that drinking water quality management measures are in place.

2.2 Statutory Requirements

The drinking water quality management plan was prepared in accordance with legislative requirements that impose rigorous and mandatory management practices on Council's drinking water infrastructure to ensure compliant drinking water quality. To be compliant the plan must include:

(i) A statement on the registered services to which the plan applies;
(ii) Details of the infrastructure for providing the services;
(iii) Identification of the hazards and hazardous events we consider may affect the quality of water to which the services relate;
(iv) An assessment of the risks posed by the hazards and hazardous events;
(v) A demonstration of how we intend to manage the risks posed by the hazards and hazardous events; and,
(vi) Details of the operational and verification monitoring programs under the plan, including the parameters to be used for indicating compliance with the plan and the water quality criteria for drinking water.

The plan was written in accordance with the Australian Drinking Water Guidelines (ADWG) which covers the above items.

2.3 Drinking Water Service Provider

Richmond Shire Council is the service provider that supply's, treats and is in charge of the reticulation of potable water supply to the community of Richmond.

Provider: Richmond Shire Council
SPID: 111
Address: 50 Goldring Street
Richmond
QLD 4822

Telephone: (07) 4741 3277

2.4 Background

The Shire of Richmond comprises approximately 26,665 square kilometres in the heart of Queensland, representing 1.5% of the total area of the State. It is predominantly grazing country and has recently gained prestige for its dinosaur fossil discoveries, due to being situated at the geographical centre of an ancient Cretaceous inland sea 120 million years ago. The town of Richmond has a thriving tourism industry that sees 100+ visitors staying overnight during the tourist season between April and September. Richmond has an average daily temperature range of 17.3°C to 32.6°C and on average receives 482mm of rainfall annually.

The urban centre of the Shire is the town of Richmond, which has a population of approximately 520, with approximately 648 in the entire Shire (*2016 Census*). The town of Richmond is located approximately 500km west of Townsville, on the Flinders Highway halfway between Townsville and Mount Isa. The town itself is a vital hub for the area and is easily accessible by air, train, bus and car. An outback oasis, the town features grassy parks and a large recreational lake dedicated to water sports and outdoor activities, while the surrounding region has all the beauty and dramatic landscapes of the outback. Regular community events, rodeos and races provide year-round entertainment. The principal industries in the Shire are grazing and tourism.

As a small, remote community Richmond Shire Council (RSC) faces the challenge of balancing community expectations with the capacity to resource these needs. There is limited trade and technical expertise locally. The only qualified plumbers in the Shire are Council employees, and each has taken on the responsibility of mentoring an apprentice to establish capacity for succession. The mines to the west offer much higher wages than Council can provide and therefore place great pressure on Council's capacity to retain key staff.

2.5 Further information

Water supply scheme management and operational responsibilities are detailed in Table 1.

- Table 1 Listing of drinking water supplies

Scheme Name	Operator	Communities Served	Current			Projected in 10 years		
			Population served	Connections	Demand kL/d	Population served	Connections	Demand kL/d
Richmond Water Supply Scheme	Richmond Shire Council	Richmond	520 residents plus 100+ tourists	406	2,072	623	400	2,283

3 INFRASTRUCTURE DESCRIPTIONS

3.1 Richmond Water Supply Scheme Overview

The source of water for the Richmond water supply scheme is the Great Artesian Basin. The water supply scheme commenced in 1900 when Bore No.1 (decommissioned in 1984) was sunk to a depth of 359 metres. Further bores were added to the water supply scheme Bore No.2 (1959), Bore No.3 (1969), and Bore No.4 (2017). Boreholes No.2, No.3 and No.4 have now been decommissioned and were capped in 2006 (Bores 2 & 3) and 2016 (Bore 4).

Two bores remain that supply the Richmond Township, (Bore 5 and Bore 6). Water from these two bores is treated to achieve compliance with drinking water guidelines by a water treatment plant using pre-oxidation, flocculation/coagulation, dual media filtration and disinfection.

A third Bore (Bore No. 7) was commissioned in 2016 and provides a non-potable supply to the cattle yards and truck wash bay, road works water tankers and three rural properties on the outskirts of the township.

3.2 Richmond Water Supply Infrastructure Summary

Table 3.2 summarises the key components in the Richmond Water Supply Scheme. Figure 3.1 shows a schematic of the schemes key components including primary monitoring and control points.

Table 3.2 Richmond Water Supply Infrastructure Summary

Component		Description
Water Sources	**Bore 5**	Source 1
	Location	Within WTP compound
	Type	Bore – Great Artesian Basin
	Volume/Capacity	19L/sec – (1.5ML/d)
	Age/Date of construction	Constructed 1990's
	Reliability	Excellent
	Catchment	Great Artesian Basin – Original source water undefined.
	Water quality issues	Good quality water with no pathogens detected due to elevated temperatures. Low turbidity on extraction (0.2-0.3NTU) however subject to staining from Iron and Manganese creating an aesthetic issue.
	Bore 6	Source 2
	Location	Adjacent to recreational lake – Approximately 1.2km from WTP.
	Type	Bore – Great Artesian Basin
	Volume	19.5L/sec (1.5ML/day)
	Age/Date of construction	Constructed 2000's
	Reliability	Excellent
	Catchment	Great Artesian Basin – Source water catchment undefined.
	Water quality issues	Good quality water with no pathogens detected due to elevated temperatures. Low turbidity on extraction (0.2-0.3NTU) however subject to staining from Iron and Manganese creating an aesthetic issue. Presence of sulphides causes odour issue if not aerated prior to distribution.

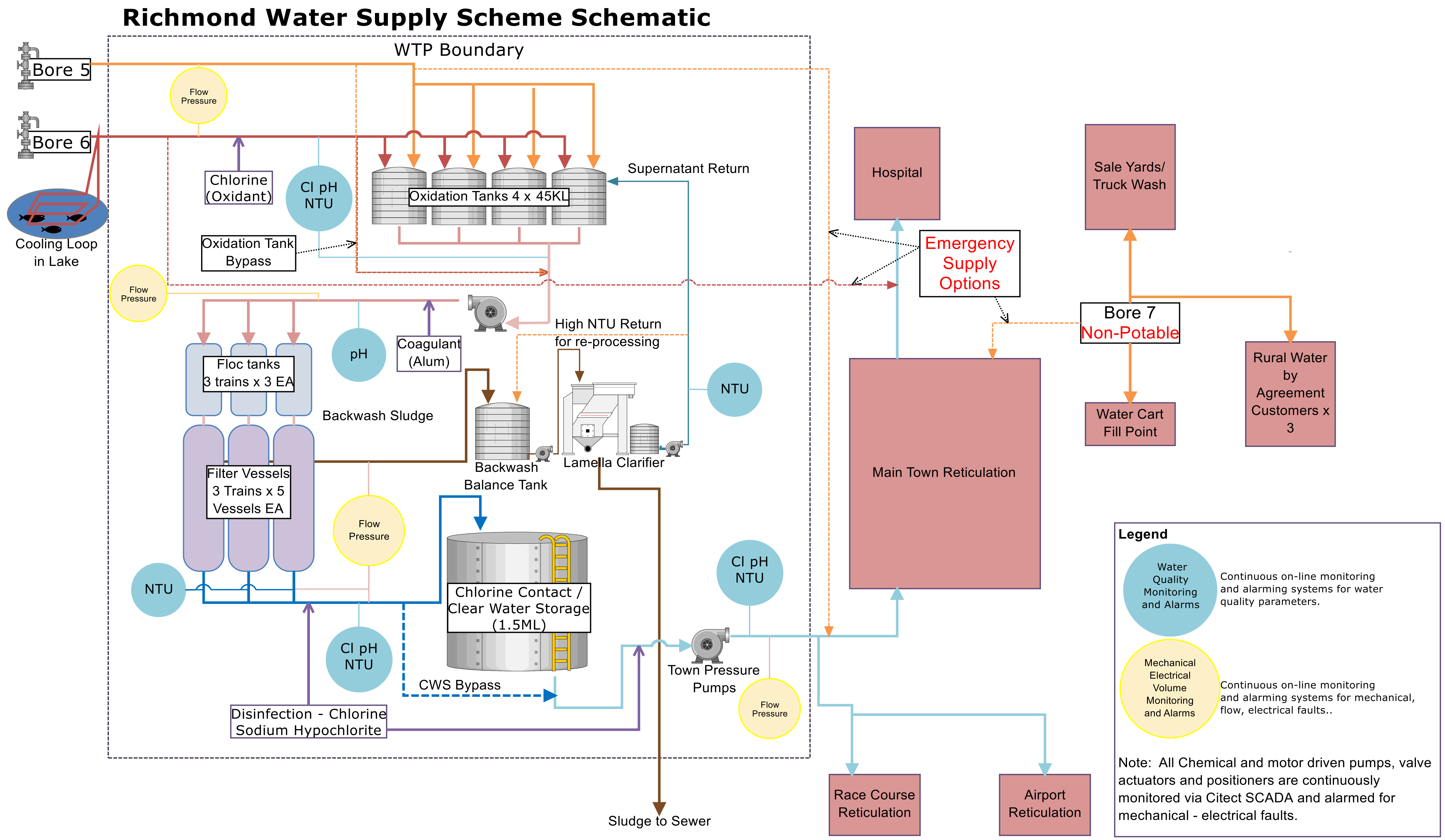
Component		Description
Sourcing Infrastructure 	Variable speed Pump Sets	Both Bores are fitted with a four pump VSD controlled pumps set.
	Raw water supply mains	Bore 5 feeds the plant via a 150mm Poly Ethylene pipe approximately 20m length constructed 2014. Bore 6 is delivered to the WTP via a 1.2km 150mm PVC pipeline constructed in 2014.
Are there any sources that **do not** undergo treatment prior to supply?	No. Both bores are treated via the WTP. Each bore has a bypass valve to enable direct supply to town in the event of an emergency.	
Treatment Plant	**Richmond Water Treatment Plant**	
	Location	Corner Goldring and Hillier St, Richmond QLD.
	Process	Process comprises Oxidation, Coagulation/Flocculation using Aluminium Sulphate, Direct Filtration (dual media, Sand – Granular Activated Carbon). Disinfection by Sodium Hypochlorite.
	Age – Date of construction	Commissioned 2015
	Materials – Type	Fibre reinforced pressure flocculation & filtration vessels, PE pipework – Enclosed in colourbond shed.
	Design capacity (22 hour operation)	6.5ML/day
	Daily flow range	2 - 3 ML/d (22hr day)
	Chemicals added	Flocculant - Aluminium Sulphate, Disinfectant – Sodium Hypochlorite
	Standby chemical dosing facilities (Y/N)	Coagulant and pH correction systems have 'duty-standby' pump systems.
	Water sourced from and percentage	Bore 5 45%
		Bore 6 55%
	Percentage of average day demand provided	100%
	Percentage of scheme supply distribution area supplied	100%
	Alarms	Raw and filtered water turbidity, treated water pH, chlorine residual. Mechanical faults (all pumps, compressors, control valves), Water Treatment Plant, treated water storage and backwash tank levels.
	Bypasses/variations	Able to bypass whole or part of plant in the event of a major failure.
Are there any sources that **do not** undergo disinfection prior to supply?	All supplies are disinfected prior to entering the reticulation network.	
Disinfection	Location	WTP site
	Type	Sodium Hypochlorite
	Dose rate	0-5mg/L
	Target residual levels	0.8-1 mg/L Free Cl leaving Treated Water Storage
	Duty/standby	Duty standby dosing pumps with auto changeover
	Dosing arrangements	Flow paced dosing linked to totalised instantaneous flow from 1, 2 or three filter trains. Injected after the three filter train outlets are combined. Residual

Component				Description
				analyser in place for monitoring and alarming only – option to use residual trim control loop exists.
	Alarms			Pump failure, low low – low / high - high high chlorine residual
	Auto shut-off arrangements			WTP shut down on chlorine dosing system failure
	Chlorine Contact Time			Suitable chlorine contact is achieved in the treated water storage which has between 12 and 24 hrs detention subject to demand
Distribution and reticulation system	Pumping Stations	VSD	Auto Control	Control Functionality
	Main Town Pressure Pumps	YES	YES	Controlled to maintain constant pressure regardless of demand or instantaneous flow rate
	Pipe material	**Age Range**	**Size**	**Approximate Percent of Total Length %**
	Asbestos Cement	35-100yrs	100-250mm	15%
	HDPE (Poly)	1-15yrs	50-150mm	10%
	PVC/Other	1-20yrs	100-200mm	5%
	PVC – Blue Brute	1-20yrs	100-250mm	70%
	Areas where potential long detention periods could be expected			Hospital, Racecourse, and Airport
	Areas where low water pressure (example < 12 m) could be expected during peak or other demand periods)			Airport - 2 x 15KL storage tanks and booster pump set for firefighting purposes only installed.
Reservoir -Treated Water Storage	**Main Reservoir**			
	Name			Treated Water Storage
	Capacity (ML)			1.5 ML
	Type			Above ground HDPE lined steel tank/colorbond roof
	Age (date constructed)			2014
	Roofed (Y/N)			Yes Roofed
	Vermin-proof (Y/N)			Yes
	Runoff directed off roof (Y/N)			Yes
Water quality responsibility changes	Upstream location			None
	Downstream location			None

3.3 Supply system schematic diagram

A basic system schematic (see Figure 3.1) shows the general arrangement of the Richmond water supply scheme. The schematic includes all process steps, emergency alternative supply/bypass options, and key on line water quality and critical system monitoring and alarming points.

Figure 3.1: Richmond Water Supply Scheme Raw Water and Pre-treatment Schematic



4 SOURCE, TREATMENT AND DISTRIBUTION DETAILS

The water supply system utilises the following infrastructure and key processes:

- Raw water extraction from the Great Artesian Basin via two bores – (Bore 5, and Bore 6)
- Chemical (Chlorine) and Mechanical Oxidation (aeration)
- Flocculation – Coagulation
- Filtration
- Disinfection

Richmond has an average daily temperature range of 16.7°C to 32.8°C and on average receives 478mm of rainfall annually.

Flooding

Flooding has the potential to cause the greatest threat to the area. Richmond town is located on the edge of the Flinders River Sub Basin. All three bore locations are outside of the floodplain. There has been no recorded flooding issues at the bore locations.

Bushfires

Bushfires can occur in the area but the Richmond Shire Local Disaster Management Plan evaluates there being a low risk of property damage due to bushfire. All water supply assets (except bore head works) are located within flame retardant structures and maintain good separation zone between bushland.

Earthquakes

Damaging earthquakes are relatively rare in Australia and there have been no reported instances of earthquakes at Richmond.

4.1 Raw Water and Great Artesian Basin Water Quality Characteristics

100% of Richmond's water supply is drawn from the Great Artesian Basin (GAB) and as such the catchment characteristics are not as well understood as with a surface water catchment. The GAB is one of the world's largest groundwater resources with a coverage that extends across up to 25% of Australia from the far north Cape York, extending south and west of the Great Dividing Range into New South Wales, South Australia and the Northern Territory (Figure 4.1).

Figure 4.1: Great Artesian Basin

There are conflicting ideas regarding how the basin is replenished and the water volume maintained, the most accepted being that most of the water entering the Basin filters down from riverbeds on the western slopes of the Great Dividing Range. Other theories include migration of water from islands further north, or that the basin is a non-renewable, closed system with no means of external replenishment from surface waters.

Water from the GAB can range in temperature from 30°C to 100 °C and often contains elevated levels of Iron, Manganese and other dissolvable metal ions. Water from the GAB is sourced via bores, historically bores often ran freely releasing the hot thermal water however over time natural flows have diminished. This is led to Government capping several wells and placing limits on extraction to preserve the resource.

Most of the GAB's water is of a quality suitable for most uses, including drinking water. As the water moves from the north in Queensland towards the south, minerals are absorbed by the water influencing the quality. Water in the southern zone contains higher levels of salt absorbed over time as it moves slowly south at a rate estimated at 1 to 5 metres a year. GAB water can be millions of years old since rain fell on the land surface.

The bores supplying the township of Richmond draw water from depths between 336 and 405m and provide water suitable for potable use. Key water quality characteristics of Bore 5 and Bore 6 can be seen in section *6.2 Water Quality Data analysis and Interpretation*.

4.2 Raw water extraction and delivery

Pump Stations - Bores 5 & 6 both have independent variable speed pumps supplying the raw water oxidation/balance tanks at the WTP. Details of the two bores supplying the township can be seen in Table 4.1 below:

Table 4.1: Bore depth and casing details for Bore 5 and 6 supplying the township of Richmond.

Bore 5				
Material description	**Mat Size (mm)**	**Outside Diameter**	**Top (m)**	**Bottom (m)**
Steel Casing (unspecified)	9.5	305	0.00	84.00
Fibreglass reinforced plastic	10.00	220	0.00	85.00
Fibreglass reinforced plastic	10.00	10.00	85.00	360.00
Grout		305	0.00	84.00
Grout		220	0.00	85.00
Grout		175	0.00	240.00
Perforated Slotted Casing			270.00	360.00
Bore 6				
Material description	**Mat Size (mm)**	**Outside Diameter**	**Top (m)**	**Bottom (m)**
Steel Casing (unspecified)	6.4	510	0..00	6.25
Steel Casing (unspecified)	6.4	355	0.00	85.00
Fibreglass reinforced plastic	10.00	250	0.00	74.00
Fibreglass reinforced plastic	11.00	200	74.00	218.00
Fibreglass reinforced plastic	14.00	200	218.00	386.00
Perforated slotted casing		200	386.00	438.00
Open Hole		311	438.00	456.00
Grout	45.00	600	0.00	6.25
Grout	45.00	445	0.00	85.00
Grout			0.00	358.00

4.3 Water Treatment Plant Process Description

Below summarises the purpose and processes involved in the water treatment plant for the Richmond water supply scheme. A summary table detailing the specifications/capacities of components involved in the process is provided in Appendix A. This is also available to operations staff in the WTP Operations & Maintenance (O&M) Manual.

Oxidation

A combination of both mechanical and chemical oxidation is utilised in the initial treatment stage of the RSC water treatment plant. Raw water from Bore 6 is dosed with chlorine in the form of Sodium Hypochlorite (chemical oxidation) then mixed with Bore 5 through jet aeration nozzles (mechanical oxidation) into the oxidation tanks. The oxidation tanks have a holding time of between 45 and 90 minutes depending on the flow through the plant at any given time.

Coagulation - Liquid Aluminium Sulphate, $Al_2(SO_4)_3$ is utilised as the coagulant. This positively charged metal attracts negatively charged particles in the water such as silts, clays, organics and oxidised metals.

Flocculation - This process takes place in the three flocculation vessels at the start of each filtration train.

Filtration - Each filter train consists of five pressure filtration vessels. These vessels contain a dual media configuration with four different media graduations throughout each vessel. Course gravel media forms the bottom layers around the filtrate outlet drains, fine sand of 0.4-0.6mm diameter and Granular Activated Carbon (GAC) comprises the upper two layers. The graduated sizing of the GAC and sand enables appropriately sized floc to penetrate the depth of the bed, maximising filter run times.

Disinfection - Filtered water is disinfected with liquid Sodium Hypochlorite (NaClO) to kill chlorine sensitive pathogens present in the water supply which have carried over through the treatment process. Disinfection levels are maintained to provide adequate residual chlorine to protect the water against pathogen or bacterial regrowth in the reticulation system.

Clear Water Storage Tank - Treated and disinfected water is stored in a 1.5ML HDPE lined steel tank prior to supply to town. The tank gives the system capacity to buffer high demand periods or times of plant shut down for maintenance or breakdowns.

Sludge Management - Water utilised in backwashes is deposited into the backwash collection tank. From here water is treated through the Lamella Plate Separator with sludge being separated out of the water column. Acceptable supernatant passes into the supernatant collection tank before being recycled back into the Raw Water Tanks. Sludge generated in the Lamella Plate Separator is disposed of in the town sewer system.

4.4 System Capacity and Loading Summary

Table 4.2 below summarises the capacity of key elements of the water supply system for Richmond. The WTP has ample capacity to satisfy current needs and expand into the future. The limiting factor in deliverable volume is the two bores supplying the plant which limits maximum daily production to approximately 3.04ML/day (vs. WTP capacity of 6.5ML/day).

The plant has capacity to satisfy average daily demand utilising only one of the three filtration trains, providing redundancy for breakdown and routine maintenance. Current mode of operation utilises two filter trains at a time and sequentially rests a train for 24 hours after each backwash ensuring all trains are utilised.

The raw and treated water pumps sets are sized to match maximum filtration capacity of 80L/sec.

All chemical dosing systems are duty standby with redundancy to maintain operation in the event of a failure. One spare dosing pump is kept on site, and a minimum of two (2) dosing pumps service kits are also held to enable simple repairs to be undertaken in house. All dosing pumps in the system including raw water oxidation pumps, coagulant pumps and post filtration disinfection pumps are the same brand and size, and as such are interchangeable.

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Monitoring equipment such as pH and chlorine analysers all have a spare probe held on site in the event of a probe failure.

Table 4.2: Flow capacities and loadings of the Richmond Water Supply System

Process Supply Point	Maximum Capacity (L/sec)	Maximum Capacity ML/day (22hr run time)	Loading vs Capacity
Bore 5	19.5	1.5	100%
Bore 6	19	1.5	100%
Raw Water Pump Set	80	6.3	47%
Treated Water Pump Set	80	6.3	47%
Filtration Trains (Combined)	82.5	6.5	46%

4.5 Disinfection Process Summary

The Richmond water supply is disinfected with Sodium Hypochlorite. The system has two opportunities to provide a disinfection barrier to pathogens entering the reticulation;

- Primary disinfection via oxidation with Sodium Hypochlorite
- Secondary disinfection after filtration with Sodium Hypochlorite

Both systems are flow-paced and have a proportional residual trim functionality that adjusts the dose to achieve an operator adjustable set-point. Dosing pumps and chlorine residual after dosing and storage in the treated water storage are monitored, trended and alarmed via SCADA. Adjustment of the target residual is achieved through routine monitoring of the reticulation to ensure a minimum residual of 0.2mg/L free chlorine is maintained at the extremities of the reticulation.

Target residuals are summarised in Table 4.3 below along with the alarm and responses The Operational Limits provided identify where subject to flow and town demand, usually provides a suitable free chlorine residual for the reticulation.

Table 4.3: Target chlorine system residual levels and alarms summary

Alarm	Operation Limit (Free Chlorine)	Alarm Range (Free Chlorine)	Response	Plant Shut Down
Dosed Chlorine Residual Low - High	0.8-1mg/L	0.8 – 1.2 mg/L	SMS to operator	NO
Dosed Chlorine residual Low-Low – High-High		0.4 – 1.4mg/L	SMS to Operator	YES
Water to town Chlorine Low-High		0.3 – 1.0mg/L	SMS to Operator	NO
Water to town Chlorine Low-Low – High-High	0.5-6mg/L	0.2 – 1.2 mg/L	SMS to Operator	YES
Dosing pump failure		NA	SMS to Operator	NO
Standby pump failure		NA	SMS to Operator	NO
Raw water oxidation control Low - High		0.8 – 1.2mg/L	SMS to operator	NO
Raw water oxidation Low-Low – High-High		0.5 – 1.5mg/L	SMS to Operator	YES
Raw water oxidation pump failures		NA	SMS to Operator	NO (captured via low-low residual)

4.6 Distribution and Reticulation System

The Richmond distribution system starts with a 1.5ML above ground steel tank. The tank was constructed in 2014, commissioned in 2015 to the current Australian Standards including complete roof where runoff is directed off the roof, stairway and access hatch and vermin protection including pre-treatment of the soil sub surface for prevention of termites. The storage levels and water quality (pH, Chlorine and turbidity) are monitored via the WTP PLC. These systems govern plant operation (start-stop), alarming and operator notification and shutdowns.

The reticulation consists of approximately 42.5km of pipe. Significant proportions of the reticulation have been replaced over the past years with Blue Brute PVC pipe. Richmond Shire Council is engaged in a continual mains renewal program, focused on replacement of pipework sections based on a risk/failure review. Areas prone to the highest number of failures are prioritised on the renewals program. A summary of pipe types, approximate age and percentage of existing reticulation is provided in Table 4.4 below.

Table 4.4: Richmond water main summary

Pipe material	Age	Approximate Percentage
Asbestos Cement	40+ yrs	15%
Blue Brute PVC	<10 yrs	70%
Poly/HDPE	<10 yrs	5%
PVC/Other	10 – 40 yrs	10%

Due to the nature of soil movement within the area, the ageing asbestos cement (AC) pipework often break causing leakages in the networks. Older AC pipes are being replaced by PVC in both reactive and planned upgrades of reticulation networks. Since March 2014, council has completed the replacement of 2.3km of asbestos cement pipework with 150mm PVC-O pipework at three locations in Richmond reticulation network:

- Harris and Middleton Street (590m)
- Goldring Street (860m)
- Simpson and Middleton Street (920m)
- 3km 100mm Poly replaced with Blue Brute PVC

- Goldring Street Sth end (800m)

Managing Stagnation

The majority of the reticulation is designed to minimise stagnation of water in dead end pipes. The township has a high per capita water use and much of this is used by council and residents for irrigation of parks, ovals, lawns and gardens. The high use generates consistent turnover of water in the reticulation which is maintained almost 24 hours per day via the controlled irrigation of many council parks and gardens on automatic timers during the night.

Three users are located at extremities of the township on 'dead end' mains. The Richmond Racetrack (West), Airport (North) and Richmond Hospital (East) are all located at the end of supply lines.

The hospital is a high-volume water user, due to in house 'hospital' use and irrigation of the grounds, stagnation is unlikely. The hospital entry point is a reticulation verification monitoring site for water quality and is the primary gauge for adjustment of chlorine dosing set points at the WTP to ensure the extremities of the township are adequately disinfected.

The Racecourse is not used regularly however irrigation of the grounds maintains regular movement of water. There are a number of houses on the road towards the Racecourse with approximately 2km of 100mm poly pipe from the last residence to the track.

The airport has one residence in the vicinity and is in use a minimum of three days per week. Irrigation of grounds is the primary means of maintaining a fresh water supply. The airport is supplied by a 50mm pipe made of poly and PVC of approximately 4km in length. Due to the length of the pipe, pressure is not sufficient to meet regulations for firefighting. RSC has a dedicated storage with booster pumps at the Airport to supply water in the event of a fire.

Figure 4.2 below shows the general layout of the Richmond water reticulation network.

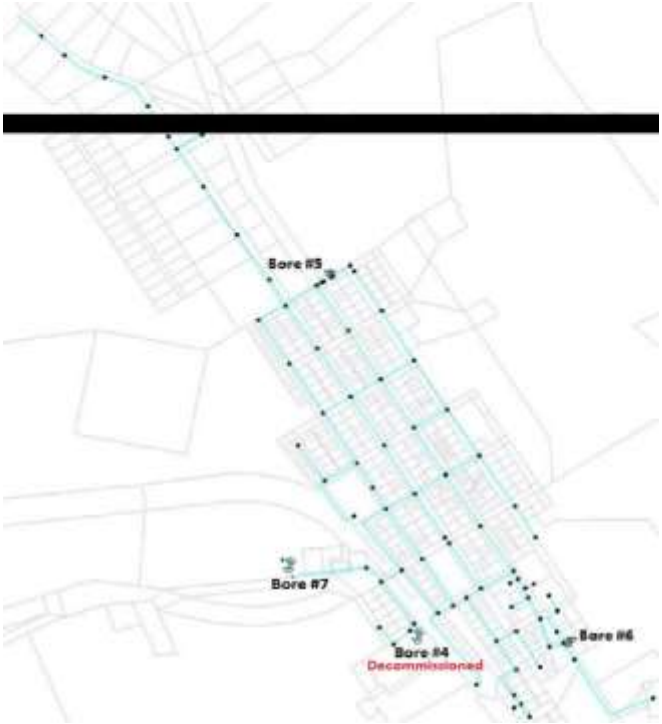

Figure 4.2: – Richmond Reticulation Network

5 Key Stakeholders

Stakeholders involved in the management, operation and regulation of the Richmond Water Supply Scheme are shown in Table 5.1.

Table 5.1 Richmond Water Supply Stakeholders

Organisation	Relevance to management of drinking water quality	How the stakeholders are engaged in the DWQMP
Richmond Shire Council	Consumers or customers	Informed of water quality issues
	Overall management, budget and finances	Kept up to date and informed of water operations
	Consumer end plumbing	Communication of leaks and other issues directly with Council Plumbers and/or Water and Sewage treatment plant operator - Supervisor
DNRME – Dept Natural Resources Mining & Energy	Regulator	Consulted during development of DWQMP, water quality incidents and routine monitoring reported to QWSR
QLD Public Health Unit Townsville 07 44336900	Regulation and Health Advice	Notifications for incidents and reporting for out of spec sample results that Public Health Regulation Schedule 3A Standard for Quality of Drinking Water
Richmond Hospital – (07) 4741 6100 Gallagher Drive Richmond QLD 4822	Key stakeholder in the drinking water supply	Direct communication about supply arrangements between Hospital and Water and Sewage treatment plant operations – Supervisor. Hospital conducts water quality monitoring.

6 HAZARD IDENTIFICATION & INFORMATION GATHERING

6.1 Water Quality Information

The Richmond Shire Council undertakes weekly monitoring of the treated water quality and reticulation system to ensure ongoing compliance with ADWG. Water analysis at the bores and throughout the reticulation network is conducted periodically but remains consistent where *E. coli* has never been detected at the bore heads, treatment plant or within the reticulation system.

The Richmond WTP reduces the average levels of Iron and Manganese to <0.052 mg/L and <0.02 mg/L respectively from Bore 5 and 6 achieving compliance with the aesthetic guideline values prescribed by ADWG to prevent staining and discolouration. The process also provides removal of taste and odour and provides disinfection to manage biological risks.

From available chemical quality data, no other threats to human safety have been identified with heavy metals and other parameters all rarely detected, or detected at levels well below ADWG threshold values. A lack of data from 2015 – 2018 has been addressed through the implementation of a revised external analysis program implemented in October 2018. Data obtained in the 9 months of monitoring indicates the raw water supplies have remained consistent in their quality and are stable over time. The monitoring program will be reviewed after 24 months and scaled back if results continue to indicate little change in reported quality levels.

6.2 Water Quality Data Analysis and Interpretation

The Richmond Water supply is a low risk supply with respect to pathogens where *E.coli* have never been detected in the raw water supplies. The primary purpose of the water treatment plant in Richmond is to control problematic staining caused by oxidation of Iron and Manganese from the Raw Water supplies, and to provide appropriate disinfection to manage biological risks.

Key parameters monitored by staff include raw and treated water turbidity, Chlorine (Free), Iron, Manganese and pathogens *E.coli* and Coliforms. A summary of historic data obtained in routine monitoring and internal verification of the treatment process is provided in Appendix B.

Bacterial analysis presented in Table 6.1 shows that the raw water quality from the Richmond bores is acceptable for human consumption and meets ADWG limits for *E.coli*. The results when assessed against the Tables 5.7.1, 5.7.2 and 5.7.3 of the *ADWG Draft Microbial health-based targets for drinking water supplies – Version 15 – August 2016*, indicate that the raw water supply for Richmond would be classified as a fully protected groundwater supply requiring minimal Log Reduction Values (LRV) targets and no indicative treatment requirements. The raw water sources are therefore well protected and are considered low risk water supplies.

No data is available for cryptosporidium, viruses or other bacteria to verify this classification. Based on the thermal nature of the bores, it could be expected that pathogen contamination is unlikely due to the temperature of the water supply and the estimated age of the water underground providing a lengthy time for thermal destruction of pathogens prior to extraction and use.

Data presented in Tables 6.1, 6.2, 6.3 and 6.4. reflects external verification analysis from the periods 2004 to 2013.

Table 6.1: Richmond External Microbiological Analysis Results Summary (1999-2009)

Units- (CFU/100ml)	**Bore 5 *E.coli***	**Bore 5 Coliforms**	**Bore 6 *E.coli***	**Bore 6 Coliforms**	**Reticulation *E.coli***	**Reticulation Coliforms**
Mean	0	0.42	0	0.06	0	1.53
Median	0	0	0	0	0	0
Mode	0	0	0	0	0	0
Minimum	0	0	0	0	0	0
Maximum	0	6	0	1	0	31
Sample Count	24	24	18	18	38	38
Confidence Level (95.0%)	0	0.61	0	0.12	0	1.82
Number of samples positive	0	2	0	1	0	5
% Samples Positive	0%	8%	0%	4%	0%	13%

Table 6.2: Richmond External Microbiological Analysis Results Summary (1999-2009) (All Samples & Sites).

	E.coli (CFU/100ml)	**Coliforms *(CFU/100ml)***
Mean	0	0.86
Median	0	0
Mode	0	0
Minimum	0	0
Maximum	0	31
Sample Count	80	80
Confidence Level (95.0%)	0	0.87
Number of samples positive	0	8
% Samples positive	0%	10%

Tables 6.3 and 6.4 below show summary statistics for external analysis of the Richmond potable water supply from 2004 to 2013. It can be seen that on no occasion for either bore has a health based target been breached. Non-compliances reported relate only to the aesthetic limit for the presence of Iron and Manganese, while Bore 6 has shown elevated turbidity on two occasions. Turbidity non-compliances are not reflective of the raw water in its state at the source where turbidity recorded from internal tests at the source are generally below 0.25NTU. The oxidation of Iron after sample collection and while in transit, will be contributing to the observed turbidity readings that are above the 5NTU ADWG aesthetic limits.

Table 6.3: Richmond External Microbiological Analysis Results Summary (2018 – 2019)

Units- (CFU/100ml)	**Bore 5 *E.coli***	**Bore 5 Coliforms**	**Bore 6 *E.coli***	**Bore 6 Coliforms**	**Reticulation *E.coli***	**Reticulation Coliforms**
Mean	0	0.88	0	2.44	0	0.17
Median	0	0	0	0	0	0
Mode	0	0	0	0	0	0
Minimum	0	0	0	0	0	0
Maximum	0	8	0	22	0	3
Sample Count	9	9	9	9	9	9
Confidence Level (95.0%)	0	0.61	0	0.12	0	1.82
Number of samples positive	0	8	0	1	0	2
% Samples positive	0%	4%	0%	4%	0%	8%

In addition to the above external monitoring data, RSC operations staff also undertake internal microbiological analysis on one of the two bores, the water treatment plant outlet (reticulation entry point) and on a reticulation site on a weekly basis. Since implementation of the verification monitoring program in 2018, there have been no detections of *E-coli* at any site. Results are summarized in Table 6.4.

Table 6.4: Richmond Internal Microbiological Analysis Results Summary (2018-2019)

Units- (CFU/100ml)	**Bore 5 *E.coli***	**Bore 5 Coliforms**	**Bore 6 *E.coli***	**Bore 6 Coliforms**	**Reticulation *E.coli***	**Reticulation Coliforms**
Mean	0	0.88	0	2.44	0	0.17
Median	0	0	0	0	0	0
Mode	0	0	0	0	0	0
Minimum	0	0	0	0	0	0
Maximum	0	0	0	0	0	3
Sample count	18	18	19	19	37	37
Confidence Level (95.0%)	0	0.61	0	0.12	0	1.82
Number of samples positive	0	8	0	1	0	2
% Samples positive	0%	4%	0%	4%	0%	8%

Chemical Contaminants

Historical analysis (Table 6.5) shows there had been no detection of chemical contaminants above ADWG health guidelines in the untreated water supply (1999-2013). This has been validated as consistent with the analysis undertaken since implementation of the revised monitoring program in 2018 (Table 6.6). Iron and Manganese are two parameters that consistently breach aesthetic guideline limits in raw water contributing to staining and discolouration of the water supply on exposure to air and subsequent oxidation of these metal ions.

Recent monitoring has proven that the chemical quality of the water supply has remained stable since sampling and analysis lapsed during the 2014 to 2017 period. Results of external analysis between 2018 to 2019 and internal analysis 2015-2019 for Iron and Manganese are summarised in Table 6.7 and 6.8.

Table 6.5: External Analysis Results for Richmond Water Supply – Untreated (2004 – 2013)

Richmond Shire Council - Reticulation External Verification Analysis Summary 2004 - 2013								
Parameter	**ADWG Limit**	**Number of Samples**	**Average**	**Min**	**Max**	**% samples below detection limit**	**Detection Limit**	**% Compliance**
Alkalinity	NA	16	184.87	120	240	0	NA	100
Aluminium	0.3	24	0.05*	<0.01	0.08	88.00%	0.05 - 0.01[b]	100
Arsenic	0.007	16	<0.005*	<0.005	<0.005	100.00%	0.005	100
Bicarbonate	NA	16	224	142	289	0.00%	NA	100
Boron	4	16	0.051	0.04	0.07	0.00%	0.02	100
Cadmium	0.002	8	<0.004*	<0.004	<0.004	100.00%	0.004 - 0.0001[b]	100
Calcium	NA	16	13.58	7.6	19	0.00%	NA	100
Carbonate	NA	16	0.76	0.1	1.9	0.00%	NA	100
Chloride	250	16	42	39	44	0.00%	NA	100
Chromium	0.05	8	<0.004*	<0.004	<0.004	100.00%	0.004 - 0.0001 [b]	100
Conductivity	NA	16	502	420	598	0.00%	NA	100
Copper	2[h] 1[a]	24	0.075*	<0.005	0.008	76.00%	0.03 - 0.005[b]	100
Fluoride	1.5	16	0.1	0.1	0.11	0.00%	NA	100
Iron Soluble	0.3[a]	16	0.18*	<0.1	0.68	44.00%	0.01	81.25
Iron Total	0.3[a]	16	NA	NA	NA	NA	NA	NA
Lead	0.01	8	<0.005*	<0.005	<0.005	100.00%	0.005	100
Manganese	0.5 - 0.1	24	0.035*	<0.01	0.06	24.00%	0.01	100
Magnesium	NA	16	8.96	3.4	14	0.00%	NA	100
Nitrate	50	16	<0.5*	<0.5	<0.5	100.00%	0.05	100
Nickel	0.02	16	<0.005*	<0.005	<0.005	100.00%	0.005	100
pH	6.5 - 8.5	16	7.56	7.04	8.07	0.00%	NA	100
Potassium	NA	16	9.46	4.2	14	0.00%	NA	100
Silica	NA	16	22.18	20	24	0.00%	NA	100
Sodium	180	16	77.18	36	118	0.00%	NA	100
Sodium Adsorbtion ratio	NA	16	4.64	1.5	8.5	0.00%	NA	100
Sulphate	500[h] 250[a]	16	12.69	11.6	14.4	0.00%	NA	100
Total Dissolved Ions	NA	16	388.62	295	485	0.00%	NA	100
Total Dissolved Solids	500[a]	16	296.88	256	358	0.00%	NA	100
Total Hardness	200[a]	16	70.93	33	106	0.00%	NA	100
True Colour	15	16	2.25	<1	5	50.00%	1	100
Turbidity	5[a]	16	3.91	<1	30***	31.25%	1	91
Zinc	3[a]	16	0.04	<0.01	0.17	25.00%	0.01	100

Notes:

[h] = health Based Guideline Limit

[a] = Aesthetic Guideline limit

[b] = Detection limit changed during the sample period

* = Average derived from real numbers only - numbers less than detectioin limit excluded from calculation or all samples recorded as below detection limit.

** = At point of collection turbidity generally <1.5ntu. Oxidatioin of iron and manganese in transit to laboratory leads to increased turbidity, possible aeration during sample collection contributing to increased turbidity at time of analysis.

*** = Outlier result vastly different to all other records, suspect due to sampling error - lack of flushing or sample taken in response to dirty ater event. All other samples were less than 3ntu (average without outlier is 1.3ntu). Not considered accurate reflection of water quality.

Aesthetic guideline value breached

Table 6.6: Richmond Verification monitoring results summary 2018-2019

Richmond Reticulated Water Results Summary 2018-2019 Verification Sites					
	Units	**Average**	**Min**	**Max**	**% Compliance with ADWG**
pH	pH	7.514	7.35	7.75	100
Electrical Conductivity	uS/cm	497.7	477	521	100
Colour, True	Pt/Co	<1	<1	<1	100
Colour, Apparent	Pt/Co	15.57	1	59	100
Turbidity	NTU	1.12	0.2	4.7	100
Total Dissolved Solids by EC	mg/L	315.5	308	323	100
Alkalinity	mg/L	154.1	153	155.2	100
Bicarbonate	mg/L	94.05	93.4	94.7	100
Carbonate	mg/L	<5	<5	<5	100
Hydroxide	mg/L	<5	<5	<5	100
Sodium Adsorption Ratio*	Index	2.65	2.5	2.8	100
Aluminium	mg/L	0.152	0.131	0.173	100
Calcium	mg/L	16.35	16	16.7	100
Chromium	mg/L	<0.0003	<0.0003	<0.0003	100
Copper	mg/L	0.0105	0.01	0.011	100
Lead	mg/L	0.001	0.001	0.001	100
Magnesium	mg/L	10.5	10.3	10.7	100
Potassium	mg/L	11.5	11.2	11.8	100
Sodium	mg/L	55.7	52.3	59.1	100
Zinc	mg/L	0.0125	0.005	0.02	100
Chloride	mg/L	44.05	43.7	44.4	100
Sulfate	mg/L	16.55	16.4	16.7	100
Fluoride	mg/L	0.14	0.13	0.15	100
Bromide	ug/L	111	103	119	100
Ammonia as N	mg/L	<0.02	<0.02	<0.02	100
Oxidised Nitrogen as NOx-N	mg/L	0.03	0.02	0.04	100
Phosphate as P	mg/L	<0.01	<0.01	<0.01	100
Silica as SiO2	mg/L	24.55	24.3	24.8	100
Total Hardness	mg/L	84	82.4	85.6	100

Table 6.7 Richmond External Iron and Manganese Analysis Summary (2018 – 2019)

	Bore 5 Iron	**Bore 6 Iron**	**Reticulation Iron**	**Bore 5 Manganese**	**Bore 6 Manganese**	**Reticulation Manganese**
AVERAGE	0.42	1.03	0.16	0.03	0.05	0.03
MAX	0.86	1.30	0.71	0.05	0.07	0.12
MIN	0.28	0.05	0.04	0.02	0.01	0.00

Table 6.8: Richmond Internal Iron and Manganese Analysis Summary (2015 – 2019)

	Raw Water Iron (mg/L)	Reticulation Iron (mg/L)	Raw Water Manganese (mg/L)	Reticulation Manganese (mg/L)
Average	0.918	0.051	0.046	0.019
Max	1.870	0.120	0.076	0.041
Min	0.650	0.000	0.024	0.001
Count	24	24	24	24
Confidence Level (95.0%)	0.102	0.014	0.004	0.005

The results obtained since the monitoring program was implemented (October 2018 – Aug 2019) demonstrate that the raw water sources have remained stable with no observable change in quality. A summary of historical data (2003-2014) including average, minimum and maximum values reported is shown in Table 6.7. Prior to treatment the only parameters that breached ADWG limits were Turbidity and Soluble Iron (19% failure rate), no data was available for Total Iron. The turbidity compliance was 91%, these non-compliances are likely due to the oxidation of the sample after collection and prior to analysis. On collection, raw water turbidity is reported generally at <0.3NTU.

Summary analysis and interpretation of historic data is available in Appendix B.

Disinfection Byproducts

Due to the use of chlorine as a disinfection and an oxidant for Iron and Manganese removal, the monitoring program implemented in 2018 includes periodic quarterly monitoring for disinfection byproducts, Trihalomethanes (THM's), Chlorate and Chlorite.

Of five verification samples analysed (October 2018 to Aug 2019), three returned undetectable levels of THM's (<5ug/L), two samples detected THM's at 84ug/L and 5ug/L which is well below ADWG health compliance limits of 250ug/L.

Chlorite was not detected in any samples collected during the period of sampling available, while Chlorate (no ADWG Health or aesthetic limit prescribed) was detected in all samples at levels ranging from 325ug/L to 836ug/L. WHO Chlorate guideline limit is 0.7mg/L while QLD Health adopts a chlorate compliance limit of 0.8mg/L indicating that one sample has returned a non compliant result at 0.83mg/L.

The Chlorate guideline limit is currently under review by ADWG however the WHO summary of the chlorate guideline value states that "*difficulties in meeting chlorate and chlorite guideline values must never be a reason for compromising adequate disinfection"*. The results indicate that the chlorine dosing systems and sodium hypochlorite management practices are being well managed.

Operational Data Gathering

The water supply system is monitored constantly via Citect/SCADA for both quality and mechanical performance with data available via pre-set trends for each process point or operator created trends. Data is constantly logged and recorded so root cause of failures or issues with process performance can be assessed and addressed. A summary of key on-line monitoring and notifications is provided in Table 6.8 below, these are detailed in the WTP Operations and Maintenance Manual.

Table 6.8 Critical monitoring and alarming points in the Richmond Water Supply

Monitoring Type	Process Area	Data	Location	Alarms	Process Shut Down	Trended
Water Quality	Raw Water supply – Oxidant dosing	Cl (Free), pH, Turbidity, Temp	Bore 6 dosed water	Y	N	Y
Water Quality	Pre-treatment - Oxidation	Cl (Free), pH Turbidity, Temp	Post oxidation tanks	Y	N	Y
Water Quality	Coagulation	pH	Post coagulant dose	Y	Y	Y
Water Quality	Filtration	Turbidity	Outlet of each filtration train	Y	Y	Y
Water Quality	Disinfection	Cl (Free), pH, Turbidity, Temp	Post filtered water chlorine dose point	Y	Y	Y
Water Quality	Disinfection – Storage - Distribution	Cl (Free), pH Turbidity, Temp	WTP treated Reservoir outlet	Y	N	Y
Water Quality	Supernatant	Turbidity	Supernatant storage tank	Y	N	Y
Mechanical	Bores	Pressure	Suction and outlet of bore pump sets	N	N	N
Mechanical	Pressure pumps/ WTP and Town	Pressure, pump status, pump speed	Pump sets	Y	Y	N
Mechanical	Pumps Chemical Dosing	Fault	Each dosing skid	Y	Y	N
Mechanical	Filtration	Pressure, Valve position, Valve fault	Each filtration train, every valve.	Y	N	
Mechanical	Valving	Control valve position	All control valves	Y	N	Y
Process	Level	All chemical and water storage tanks/vessels	High, High High, Low, Low Low	Y	Y	Y
Process	Flow	Bore 6, Bore 5, WTP inlet, Each filtration train, Water to town	High Flow, High High, Low Flow, Low Low, No Flow.	Y	Y	Y
Process	Air Pressure	Duty and standby Air compressors	Low pressure – high pressure	Y	N	Y
Power Supply	Volts, Amps,	Power failure or inconsistent/insufficient power supply.	Power failure	Y	Y	Y

Further to on-line monitoring, Richmond Shire Council staff monitor key process control points within the WTP and record data on the plant record sheet (Appendix C). Operators verify the accuracy of on-line instruments, identify the need to perform calibrations, maintenance and/or probe replacements when observed values deviate beyond a reasonable tolerance from laboratory results. They also monitor other parameters of interest such as Iron and Manganese to ensure the oxidation and filtration process is performing at its optimum.

Alert limits and suggested actions for operations staff are detailed in Operational Control Point Tables detailed in the Section 10.1 Operational Monitoring Program and Appendix D.

6.3 Local Community/Industry

Richmond is a quiet rural town with no reported incidents of vandalism to Richmond Shire Council assets.

Richmond Shire is predominantly grazing country and has gained prestige for its dinosaur fossil discoveries, due to it being situated at the geographical centre of an ancient Cretaceous inland sea 120 million years ago. The town of Richmond has a thriving tourism industry that sees 100+ visitors staying overnight during the tourist season between April and September.

There are no mining activities being carried out that are located in the Richmond Shire that would affect the water quality.

6.4 Customer Service

There are approximately 370 water supply connections in Richmond each having 24 hour water supply available. All services within the Shire have meters installed. Council is yet to determine a process in which to charge residents on their personal water consumption.

Council has developed and maintains a 'Complaints Process' and also has Customer Service Standards for Water Supply & Sewerage Services. Council aims to provide a level of customer service that does not attract complaints.

6.5 Demand Management

Water demand in the township is high, as this reflects the current value placed on achieving a high quality of lifestyle for residents and visitors through the overall aesthetics of the town. While Richmond Shire Council has a reliable source through the Great Artesian Basin, the Council is conscious of the need to balance the need for water in an arid climate with responsible and efficient use of water.

Council is planning to develop a suitable pricing structure for metering the water scheme to reflect the desired vision for the town and achieve government's objective of reducing overall water consumption.

7 OPERATIONS AND MAINTENANCE

Richmond Shire Council has developed and maintains a *Strategic Asset Management Plan for Water and Sewage Services* which fully details the operation and maintenance (O&M) processes/procedures of both the water and sewage system. The water treatment plant also has a dedicated Operations and Maintenance Manual. This manual includes detail as to the theory of operation, routine maintenance and monitoring requirements as well as drawings and manufacturers manuals for all mechanical or technical process equipment on the site.

The following sections assess the impacts of the O&M on the water quality.

7.1 Qualified Operators / Maintenance Staff

As a small, remote community Richmond Shire Council faces the challenge of balancing community expectations with the capacity to resource these needs. There is limited trade and technical expertise locally and for the first time in many years the Shire now has a resident electrical contractor. The only qualified plumbers in the Shire are Council employees, and each has taken on the responsibility of mentoring an apprentice in an effort to establish some capacity for succession planning. The mines to the west offer much higher wages than Council can provide and therefore place great pressure on Council's capacity to retain key staff.

In managing water quality related risks, Richmond Shire Council maintains relationships with reputable process experts who can provide remote troubleshooting support for the water treatment plant via logging in to the Process Logic Controller (PLC) remotely. Assisting RSC operations personnel with identifying cause for failures and the development of corrective actions. As a remote community, this has proven valuable in assisting with the prompt rectification of any issues that arise.

7.2 Water Treatment Plant

Council completed the construction of a new water treatment plant (WTP) for Richmond in 2015, which ensured the reduction of Iron and Manganese levels to <0.05 mg/L and <0.01 mg/L, respectively from Bore No 5 and 6. These are the primary contaminants of concern due to aesthetic reasons associated with staining. In addition to the removal of Iron and Manganese, the treatment process also provides aeration and removal of the Hydrogen Sulphide odour that is predominant in Bore 6.

Supervisory Control and Data Acquisition (SCADA) is the logic behind the plant's operation. SCADA provides system overview, a menu for parameter changes, trending of the system and water quality parameters via a PC interface utilising Citect software.

Treatment Plant Modes of Operation:
The treatment plant will operate in two primary modes depending on the circumstance. The following summarises the function of the plant in a simplistic manner.

Filtration mode
Regular filtration mode provides treated water for the town reticulation system. In this mode, two filtration trains will be in an operational state at any given time with one train in a 'rest' or standby mode. Nominal flow rates in standard filtration mode are operator adjustable, which is generally set at 15L/second per train supplying a total of 30L/second total flow. In this mode raw water is fed into the oxidation tanks via jet nozzles, Bore 6 is dosed with chlorine to enable chemical oxidation to aid the aeration stage.

Bores 5 and 6 have operator adjustable start and stop points. In order to achieve optimal mechanical aeration (oxidation) the bore flows are set at their maximum of 19L/sec. To minimise pump starts and stops at the bores, Bore 5 stop set-point is set slightly lower than Bore 6. This ensures that Bore 6 runs consistently and the chlorine dose is maintained steady to facilitate oxidation. Since the total maximum flow of the plant is higher than that of the plants standard total flow of 30L/sec, Bore 5 starts and stops to trim the level in the raw water oxidation tanks to provide the maximum possible oxidation time.

In periods of high town demand the plant total flow rate can be increased to a maximum of 38L/sec to match the bores (eg. 19L/second per train). This is achieved by adjusting the "maximum flow set-point" on each train via the SCADA computer.

During standard filtration mode following oxidation, the water is dosed with Hydrated Aluminium Sulphate as the a coagulant, jar testing is not required regularly due to the stability of the raw water supplies and is undertaken on an as-required basis if and when treated water turbidity falls outside desired alert limit ranges or when there is an observed variation in raw water turbidity indicating a change in raw water quality.

Backwash mode
Backwash sequences are performed in order to clean the media bed of all flocculated particles captured within the filter vessels during filtration mode. Backwash frequency and duration can be manipulated via the PLC although the logic dictates that the filters undergo a back wash after either of the below two situations occur (whichever is first):

- Three days of operation
- When differential pressure indicates a clogging of the filters

In backwash mode, one train is taken offline each day and the flow is reversed through the filters. Sequentially, each filter is backwashed on the water the other four filters in the train are producing. Four cells remain in normal operation mode while one filter cell reverses its inlet and outlet valves to facilitate a backwards flush. Each train must be backwashed every 48 hours of operation.
The Backwash sequence includes an operator adjustable 'rinse' period where each filter is rinsed to waste for 1-3 minutes following the backwash.

Emergency Water Supply Modes

In the event of a major fault disabling an entire pump set, the plant has bypasses available that ensure supply and treatment.

- Bypassing the raw water oxidation tanks and raw water feed pump set,
- Bypassing the treated water storage and town supply pump set.

The above bypasses include manual aspects to ensure they cannot be activated accidently via the PLC SCADA interface. If a major event renders the WTP site totally inactive, the town can be supplied directly from all bores with the removal of blank ends and reinstatement of original supply connections directly from the bore heads.

7.3 Maintenance scheduling

Council has developed and is in the process of implementing a number of routine task lists and check sheets for routine maintenance and inspections of assets. These check sheets provide the routine weekly, monthly, quarterly and annual maintenance tasks that must be scheduled and signed off as completed (Refer to Operational documents list in Appendix I).

In conjunction with this, RSC has also invested in the development of the SWIM Local Task Scheduling capability and has populated a SWIMLocal database with some critical routine tasks for implementation and automatic scheduling, reminders and missed task notification processes. The SWIM platform will also will be field tested and trialed for suitability to the RSC operational environment and resources during 2019-20 (as per the RMIP).

8 IDENTIFY HAZARDS AND HAZARDOUS EVENTS

8.1 Hazard Identification

The responsible officers within Richmond Shire Council for ensuring hazards are identified, risk assessed and managed are detailed below;

- Chief Executive Officer (CEO)
  - Resourcing and executive responsibility for implementation and maintenance of the DWQMP.
- Director of Works (DoW)
  - Responsible for all procedures and objectives as defined in the DWQMP, the hazards are risk assessed, managed and corrective actions are implemented. Any outstanding actions are reviewed and prioritised ensuring the ongoing commitment and improvement of the system.
- Water & Sewerage Officer (W&SO)
  - Management of day to day operation of water supply assets, the implementation of maintenance, monitoring and improvement programs, and supervisor of Council plumbing staff including supervision of capital and maintenance works.
- Plumbers
  - Day to day maintenance operation and documenting of water supply operations in line with council requirements. Assist with operation and maintenance for the collection, treatment and distribution systems.
- Works Administration Officer
  - Document and records management including compliance reporting.

Hazards were initially identified through inspection of water quality data and historical knowledge by the, Director of Works, Administration Officer and Operational staff in conjunction with external contractors. These initial hazards with the associated risks and controls are detailed *APPENDIX F - Risk Assessment Tables*.

8.2 Risk Assessment Methodology

Hazards were identified through a review of the water supply, inspection of water quality data and historical knowledge by the Director of Works, Water and Sewer Officer, Operational and administration staff and external consultants during a risk assessment workshop. The risk tables were prepared based on the hazard known to the water supply and discussed during a workshop with internal and other key stakeholders. Attendees were then invited to review and add hazards, impacts, actions and comments where required. See Appendix E for the attendees list of the risk workshops.

The methodology from the materials issued to support the DWQMP guidelines were adapted. The risk assessment methodology is based on the *ADWG (2011)* Framework and industry guidance notes.

The risk is defined as the likelihood of identified hazards causing harm in exposed populations in a specified timeframe, with consideration for the severity of the consequences (ie risk = likelihood x consequence).

For each hazard and hazardous event, the likelihood and consequence were assessed using the following tables (Tables 8.1, 8.2, & 8.3):

Table 8.1: Likelihood and consequence of risks descriptions

Likelihood scale (*ADWG 2011*)

Level	Likelihood ranking	Description
A	Almost certain	Is expected to occur in most circumstances
B	Likely	Will probably occur in most circumstances
C	Possible	Might occur or should occur at some time
D	Unlikely	Could occur at some time
E	Rare	May occur only in exceptional circumstances

Consequence or Impact scale (*ADWG 2011*)

Level	Consequence ranking	Description
1	Insignificant	Insignificant impact, little disruption to normal operation, low increase in normal operation costs
2	Minor	Minor impact for small population, some manageable operation disruption, some increase in operating costs
3	Moderate	Minor impact for large population, significant modification to normal operation but manageable, operation costs increased, increased monitoring
4	Major	Major impact for small population, systems significantly compromised and abnormal operation if it all, high level of monitoring required
5	Catastrophic	Major impact for large population, complete failure of systems

Table 8.2: ADWG 2011 Risk Matrix

Level Of Risk Matrix (*ADWG 2011*)

Likelihood	Consequences				
	1 – Insignificant	2 - Minor	3 - Moderate	4 - Major	5 – Catastrophic
A - Almost certain	Moderate	High	Very High	Very High	Very High
B - Likely	Moderate	High	High	Very High	Very High
C - Possible	Low	Moderate	High	Very High	Very High
D - Unlikely	Low	Low	Moderate	High	Very High
E - Rare	Low	Low	Moderate	High	High

Table 8.3: Certainty and Uncertainty descriptions

Level of Uncertainty	Description (Examples for degrees of uncertainty)
Certain	There is five 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 five years of continuous monitoring data, which has been collated and assessed, with at least weekly monitoring or for the duration of seasonal events. There is a very good understanding of the processes involved.
Reliable	There is at least a year of continuous monitoring data available, which has been assessed and there is a good understanding of the processes involved.
Estimate	There is limited monitoring data available and there is a reasonable understanding of the processes involved.
Uncertain	There is limited or no monitoring data available and the processes are not well understood.

For each of the hazards identified for the drinking water supply, an assessment of risk and priorities for risk management was determined.

The Maximum Risk was first determined in the absence of preventive measures, to identify high-priority risks and provide an indication of worst-case scenarios in the event of failures.

The Residual Risk was determined in conjunction with evaluation of existing preventive measures, and was assessed on information on the effectiveness of existing strategies and the need for improvements.

Uncertainty- Assessing uncertainty provides an indication of the need to undertake further work or gather more data to ensure that the risk assessment is accurate and reliable.

8.3 Hazard Risk Assessment and Uncertainty

Drinking water quality risks were identified and included in the Risk Assessment Table during a workshop with RSC Management, Administration staff, Operational staff and other key stakeholders.

The hazards and hazardous events were reviewed following the risk assessment methodology (as detailed above) and the finalised risk assessments are included in *APPENDIX F - Risk Assessment Tables*.

8.4 Acceptable Risk Ranking

Richmond Shire council accepts risks as low and moderate as acceptable. The foundation of this level of acceptance is based on the consequence being un-changeable regardless of controls being in place. Controls can only reduce the likely hood of a risk occurring and where the consequence is moderate or above no matter how many controls are in place to reduce the likely hood of the risk occurring, even if the likelihood is reduced to rare, a moderate risk score results.

9 MANAGING RISKS

9.1 Residual Risk Management Measures

A total of 62 hazardous events were identified in the risk assessment process. Ranking of these risks has shown a significant reduction in risks classified as 'Very high' and 'High' from the initial to the controlled (residual) risk rating. A summary table of results can be seen in Table 9.1 where 23% of 'Very High' reduced to 6% with the identified controls, and 39% of 'High' went down to 26%. There was a similar trend in the opposite direction was seen in the 'Low' risk category which moved from 16% up to 23% when the higher risk controls were considered. There was a slight reduction in the number of 'Moderate' hazards where these went from 23% down to 45%.

Table 9.1: Risk Summary – Richmond Water Supply Scheme

Risk Rating	Initial	Initial %	Residual	Residual %
Very High	14	23	4	6
High	24	39	16	26
Mod	14	23	28	45
Low	10	16	14	23
Total	**62**	**100**	**62**	**100**

Figure 9.1 presents this data graphically. The summary shows that overall risk is being reduced with current controls in place, however there are improvements that can be made to better manage the risks.

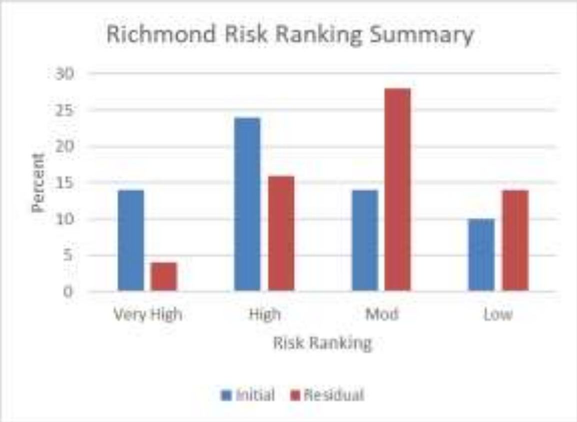

Figure 9.1: Initial and Controlled risk profile for the Richmond Water Supply Scheme.

Following the risk assessment process and consideration of the existing preventative measures, monitoring requirements and notes on the assessment were included. Additional actions (outstanding actions) were identified to be taken by Council, to reduce and improve the knowledge and safety of the water supply. These outstanding actions have been included in the DWQMS Risk Management Improvement Plan (RMIP) which identifies the residual risk rating, actions to be taken, priority and who is responsible for the task. See *Appendix G. DWQMS Risk Management Improvement Plan (RMIP*). RSC management have identified that the risks within the 'Moderate' and 'Low' ranking are acceptable levels of risk where finances and resources are limited. Business and project actions will be allocated to the identified 'High' and 'Very High' hazard and hazardous events, with the improvement plan capturing the proposed actions to ensure continual upgrading of the water system.

9.2 Operation and Maintenance Procedures

Operation and maintenance procedures formalise the day to day activities necessary for the correct functioning of the water supply system and ensure that all preventive measures are effective in managing the identified risks.

The Richmond Shire Council Drinking Water Quality Management Plan is a resource document that identifies management strategies which will ensure that water services deliver high quality services into the future. The preventive measures identified in the risk assessment process and used to achieve the assessed residual risks, are supported and managed by appropriate O&M procedures which are as detailed in *Appendix I - O&M Procedure Documentation.*

Any further actions have been included in the Risk Management Improvement Program (see Appendix G).

Procedure Development

Limited task specific O&M procedures exist, where much of the information is in dot point format to act as operational prompts rather than any verbose instructions. Where O&M procedures and documentation is required, it will be developed so it is appropriate, user-friendly and suitable for incorporation into the councils operations and the DWQMS. Flow charts will be used where appropriate and procedures will also include data collection sheets (if appropriate).

All manufacturers manuals detailing routine maintenance and calibration procedures are available for key operational and monitoring equipment within the WTP O&M Manual.

9.3 Management of Incidents and Emergencies

Richmond Shire Council has developed and maintains a Richmond Shire Local Disaster Management Plan (LDMP). This plan is prepared under the provision of *Section 57 of the Disaster Management Act 2003*, and replaces the former Local Government Disaster Management Plan. The LDMP assess the risks and identifies actions associated with natural disasters including but not limited to flooding, bushfires and earthquakes.

Given that Richmond Shire Council is a small organisation and the residual risks detailed in this document are manageable within existing resourcing, a specific RSC Drinking Water Incident & Emergency Response Plan has not been developed to date. However, Council have an *Incident and Emergency Response Table* which identifies incidents and emergencies into three levels with a description and summary of actions to be taken along with the responsible officer. This table is available in Appendix H.

Employee awareness and training

All managers and coordinators are responsible for ensuring their team members have the appropriate skills and knowledge to ensure the safety of the drinking water.

Within Richmond, typical training programs can include –

- Weekly toolbox and supervisors meetings include water issues as they arise.
- Attending industry events
- Role and site-specific inductions include OH&S and regulatory responsibilities
- Familiarisation with any emergency response plans and the employee's responsibilities under the plan
- Appropriate training requirements to ensure employees are able to fulfil the responsibilities of their role.

In addition, after hours contact details for staff responsible for water quality management are included in the Richmond Shire Council internal phone directory.

As part of the induction process, the DWQMP is presented to all employees whose work relates to provision of and record keeping associated with the delivery of water services, to ensure they understand the requirements and the goals of the plan. The presentation may be followed by appropriate 'on site' training.

Long term incident management and implications for the DWQMP

All incident reports and operational records are reviewed by the Director of Works in consultation with the Water and Sewerage Officer to ensure the following:

- timely responses and notification to the regulator have been achieved
- incidents have been appropriately investigated

The Director of Works is also responsible for considering the findings of incident investigations and determine whether there are any long term improvement actions needed to prevent the reoccurrence of the incident in the future (e.g.: need for system and operational improvements) and how these might be achieved. Actions developed out of this process are to be included in the DWQMP Improvement Plan.

9.4 Service Wide Support – Information Management

All information related to the management of drinking water quality is registered in Council's Information Management System (InfoXpert) and/or stored on network drives so that information is readily accessible, accurate, reliable and up to date. Administration support is provided to operational staff to assist with duties and reporting requirements.

Supporting Documentation

The documents that Richmond Shire Council have identified as required to support the operation and maintenance of the water supply schemes and manage risks (as identified through the risk assessment and review workshop) is available in *Appendix I - O&M Procedure Documentation*. Procedures are also listed and identified in the DWQMP Improvement Plan

Water Quality Data Management

All operational and verification monitoring water quality results are entered into the SWIM Local data base developed in 2018-19. At the time of preparing this plan data is entered by an external contractor and an RMIP action exists to transfer this responsibility to RSC personnel along with the development of a user manual specific to the RSC SWIM database set up.

Cyber – Software Security

Council has assessed risks with cyber security in this review of the DWQMP. Council maintains a commitment to remain aware and familiar with National, State and Local government approach and standards (in development) towards managing this issue and have identified some specific actions in the RMIP to ensure ongoing compliance with security risks associated with a cyber attack.

Further risks directly related to external tampering or hacking, RSC assessed these risks and identified actions to ensure that all hardware (PC) and CITECT SCADA software is updated, with both routine security patches and major version updates (at less regular intervals). The control program logic "code" is routinely backed up and stored within RSC's information management system as well as with nominated contractors who may amend the code.

Key controls (current and proposed for cyber security management are summarised below, for further information refer to RMIP.

Current Controls;

- WTP Citect control computer is not on RSC's primary network and operates on an independent 4G network for SMS alarm distribution.
- Internal staff and nominated contractors can access they system via Teamviewer to assist with interrogating trends and address faults/acknowledge alarms.
- Two levels of access are available Administrator or operator, both are encrypted password protected. Without password system is view only and no changes can be made to setpoints or mode of operation.

Proposed Controls;

- RSC to generate a back up of the control code to be stored in the council information management system.
- RSC to ensure the Citect software is regularly updated to include security patches and major software updates to prevent security.
- RSC to assess feasibility of running the system and setting up remote access through the RSC internal network.
- RSC to ensure hardware such as Personal Computer (PC) that runs Citect control software is maintained and updated routinely - frequency to be determined (nominal 5 year replacement cycle).

9.5 Risk Management Improvement Program

A Risk Management Improvement Program (RMIP) has been developed for the short- and long-term strategic plans to address and reduce the identified risks. See *Appendix G. DWQMP Risk Management Improvement Plan (RMIP)* for the actions, timelines, responsibilities and priority ratings provided for each of the outstanding action items as identified during the Risk Assessment and any additional internal/external reviews of the DWQMP.

10 Operational and Verification Monitoring Programs

10.1 Operational Monitoring

The Richmond Shire Council executes a basic O&M program, which is manually managed to ensure cleaning, work procedures, and inspections are completed to maintain water quality. Water & Sewage Officer ensures the required maintenance is scheduled in to daily work orders throughout out the year.

The Richmond and Maxwelton Water supply schemes are monitored by both on-line continuous instrumentation via the WTP PLC and manually to verify accuracy of on line instruments. Visual inspections are also carried out routinely. A summary of routine internal water quality monitoring is provided in Table 10.1 below:

Table 10.1: Internal monitoring of the Richmond Water supply system

Analysis Internal	Frequency and Location.				
Phys-Chem Parameters	**Continuous On line**	**Daily**	**Weekly**	**Monthy**	**Sample Sites**
pH	X	X	X	X	WTPRWO, WTPO
Turbidity, ntu	X	X	X	X	WTPRWO, Two of WTPFT1O, WTPFT2O, WTPFT3O (Operating filters only), WTPO
Colour True, Pt/Co			X	X	WTPRWO, Two of WTPFT1O, WTPFT2O, WTPFT3O (Operating filters only), WTPO
Temperature	X	X	X	X	WTPRWO, Two of WTPFT1O, WTPFT2O, WTPFT3O (Operating filters only), WTPO
Chlorine Free	X	X	X	X	WTPRWO, WTPFWC, WTPO
Chlorine Total			X	X	WTPRWO, WTPFWC, WTPO
Iron total				X	WTPO
Manganese Total				X	WTPO
Bacterial Parameters					
E.coli			X	X	One of Bore 5 or 6, Bore 7, WTPO, PLUS 1 RETICULATION SITE
Total Coliforms			X	X	One of Bore 5 or 6, Bore 7, WTPO, PLUS 1 RETICULATION SITE

Council Operations staff travel between Richmond and Maxwelton townships to address any operational or maintenance issues, they attend to any notification of disruption to the water supply during normal working hours and after hours.

In addition to water quality monitoring, the Water and Sewage Officer monitors the following 3-5 days per week (Monday to Friday – weekends on alarms only):

- Visual inspection of plant and equipment
- Records bulk water input into the system
- On *Demand Pump* running hours
- Chlorine dosing rate and consumption at the WTP

These inspections ensure that the general running of the plant is inspected so any operational issues can be recorded and rectified with reactive maintenance. All records are held at the council office.

Operational monitoring is supported by the development of Operational Control Point Alert Limits. These alert limits are key parameters that are readily measurable and are summarised in *Table 10.2 Operational Control Point Overview* . Further detail as to the recommended actions for operations personnel if an adjustment or critical limit is breached, are detailed in a separate table for each control point location. These actions include operational adjustment, checks and tests as well as any internal and external reporting requirements. Control points are summarised as follows;

- Raw Water Abstraction – Bores - *Turbidity*
- Oxidation – Aesthetic only (Fe, Mn) – *Turbidity - Chlorine*
- Filtration – Aesthetic (Fe, Mn) / Health (Maintain turbidity to optimise Cl disinfection) - *Turbidity*
- Disinfection – Health only – *Chlorine, pH*
- Storage – Distribution – Aesthetic/Health – *Turbidity, Chlorine, pH.*

Table 10.2: Operational Control Point Overview – Richmond Shire Council

System	Process Step / Control Point	Hazard	Control Parameter	Target	Alert Level	Critical Limit	Monitoring Frequency
Richmond	Raw water abstraction / Bores	All pathogens	Turbidity	1 NTU	4 NTU	10 NTU	Continuous on-line Manual 3- 5 days /week
	Water Treatment Plant - Oxidation	Iron - Manganese	Turbidity & Chlorine	1-1.5 NTU 1.1-1.4 mg/L Cl	4 NTU <1 mg/L or >1.5 mg/L Cl	10 NTU <0.5 mg/L or > 2 mg/L Cl	Continuous on-line Manual 3 – 5 days/week
	Water Treatment Plant Filter Outlet	All pathogens, Iron - Manganese	Turbidity	<0.2 NTU	>0.5 NTU	>5 NTU	Continuous on-line Manual 3- 5 days/week
	Disinfection (Sodium Hypochlorite)	Chlorine sensitive pathogens & Chemical (Chlorine)	Chlorine & pH	1.1 - 1.3 mg/L Free Cl (After filtration) pH 7.0	<1 mg/L or >1.5 mg/L Free Cl (After Filtration) pH <6.7 or >8.2	<0.2 or >4.5 mg/L Free Chlorine pH <6.5 or >8.5	Continuous on-line Manual 3- 5 days/week
	Reservoirs	All pathogens and All chemicals	Reservoir integrity, Chlorine, Turbidity & pH	No breach of integrity <0.2ntu <0.7mg/L or > 1.5mg/L Cl 7.0 pH	Any sign of integrity breach >0.5ntu <0.5 mg/L or > 2mg/L Cl <6.7 or > 8.2 pH	Evidence of contamination >5ntu <0.2 mg/L or > 4.5mg/L Cl <6.5 or > 8.5pH	Manual inspection daily (3-5d/wk) Continuous on-line WQ monitoring, Manual 3 – 5 days/week.

Target	This is where you want your system to be operating. Try to maintain levels equal to or greater quality than the required value(s).
Alert Level	First indication your system may have a problem or a potential problem. Increase monitoring and refer to CCP management plans.
Critical Limit	At this limit you have lost control of your system. As a matter of urgency refer to CCP management plans and try to remediate problem.

10.2 Verification Monitoring

Richmond Shire Council monitors the water quality of the Richmond water supply scheme routinely. Testing is carried out in accordance with the program detailed in Appendix J. This includes external verification for key parameters on a regular basis as per the below summary.

- Monthly for *E. coli* at each raw water source, WTP outlet and one of six reticulation sites
- Quarterly for disinfection by-products, Iron and Manganese
- Six monthly for additional chemical analysis

Water Quality Testing

Water quality has been tested sporadically in the past. Regular water quality tests shall be carried out as detailed in Appendix J. Routine sampling is conducted at the following locations:

- All Bore Sources
- Outlet of the WTP
- One of six reticulation sample sites rotated monthly (externally).

***E.coli* Testing**

Internal *E.coli* sampling and analysis is conducted weekly at the WTP Outlet, Bore 7 and either Bore 5 or Bore 6 (rotated weekly) and one of six sites within the reticulation. This testing is verified monthly via external analysis as detailed in Appendix J. Sample sites are detailed in Table 10.3 below:

Table 10.3: Richmond Drinking Water Supply Sampling Sites and Analysis

Site ID	Site Description	Location	Internal/External Analysis
RWB5	Raw water Bore 5	Bore 5 - inlet sample tap	Internal & External
RWB6	Raw Water Bore 6	Bore 6 Inlet sample tap	Internal & External
RWB7	Raw Water Bore 7	Bore 7 Inlet sample tap	Internal & External
RWMB	Raw Water Maxwelton Bore	Maxwelton Bore	Internal Only
WTPRWO	Water Treatment Plant - Raw Water combined Post Oxidation	Sample tap post raw water booster pumps	Internal Only
WTPFT1O	Water Treatment Plant - Filter train 1 Outlet	Sample tap Filter train 1 outlet	Internal Only
WTPFT2O	Water Treatment Plant - Filter train 2 Outlet	Sample tap filter train 2 outlet	Internal Only
WTPFT3O	Water Treatment Plant - Filter train 3 Outlet	sample tap filter train 3 outlet	Internal Only
WTPFWC	Water Treatment Plant Filtered Water Post Chlorination	Filtered Water Analyser outlet	Internal Only
WTPO	Water Treatment Plant Outlet (Water to Town)	Sample tap at town pressure pumps – reticulation entry point	Internal & External
RS1	Reticulation System Boat Ramp	Sample at water bubbler/tap	Internal & External
RS2	Reticulation System Lions Park	Sample Tap centre of park	Internal & External
RS3	Reticulation System Hospital Pump Station	Sample tap at Hospital PS	Internal & External
RS4	Carpentaria Fuel Depot	Sample tap next to council pumping station	Internal & External
RS5	Race Course	Sample tap under tree behind bar	Internal & External
RS6	Skate Park	Sample tap and water bubbler/tap	Internal & External

The sampling is carried out as per the updated monitoring program provided in Appendix J. Sampling is conducted in accordance with the *Queensland Water Directorate E.coli Fact Sheet 22 June 2009*.

11 References

Australian Drinking Water Guidelines 6, 2011 (ADWG)

ADWG Draft Microbial health-based targets for drinking water supplies – Version 15 – August 2016,

Drinking Water Quality Management Plan Guideline September 2010 (DNRME)

Richmond Shire Council Local Disaster Management Plan – Date

Queensland Water Directorate E.coli Fact Sheet 22 June 2009.

12 APPENDIX A - Summary Table of WTP Process Components and Specifications

Component	**Specifications**
General	
Client	Richmond Shire Council, QLD 4822
System	Oxidation – Coagulation - Direct filtration - Disinfection
Type	Pressurised
Duty	Treatment for potable water supply
No. of Units/ No. operating	➢ 3 treatment trains: Each train comprising 3 flocculation and 5 filtration vessels ➢ Operation requirement determined by SCADA logic and ultimately town water requirements
Filtrate Water Requirements	Compliance with ADWG 2011
System Operating Pressure Range	Up to 700 kPa
Pressure reduction range through train	<150Kpa
Max operating temp	60°C
Raw Water	
Supply	➢ Bore 5 ➢ Bore 6
Supply flow	Limit bore extraction to 19l/s each, combining flow to provide 38l/s
Supply pressure	➢ Bore 5-500kPa ➢ Bore 6-500kPa
Quality	➢ Elevated Iron ➢ Elevated Manganese ➢ Hydrogen Sulfide odour
Communications	Telemetry between bore 6 and SCADA
Program Logic Control	
Control type	CitecSCADA
Oxidation	
Oxidation method	➢ Chemical-Sodium Hypochlorite ➢ Mechanical- Aeration
Balance tank capacity	➢ 4x 45,000L tanks ➢ Total Capacity 200,000L
Minimum required retention time for acceptable oxidation	45 minutes
Jet Nozzle operating range	200-500 kpa
Pre Oxidation Dose pump capacity	11.6L/m
Pump Stations	
Pump Model	Grundfos MPC pressure Boosting System - CU3x4 controller
Coagulation	
Coagulant	Liquid Aluminium sulphate
Dose pump capacity	11.6L/min
Chemical Storage Capacity	1000L
Flocculation	
Pressure Vessel No	➢ 3 per train

	➢ 9 in total
Pressure Vessel Rating	800 kpa
Minimum retention time at max flow	9 minutes
Vessel Pressure release setting	700 kPa
Pressure Vessel material	Spiral wound Fibreglass
Filtration	
Pressure Vessel No.	5 x 3 trains; 15 total
Pressure Vessel Rating	800Kpa
Filtration flow rate range	➢ 0.5 ML/day/filter ➢ 2.5ML/day/train
Media configuration	Dual media comprising of: ➢ 06-12mm Gravel ➢ 03-06mm Gravel ➢ 0.55- 0.65mm Sand ➢ Acticarb GA1000n - Granular Activated Carbon
Vessel pressure release setting	700 kPa
Maximum Recommended Filtration rate	19.8m^3 hour/ 9.9m/hr
Recommended filtration rate	9.9m^3/hr - 4.95m/hour
Pressure vessel material	Spiral wound Fibreglass
Disinfection	
Disinfection method	Sodium hypochlorite
Chemical storage capacity	1000L
Dose pump capacity	11.6 L/min
Clear Water Tank	
Tank capacity	1.5ML
Bypass mode	
Trigger for booster pump bypass	➢ Reticulation pressure below 300kpa ➢ CWT level reaches critically low point
Trigger for raw water pump bypass	➢ Oxidation tank levels reach critical low points
Sludge Management/ Backwash	
Backwash trigger	Either of the following, whichever comes first: ➢ Pressure differential ➢ Time ➢ Water quantity (ML) These are readily adjustable via the SCADA, pending plant requirements
Designed Backwash flow rate	20l/s per filter
Backwash Period	Variable via PLC
Rinse Period	Variable via PLC
Pneumatic system	
Air supply Flowrate - Duty	15.2 CFM
Duty System design pressure	800 Kpa
Air Supply Flow Rate – Back up Compressor	11.9 CFM
Backup system design pressure	700 Kpa

13 APPENDIX B - Historic water quality data and interpretation

13.1 Water quality data analysis and interpretation

The primary purpose of the water treatment plant in Richmond is to control problematic staining caused by oxidation of Iron and Manganese from the Raw Water supplies, and to provide appropriate disinfection to manage biological risks. Key parameters monitored by staff include Raw and Treated Water Turbidity, Chlorine (Free), Iron, Manganese and pathogens including *E.coli* and Coliforms. A summary of data obtained in routine monitoring and internal verification of the process is provided below for each key process stage. Additional historic data both with and without treatment is also included.

13.1.1 Chlorine Monitoring Oxidation Stage

Both dosed water from Bore 6 and water post oxidation tanks is monitored for Free chlorine by operations personnel in order to verify on line instrumentation is reading and controlling dose rates accurately. The target Free chlorine residual after dosing of Bore 6 is 1.3mg/L, which is sufficient to aid in the oxidation and removal of iron and manganese from both raw water sources once blended in the oxidation tanks. The oxidation tanks have a holding time of between 45 and 90 minutes depending on the flow through the plant at any given time.

Summary statistics presented in Table 13.3, below indicate that on average this process is managed within the tolerances prescribed in the operations and maintenance manual and critical limits as noted in the Risk Assessment Tables. Average dosed water free chlorine residual is 1.31 ± 0.09 mg/L for the dosed oxidation feed from Bore 6. When combined with Bore 5 and allowed time to oxidise iron and manganese as described above, the remaining residual is 0.22 ± 0.03mg/L free chlorine. There is some variation observed (as seen in FIGURE 13.1), where occasional high and low readings are observed. These deviations are alarmed to notify the operator that intervention is required and may be associated with pump failures, overcompensation of PID control loops leading to inaccurate readings from on line instruments or other short-term failures in mechanical aspects of the process.

Table 13.3: Summary Statistics for internal verification Chlorine monitoring

Descriptive Summary Statistics - Free Chlorine (mg/L) - Richmond Water Supply				
	Bore 6 Dosed Free Chlorine Residual, mg/L	Combined Raw Water Free Chlorine Residual, mg/L (Post Oxidation Tanks)	Filtered Water (Dosed) Free Chlorine Residual, mg/L	Water to Town Free Chlorine residual, mg/L
Mean	1.31	0.22	0.73	0.77
Median	1.27	0.16	0.77	0.76
Mode	1.66	0.13	0.77	0.75
Minimum	0.02	0	0	0.21
Maximum	2.7	1.13	1.49	1.45
Count	138	145	140	145
Confidence Level (95.0%)	0.09	0.03	0.04	0.03

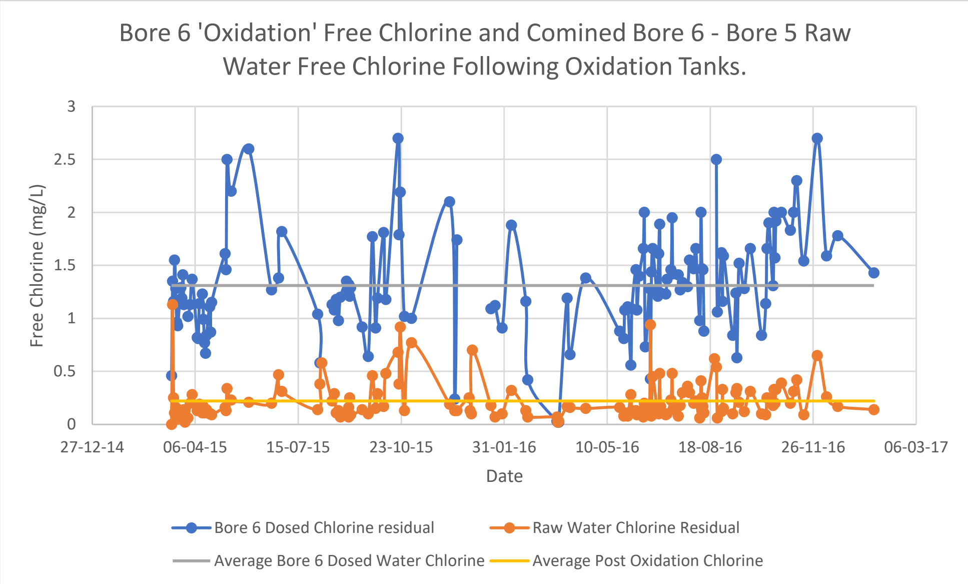

Figure 13.1: Oxidation free chlorine monitoring – Richmond Water Treatment Plant.

13.1.2 Chlorine Monitoring Post Filtration

As shown in Table 13.3 above and Figure 13.2 below, filtered (dosed) water chlorine residual and water to town post the clear water storage has been within range of acceptance for the 18 month time period of available data at this point in time. Dosed water has however dropped below desired limits on occasion due to various failures, however as with the oxidation dosing system these events are alarmed to inform the operator of the need to intervene and have not led to a lack of free chlorine residual entering the reticulation. Average free chlorine residual of dosed and town waters are 0.73±0.04 mg/L and 0.77±0.03 mg/L respectively. Minimum recorded free chlorine residual entering the reticulation is observed as 0.21mg/L from the 145 records available at the time of preparing this analysis.

Figure 13.2 below shows close correlation of dosed and water to town chlorine residuals over time.

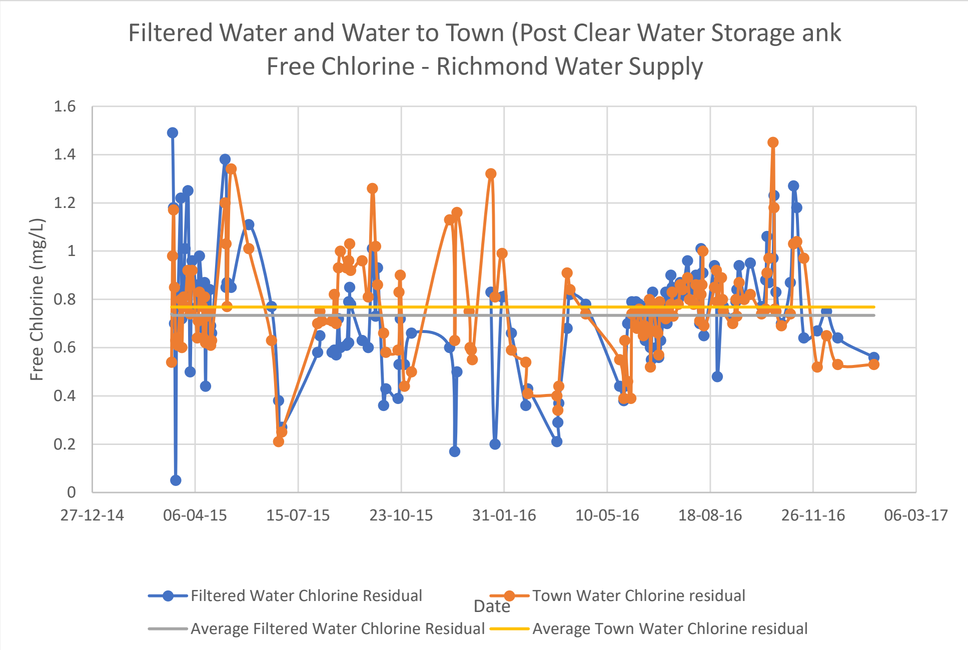

Figure 13.2: Filtered and water to town free chlorine residual over time – Richmond WTP

13.1.3 Turbidity Monitoring – Richmond Water Treatment Plant

Turbidity is monitored at multiple points within the treatment process. These points include Raw Water, Filtered Water from each of the three Filter trains, combined filtered water (generally two trains operating at any one time however can be three or 1 subject to demand) and Water to town post the clear water storage. Monitoring at these points provides information as to the effectiveness of the oxidation process, coagulation and filtration systems and final water quality after storage in the clear water tank. Any observed increase in water to town or filtered water turbidity is a trigger for operators to review the oxidation and coagulation processes. Breakthrough of un-oxidised iron and or manganese increases chlorine demand of filtered water and leads to both a reduction in chlorine levels in water to town, and an increase in final water to town turbidity.

Summary statistics provided in Table 3.4 below shows that the process consistently achieves satisfactory water quality for optimal disinfection performance as per ADWG 2011, where average filtered water and water to town turbidities are 0.17±0.2 and 0.21±0.017 NTU respectively. Minimum values recorded are below 0.1NTU and observed as 0.07 and 0.08 NTU respectively for Filtered and Town water turbidity.

Table 13.4 – Descriptive statistics - Turbidity

Descriptive Summary Statistics - Turbidity (NTU) - Richmond Water Supply			
	Raw water Turbidity	Filtered Water Turbidity	Town Water Turbidity
Mean	0.963	0.173	0.206
Median	0.660	0.140	0.175
Mode	0.540	0.120	0.170
Minimum	0.074	0.070	0.080
Maximum	14.800	0.960	0.690
Count	136	136	136
Confidence Level (95.0%)	0.255	0.018	0.017

Data is presented graphically in Figure 13.3 below. Note for the purposes of graphical presentation, three raw water turbidity "outliers" have been omitted from the chart. Values of 5.1, 14.8 and 9.6 NTU were removed from the data set in order to improve presentation. These outliers are generally associated with sloughing off of iron/manganese precipitate from sample lines and generally not representative of the actual turbidity as observed with long term average. These outliers were included in the descriptive analysis presented above, leading to the higher observed confidence interval (95%) of 0.255 NTU .

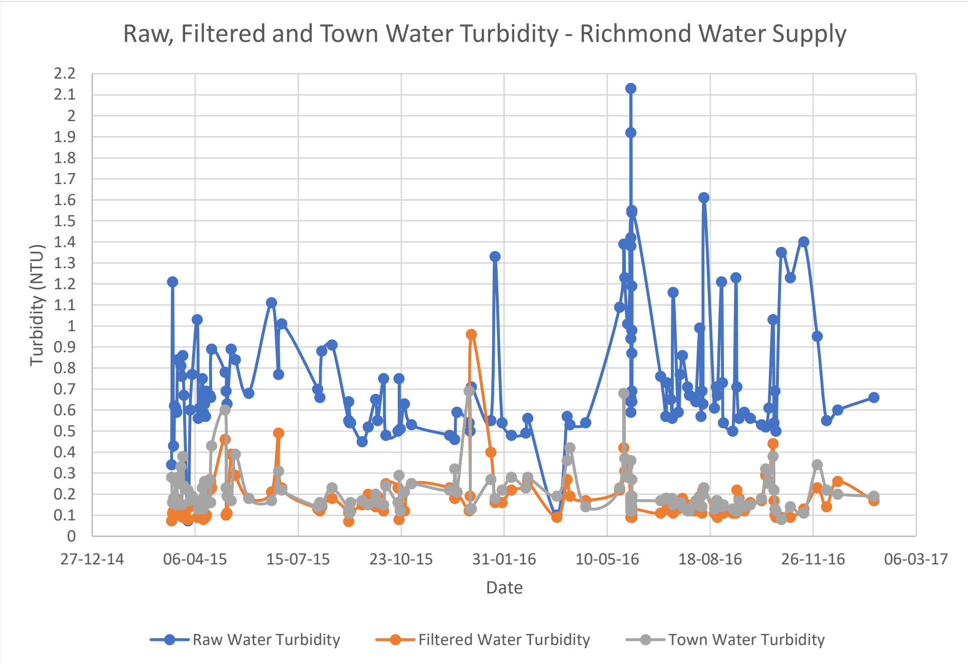

Figure 13.3 – Raw, Filtered and Town water turbidity for the Richmond Water supply

13.1.4 Iron and Manganese Monitoring – Richmond Water Treatment Plant

Iron and Manganese are monitored periodically to verify performance of the oxidation process. Although failures are noted generally via increases in turbidity of treated water and a higher chlorine demand, these parameters are monitored manually to ensure the process is performing as it should.

In Table 13.5 below it can be seen that Raw Water Iron and Manganese average 0.918±0.102 mg/L and 0.046±0.004 mg/L respectively, while treated water Iron and Manganese average 0.051±0.014 and 0.019±0.005.

Treated water values for Iron and Manganese are well below aesthetic guideline values of 0.3 and 0.05 mg/L (desirable) as noted in ADWG 2011 on all occasions (maximum Iron 0.12 mg/L, maximum Manganese 0.041 mg/L).

Table 13.5; Iron and Manganese in the Richmond Water Supply

Descriptive Summary Statistics - Iron and Manganese (mg/L) - Richmond Water Supply				
	Raw Water Iron	Raw Water Manganese	Town Water Iron	Town Water Manganese
Mean	0.918	0.046	0.051	0.019
Median	0.835	0.044	0.050	0.019
Mode	0.820	0.042	0.030	0.024
Minimum	0.650	0.024	0.000	0.001
Maximum	1.870	0.076	0.120	0.041
Count	24.000	24.000	24.000	24.000
Confidence Level(95.0%)	0.102	0.004	0.014	0.005

Figure 13.4 below presents the above data graphically. It can be seen that following commissioning and optimisation of the Water Treatment Plant process from March – May 2015 that treated water Manganese is generally below 0.01 mg/L with only one exception in May 2016 where a value of 0.012 was observed. (Note Raw water Iron is plotted on a secondary vertical axis).

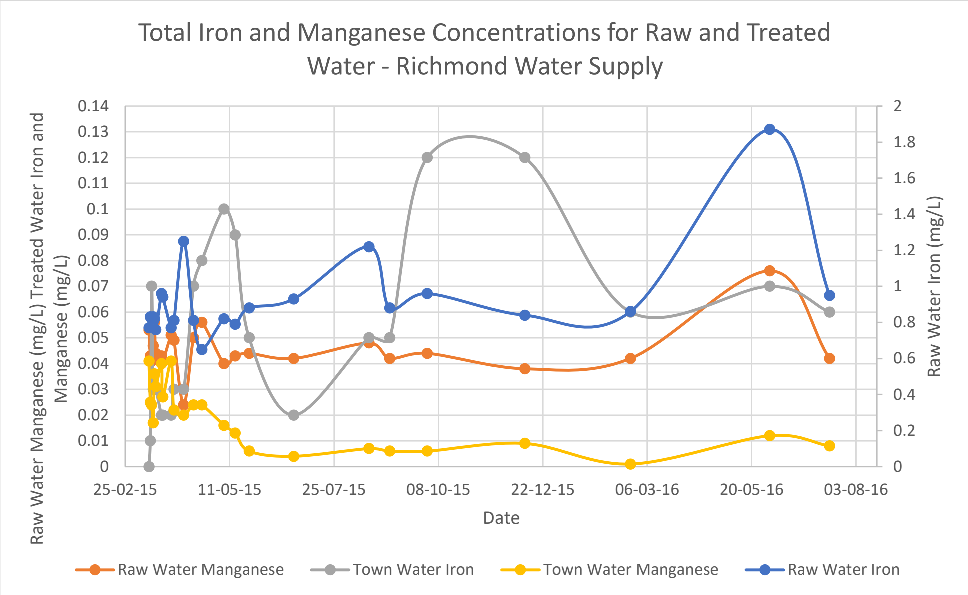

Figure 13.4 Raw and treated water Iron and Manganese for the Richmond Water Supply

13.1.5 Microbioological Monitoring, *E.coli* and Coliforms – Richmond Water Supply.

Richmond Shire Council undertakes routine internal monitoring and testing for pathogens including *E.coli* and coliforms. Data for this analysis is not presented graphically nor in summary statistics because no coliforms nor *E.coli* have been detected. Over 127 samples from the reticulation and the treatment plant outlet collected and analysed between May and October 2017, confirmed no detections of coliforms or *E.coli* were noted.

Biological assessment of raw water is currently lacking and is now incorporated into a revised monitoring and external verification program to be implemented in 2018 subject to approval by DEWS.

13.1.6 External verification data analysis – reticulation

Results of external verification analysis prior to the commissioning of the Richmond Water treatment plant (2015) is presented in Table 3.6 below. Data presented reflects results obtained via internal analysis for the raw water supplies as presented above. Between 2004 and 2013 there were no occasions were any health based targets were breached. As with raw water quality, only a few breaches of aesthetic limits for Iron and Turbidity were observed. These non-compliances are the result of oxidation of iron and manganese following the addition of chlorine. Removal of iron and manganese are the primary objectives of the treatment process for the Richmond water supply.

Table 13.6; External verification results for Richmond Water Supply – Untreated 2004 - 2013

Parameter	ADWG Limit	Number of Samples	Average	Min	Max	% samples below detection limit	Detection Limit	% Compliance
Richmond Shire Council - Reticulation External Verification Analysis Summary 2004 - 2013								
Alkalinity	NA	16	184.87	120	240	0	NA	100
Aluminium	0.3	24	0.05*	<0.01	0.08	88.00%	0.05 - 0.01[b]	100
Arsenic	0.007	16	<0.005*	<0.005	<0.005	100.00%	0.005	100
Bicarbonate	NA	16	224	142	289	0.00%	NA	100
Boron	4	16	0.051	0.04	0.07	0.00%	0.02	100
Cadmium	0.002	8	<0.004*	<0.004	<0.004	100.00%	0.004 - 0.0001[b]	100
Calcium	NA	16	13.58	7.6	19	0.00%	NA	100
Carbonate	NA	16	0.76	0.1	1.9	0.00%	NA	100
Chloride	250	16	42	39	44	0.00%	NA	100
Chromium	0.05	8	<0.004*	<0.004	<0.004	100.00%	0.004 - 0.0001 [b]	100
Conductivity	NA	16	502	420	598	0.00%	NA	100
Copper	2[h] 1[a]	24	0.075*	<0.005	0.008	76.00%	0.03 - 0.005[b]	100
Fluoride	1.5	16	0.1	0.1	0.11	0.00%	NA	100
Iron Soluble	0.3[a]	16	0.18*	<0.1	0.68	44.00%	0.01	81.25
Iron Total	0.3[a]	16	NA	NA	NA	NA	NA	NA
Lead	0.01	8	<0.005*	<0.005	<0.005	100.00%	0.005	100
Manganese	0.5 - 0.1	24	0.035*	<0.01	0.06	24.00%	0.01	100
Magnesium	NA	16	8.96	3.4	14	0.00%	NA	100
Nitrate	50	16	<0.5*	<0.5	<0.5	100.00%	0.05	100
Nickel	0.02	16	<0.005*	<0.005	<0.005	100.00%	0.005	100
pH	6.5 - 8.5	16	7.56	7.04	8.07	0.00%	NA	100
Potassium	NA	16	9.46	4.2	14	0.00%	NA	100
Silica	NA	16	22.18	20	24	0.00%	NA	100
Sodium	180	16	77.18	36	118	0.00%	NA	100
Sodium Adsorbtion ratio	NA	16	4.64	1.5	8.5	0.00%	NA	100
Sulphate	500[h] 250[a]	16	12.69	11.6	14.4	0.00%	NA	100
Total Dissolved Ions	NA	16	388.62	295	485	0.00%	NA	100
Total Dissolved Solids	500[a]	16	296.88	256	358	0.00%	NA	100
Total Hardness	200[a]	16	70.93	33	106	0.00%	NA	100
True Colour	15	16	2.25	<1	5	50.00%	1	100
Turbidity	5[a]	16	3.91	<1	30***	31.25%	1	91
Zinc	3[a]	16	0.04	<0.01	0.17	25.00%	0.01	100

Notes:

[h] = health Based Guideline Limit

[a] = Aesthetic Guideline limit

[b] = Detection limit changed during the sample period

* = Average derived from real numbers only - numbers less than detectioin limit excluded from calculation or all samples recorded as below detection limit.

** = At point of collection turbidity generally <1.5ntu. Oxidatioin of iron and manganese in transit to laboratory leads to increased turbidity, possible aeration during sample collection contributing to increased turbidity at time of analysis.

*** = Outlier result vastly different to all other records, suspect due to sampling error - lack of flushing or sample taken in response to dirty ater event. All other samples were less than 3ntu (average without outlier is 1.3ntu). Not considered accurate reflection of water quality.

Aesthetic guideline value breached

14 APPENDIX C - Example plant records monitoring sheet, Richmond WTP

Richmond Water Treatment Plant Daily Records Sheet

Year	2019	Month	

		Flow Records					Raw Water Quality Records								Filtered Water Quality Records							Town Water Quality Records						
SWIM SITE NAMES		RWB5	RWB6	WTP_RWO	WTPO	WTPO	RWB6	RWB6	WTP_RWO						WTP_FT1O	WTP_FT2O	WTP_FT3O	WTP_CDFW				WTPO						
Date	Time	Bore 5 Flow rate L/sec	Bore 6 Flow Rate L/sec	Total Flow Raw Water	Town Water Flow Rate L/sec	Consumption KL	Bore 6 Chlorine residual	Bore 6 Temperature	Raw Water Chlorine Residual	Raw Water Turbidity	Raw Water pH	Raw Water Temperature	Raw Water Iron	Raw Water Manganese	Train 1 Filtered Turbidity	Train 2 Filtered Turbidity	Train 3 Filtered Turbidity	Filtered Water Chlorine Residual	Filtered Water Turbidity	Filtered Water pH	Filtered Water Temperature	Town Water Chlorine residual	Town Water Turbidity	Town Water pH	Town Water Temperature	Town Water Iron	Town Water Manganese	Operator
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15 APPENDIX D - WTP Control Point Alert Limit Tables

15.1 Operational Monitoring and Alert Limits – Raw Water Treatment Plant Inlet

Water Supply System	Richmond		
Process Step / CCP ID	RSC CCP1		
What is the process step / control point?	Raw water abstraction / Bores	**What are the hazards?**	All pathogens, Iron and Manganese
What is being monitored?	Turbidity and Chlorine	**Monitoring Frequency:**	On–line continuous while operating, RW grab sample 3-5 days/wk when WTP operational.
Monitoring location	WTP inlet – Bore in operation selectable to on-line instrument and grab sample(s).		
What will initiate response?	Alarm from on-line instrument reading or Test on turbidity grab sample or manual cross check of on-line instrument.		

Target **1 NTU**	**Alert Level** **4 NTU**	**Critical Limit** **10 NTU**
• Routine site and operational checks • Equipment correlation checks (Plant record is maintained with cross checks against bench meters and records monitored via WTP PLC) • Raw water testing (Tb) • Individual Bore test 1/fortnight. • Once/month Total Fe, Tb, pH, temp, • Visual Inspections of Bores Weekly	**Corrective actions** • Repeat manual tests to confirm levels. • Test turbidity for each bore – change to alternative Bore if better water quality. • Visually assess Bore for increased turbidity and measure manually. • Initiate an incident monitoring program in both Bores if required. • Notify Water and Sewerage Coordinator (WSC) • Check coagulant dose rates – jar test and adjust as required. • Monitor and Increase Chlorine dose at plant, if needed. • Complete *'Initial Incident Report Form'*	**Corrective actions** • Isolate and contain source of high turbidity • Shutdown the treatment plant • Contact WSC • Consider alternative water supply/storage where possible • WSC to inform Manager – Director of Works • Monitor treatment process closely. Jar test and adjust plant set points/slow flow and monitor chemical dosing closely. • Maintain appropriate disinfection levels in the network • Management consider implementation of Incident Plan of Action – refer to Incident and Emergency Response Plan (e.g. boil water alert) • Complete *'Initial Incident Report Form'*

15.2 Operational Monitoring and Alert Limits – WTP Oxidation Stage

Water Supply System	Richmond		
Process Step / CCP ID	RSC CCP2		
What is the process step - control point?	Water Treatment Plant Oxidation Stage	**What are the hazards?**	Iron - Manganese (Aesthetic staining)
What is being monitored?	Turbidity	**Monitoring Frequency:**	Continuous on-line, Manual test 3-5d/wk
Monitoring location	Water Treatment Plant Bore 6 Dosed Water		
What will initiate response?	Increasing Filtered Water Turbidity – Low dosed water chlorine		

Target **<1 – 1.5 NTU** **1.1 – 1.4mg/L Cl**	**Alert Level** **>0.5 NTU** **<1mg/L or > 1.5mg/L Cl**	**Critical Limit** **>5NTU** **<0.5mg/L or > 4mg/L Cl**
• Routine site and equipment checks at WTP (Equipment correlation with bench meters and records stored in WQ Data Base/Plant sheets) • Oxidation dosing system inspection weekly • Oxidation tank inspection and jet nozzels weekly/fortnightly • Chemical procurement and delivery requirements • Chemical dosing rate checks • Instrument calibration and records maintained	**Corrective actions** • Validate readings with alternative meter where possible • Check sodium hypochlorite dosing rates and residuals. Adjust dose rate as required. • Jar test and adjust coagulant dose rate. • Initiate filter backwash sequence and observe. • Check raw water conditions e.g. Turbidity, pH, iron. • Check Bore for any signs of contamination. • Increase chlorine dose at plant if needed • Contact Tech Officer • Complete initial incident response notification form.	**Corrective actions** • Follow Alert Level corrective actions • Inform WSC • Take micro-sample if low disinfection levels or nitrification suspected. • Ensure adequate chlorine residual, increase dose rate to ensure residual is maintained to outlet of oxidation tanks (0.1 – 0.3mg/L). • WSC to contact manager • Management consider implementation of Incident Plan of Action – refer to Incident and Emergency Response Plan (e.g. boil water alert) • Complete *'Water Quality Incident Report Form part A & B', submit to DNRME.* • Seek technical support to identify and rectify fault

15.3 Operational Monitoring and Alert Limits – WTP Filtration Stage

Water Supply System	Richmond		
Process Step / CCP ID	RSC CCP3		
What is the process step - control point?	Water Treatment Plant Filtration Stage	**What are the hazards?**	Iron - Manganese
What is being monitored?	Turbidity	**Monitoring Frequency:**	Continuous on-line, Manual test 3-5d/wk
Monitoring location	Water treatment Plant Filter Outlet		
What will initiate response?	Increasing filtered water turbidity		

<u>Target</u> **<0.2 NTU**	**<u>Alert Level</u>** **>0.5 NTU**	**<u>Critical Limit</u>** **>5NTU**
• Routine site and equipment checks at WTP (Equipment correlation with bench meters and records stored in WQ Data Base/Plant sheets) • Routine checks of coagulant dose rates – dosing system. • Routine observation of backwash sequences and flow trends. • Chemical procurement and delivery requirements • Chemical dosing rate checks • Instrument calibration and records maintained	**Corrective actions** • Validate readings with alternative meter where possible • Check oxidation dosing rates and residuals. Adjust Dose rate as required. • Jar test and adjust coagulant dose rate. • Initiate filter backwash sequence and observe. • Check Bore Raw Water quality conditions e.g. Turbidity, pH, iron. • If RW NTU is >4NTU this may indicate a failure of a bore casing. • Check Bore for any signs of contamination. • Increase oxidation chlorine dose at plant to ensure adequate oxidation. • Contact Tech Officer – Notify Director of Works. • Complete initial incident response notification form.	**Corrective actions** • Follow Alert Level corrective actions • Inform WSC • Take micro-sample if low disinfection levels or nitrification suspected. • Increase chlorine residual rate to ensure residual is maintained to end of reticulation. • Consider top up chlorine dosing Reservoir • WSC to contact Director of Works (DOW) • DOW to contact DNRME & QLD Health • DOW consider implementation of Incident Plan of Action – refer to Incident and Emergency Response Plan (e.g. boil water alert) • Complete *'Water Quality Incident Report Form part A & B', submit to DNRME.* • Seek technical support to identify and rectify fault if necessary. • Consider scheduling filter inspection to assess media and internal condition of Filters.

15.4 Operational Monitoring and Alert Limits – Water Treatment Plant Outlet (Post Chlorine)

Water Supply System	Richmond		
Process Step - CCP ID	RSC CCP4		
What is the process step - control point?	Disinfection – Chlorine mg/L	**What are the hazards?**	Chlorine sensitive pathogens & Chemical (Chlorine)
What is being monitored?	Free Chlorine residual & pH	**Monitoring Frequency:**	Continuous on line and Manual test 5d/wk
Monitoring location	Water treatment Plant Filter Outlet		
What will initiate response?	In response to low or high Chlorine residual &/or pH		

Target **1.1 – 1.3mg/L Free Chlorine** **pH 7.0**	**Alert Level** **<1.0 or >1.5 mg/L Free Chlorine** **pH 8.3**	**Critical Limit** **<0.2 or >4.0 mg/L Free Chlorine** **pH <6.5 or >8.5**
• Routine site and equipment checks at WTP (Equipment correlation with bench meters and records stored in WQ Data Base/Plant sheets) • Chemical procurement and delivery requirements • Chemical dosing rate checks • Instrument calibration and records maintained	**Corrective actions** • Validate readings (using high ranges or dilution methods if required) • Check primary dosing equipment, chlorine tank levels and injection point. • Check disinfection levels (Free & Total chlorine, NTU & pH) from primary dosing and adjust as required • Sample upstream and downstream of sample to confirm • Check raw and/or filtered water conditions e.g. Turbidity, pH, colour • Increase/decrease chlorine dose at plant if needed. • Contact DOW • Complete *'Initial Incident Report Form'*	**Corrective actions** • Follow Alert Level corrective actions • Inform WSC • Take micro-sample if low disinfection levels or nitrification suspected. • Check reservoir outlet – Water to town chlorine residual. • Consider top up dosing of Reservoir • WSC to contact Director of Works (DOW) • DOW to consider advising DNRME – QLD Health (Precautionary advice) • Management consider implementation of Incident Plan of Action – refer to Incident and Emergency Response Plan (e.g. boil water alert) • Complete *'Initial Incident Report Form'*

15.5 Operational Monitoring and Alert Limits – Reservoir Integrity -

Water Supply System	Richmond		
Process step - CCP ID	RSC CCP5		
What is the process step - control point?	Reservoirs	**What are the hazards?**	All pathogens and all chemicals
What is being monitored?	Reservoir integrity – Chlorine Turbidity.	**Monitoring Frequency:**	Weekly – Monthly physical inspection with on-line WQ monitoring and manual WQ cross checks 3-5 d/wk.
Monitoring location	Reservoir outlet – reticulation entry point		
What will initiate response?	Any sign of Reservoir integrity breach		

Target **No breach of Reservoir integrity** **0.8 – 1mg/L Cl** **<0.2ntu**	**Alert Level** **Any sign of integrity breach** **<0.5 or > 1.5mg/L** **>0.5ntu**	**Critical Limit** **Evidence of contamination** **<0.2 or > 4mg/L Cl** **>5ntu**
• Reservoir inspection program (routine) with records maintained • Scheduled contractor reservoir cleaning and inspection program (in place?) • Routine equipment maintenance and calibration. • Routine inspection of dosing systems, and reservoir • Routine monitoring of SCADA trends	**Corrective actions** • Visual inspection (outside/inside of Reservoir) • Check disinfection levels free and total chlorine • Increase or decrease dose at plant, • Contact DOW • Adjust dose rates as required (Consider reservoir top up if low Cl) • Review trends and check backwashes have been completed, look for point of change and possible causes. • Repair breach of integrity • Complete *'Initial Incident Report Form'*	**Corrective actions** • Follow Alert Level corrective actions • Inform WSC • Take micro-sample if required • Remove contaminants, if safe to do so • Dose disinfectant to reservoir if needed • WSC to contact Director of Works (DOW) • Manager to contact DNRME – QLD Health • Management to consider the need to initiate an incident response. • Complete *'Initial Incident Report Form'* • Seek technical support as required.

16 APPENDIX E – Risk Assessment Review Workshop Attendees

Two risk workshops have been held in the development and ongoing implementation of the DWQMP. Attendees at 2017 and 2019 workshops are detailed below.

Review Update Attendees - 2017

Richmond Shire Council
Drinking Water Quality Risk Assessment
Workshop 9th Oct 2017

Location: Richmond SC Committee Room

Worksop facilities: Lap top with data projector (RSC) / Flip charts and pens (RSC) / Flip Chart stand (RSC) White Board

INVITEES			Record of Attendance	
Name	Organisation	Position/ Job title	Risk Workshop Monday 9th Oct 2017 1.00pm – 4.30pm * Tuesday 10th Oct 9.00am – 12.30pm.	Have you attended previous workshops for RSC DWMP review? Yes /No
Mark Samblebe	MBS Water Pty Ltd	Project Lead Workshop facilitator	[illegible]	No
Jillian Busch	Aqualift Project Delivery P/L	Scientific Officer & Risk Workshop facilitator	Jillian Busch.	No.
Michael Wanrooy	Richmond Shire Council	Director of Works	[illegible]	No
Amy Lawry	Richmond Shire Council	Works Administration Officer	[illegible]	No
Michelle Anstis	Richmond Shire Council	SUPPORT OFFICER	[illegible]	No.
Geoffrey Johnson	Richmond Shire Council	Water and Sewerage Officer	Geoffrey Johnson	NO
Peter Bennett (optional attendance)	Richmond Shire Council	CEO		
John Wharton (optional attendance)				
ALLAN-JOHN MATTHEWS	Richmond Shire Council	Junior Plumber.	Allan Matthews	NO

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Risk Review Update – August 2019 attendees

Richmond Shire Council
Drinking Water Quality Risk Assessment Review Workshop 6th Aug 2019

Location: Richmond SC Committee Room

Worksop facilities: Lap top with data projector (RSC) / Flip charts and pens (RSC) / Flip Chart stand (RSC) White Board

INVITEES			Record of Attendance	
Name	Organisation	Position/ Job title	Risk Workshop Monday 6th Aug 2019 1.00pm – 3.30pm	Have you attended previous workshops for RSC DWMP review? Yes /No
Mark Samblebe	MBS Water Pty Ltd	Project Lead Workshop facilitator	[illegible]	YES.
Jillian Busch	Aqualift Project Delivery P/L	Scientific Officer & Risk Workshop facilitator	[illegible]	Yes
Bart Servaas	Richmond Shire Council	Director of Works		
Amy Lawry	Richmond Shire Council	Works Administration Officer	[illegible]	Yes
Alan Matthews	Richmond Shire Council	Acting Water and Sewerage Officer	[illegible]	[illegible] YES
Peter Bennett (optional attendance)	Richmond Shire Council	CEO		
John Wharton (optional attendance)	Richmond Shire Council	RSC Mayor		

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17 APPENDIX F - Risk Assessment Tables

Below are the outcomes of risk assessment workshops and reviews undertaken in August 2019. Where an outstanding action has been completed, a residual risk ranking has changed or a new risk or hazard has been identified cells have been highlighted purple. Outstanding actions have been assessed and reviewed, where incomplete and estimate has been made to the percent completion of the actions.

This appendix is a working document and can be obtained by contacting the Office.

18 Appendix G. DWQMP Risk Management Improvement Plan (RMIP)

This appendix is a working document and can be obtained by contacting the Office.

19 Appendix H. Incident and Emergency Response Table

Incident / Emergency Level	Description of Level	Incident investigation and management Summary of Actions	Position / s responsible for Action /s
Level 3	Any of the following events		
	- Widespread outbreak of waterborne disease - Declared disaster Localised emergency impacting on water quality (e.g.. Industrial spill, accidents) - Terrorist or deliberate contamination threat Incident requires coordination across the council departments and is likely to require external resourcing and support from agencies, such as Qld Health, local disaster management groups, emergency responders QFRS, Police, Office of the Water Supply Regulator. -Cyber Security attack rendering WTP process control system inoperable or inaccessible. Emergency Response Plan / Disaster Management Plans activated.	- Notify CEO and internal Communications Department - Coordinate notification, investigation and response of aspects as defined in the Emergency Response / Disaster Management Plan or as directed by relevant agencies. - Notify Qld Health and OSWR immediately - Consider what community notification / messaging is needed (e.g. do not drink, boil water or bottled / emergency water distribution (see Appendix 3 and 4 of *Emergency Response Plan* for templates) in coordination with regulatory agencies. Notify internal communication department. Coordinate community messaging with Emergency Response process (such as issuing boil water or do not drink alerts)	Directors of Works Communications Department
Level 2	Any of the following events	Summary of action to be taken:	
	- A positive *E.coli* detection in the reticulation. - An exceedance of the ADWG health guideline value for a chemical parameter - Detection of a pathogen in the reticulation system - Failure of infrastructure that results in a the failure of supply to a large number of customers over an extended period. - Any event that is likely to have resulted in the delivery of contaminated water to customers where the delivery of contaminated water cannot be prevented. - Cyber Security attack that prevents process changes, or renders part of process inoperable. Incident may require coordination across Council departments and may require external resources and support.	- Notify Director of Works - Report detection of *E.coli* or chemical parameter that has exceeded the ADWG Health Guideline limit to Qld Health/OSWR immediately by phone and follow up with written confirmation (email) as per the Water Quality and Reporting Guidelines For Drinking Water - Commence investigation to determine cause - Specifically for *E.coli* detections, determine chlorine residuals and other operational parameters from the initial site and potentially affected areas - Arrange for re-samples to be taken where required - Investigate and instigate appropriate immediate remediation actions , including isolation of the affected areas, where possible - Review associated laboratory reports and operational records - Notify CEO - Coordinate community notification response where required	Water & Sewage Officer Emergency Incident Manager (if appointed by CEO) or Director of Works
Level 1	Any of the following events	Summary of action to be taken:	
	- An event including failure of the infrastructure where the quality of the drinking water is unlikely to affect public health or the water has not and will not be delivered to customers. - Exceedances of ADWG aesthetic guidelines This incident is likely to be managed within the teams responsible for drinking water operations and management. Customer complaints may result. Incident can be managed within the water operations team and support of Operations Coordinator	- Complaints recorded in customer correspondence log - Notify Water & Sewage Officer of complaints Coordinate investigation of complaints as per Customer Service Standards Procedure, including obtaining water samples where required. Where an investigation determines that the incident has occurred as described in Levels 2 or 3, escalate to the appropriate level. Operational monitoring and responses recorded in operational logs.	Customer service section Water & Sewerage Officer

20 Appendix I - O&M Procedure Documentation

Richmond Shire Council Drinking Water Supply Documents and Procedures								
Supply Area	**Document Title**	**Description**	**Document Reference**	**File Type**	**Electronic File Location**	**Hard Copy File Location**	**Last Updated**	**Document Owner**
Whole of Supply	Richmond Shire Disaster Management Plan	Regional disaster response plan	Exists - File location to be noted	Electronic/ Hard Copy		Head Office	Dec-17	CEO
Bores - Raw Water	Bore Inspection Procedure	Routine inspection and maintenance requirements (incl pumps) and record sheet for bore inspections. Valving diagrams.	In development	Electronic/ Hard Copy				Water and Sewage Officer
Bores - Raw Water	Bore Maintenance Procedure	Routine maintenance requirements and responsibilities for bores.	In development	Electronic/ Hard Copy				Water and Sewage Officer
Bores - Raw Water	Cooling System Operation and Maintenance Procedure	Cooling system operation/isolation procedure, valving diagrams.	In development	Electronic/ Hard Copy				Water and Sewage Officer
Water Treatment Plant	WTP Operations and Maintenance Manual	Basic WTP operations principals, equipment manufacturers manuals, as constructed drawings.	Exists - requires storage in DWQMP Document folder	Electronic/ Hard Copy	WTP Computer	Water Treatment Plant/ Council Offices	Jun-15	Water and Sewage Officer
Water Treatment Plant	Dosing System Inspection Procedure	Routine chemical dosing inspection requirements, delivery and storage refilling instructions. Inspection record sheet.	In development	Electronic/ Hard Copy				Water and Sewage Officer
Water Treatment Plant	Chemical delivery and acceptance procedure	Instructions for accepting and transferring new chemical deliveries. Chemical ordering setpoints.	In development	Electronic/ Hard Copy				Water and Sewage Officer
Water Treatment Plant	Oxidation tank inspection and record procedure.	Inspection procedure for oxidation tank, corrective actions summary, inspection record sheet.	In development	Electronic/ Hard Copy				Water and Sewage Officer
Water Treatment Plant	On line and portable instrument maintenance and calibration procedure.	Maintenance and calibration requirements for on line and portable monitoring equipment, calibration and maintenance log sheet. Include external contractor scheduled maintenance requirements.	In development	Electronic/ Hard Copy				Water and Sewage Officer
Water Treatment Plant	Filter inspection and maintenance procedure	Filter inspection and maintenance requirements, corrective actions and inspection log sheet	In development	Electronic/ Hard Copy				Water and Sewage Officer
Water Treatment Plant	Pumpset maintenance and inspection procedure	Frequency and overview of routine pump maintenance requirements. Maintenance record sheet.	In development	Electronic/ Hard Copy				Water and Sewage Officer
Water Treatment Plant	Generator maintenance and inspection procedure.	Routine generator maintenance and inspection requirements, maintenance and inspection record sheet.	In development	Electronic/ Hard Copy				Water and Sewage Officer

Water Treatment Plant	WTP WQ and flow record sheet	Record sheet for routine water quality testing and flow reporting for water treatment plant	Exists - requires storage in DWQMP Document folder.	Electronic/ Hard Copy				Water and Sewage Officer
Water Treatment Plant	Site security and general inspection procedure	Routine site inspection and security inspection requirements and record sheet.	In development	Electronic/ Hard Copy				Water and Sewage Officer
Water Treatment Plant - Reservoir	Clear Water Storage inspection and maintenance procedure	Routine inspection and maintenance guide for clear water storage reservoir including after storm events.	In development	Electronic/ Hard Copy				Water and Sewage Officer
Water Treatment Plant - Reservoir	Master inspection record sheet	Record sheet of all WTP site inspection activities.	In development	Electronic/ Hard Copy				Water and Sewage Officer
Distribution System	Main Break Repair Procedure.	Main break repair and water quality monitoring requirements. Repair record sheet.	In development	Electronic/ Hard Copy				Water and Sewage Officer
Distribution System	Backflow Prevention device inspection and testing procedure.	Routine maintenance and inspecting requirements for back flow prevention.	Exists - storage in DWQMP Document folder.	Electronic/ Hard Copy				Water and Sewage Officer
Distribution System	New mains commissioning and activation procedure.	Requirements for bringing a new main into service.	In development	Electronic/ Hard Copy				Water and Sewage Officer
Distribution System	WTP bypass procedure	Instruction for bypassing of WTP in the event of a major malfunction or process/equipment failure.	In development	Electronic/ Hard Copy				Water and Sewage Officer
Distribution System	Mains flushing and monitoring procedure	Instruction for routine flushing or flushing due to event/failure.	In development	Electronic/ Hard Copy				Water and Sewage Officer
Distribution System	Chemical - Physical Water Quality Monitoring Procedure	Instructions for field testing of WQ parameters	Draft developed for approval	Electronic/ Hard Copy				Water and Sewage Officer
Whole of supply	Water quality monitoring and external verification procedure.	Instruction for sample collection and analysis, external verification sampling frequency and analysis.	Exists - requires storage in DWQMP Document folder.	Electronic/ Hard Copy				Water and Sewage Officer
Whole of supply	Complaints management and record keeping procedure.	Instructions for dealing with and recording activities in response to complaints.	In development	Electronic/ Hard Copy				Water and Sewage Officer
Whole of Supply	Richmond Water Supply Operational Monitoring Program 2018	Summary of key operational monitoring priorities and reasoning.	Draft developed for approval	Electronic/ Hard Copy				Water and Sewage Officer
Whole of Supply	Richmond Verification Monitoring plan	Details requirements and schedule for verification monitoring	Draft developed for approval	Electronic/ Hard Copy				Water and Sewage Officer
Whole of Supply	Drinking Water Incident Report Form	Template for reporting of incidents	Draft developed for approval	Electronic/ Hard Copy				Water and Sewage Officer & DoW
Whole of Supply	Operator Site Task List	Listing of all the daily, weekly, monthly, annual operational tasks	Draft developed for approval					

21 Appendix J – Verification Monitoring

Parameters for analysis under Richmond Shire Council Verification Monitoring Program are detailed in the table below. Frequency and location of samples can be seen in Tables provided below. Verification monitoring is undertaken at four town sites per month within the Richmond Water Supply scheme. All external samples must include field results for Chlorine (Free), Turbidity, temperature and pH.

Richmond Shire Council External Verification Water Quality Analysis Program				
Analysis External	**Frequency and Location.**			
Physicochemical Parameters	**Monthly**	**Quarterly**	**Six Monthly**	**Sample Sites**
pH	X	X	X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Turbidity, ntu	X	X	X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Colour True, Pt/Co	X	X	X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Conductivity	X	X	X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Alkalinity, mg/L as CaCO3			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Silica, mg/L as SiO2			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Biological - Pathogens				
Total Coliforms, CFU/100ml	X	X	X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Ecoli, CFU/100ml	X	X	X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Cations				
Calcium			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Magnesium			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Sodium			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Potassium			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Ammonium an N			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Iron Total	X	X	X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Iron Soluble	X	X	X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Manganese Total	X	X	X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Manganese Soluble	X	X	X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Copper			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Zinc			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Aluminium			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Lead			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Chromium			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Anions				
Carbonate			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Bicarbonate as HCO3-			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Bicarbonate as CaCO3			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Hydroxide			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Fluoride			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Chloride			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Sulphate			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Nitrate as N			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Phosphate as P			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Bromide			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Derived values and indeces				
Hardness as CaCO3 mg/L			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Total Dissolved Solids			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Sodium adsorption ratio			X	RWB5, RWB6, WTPO, PLUS 1 RANDOM RETICULATION SITE
Disinfection By-Products				
Chlorate		X*	X	WTPO, PLUS 1 RANDOM RETICULATION SITE
Chlorite		X*	X	WTPO, PLUS 1 RANDOM RETICULATION SITE
Trihalomethanes		X*	X	WTPO, PLUS 1 RANDOM RETICULATION SITE
* = Only for water treatment plant outlet and reticulation sites - disregard for Raw water sample sites.				

RICHMOND SHIRE COUNCIL INTERNAL & EXTERNAL VERIFICATION MICROBIOLOGICAL AND CHEMICAL SAMPLING AND ANALYSIS SCHEDULE											
Scheme	**Richmond Shire**										
Supply Area- Township	**Richmond**										**Maxwelton**
All Samples to include field testing for Free Chlorine, Total Chlorine, Turbidity, Temperature and pH.											
Sample Site Code	RWB5	RWB6	RWB7	WTPO	RS1	RS2	RS3	RS4	RS5	RS6	RWMB
Sample Site	**Bore 5 Raw Water**	**Bore 6 Raw Water**	**Bore 7 Raw Water**	**Water Treatment Plant Outlet**	**Reticulation System Boat Ramp**	**Reticulation System Lions Park**	**Reticulation System Water park**	**Reticulation System Carpentaria Fuel Depot**	**Reticulation System Race Course**	**Reticulation System Skate Park**	**Raw Water Maxwelton Bore**
Week #											
1	Internal Micro		Internal Micro	Internal Micro	Internal Micro						
2		Internal Micro	Internal Micro	Internal Micro		Internal Micro					
3	6 Monthly Micro & Chemistry*	6 Monthly Micro & Chemistry*	6 Monthly Micro & Chemistry*	6 Monthly Micro & Chemistry			6 Monthly Micro & Chemistry				Internal Micro
4		Internal Micro	Internal Micro	Internal Micro				Internal Micro			
5		Monthly Micro & Chemistry	Monthly Micro & Chemistry	Monthly Micro & Chemistry		Monthly Micro & Chemistry					Internal Micro
6	Internal Micro		Internal Micro	Internal Micro					Internal Micro		
7		Internal Micro	Internal Micro	Internal Micro						Internal Micro	
8	Internal Micro		Internal Micro	Internal Micro	Internal Micro						
9	Monthly Micro & Chemistry		Monthly Micro & Chemistry	Monthly Micro & Chemistry			Monthly Micro & Chemistry				Internal Micro
10		Internal Micro	Internal Micro	Internal Micro		Internal Micro					
11	Internal Micro		Internal Micro	Internal Micro			Internal Micro				
12		Internal Micro	Internal Micro	Internal Micro					Internal Micro		
13		Quarterly Micro & Chemistry*	Quarterly Micro & Chemistry*	Quarterly Micro & Chemistry				Quarterly Micro & Chemistry			Internal Micro
14	Internal Micro		Internal Micro	Internal Micro						Internal Micro	
15		Internal Micro	Internal Micro	Internal Micro	Internal Micro						
16	Internal Micro		Internal Micro	Internal Micro		Internal Micro					
17	Monthly Micro & Chemistry		Monthly Micro & Chemistry	Monthly Micro & Chemistry					Monthly Micro & Chemistry		Internal Micro
18	Internal Micro		Internal Micro	Internal Micro			Internal Micro				
19		Internal Micro	Internal Micro	Internal Micro				Internal Micro			
20	Internal Micro		Internal Micro	Internal Micro						Internal Micro	
21		Monthly Micro & Chemistry	Monthly Micro & Chemistry	Monthly Micro & Chemistry						Monthly Micro & Chemistry	Internal Micro
22		Internal Micro	Internal Micro	Internal Micro	Internal Micro						
23	Internal Micro		Internal Micro	Internal Micro		Internal Micro					
24		Internal Micro	Internal Micro	Internal Micro			Internal Micro				
25	Internal Micro		Internal Micro	Internal Micro				Internal Micro			Internal Micro
26		Internal Micro	Internal Micro	Internal Micro					Internal Micro		
27	6 Monthly Micro & Chemistry	6 Monthly Micro & Chemistry	6 Monthly Micro & Chemistry	6 Monthly Micro & Chemistry	6 Monthly Micro & Chemistry						
28		Internal Micro	Internal Micro	Internal Micro						Internal Micro	
29		Monthly Micro & Chemistry	Internal Micro	Monthly Micro & Chemistry		Monthly Micro & Chemistry					Internal Micro
30			Internal Micro	Internal Micro	Internal Micro						

31	Internal Micro		Internal Micro	Internal Micro			Internal Micro				
32			Internal Micro	Internal Micro				Internal Micro			
33	Monthly Micro & Chemistry	Internal Micro	Monthly Micro & Chemistry	Monthly Micro & Chemistry	Monthly Micro & Chemistry						Internal Micro
34			Internal Micro	Internal Micro					Internal Micro		
35			Internal Micro	Internal Micro	Internal Micro						
36			Internal Micro	Internal Micro		Internal Micro					
37		Internal Micro	Internal Micro	Internal Micro				Internal Micro			Internal Micro
38	Internal Micro		Internal Micro	Internal Micro					Internal Micro		
39	Quarterly Micro & Chemistry	Quarterly Micro & Chemistry	Internal Micro	Quarterly Micro & Chemistry			Quarterly Micro & Chemistry			Internal Micro	
40	Internal Micro		Internal Micro	Internal Micro	Internal Micro						
41	Monthly Micro & Chemistry		Monthly Micro & Chemistry	Monthly Micro & Chemistry					Monthly Micro & Chemistry		Internal Micro
42		Internal Micro	Internal Micro	Internal Micro		Internal Micro					
43	Internal Micro		Internal Micro	Internal Micro			Internal Micro				
44		Internal Micro	Internal Micro	Internal Micro				Internal Micro			
45	Anual Micro & Chemistry	Anual Micro & Chemistry	Internal Micro	Monthly Micro & Chemistry					Internal Micro		Internal Micro
46			Internal Micro	Internal Micro			Internal Micro		Internal Micro		
47			Internal Micro	Internal Micro		Internal Micro				Internal Micro	
48			Internal Micro	Internal Micro				Internal Micro	Internal Micro		
49		Monthly Micro & Chemistry	Monthly Micro & Chemistry	Monthly Micro & Chemistry		Monthly Micro & Chemistry					Internal Micro
50	Internal Micro		Internal Micro	Internal Micro			Internal Micro				
51		Internal Micro	Internal Micro	Internal Micro	Internal Micro			Internal Micro			
52	Internal Micro		Internal Micro	Internal Micro					Internal Micro		