Report

Water Safety Plan for the Palmerston North Water Supply

Prepared for Palmerston North City Council

By CH2M Beca Limited

9 June 2017

Revision History

Revision Nº	Prepared By	Description	Date
A	Claire Scrimgeour	Draft for Discussion and Client Input	2/4/2015
B	Claire Scrimgeour	Final Draft for Client Approval	25/5/2015
C	Claire Scrimgeour	Final	11/6/2015
D	David Yorke	Final incorporating Drinking-Water Assessor comments as provided by Client.	09/09/2015
E	Dora Luo	Update followed the implementation inspection	09/06/2017

Document Acceptance

Action	Name	Signed	Date
Prepared by	Claire Scrimgeour		09/09/2015
Reviewed by	David Yorke		09/09/2015
Approved by	Andrew Watson		09/09/2015
on behalf of	CH2M Beca Limited		

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Appendices

1 Introduction

The Health (Drinking-water) Amendment Act 2007 requires drinking-water suppliers to prepare and implement a Water Safety Plan (previously known as a Public Health Risk Management Plan) for their supplies.

The first Water Safety Plan (WSP) for the Palmerston North Water Supply was prepared by Palmerston North City Council in 2008 and the document was updated in May 2010. The original document has proved difficult to maintain so it was decided to put all the information into 1 main document with the risk tables in 1 spreadsheet.

Progress with the tasks on the improvement schedule for the 2010 WSP has been assessed annually and an update provided to the Drinking Water Assessor.

Compliance for the Palmerston North Water Supply is assessed annually by the Drinking Water Assessor. Palmerston North Water Supply is currently fully compliant with the requirements of the Drinking-water Standards for New Zealand 2005 (Revised 2008) as summarised in Table 1.

Table 1 – Compliance with DWSNZ for 1 July 2013 to 30 June 2014

Zone name	Bacterial Compliance	Protozoal Compliance	Cyanotoxin Compliance	Chemical Compliance	Radiological Compliance	Overall Compliance
Treatment Plants/Bores						
Keith St	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
Papaioea	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
Roberts Line	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
Takaro	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
Turitea	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
Distribution						
Aokautere	Compliant	Not applicable	Compliant	Compliant	Not applicable	Compliant
Fitzherbert West	Compliant	Not applicable	Compliant	Compliant	Not applicable	Compliant

Table from: Report on Compliance with the Drinking-water Standards for New Zealand 2005 (Revised 2008) and duties under Health Act 1956, Central North Island Drinking Water Assessment Unit, MidCentral Health.

This Water Safety Plan (WSP) for the Palmerston North Water Supply was prepared by Palmerston North City Council and CH2M Beca. Representatives from Operations and Maintenance, Risk Management, Planning and Development and Health & Safety have been consulted and involved in identifying risks for the WSP, including participation in a WSP workshop.

This WSP is submitted based on the water supply in its current state as at August 2015. This WSP will be briefly reviewed and updated annually in accordance with the Annual Compliance Reports and fully reviewed and updated every five years and/or whenever there is a significant change made to the Palmerston North Water Supply. All reviews and updates will be completed by Palmerston North City Council and the new WSPs will be forwarded to the Drinking-Water Assessor. On approval of the WSP by The Drinking-Water Assessor, the approval report will be presented to the Council's Management Team for implementation of the WSP.

The key steps in preparing this Water Safety Plan for Palmerston North Water Supply are:

- Risk Assessment: The first part of the document considers the barriers to contamination. Securing the safety of drinking water supplies is based on the use of multiple barriers, from catchment to consumer, to prevent the contamination of drinking water or to reduce contamination to levels not injurious to health. Possible events that might lead to hazards are identified, preventive measures are considered and the level of risk to public health from these events is assessed.
- Risk Management: Based on the results of the risk assessment the second part of the document lists improvements to the supply with a programme for their introduction and the resources needed to do this.

Note this WSP considers risks to public health. It is acknowledged that staff or contractors' health may be at risk from a number of site specific issues related to the operation and maintenance of the Palmerston North Water Supply, but these are not covered by this WSP as such risks are the subject of health and safety in employment legislation, and site specific operations and health and safety manuals.

"A Framework on How to Prepare and Develop Public Health Risk Management Plans for Drinking-water Supplies", Ministry of Health 2005, has been used in preparing this plan.

The Ministry of Health guides listed below have been used to assist in identifying risks to the water supply. Additional risks have been identified through a workshop and consultation with PNCC staff.

- Source and Abstraction
  - S1.1 Raw water: Surface and groundwaters
  - P1.2 Source abstraction: Surface Water - Lakes and Reservoirs
  - P1.3 Source abstraction: Groundwaters – Bores and Wells
- Treatment
  - P4.2 Pre-treatment: Destratification
  - P5.1 Conventional Coagulation/Flocculation/Sedimentation
  - P6.1 Rapid Sand Filtration
  - P7.1 Disinfection: Chlorine Disinfection
  - P8.1 Aesthetic property adjustment: pH adjustment
  - P8.2 Aesthetic property adjustment: Iron/Manganese removal
  - P9.1 Fluoridation
  - P10 Pump operation (also applicable to distribution system)
  - P11 Drinking-water treatment plant construction and operation
- Storage and Distribution System
  - D1 Post-treatment storage
  - D2.1 Reticulation network: Construction Materials
  - D2.2 Reticulation network: System pressure
  - D2.3 Reticulation network: Operation
  - D2.4 Reticulation network: Backflow prevention
  - P2 Water Transmission (also applicable to distribution system)
- General Elements
  - G1 Staff training (draft)
  - G2 Monitoring (draft)

2 Palmerston North Water Supply

2.1 Description

The city of Palmerston North is situated in the Manawatu and has a population of approximately 85,000.

The water supply to the main urban area of Palmerston North is sourced from the Turitea Stream and is supplemented by four bore sites at Papaioea Park, Takaro Park, Keith Street and Roberts Line. There are two storage dams in the Turitea Valley that provide approximately 60 days of storage at average day demand.

Surface water treatment involves coagulation, flocculation, clarification, rapid sand filtration and disinfection using chlorine. Groundwater is from a secure aquifer and of good quality. Groundwater is disinfected with chlorine to remove small amounts of ammonia and manganese and provide a disinfectant residual. Fluoride is added to the surface and groundwater supplies as a dental health measure.

Treated water from Turitea WTP is stored in three reservoirs, a small reservoir located at the Turitea WTP and two larger reservoirs at Ngahere Park. The water supply reticulation servicing the main urban area comprises approximately 481km of pipelines, three pressure booster pumping stations and a pressure management station with booster facilities. Water is delivered to approximately 27,700 service connections.

The layout of the Palmerston North water supply is shown in Figure 1.

2.2 Ownership

Palmerston North City Council owns the majority of the land within the Turitea Catchment, the land and the buildings occupied by the Turitea Treatment Plant, four bores (Papaioea Park, Takaro Park, Keith Street and Roberts Line), and the two reservoirs at Ngahere Park. All of these sites are designated for water supply purposes.

City Networks oversee the water supply operations and make key decisions about asset management. The day to day operation and maintenance of the water supply activity is carried out by the City Enterprises operations team, assisted by specialist external contractors for electrical/control maintenance work, in accordance with a number of Service Level Agreements.

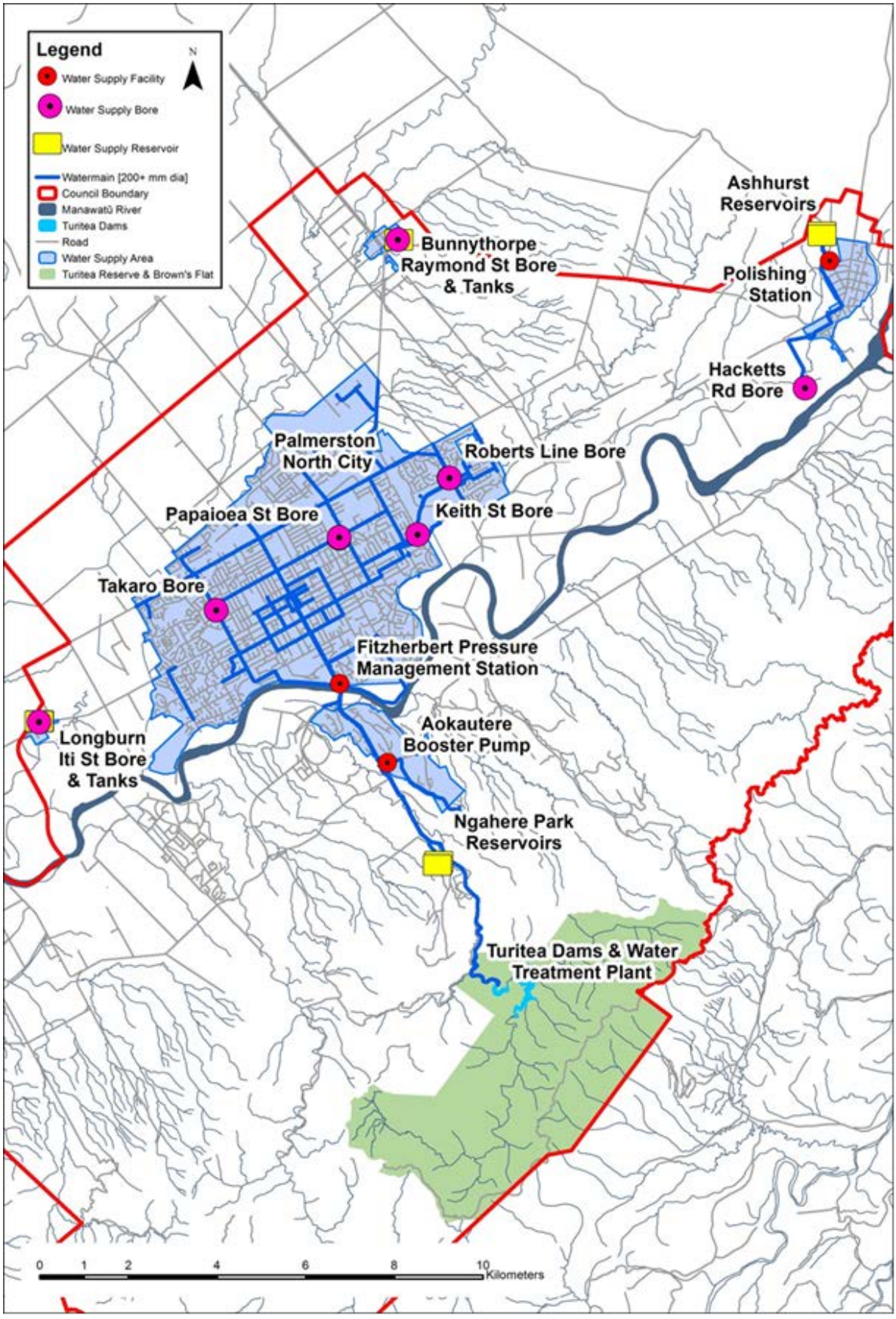

Figure 1 – Layout of Palmerston North Water Supply

2.3 Sources and Treatment Plants

2.3.1 Turitea Water Treatment Plant

The Turitea supply is drawn from the catchment area of the Turitea Stream at the northern end of the Tararua Ranges. The catchment area of 2,400 ha is located in the Turitea Reserve which is managed to protect water supply quality and storage.

Two dams store water from the Turitea Stream. The Lower Dam with 180 ML capacity was constructed in 1913 and raised to its current height in 1997. The Upper Dam with 1,682 ML capacity was completed in 1956.

Water flows from the Upper Dam, through the intake pipe and mini-hydro, into a stilling basin at the toe of the Upper Dam before discharging via the Turitea Stream into the Lower Dam.

Water is abstracted from the Lower Dam and flows to the Turitea WTP via a single raw water pipe.

A schematic of the Turitea WTP is shown in Figure 2.

The treatment process involves:

- Pre-pH correction using soda ash;
- Dosing with potassium permanganate ($KMnO_4$) (as required for manganese removal);
- Coagulation, flocculation and sedimentation;
- Rapid sand filtration;
- pH adjustment;
- Chlorination;
- Fluoridation;
- PAC dosing (as required for taste/odour removal).

The water treatment process is further detailed in Figure 3.

Historical issues at the Turitea WTP have included: low dam levels during droughts, algal blooms, manganese released when dams turn over, dam safety, and the treatment plant access road. In future there could be increased impact from forestry harvesting in the catchment and heavy traffic on the access roads. Resource consent has been obtained by an energy company for a wind farm partly on the Turitea Reserve area, however, a construction date for the wind farm is not known at this stage.

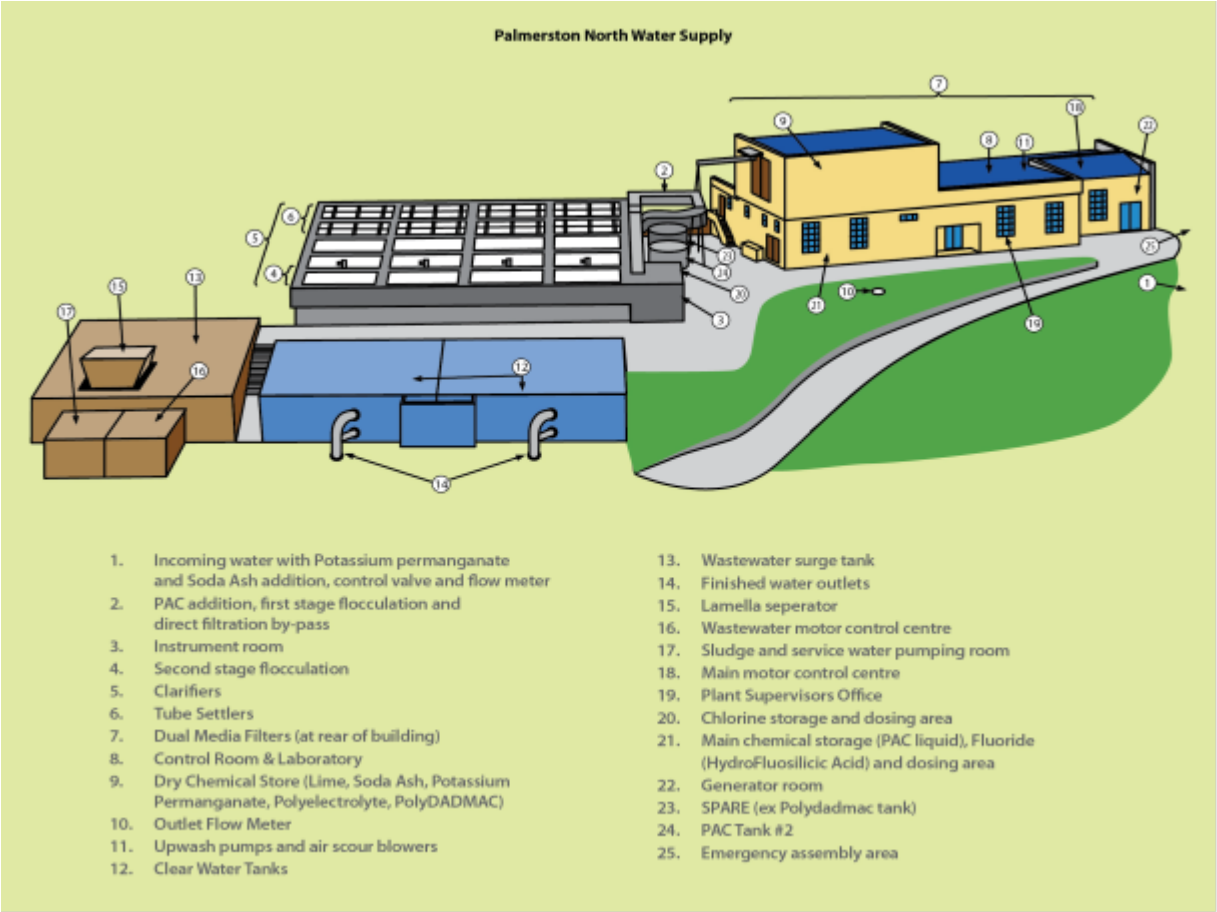

Figure 2 – Turitea WTP Schematic

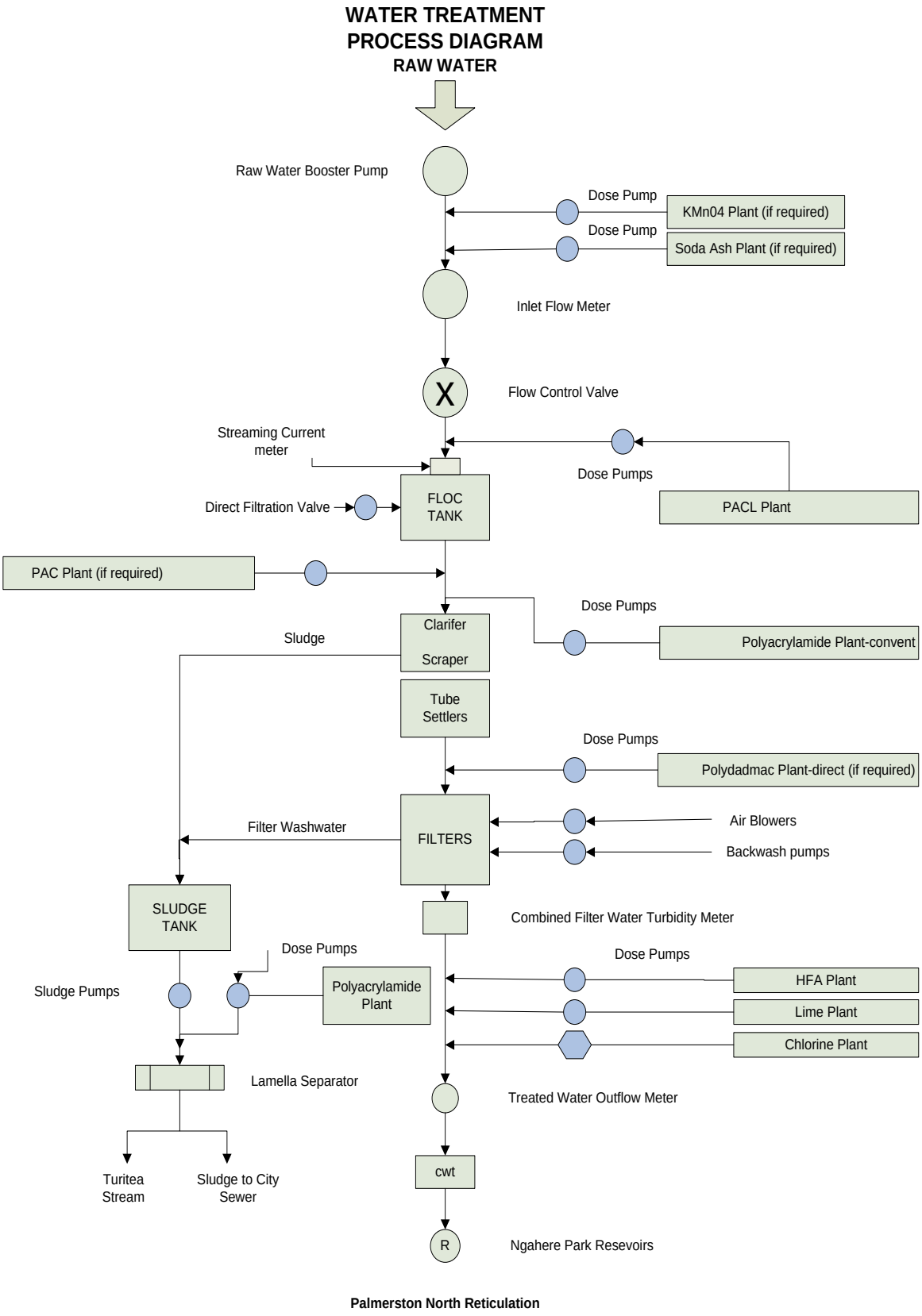

Figure 3 – Turitea WTP Treatment Process Flow Diagram

2.3.2 Bores

Bores are located at four locations on the western side of Palmerston North. Papaioea and Roberts Line have 2 bores at the sites with the older bores being used as standbys. The remaining bores are located at Takaro Park and Keith Street. Appendix B outlines the capacity of the bores, construction and operation details and age.

The bores are deep enough to be protected from surface water contamination and meet the requirements for secure groundwater under the DWSNZ. The bore water does not need to be disinfected to ensure water quality, however, a small amount of chlorine (or hypochlorite at Roberts Line) is added to oxidise hydrogen sulphide and ammonia naturally present and provide a protective residual in the reticulation (chloramines). Fluoride is added for dental health purposes.

No storage is provided at the bore sites so water is pumped directly into the reticulation which is controlled by pressure in the system.

Historical issues at the bores have included: declining yield, sand ingress into supply from aquifer, flow reversal disturbing mains sediment, hardness, meeting growth requirements, and lack of a standby for the Upper Kelvin Grove pressure zone.

2.4 Reservoirs

The treated water storage reservoirs are located at:

- Turitea WTP - 1,000m^3
- Ngahere Park (old) - 9,000m^3
- Ngahere Park (new) - 6,000m^3

The reservoirs are of reinforced concrete with roofs and are in good structural condition. None of the reservoirs has earthquake shut down facilities.

2.5 Reticulation Network

There is approximately 535km of main in the network (including rural pipes), which consists mainly of asbestos cement (AC) and PVC pipe with small amounts of cast iron (CI) pipe. Other assets in the reticulation include valves, hydrants, pressure reducing/sustaining valves and booster stations.

There are five main pressure zones:

- Main Aokautere Pressure Zone;
- Lower Aokautere Pressure Zone;
- Main Pressure Zone;
- Lower Kelvin Grove Pressure Zone;
- Upper Kelvin Grove Pressure Zone.

Water is also supplied to Linton area from the Main Aokautere pressure zone.

2.6 Operations, Monitoring and Control

City Networks oversee the water supply operations and make key decisions about asset management. The day to day operation and maintenance of the water supply activity is carried out by the City Enterprises operations team in accordance with a number of Service Level Agreements.

In order to achieve compliance with the DWSNZ, City Networks and City Enterprises work with an accredited contracted laboratory (CEL) to sample, test and store the test results.

Council has a telemetry system which links the Turitea WTP, bores and reservoirs to a central site. Turitea WTP has a separate SCADA system for monitoring and controlling the plant.

The Turitea WTP has an ISO9001/14000 Series Quality Assurance System which has maintained AS/NZS ISO 9001:2008 registration.

3 WSP Preparation and Methodology

The purpose of a WSP is to assist the Water Authority to identify and manage risks to the water supply that may have an effect on public health. WSPs encourage the use of risk-management principles, and identify situations that may lead to the contamination of the water supply and the actions necessary to protect the public.

Information provided by the Ministry of Health[1] was used as a guide in preparing the WSP. The Ministry of Health recommends the following steps are taken when preparing a WSP:

- Develop a flow diagram of the supply that includes all elements that must be considered as part of the WSP;
- Identify barriers to contamination present in the supply;
- Identify events that may introduce hazards into the water, and then consider causes, preventative measures and corrective actions for each event.

The WSP has been prepared in collaboration with PNCC staff and using available information from the 2010 WSP and other Council documents. Key documents relevant to this WSP are:

- Turitea Operations Manuals – Quality System, Chemical Plant, Work Instructions Operation (audited 6 monthly);
- Cyanobacteria Management Framework;
- Water Supply Asset Management Plan 2014;
- Draft Water Supply Bylaw and Backflow Prevention Policy 2015;
- Water Supply Development Plan Project reports 2014/15.

Further input was provided by PNCC staff into the monitoring and maintenance plans and improvement schedule.

[1] Ministry of Health. 2005. *A Framework on How to Prepare and Develop Public Health Risk Management Plans for Drinking-water Supplies.* Wellington: Ministry of Health.

4 Barriers to Contamination

The following table describes the barriers to contamination present for the Palmerston North Water Supply.

Table 2 – Barriers to Contamination

Supply	Barrier	Barrier Description
Turitea WTP	Stop contamination of raw water	■ Protected surface catchment. ■ Turitea Reserve fenced off from surrounding farmland.
	Remove particles from the water	■ Coagulation/ flocculation/ filtration. ■ PAC.
	Kill germs in the water	■ Disinfection (chlorine).
	Prevent recontamination after treatment	■ Water is delivered through pressurised pipes and covered reservoirs. ■ PNCC has a backflow prevention policy. ■ Backflow prevention device installation and maintenance programme. ■ Chlorine residual maintained in reticulation. ■ Trained staff and contractors. ■ Alarm systems.
Bores	Stop contamination of raw water	■ Existing planning rules regarding land use. ■ Meet DWSNZ secure groundwater classification. ■ Wells are fenced off. ■ Wellheads are constructed to avoid contamination and are raised above flood level.
	Remove particles from the water	■ The groundwater turbidity is typically less than 0.2 NTU. *E. coli* monitoring has shown concentrations consistently less than 1 MPN/100mL.
	Kill germs in the water	■ Disinfection (chlorine/hypochlorite).
	Prevent recontamination after treatment	■ Water is delivered through pressurised pipes ■ PNCC has a backflow prevention policy. ■ Backflow prevention device installation and maintenance programme. ■ Chlorine/chloramine residual maintained in reticulation. ■ Trained staff and contractors. ■ Alarms system.

5 Risk Information Tables

The risk information tables set out possible events for the Palmerston North water supply that may create public health risks. These are included in Appendix A.

The risk information tables include:

- The level of risk based on the likelihood and consequence of the event;
- The causes of each risk event;
- Preventive measures currently in place to avoid consequences of the risk event;
- Checks to determine whether the preventive measures are working;
- Corrective actions required where current preventive measures are insufficient to avoid consequences of the risk event.

Appendix 2 of *"A Framework on How to Prepare and Develop Water Safety Plans for Drinking-water Supplies"* provides scale descriptions for five categories of likelihood and five categories of consequences which are then used in a matrix for estimating risk. These scale descriptions and the resulting risk matrix has been used for the purposes of this WSP and is repeated below. The level of risk was assessed by Palmerston North City Council's engineering and operations teams.

5.1 Likelihood scale

Table 3 – Likelihood Scale

Likelihood ranking	Description
Rare	May occur only in exceptional circumstances (once in 1000 years)
Unlikely	Could occur (once in 100 years)
Possible	Might occur at some time (once in 10 years)
Likely	Will probably occur (once in 1 or 2 years)
Almost certain	Is expected to occur in most circumstances

Table from: *A Framework on How to Prepare and Develop Public Health Risk Management Plans for Drinking-water Supplies, MoH, 2005*

5.2 Consequence scale

The consequence table has been developed for this WSP to provide more specific and measurable consequences.

Table 4 - Consequence Scale

Consequence ranking	Description
Insignificant	■ Insignificant impact ■ Little disruption to normal operation ■ Small increase in operation costs
Minor	■ Short disruption of service (<1 hour) to part of a zone ■ Limited restrictions on outdoor water use to reduce demand ■ Aesthetic water quality event for some consumers ■ No reported illness ■ Some manageable operation disruption ■ Some increase in operating costs.

Consequence ranking	Description
Moderate	■ Disruption of service (<4 hours) to one or more zone ■ Restrictions on outdoor water use to reduce demand ■ Water quality event that requires flushing to clear ■ Boil water notice for up to 3 days ■ No reported illness ■ Significant modification to normal operation but manageable ■ Operation costs increased ■ Increased monitoring
Major	■ Disruption of service (>4 hours) to two or more zones ■ Prolonged boil water notice ■ Probable illnesses ■ Adverse publicity and loss of trust of consumers ■ Systems significantly compromised and abnormal operation if at all ■ High level of monitoring required
Catastrophic	■ Disruption of complete supply for one or more day ■ Several instances of illness in the community or instance of death ■ Prolonged boil water notice ■ Significant negative national press and long term loss of trust of consumers ■ Complete failure of systems

5.3 Level of Risk

Table 5 – Risk Framework

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	**High**	**High**	**Extreme**	**Extreme**	**Extreme**
Likely	**Moderate**	**High**	**High**	**Extreme**	**Extreme**
Possible	**Low**	**Moderate**	**High**	**Extreme**	**Extreme**
Unlikely	**Low**	**Low**	**Moderate**	**High**	**Extreme**
Rare	**Low**	**Low**	**Moderate**	**High**	**High**

Table from: *A Framework on How to Prepare and Develop Public Health Risk Management Plans for Drinking-water Supplies, MoH, 2005*

6 Summary of Level of Risk

The risk assessment for the Extreme, High, Moderate and Low risk events from the risk information tables contained in Appendix A are summarised in the tables below.

6.1 Source and Abstraction

Table 6 - Source and Abstraction Risks

Event Reference	Event	Cause	Risk Assessment of Existing		
			Likelihood	Consequence	Residual Risk
	Raw Water				
SA1	Source water receives more faecal matter from livestock or feral animals than the treatment plant is designed for.	• Animals within source protection zone (pests.)	Rare	Moderate	Moderate
SA2	Source water receives more sediment and agrichemicals from forestry activities than the treatment plant is designed for.	• Poor forestry management practices.	Unlikely	Insignificant	Low
SA3	Source water receives ash from volcanic activity.	• Volcanic eruption.	Rare	Minor	Low
SA4	Source water receives diesel spill or other contamination as a result of third party construction activities (electricity transmission lines & pylons).	• Third party activities.	Unlikely	Minor	Low
SA5	Source water experiences algal bloom.	• Conditions are suitable for algal growth - elevated nutrient levels, sunshine, warmth and relatively still water. • Temperature stratification.	Possible	Minor	Moderate
SA6	Source water receives leakage of contaminants down abandoned or decommissioned wells.	• Abandoned or improperly decommissioned wells within the source protection zone.	Unlikely	Major	High
SA7	Bore source water contaminated by sand.	• Excessive abstraction, sand passing the bore structure and screen.	Likely	Insignificant	Moderate

Event Reference	Event	Cause	Risk Assessment of Existing		
			Likelihood	Consequence	Residual Risk
	Surface Water Abstraction - Surface Waters - Lakes/Reservoirs				
SA8	Not enough source water available for abstraction.	• Drought. Discharge required from lower dam to maintain the stream Eco-flow.	Possible	Moderate	High
SA9	Raw water quality too poor to treat.	• Heavy rain leading to high levels of turbidity and organic matter in water entering the plant. • High algal content. • Seasonal turnover within dams. • Water level too low so forced to take poorly oxygenated water.	Unlikely	Moderate	Moderate
SA10	Too little water can be drawn from the intake to meet demand (as a result of pipe or mechanical failure).	• Screens damaged or clogged. Failure of the intake structure due to mechanical, structural or pipe failure. • Vandalism/sabotage.	Possible	Moderate	High
	Source Abstraction - Groundwaters - Wells/Bores				
SA11	Not enough source water available for abstraction.	• Drought.	Rare	Major	High
SA12	Contamination of bore during construction.	• Cross-contamination by drilling equipment. • Residual substances used in drilling releasing health significant determinands (e.g. barium from barite).	Unlikely	Moderate	Moderate
SA13	Contaminated water getting into the bore from shallower depths.	• Poor joints, cracks, or corrosion in the bore casing. • Drawdown bringing contaminants from shallower regions of the aquifer.	Unlikely	Moderate	Moderate
SA14	Contaminated water getting into the bore from the surface.	• Water inundates the bore head. • Inappropriate bore head design, or poor construction. • Bore head not properly sealed. • Bore head or casing damaged. • Contamination sources (e.g. stock) too close to the bore head. • Back siphoning.	Unlikely	Major	High
SA15	Contamination of the aquifer.	• Contamination sources too close to the bore head, or bore too shallow. • Aquifer is not secure.	Unlikely	Major	High
SA16	Too little water can be drawn from the bore to meet demand.	• Damage to the pump or bore head. • Catastrophic failure (e.g. flood, slips or earthquake related damage). • Pump failure. • Vandalism/sabotage. • Screens clogged. • Deterioration in bore condition/structure.	Possible	Moderate	High

6.2 Treatment (Turitea and Bores)

Table 7 - Treatment Risks

Event Reference	Event	Cause	Risk Assessment of Existing		
			Likelihood	Consequence	Residual Risk
	Pre-treatment Processes - Destratification				
T1	Poor mixing of the water body leading to algal blooms (under some circumstances), raw water unsuitable for treatment, and difficulties with treatment control because of variability in raw water quality.	• Poor selection of intake level. • Destratification process started too late. • Power failure.	Possible	Moderate	High
	Coagulation/Flocculation Processes - Conventional Coagulation/Flocculation/Sedimentation				
T2	Particles not removed to expected treatment levels.	• Dosing malfunction. • Dosing rates set incorrectly or inappropriately. • Power failure. • Chemical supply exhausted. • Incorrect chemical used. • Chemicals of poor quality. • Inadequate mixing of chemicals. • Insufficient contact time for floc formation. • Ineffective settling of floc. • Floc removal mechanism malfunction. • High algae loading/particular algae specie issues.	Unlikely	Moderate	Moderate
T3	Natural organic matter not removed.	• The causes, preventive measures etc for this event are the same as those given for event T2 above.	Possible	Moderate	High
T4	Treatment chemicals carried into distribution system.	• The causes, preventive measures etc for this event are the same as those given for event T2 above.	Possible	Moderate	High
	Filtration - Rapid (Gravity) Sand Filtration				
T5	Particles not removed.	• Media deficiencies. • Inappropriate flow rates. • Incorrect filter backwash procedure. • Inadequate filter maintenance. • Poor coagulation. • Backwash pump failure. • Turbidity meter failure.	Unlikely	Major	High
T6	Natural organic matter not removed.	• The causes, preventive measures etc for this event are the same as those given for event T5 above.	Possible	Minor	Moderate

Event Reference	Event	Cause	Risk Assessment of Existing		
			Likelihood	Consequence	Residual Risk
T7	Treatment chemicals carried into distribution system.	• The causes, preventive measures etc for this event are the same as those given for event T5 above.	Possible	Moderate	High
	Disinfection - Chlorination				
T8	Not enough free available chlorine or monochloramine.	• Dosing malfunction. • Dose controller's sensor incorrectly calibrated. • Dose controller's set-point incorrect or incorrect dose calculation. • High chlorine demand coupled with poor dose control. • Power failure. • Chlorine supply exhausted. • Chlorine supply adequate, but insufficient chlorine reaching dosing point. • FAC monitoring samples taken incorrectly or incorrectly recorded. • Method of FAC measurement incorrect, incorrectly calibrated, or analysis reagents have deteriorated. • Interaction of bore and Turitea water. • pH too high (resulting in a lower percentage of the FAC existing in its more powerful disinfection form).	Likely	Minor	High
T9	Too much free available chlorine.	• Dosing malfunction. • Dose controller incorrectly calibrated. • Dose controller's set-point incorrect, or incorrect dose calculation. • Low chlorine demand coupled with poor dose control.	Likely	Insignificant	Low
T10	Excessive formation of chlorination by-products.	• Natural organic matter present in the water being chlorinated.	Unlikely	Minor	Low

Event Reference	Event	Cause	Risk Assessment of Existing		
			Likelihood	Consequence	Residual Risk
	Aesthetic Property Adjustment - pH Adjustment				
T11	pH level too high (poor disinfection by chlorine).	• Dosing malfunction. • Incorrect calibration of controller's pH probe. • Dose rate set incorrectly. • Power failure. • Chemical supply exhausted. • Incorrect chemical used, chemical of poor quality, or dosing solutions prepared at the wrong strength. • Chemical cannot be dosed at a high enough rate.	Possible	Minor	Moderate
T12	pH level too low.	• The same causes, preventive measures etc for event T11 above are appropriate here. Note, however, that the minimum pH should be no less than 7.0, and that problems with disinfection efficiency are not linked to low pH levels.	Possible	Minor	Moderate
T13	Turitea treated water manganese level higher than 0.03 mg/L.	• Dosing controller incorrectly calibrated. • KMnO4 exhausted. • KMnO4 supply adequate, but KMnO4 is not being dosed into the water - dosing pump failure or feedlines blocked. • Dose controller malfunction. • KMnO4 dosing solution concentration incorrect, or prepared with incorrect chemical. • Poor removal of precipitated metal by filtration. • Power failure.	Unlikely	Minor	Low
T14	Oxidant dose to high.	• $KMNO_4$ dose rate set incorrectly or incorrect dose calculation. • Dosing controller malfunction. • Dosing controller incorrectly calibrated. • $KMnO_4$ dosing solution concentration too high.	Unlikely	Minor	Low

Event Reference	Event	Cause	Risk Assessment of Existing		
			Likelihood	Consequence	Residual Risk
	Fluoridation				
T15	Fluoride concentration greater than required for dental protection.	• Fluoride dosing solution (or day tanks) delivered at the wrong concentration, or using the wrong fluoride chemical. • Dosing system malfunction. • Dose rate set incorrectly. • Controller's fluoride sensor out of calibration or malfunctioning (if dose controlled by feedback from in-line probe). • Monitoring samples not taken, or results incorrectly recorded. • Monitoring method incorrectly calibrated, performed incorrectly, or analysis reagents deteriorated. • Excessive dose as a result of any of the above faults.	Unlikely	Moderate	Moderate
	Pump Operation (Bores & Boosters only)				
T16	Changes in pressure, or water hammer (pressure surges), suck contaminants into the water.	• Bore/booster pump failure due to mechanical failure or overload. • No water because of pump failure due to power failure. • No water because of pump failure due to flooding or other damage.	Possible	Moderate	High
T17	Incorrect chemical dosing leads to poor treatment.	• Process pumps do not add the correct dose of chemical.	Rare	Major	High
	Plant Construction and Operation				
T18	Treatment plant cannot produce water of satisfactory quality.	• Structural failure of part of the plant. • Inadequate plant design. • Inadequate maintenance resulting in mechanical failure. • Inadequate monitoring/quality assurance systems. • Inadequate security measures to prevent vandalism/ sabotage. • Unhygienic practices (including no separation between water and wastewater operations).	Rare	Major	High
T19	Treatment plant cannot produce enough water.	• Explosion/fire. • Earthquake. • Vandalism. • Landslide / flooding.	Rare	Major	High

6.3 Storage and Distribution

Table 8 - Storage and Distribution Risks

Event Reference	Event	Cause	Risk Assessment of Existing		
			Likelihood	Consequence	Residual Risk
	Post-treatment Storage				
SD1	Not enough water in post-treatment storage to meet demand.	• Insufficient water treatment capacity, or output limited by one or more treatment stages not operating. • Inadequate post-treatment storage capacity. • Inability to transmit water from source to plant, or plant to post-treatment storage. • Leakage from the storage facility.	Possible	Moderate	High
SD2	Chlorine contact time too short.	• Short-circuiting.	Unlikely	Insignificant	Low
SD3	Introduction of contaminating material into service reservoir.	• Access by animals/birds. • Unauthorised access/vandalism/sabotage. • Leaching/corrosion from construction materials. • Entry of roof drainage. • Entry of contaminated groundwater for in-ground tanks. • Chemical contamination from incorrect chemical dosing. • Backflow from drains.	Possible	Minor	Moderate
SD4	Development or re-suspension of sediment within tank or reservoir.	• Sediment/slime accumulation and release.	Likely	Insignificant	Moderate

Event Reference	Event	Cause	Risk Assessment of Existing		
			Likelihood	Consequence	Residual Risk
	Reticulation Network - Construction Materials (also applicable to Treatment Processes)				
SD5	Entry of or dissolution of chemicals from construction materials.	• Unsuitable materials in use. • Inadequate design standards. • Inadequate monitoring of new developments and construction. • Poor quality materials. • Inadequate flushing of new materials. • Inadequate maintenance or replacement of worn materials. • Materials insufficiently resistant to dissolution by the water and the surrounding environment. • Inadequate or inaccurate activity asset data. • Inadequate maintenance and repair programme.	Likely	Minor	High
SD6	Failure of the distribution system through failed construction materials.	• Deterioration of distribution system, leading to ingress of micro-organisms. • Biofilm development sustaining pathogens. • Inadequate or inaccurate activity asset data. • Inadequate maintenance and repair programme.	Likely	Minor	High
SD7	No water available.	• Material failure.	Possible	Moderate	High
	Reticulation Network - System Pressure				
SD8	Introduction of contamination by pressure fluctuations.	• Mains pressure failure elsewhere, or high instantaneous demand. • Pipe failure or accidental penetration. • Unpredicted event such as a major fire. • Failure of booster pumps to high zones or reservoirs. • Failure of bore pumps.	Possible	Insignificant	Low
SD9	Re-suspension of sediment or biofilm within the mains by pressure.	• Sediment or biofilm allowed to develop. • Significant fluctuations in reticulation pressure. • Flow reversal.	Likely	Insignificant	Moderate

Event Reference	Event	Cause	Risk Assessment of Existing		
			Likelihood	Consequence	Residual Risk
	Reticulation Network - Operation				
SD10	Introduction of contaminating material into the distribution system.	• Affected area not correctly isolated. • Standard hygiene practices not adopted. • Inadequate staff training. • Inadequate flushing and disinfection practices during repairs or commissioning of new mains. • Unsatisfactory location of water reticulation pipes. • Inappropriate materials used. • Breaks, leaks, incidental damage to water mains. • Unsuitable temporary bypass and/or supply bypass. Cross connections. • Contamination during sampling. • System pressure drop.	Possible	Minor	Moderate
SD11	Re-suspension of contaminants in sediments in the distribution system.	• System pressure drop. • Water velocity too high.	Possible	Minor	Moderate
SD12	Development of sediment or biofilm.	• Poor chemical water quality leaving the treatment plant e.g. post-treatment precipitation of floc, iron, manganese. • Poor microbiological water quality leaving the treatment plant and in the distribution system. • Water flows too low resulting in: decay of chlorine, microbiological colonisation of surfaces. • Poor repair practices allowing colonisation. • Inadequate cleaning programme.	Likely	Insignificant	Moderate
SD13	Failure to maintain sufficient water pressure.	• Insufficient water available from the source, treatment plant or post treatment reservoir. • Transmission pump failure. • Leaks in the reticulation network.	Likely	Minor	High

Event Reference	Event	Cause	Risk Assessment of Existing		
			Likelihood	Consequence	Residual Risk
	Reticulation Network - Backflow Prevention				
SD14	Water pressure in the distribution system lower than pressure in supplied premises.	• A pressure drop in the reticulated system as a result of pump failure, pipe burst. • An elevated pressure in the premise(s) supplied as compared to the reticulated system.	Likely	Minor	High
SD15	No, inadequate, faulty, or incorrectly installed backflow prevention device.	• The backflow prevention device is not actually connected, or connected improperly. No backflow prevention device installed because of insufficient knowledge of activities on the premises. An illegal cross connection to the reticulated system. • The backflow prevention device may have failed safe, but may then have been removed to maintain the water flow and not been replaced. • Failure of backflow prevention device. • Unauthorised drawing of water from fire hydrants. • Vandalism or accidental damage.	Possible	Minor	Moderate
	Water Transmission				
SD16	Contamination gets into the trunk mains.	• Mains break. • Air release valves entrain contaminated water or air. • Leaks. • Incidental damage (e.g. floods, slips, vehicle related incidents). • Poor repairs of breaks and/or leaks, • Incidental damage, and penetration of trunk mains.	Unlikely	Minor	Low
SD17	Sediment containing contaminants stirred up.	• Sediment or biofilm allowed to develop. • Velocity too high.	Possible	Minor	Moderate

6.4 General

Table 9 - General Risks

Event Reference	Event	Cause	Risk Assessment of Existing		
			Likelihood	Consequence	Residual Risk
	Staff Training				
GN1	Introduction of microbiological contaminants into the water supply, or the inadequate inactivation, or removal, of microbiological contaminants.	• Inadequate training in terms of breadth or depth or both.	Unlikely	Moderate	Moderate
GN2	Introduction of chemical contaminants (incorrect application of treatment chemicals), or the inadequate removal of chemical contaminants.	• Inadequate training in terms of breadth or depth or both. • Major chemicals all have unique feed manifolds - can only couple to the unique outlet from the chemical delivery truck.	Unlikely	Moderate	Moderate
	Monitoring				
GN3	Incorrect water quality data used for supply management.	• Inappropriate or incorrect sampling. • Inadequate or incorrect test equipment or incorrectly calibrated test equipment. • Inadequate reagents. • Inappropriate method or incorrect calibration. • Inadequate or incorrect monitoring records. • Failure of staff to follow the analytical method and other related quality assurance procedures. • Use of a non-Ministry of Health approved laboratory.	Unlikely	Moderate	Moderate

7 Improvement Schedule

The following list of improvements for the Palmerston North Water Supply has been developed from the preceding risk information tables with reference to Council's Water Asset Management Plan 2014 adopted by the Long Term Plan. Improvements are subject to Council making funding available. Regular monitoring and maintenance actions have not been included in this table but are outlined in Section 8. Improvements are prioritised from high to low according to the existing risk level, and from low to high on cost.

Table 10 - Improvement Schedule

Improvement reference	Improvement needed	Reason for improvement	Event Reference	Existing level of risk	Priority	Cost Estimate	Target date to complete	Person responsible
1	Turitea WTP Quality Management System – maintain registration under ISO 9001.	Continuous improvement.	T1 – T7, T11-T19	Low-Extreme	High	$5k p.a.	On-going	Water Asset Engineer (Dora Luo)
2	Turitea Upper Dam – Installation of destratification/aeration facility.	Reduce likelihood of algal bloom in dam and reduce likelihood of residual manganese in treated water from Turitea.	SA5/ T1/ T15	Moderate	High[2]	$50k	2017	Water Asset Engineer (Dora Luo)

[2] High priority due to Resource Consent conditions.

Improvement reference	Improvement needed	Reason for improvement	Event Reference	Existing level of risk	Priority	Cost Estimate	Target date to complete	Person responsible
3	Review mitigation strategies for a major earthquake event which is being undertaken as a part of the Water Supply Development Plan	Lack of water to meet demand or inadequately treated water.	T19	High	High	$47k	2017-19	Water Asset Engineer (Dora Luo)
4	Future planning (Water Supply Development Plan)	Review the City water sources, project for future growth and work out future water infrastructural requirement.	All	High	High	$47k p.a.	2014-2016	Water Asset Engineer (Dora Luo)
5	Replacement of reservoir specific components.	Replacement of components before they reach the end of their useful life. eg. Roofs.	SD3, SD5	Moderate High	High	$276	2015-2017	Water Asset Engineer (Dora Luo)
6	Increased budget on water bores and headworks renewal (FSA day tanks to be installed on all the bore sites).	Replacement/ upgrade of mechanical and electrical equipment to maintain their performance. To meet new fluoride CoP (2020).	T11-T18 SD8	High	High	$68k p.a.	On-going	Water Asset Engineer (Dora Luo)
7	Bore head security improvements by installation of security fencing to all the City bores	Better protection of the bore headworks and pumpstations.	SA14	High	High	$100k	2015	Water Asset Engineer (Dora Luo) /Treatment Plant Manager (Mike Monaghan)

Improvement reference	Improvement needed	Reason for improvement	Event Reference	Existing level of risk	Priority	Cost Estimate	Target date to complete	Person responsible
8	Automatic shutdown at Ngahere Park reservoirs.	Retain water storage should there be a major leak in the water supply network.	SD13	High	High	$100k	2018	Water Asset Engineer (Dora Luo)
9	Increased budget on Turitea WTP facility and equipment renewal (including filter media replacement).	Replacement/ upgrade of mechanical and electrical equipment to maintain its performance.	T1-T9, T18	High	High	$100k p.a.	On-going	Water Asset Engineer (Dora Luo)
10	Turitea WTP Retaining Walls on Access Road.	Risk of road access to Turitea WTP being unavailable following storm event or earthquake.	T19	High	High	$323k	2017	Water Asset Engineer (Dora Luo)
11	Turitea Reserve Management	Animal and weed control, Reserve entry control, managing forest harvesting.	SA1 SA2	High	High	$400k p.a.	On-going	Water Asset Engineer (Dora Luo) // Forester (Mark Johnston)
12	New bore – Kelvin Grove water supply zone.	Lack of backup and supply for growth.	SA11	High	High	$1M	2016-18	Water Asset Engineer (Dora Luo) /Tech Services Manager (Andrew Higgs)
13	Structure review & seismic strengthening of existing water infrastructure when required	Risk of failure in an earthquake and risk of introducing contamination.	T18	High	High	$1.3M	2021	Water Asset Engineer (Dora Luo)

Improvement reference	Improvement needed	Reason for improvement	Event Reference	Existing level of risk	Priority	Cost Estimate	Target date to complete	Person responsible
14	Monitor condition and rates of failure of AC and CI water mains and continue renewal programme.	Impact on water quality and availability.	SD7 SD14	High	High	$2M p.a.	On-going	Water Asset Engineer (Dora Luo)
15	Bore renewal programme.	Restore the bore capacity which has deteriorated over time.	SA16	High	High	$2.6M over 30 years	On-going	Water Asset Engineer (Dora Luo)
16	Duplicate trunk mains from Lower Dam to WTP to Ngahere Park Reservoirs.	Provide increased resilience should there be a major failure in the trunk mains.	SD16	High	High	$2.9M	2020	Water Asset Engineer (Dora Luo)
17	Aokautere reservoir and water main link.	Provide increased storage capacity for this area and also the City and meet pressure levels of service.	SD1 SD8	High	Medium	$5.8M	2017	Tech Services Manager (Andrew Higgs)

Improvement reference	Improvement needed	Reason for improvement	Event Reference	Existing level of risk	Priority	Cost Estimate	Target date to complete	Person responsible
18	Apply Council's Backflow Prevention Policy. Continue auditing of connections and installation of backflow prevention devices. The audits are prioritising the risk to the supply and initially requiring backflow prevention on high risk premises.	Backflow risk leading to contamination of treated water.	SD15	Moderate	Medium	$45k	On-going	Water Asset Engineer (Dora Luo) /Tech Services Manager (Andrew Higgs)
19	Turitea water treatment plant backwash system improvement	Improve backwash performance and provide backup back wash pump	T5	High	Medium[3]	$220k	2020	Water Asset Engineer (Dora Luo)
20	Water toby renewal.	To replace water tobies with manifolds which have backflow function.	SD15	Moderate	Medium	$120k p.a.	On-going	Water Asset Engineer (Dora Luo)
21	Albert Street and College Street trunk mains.	Provide increased resilience should there be a major failure in the trunk mains.	SD13 SD9 SD11	High	Medium	Albert St trunk mains $2.28M; College St trunk mains $830k	2019 2022	Water Asset Engineer (Dora Luo)

[3] Funding yet to be allocated. Interim measures in place i.e. pumping from Clearwater tank.

Improvement reference	Improvement needed	Reason for improvement	Event Reference	Existing level of risk	Priority	Cost Estimate	Target date to complete	Person responsible
22	Investigate risks associated with the mixing of Turitea and bore water.	Potential for residual to be removed when waters mix.	T8	High	Low	N/A	Accepted the risk of no FAC	Water Asset Engineer (Dora Luo)
23	Monitoring raw water TOC	Monitoring the potential of forming Chlorination by-product which has health risk	T10	Low	Medium	$500 p.a.	From 2017	Water Asset Engineer (Dora Luo)
24	Additional Chlorine Compound on line monitoring	Ensure residual chloramine for all the bore supplies as an additional barrier	T8 T9	High	High	$32,000	2017	Water Asset Engineer (Dora Luo) /Treatment Plant Manager (Mike Monaghan)
25	Disconnection between the treated and raw water at the Turitea Treatment Plant	Prevent from cross contamination incase of the non-return valve failed	SD10	High	High	$18,000	2017	Water Asset Engineer (Dora Luo) /Civil works Supervisor (Sean Faasen)
26	Ground water aquafer survey	To ensure the security of the aquafer and free from contamination	SA1 SA2 SA6	Low Low High	High	$20,000	2017	Water Asset Engineer (Dora Luo) /

8 Related Plans, Monitoring and Maintenance

8.1 Council Policies and Plans

This WSP will be considered in the updating of the Water Asset Management Plan, the Risk Management Plan and the preparation of Council's Annual Plans and Long Term Plan.

8.2 Regular Monitoring

The following table summarises checks that are carried out on the Palmerston North water supply, how often they need to be made and who is responsible for them.

Table 11 - Monitoring Summary

Ref	Check	Details	How often	Responsibility
1	Bacterial compliance (*E. coli* indicator) in bores/reticulation and FAC, pH, turbidity at treatment plant.	Take samples from treatment plant, bores and reticulation as per DWSNZ requirements.	For all bores: 1 sample per quarter with not more than 135 days between samples and the sampling covers 3 different days of the week; For the Turitea WTP: 4 samples per quarter with no more than 40 days between samples and the sampling covers at least 3 different days of the week.	PNCC Treatment Plant Operators
2	Fluoride (P2).	Take samples from bores/Turitea.	Weekly	CEL
3	Bore Radiological compliance.	Radiological tests.	10 yearly (2017)	Water Asset Engineer (Dora Luo)
4	Turitea Source raw water testing.	Protozoa sampling programme.	5 yearly	PNCC Treatment Plant Operators
5	Bore water age (residence time).	Tests required for bore water security assessment.	Every 5 years (2018)	Water Asset Engineer (Dora Luo)
6	Water abstraction and treatment operation.	Continuously monitor critical water supply alarms and respond accordingly.	Continuous	Water Asset Engineer (Dora Luo) /PNCC Treatment Plant Operators

Ref	Check	Details	How often	Responsibility
7	On-line monitoring instrument calibration.	Re-calibrate turbidity, pH probes using calibration buffers.	Weekly	PNCC Treatment Plant Operators
8	Chemical levels.	Check lime, chlorine, coagulant and flocculant levels and re-order if necessary.	Daily	PNCC Treatment Plant Operators
9	Water pressures and bulk flow.	Pressure and flow in reticulation (alarm if abnormal).	Continuous	Water Asset Engineer (Dora Luo) /PNCC Treatment Plant Operators
10	Backflow devices.	IQP test and record on asset management system.	Annual	Water Asset Engineer (Dora Luo) / Three Waters Technician (Brian Burmeister)
11	Cyanobacteria testing.	Take Dam water samples as per Framework.	As per Framework	CEL

8.3 Maintenance Schedules

The following table summarises key maintenance activities for the Palmerston North water supply and who is responsible for them. Refer also to Operation and Maintenance manuals.

Table 12 - Maintenance Activities

	Schedule	Frequency	Responsibility
1	Inspect wellheads condition and security.	5 yearly next due 2019	Water Asset Engineer (Dora Luo)
2	Service Bores mechanical/dosing equipment.	Monthly	Treatment Plant Senior Supervisor (Mike Monaghan)
3	Service Turitea WTP mechanical/dosing equipment.	Monthly	Treatment Plant Senior Supervisor (Mike Monaghan)
4	Annual inspection of power source, connections and electrical equipment.	Annually	Treatment Plant Senior Supervisor (Mike Monaghan)
5	Service pressure booster stations and pressure reducing/sustaining valves.	6 monthly	Treatment Plant Senior Supervisor (Mike Monaghan)
6	Exercising of valves and hydrants.	Every 4 years	Civil Works Supervisor (Bill Smith)
7	Calibrate flow meters.	5 yearly	Treatment Plant Senior Supervisor (Mike Monaghan)

	Schedule	Frequency	Responsibility
8	External condition of reservoirs/WTP.	Annually	Civil Works Supervisor (Bill Smith)
9	Reservoir cleaning.	Every 2 years	Civil Works Supervisor (Bill Smith)
10	Flushing programme for dead end mains and problem areas.	2 monthly/monthly	Civil Works Supervisor (Bill Smith)
11	Trunk main swabbing to remove deposits.	Annually	Water Asset Engineer (Dora Luo)
12	Backflow preventer inspection and re certification.	6/12 monthly	Three Waters Technician (Brian Burmeister)
13	Dam Inspections.	Monthly visual inspection; Annual deformation survey & safety review; 5 yearly critical safety review	Water Asset Engineer (Dora Luo)

9 Contingency Plans

Contingency plans for all risk events are given below. These contingency plans are based on those given in the Ministry of Health guidelines.

9.1 S1.1 Source - Surface and ground water sources

Event – Hazardous substances used or spilled from storage	
Indicators:	■ Spill has been reported in the source protection zone. ■ Elevated concentrations of hazardous substances, or their breakdown products, detected in the source water.
Required actions:	■ Identify responsible body and inform relevant authorities including civil defence, if necessary. ■ Ensure that spill is contained. ■ Check quality of source water, use alternative drinking-water supply, if necessary and inform the public. ■ Responsible body remediates area affected by spill. ■ Monitor water quality to see whether corrective action has worked. ■ Record incident and action taken. ■ Request that responsible body document the incident and determine management procedures to prevent future spills. ■ Check quality of drinking-water throughout and at end of remedial work to determine whether alternative supply is needed. ■ Determine whether there are any ways in which the source water can be protected from spills. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ The Water Asset Engineer must ensure that the source is protected. Body responsible for the spill must be responsible for all action to address the impact of the spill.

Event – Volcanic activity – leading to ash fall in the catchment resulting in lower pH, increased turbidity and soluble mineral content and affects the taste of water	
Indicators:	■ Media coverage of activity. ■ Notification from Institute of Geological and Nuclear Sciences.
Required actions:	■ Normal range of conductivity and pH values need to be known (to provide baseline data, some monitoring needs to have been undertaken before the event). ■ If conductivity values are not elevated and the pH is above 5, continue to use the source water. If conductivity is elevated (estimated increase of 5–10 mS/m), and pH is depressed below 5, inform MOH, use alternative source water or close the supply and obtain water from elsewhere until chemical analysis of the water shows it is acceptable, and inform the public. ■ If turbidity is increased, take steps to make sure disinfection of the water is still effective. ■ When the volcanic activity has ceased, measure conductivity, pH and other chemical determinands associated with the event until they return to normal range. Resume use of the source water. ■ Record incident and action taken. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Water Asset Engineer.

Event – Extreme rain events	
Indicators:	■ Quality of surface water visibly deteriorates. ■ Extreme rainfall recorded on the MetService/Horizons website. ■ Elevated turbidity.
Required actions:	■ Increase frequency of measurements of turbidity, plus all other parameters that are critical to the satisfactory functioning of treatment processes. ■ Increase disinfectant dose, if necessary, to make sure disinfection is still effective. ■ If water quality is too poor to treat, use alternative source, or close the supply and obtain water from elsewhere until there is a return to acceptable levels, or issue 'boil water' notice. Inform MOH. ■ See D2 Guide series for a contingency plan for the reticulation network. ■ After extreme rain event, check all water supply infrastructure for maintenance requirements. ■ If source water is affected by rain events frequently, consider alternative source, or upgrade treatment to cope with the variability of source water quality (eg, pre-treatment storage). ■ Record incident and action taken. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Civil Works Supervisor and Senior Treatment Plant Supervisor.

Event – Earthquake and landslides	
Indicators:	■ An earthquake may cause damage to the source, treatment plant or distribution system. The water supply may be shut down as a result.
Required actions:	■ Contact the Ministry of Civil Defence in the event of an earthquake emergency. (Keep a list of the contact details for the nearest Ministry office and of the Earthquake Commission). ■ Check all structures associated with water storage, abstraction, treatment and distribution. ■ If water supply structure is damaged so that water cannot be distributed, or cannot be distributed with a satisfactory quality, use alternative supply. Provide another source of potable water until water of acceptable quality can again be supplied. Contact the MOH. ■ Record incident and action taken. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Water Asset Engineer.

Event – Water shortage	
Indicators:	■ Low flow of rivers and springs, low level of lakes or dams, low water table of groundwaters. ■ Unexpectedly high usage, or gradually increasing usage, due to increasing population.
Required actions:	■ Notify Horizons to reduce/cease discharge to the Turitea Stream from the Lower Turitea Dam. ■ Consider restricting water use. ■ If water table has dropped to an extent where water can no longer be abstracted, use alternative source until water level has risen. ■ If water shortages occur frequently, consider additional or alternative source. ■ Record incident and action taken. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Water Asset Engineer.

9.2 P1.2 Treatment - Lakes and reservoirs

Event – Water quality too poor to treat	
Indicators:	■ Water too turbid or too coloured to treat. ■ Turbidity of water leaving plant consistently greater than 0.3 NTU‡ (See *DWSNZ:2005*).
Required actions:	■ Consider whether to cease abstraction and switch to an alternative source of potable water until water of acceptable quality can again be supplied, or to use storage. (*Make sure that the history of any tanker used to cart water has been investigated before it is used and that the tanker will not contaminate the water.*) ■ If inadequately-filtered water has entered the reticulation, inform the MOH. ■ Monitor particle counts, turbidity or colour levels until they reach acceptable limits. ■ Increase chlorine residual as an interim measure. ■ Restart plant operation, perhaps at a slower rate. ■ If very poor raw water quality is likely to be a frequent problem, consider an alternative source, or changes to abstraction method or treatment. ■ Record cause of failure and corrective steps taken. ■ Plan and develop long term countermeasures if needed. ■ Modify Water Safety Plan if necessary.
Responsibility:	Civil Works Supervisor and Senior Treatment Plant Supervisor.

Event – Not enough water reaching the treatment plant	
Indicators:	■ Upper Turitea Dam water level lower than the lowest intake level. ■ Unexpectedly high usage. ■ Structural failure of intake, or pump failure.
Required actions:	■ Implement the water supplier's emergency demand management strategy. ■ Consider whether to switch to an alternative source of water until adequate water of acceptable quality can again be supplied, or to use storage. (*Make sure that the history of any tanker used to cart water has been investigated before it is used and that the tanker will not contaminate the water.*) ■ If inadequately-filtered water has entered the reticulation, inform MOH of the transgression. ■ Put conservation measures in place. ■ Close valves at reservoirs to restrict supply if necessary. ■ Increase chlorine residual as an interim measure. ■ If appropriate, identify intake problem and rectify. ■ When restarting the treatment plant, consider doing this at a slower rate. ■ Record cause of failure and corrective steps taken. ■ If shortages occur frequently because of too little water available at the source, plan for finding and developing a new source. ■ Modify Water Safety Plan if necessary.
Responsibility:	Water Asset Engineer.

Event – Contamination enters the lake or reservoir	
Indicators:	■ Complaints of discoloured, tasting or smelling water coming from taps. ■ Continued contamination of water supply: *E coli* detected or Priority 2 chemical concentrations more than 50% of MAV. ■ Reports of illness in parts of the community that may be linked to water quality.
Required actions:	■ Close intake. ■ Notify the MOH, and in consultation warn consumers in the affected area of alternative water supply measures until further notice. ■ Identify the source of the contamination, and determine whether it is likely to be a transient problem and whether temporary treatment is available. ■ If problem is transient: – drain and flush the affected part of the distribution system, considering the need to flush with elevated chlorine concentrations if the incident may have involved microbiological contaminants (consultation with the Regional Council will probably be required with regard to disposal of the flushed water). – monitor an appropriate determinand in the affected area to determine the success of the contingency measures, and notify consumers, when the supply is safe to use, that they will need to flush their taps until good quality water can again be drawn.If problem is likely to be long-lasting or permanent: – investigate and develop an alternative supply and/or treatment. – provide another source of potable water until water of acceptable quality can again be supplied. ■ Record cause of system failure and steps taken to correct. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Water Asset Engineer.

9.3 P1.3 Treatment – Bores and wells

Event – Not enough water reaching the treatment plant	
Indicators:	■ Reduced flow, or no flow alarms from telemetry system. ■ Unexpectedly high usage. ■ Structural failure of bore/wellhead, or pump failure.
Required actions:	■ Implement the water supplier's emergency demand management strategy. ■ Consider whether to switch to an alternative source of water until adequate water of acceptable quality can again be supplied, or to use storage. (*Make sure that the history of any tanker used to cart water has been investigated before it is used and that the tanker will not contaminate the water.*) ■ If inadequately-filtered water has entered the reticulation, inform MOH of the transgression. ■ Put conservation measures in place. ■ Close valves at reservoirs to restrict supply if necessary. ■ Increase chlorine residual as an interim measure. ■ If appropriate, identify intake problem and rectify. ■ When restarting the treatment plant, consider doing this at a slower rate. ■ Record cause of failure and corrective steps taken. ■ If shortages occur frequently because of too little water available at the source, plan for finding and developing a new source. ■ Modify Water Safety Plan if necessary.
Responsibility:	Water Asset Engineer.

Event – Contamination enters the aquifer or bore/well	
Indicators:	■ Complaints of discoloured, tasting or smelling water coming from taps. ■ Continued contamination of water supply: *E coli* detected or Priority 2 chemical concentrations more than 50% of MAV. ■ Reports of illness in parts of the community that may be linked to water quality.
Required actions:	■ Close intake. ■ Notify the MOH, and in consultation warn consumers in the affected area not to draw water until further notice. ■ Identify the source of the contamination, and determine whether it is likely to be a transient problem and whether temporary treatment is available. ■ If problem is transient: – drain and flush the affected part of the distribution system, considering the need to flush with elevated chlorine concentrations if the incident may have involved microbiological contaminants. (Consultation with the Regional Council will probably be required with regard to disposal of the flushed water); – monitor an appropriate determinand in the affected area to determine the success of the contingency measures, and notify consumers, when the supply is safe to use, that they will need to flush their taps until good quality water an again be drawn. ■ If problem is likely to be long-lasting or permanent: – investigate and develop an alternative supply and/or treatment; – provide another source of potable water until water of acceptable quality can again be supplied. ■ Record cause of system failure and steps taken to correct. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Water Asset Engineer.

9.4 P4.2 Storage - Destratification

Event – Cyanobacteria bloom formation	
Indicators:	■ Dead fish in the water body. ■ High algae counts. ■ Taste/ odour complaints. ■ Visual evidence of algal mats developing in the lake or reservoir.
Required actions:	■ Implement the PNCC Cyanobacteria framework. ■ Test the cyantoxins from the raw water and treated water. ■ Maximise the PAC dosing. ■ Notify the MOH, close down the supply if still not working. Provide another source of potable water until water of acceptable quality can again be supplied. ■ In conjunction with the MOH, evaluate the risk to health posed by cyanotoxins that have been formed, or are likely to form. This will require knowledge of the algae present, the nature of toxins released, and their susceptibility to oxidation. ■ Consider (see Guide S1.1): – increased oxidant/disinfectant doses to destroy the toxins passing through the treatment plant; – an alternate water source; – water restrictions; – whether water in post-treatment reservoirs can be used if adequately dosed with oxidant. ■ Once corrective measures are in place, monitor algal levels in the raw water and assess whether toxin concentrations in the treated water are acceptable before again reticulating the water. ■ Flush the distribution system. ■ Warn consumers to flush their taps before resuming the supply of water. ■ Record cause of system failure and steps taken to correct. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Water Asset Engineer.

Event – FAC concentration is lower than minimum acceptable level	
Indicators:	■ A detectable chlorine residual cannot be obtained in the water leaving the treatment plant (high chlorine demand due to poor destratification). ■ In 100 mL samples of water leaving the treatment plant, *E. coli* or coliforms are continually detectable, or *E. coli* is present at elevated levels (more than 10 per 100 mL). ■ Widespread levels of illness in the community.
Required actions:	■ Follow the actions given in Figure 4.1 of the *DWSNZ:2005*. ■ Identify the reason for the failure and rectify. ■ Record cause of system failure and steps taken to correct. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Civil Works Supervisor and Senior Treatment Plant Supervisor.

9.5 P5.1 Treatment – Conventional coagulation, flocculation, sedimentation and P6.1 Treatment – Rapid sand filtration

Event – Turbidity higher than maximum acceptable level	
Indicators:	■ A turbidity of less than 0.3 NTU cannot be maintained in the water leaving the treatment plant and individual filter turbidity is less than 0.1 NTU
Required actions:	■ Follow the actions given in Figure 5.1 of *DWSNZ:2005*. ■ Identify the reason for the failure and rectify. ■ Record the reason for the failure and the steps taken to rectify. ■ Jar testing and modify chemical dosing ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Civil Works Supervisor and Senior Treatment Plant Supervisor.

Event – Excessive levels of treatment chemicals carried into the distribution system	
Indicators:	■ Consumer complaints of discoloration, poor taste, sensation, odour. ■ Excessive chemical concentrations measured in the water leaving the treatment plant or in the distribution system. ■ Notification of error by operator or chemical delivery contractor.
Required actions:	■ Follow Section 8.4 of *DWSNZ:2005*. ■ Identify the reason for the failure and rectify. ■ Monitor chemical until it reaches acceptable limits. ■ Record the reason for the failure and the steps taken to rectify. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Civil Works Supervisor and Senior Treatment Plant Supervisor.

9.6 P7.1 Treatment – Chlorination

Event – FAC concentration is lower than minimum acceptable level	
Indicators:	■ A detectable chlorine residual cannot be obtained in the water leaving the treatment plant. ■ In 100 ml samples of water leaving the treatment plant, *E. coli* or coliforms are continually detectable, or is present at elevated levels (more than 10 per 100 mL). ■ Widespread illness in the community.
Required actions:	■ Follow the actions given in Figure 4.1 of the *DWSNZ:2005*. ■ Identify the reason for the failure and rectify. ■ Record cause of system failure and steps taken to correct. ■ Modify Water Safety Plan if necessary.
Responsibility:	Civil Works Supervisor and Senior Treatment Plant Supervisor.

Event – FAC concentration is very much higher than maximum acceptable value	
Indicators:	■ A major spillage or overdose of chlorine into the water. ■ Inability to obtain pink colour from DPD chlorine indicator despite high chlorine dose rates. *(NB: This indicates chlorine levels well in excess of the MAV – very high chlorine levels bleach the pink colour that normally develops in the presence of chlorine.)* ■ Water develops a strongly chlorinous odour. ■ Widespread levels of taste and odour complaints, or illness, in the community.
Required actions:	■ Close down the plant. Provide another source of potable water until water of acceptable quality can again be supplied. ■ Inform the MOH of the situation. ■ Identify the reason for the chlorine overdose and rectify. ■ Dump the reservoir water, or add chemicals to neutralise the chlorine if more appropriate (neutralisation may be required before any water is dumped, anyway). ■ Flush the distribution system, if excessive levels of chlorine are also present in the distribution system, and monitor water quality until chlorine concentrations are again back to normal operating levels. ■ Warn consumers to thoroughly flush their taps before drawing water for use (if they are likely to have been affected). ■ Record cause of system failure and steps taken to correct. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Civil Works Supervisor and Senior Treatment Plant Supervisor.

9.7 P8.1 Treatment - pH adjustment

Event – pH level less than minimum acceptable level	
Indicators:	■ pH levels are below the minimum acceptable level set by the water supplier. *(NB: pH probes (glass electrodes) are required to make measurements in drinking water. Comparators or colorimeters are too inaccurate.)* ■ Knowledge of a chemical spillage or overdose that may have led to a low pH water being produced. ■ Widespread consumer complaints of brown or blue staining on white bathroom fittings. ■ Widespread consumer complaints of a strong metallic taste in the water.
Required actions:	■ Inform the MOH of the situation and shut down the plant if the pH drops below 5. Provide another source of potable water until water of acceptable quality can again be supplied. ■ Identify the cause of the problem and rectify. ■ Raise the pH of the water in the reservoir until is more than 7, or dump it (raising the pH may be required for this anyway – check on discharge consent), and flush the distribution system. ■ Warn consumers to flush their taps before resuming the supply of water. ■ Record cause of system failure and steps taken to correct. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Civil Works Supervisor and Senior Treatment Plant Supervisor.

9.8 P8.2 Treatment – Iron and manganese removal

Event – Very high oxidant concentration	
Indicators:	■ Knowledge of a major spillage or overdose of oxidant into the water. ■ Pink colour of the water ($KMnO_4$ overdose). ■ Inability to obtain pink colour from DPD chlorine indicator despite high chlorine dose rates *(NB this indicates chlorine levels well in excess of the MAV – very high chlorine or chlorine dioxide levels bleach the pink colour that normally develops in their presence)*. ■ Water develops a strongly chlorinous odour. ■ Widespread complaints of taste and odour, or black particles in the water or staining ($KMnO_4$ overdose), or illness in the community.
Required actions:	■ Close down the plant. Provide another source of potable water until water of acceptable quality can again be supplied. ■ Inform the MOH of the situation. ■ Identify the cause of the problem and rectify. ■ Dump the reservoir water, or add chemicals to neutralise the oxidant if more appropriate (neutralisation may be required before any water is dumped anyway). ■ Flush the distribution system, if excessive levels of chlorine are also present in the distribution system, and monitor water quality until chlorine concentrations are again back to normal operating levels. ■ Warn consumers to thoroughly flush their taps before drawing water for use (if they are likely to have been affected). ■ Record cause of system failure and steps taken to correct. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Civil Works Supervisor and Senior Treatment Plant Supervisor.

9.9 P9 Treatment - Fluoridation

Event – Fluoride concentration is higher than maximum acceptable value	
Indicators:	■ Elevated fluoride concentrations evident from monitoring samples. ■ Marked drop in pH (if the fluoride compound is acidic). ■ Knowledge of a chemical spillage or overdose that may have led to a high fluoride concentration being produced in the water.
Required actions:	■ Notify the MOH and shut down the plant if necessary. Provide another source of potable water until water of acceptable quality can again be supplied. ■ Identify the cause of the problem and rectify. ■ Dump the reservoir water if this is necessary and possible; flush the distribution system. ■ Warn consumers to flush their taps thoroughly before resuming the supply of water. ■ Record cause of system failure and steps taken to correct. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Civil Works Supervisor and Senior Treatment Plant Supervisor.

9.10 P11 Treatment – Plant construction and operation

Event – Treated water quality too poor	
Indicators:	■ Microbiological and/or chemical quality of the water leaving the treatment plant does not meet the requirements of *DWSNZ:2005*. ■ Outbreaks of sickness that are probably linked to water quality.
Required actions:	■ Close down the treatment plant, and supply water from post-treatment storage, or provide another source of potable water until water of acceptable quality can again be supplied. *(Make sure that the history of any tanker used to cart water has been investigated before it is used and that the tanker will not contaminate the water.)* ■ Notify the MOH and determine whether 'boil-water' notices are needed. ■ Identify the reason for the failure and rectify. ■ If water of poor quality has passed into the distribution system, flush and disinfect the network and notify consumers to flush their taps before drawing water for use. ■ Record cause of system failure and steps taken to correct. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Civil Works Supervisor and Senior Treatment Plant Supervisor.

■

Event – Not enough water produced by the treatment plant	
Indicators:	■ Post-treatment storage levels dropping. ■ Drop in distribution system pressure.
Required actions:	■ Notify the public of the need to conserve water. ■ Identify the reason for the failure and rectify, if possible. ■ If the fault cannot be rectified within a few hours, provide another source of potable water until water of acceptable quality can again be supplied. *(Make sure that the history of any tanker used to cart water has been investigated before it is used and that the tanker will not contaminate the water.)* ■ Record cause of system failure and steps taken to correct. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Civil Works Supervisor and Senior Treatment Plant Supervisor.

9.11 D1 Distribution - Post-treatment and storage

Event – Breach of the post-treatment storage tank/reservoir	
Indicators:	■ Visual inspection shows evidence of structural deterioration or a leak. ■ Water levels cannot be maintained despite water being pumped into storage at an adequate rate.
Required actions:	■ Identify the location of the leak, and repair. ■ Bypass the tank/reservoir and take water directly from the treatment plant. ■ If the normal water source does not meet the needs of the community or treatment plant capacity (i.e. the quantity is too low at that time of year): – investigate and obtain alternative source(s) of water; – implement water use restrictions. ■ Repair the storage tank/reservoir if a leak is the cause of the shortage. ■ Record cause of system failure and steps taken to correct. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Civil Works Supervisor and Senior Treatment Plant Supervisor.

■

Event – Germs detected in the stored water	
Indicators:	■ A detectable chlorine residual cannot be obtained in the water leaving the reservoir. ■ In 100 ml samples of water from the reservoir, *E. coli* or coliforms are continually detectable, or *E. coli* is present at elevated levels (more than 10 per 100 mL). ■ Widespread levels of illness in the community. ■ Knowledge of sabotage or vandalism.
Required actions:	■ Follow the actions given in Figure 4.2 of the *DWSNZ:2005*. In consultation with the MOH, consider dumping the stored water, even though indicators are clear, if there have been high levels of microbiological contamination. ■ Record cause of system failure and steps taken to correct. ■ Modify Water Safety Plan if necessary.
Responsibility:	Civil Works Supervisor and Senior Treatment Plant Supervisor.

Event – High levels of chemical contaminants in the stored water	
Indicators:	■ Knowledge of a major chemical spill, or chemical overdose (eg, chlorine), into the reservoir; sabotage or vandalism. ■ Change in the appearance, smell or taste of the water. ■ Widespread levels of illness in the community. ■ Chlorine residual not restored.
Required actions:	■ Close down the reservoir, and if necessary the supply. Provide another source of potable water until water of acceptable quality can again be supplied. ■ Inform the MOH of the situation. ■ Identify the source of contamination and take steps to avoid recontamination. ■ Dump the reservoir water. Consultation with the Regional Council will probably be required with regard to disposal of the flushed water. ■ Flush the reticulation system and monitor water quality until determinand concentrations are again less than 50% of the MAV. ■ Warn consumers to thoroughly flush their taps before drawing water for use. ■ Record cause of system failure and steps taken to correct. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Civil Works Supervisor and Senior Treatment Plant Supervisor.

9.12 D2.1 Distribution - Construction materials

Event – High chemical concentrations from dissolution of materials	
Indicators	■ Consumer complaints. ■ Elevated chemicals in the treated water originating from construction materials.
Required Actions:	■ Follow Section 8.4 of *DWSNZ:2005.* ■ Identify the reason for the failure and rectify. ■ Monitor chemical until it reaches acceptable limits. ■ Record the reason for the failure and the steps taken to rectify. ■ Modify Water Safety Plan if necessary.
Responsibility	■ Civil Works Supervisor and Water Asset Engineer.

■

Event – No water because of failure of materials	
Indicators	■ Consumer complaints. ■ Burst or leaking pipes. ■ High unaccounted for water use.
Required Actions:	■ Identify the location of the leak and repair. ■ Confirm that hygienic procedures for repairs have been followed. ■ Monitor chlorine residuals and increase residual to make sure that more than 0.2 mg/L FAC reaches all parts of the distribution system. ■ Identify the reason for the failure and rectify. ■ Record the reason for the failure and the steps taken to rectify. ■ Review of water main renewal priorities ■ Modify Water Safety Plan if necessary.
Responsibility	■ Civil Works Supervisor and Senior Treatment Plant Supervisor.

9.13 D2.2 Distribution – System pressure

Event – System pressure too low	
Indicators:	■ Unexplained water loss or observed damage. ■ Reservoir levels difficult to sustain. ■ Treatment plant working at or near maximum capacity. ■ Observed problems with air valves. ■ Mains breaks. ■ Pressure fluctuations or significant decrease in pressure. ■ Elevated turbidity, microbiological counts or chemical determinand concentrations. ■ Incidents of illness suspected of being linked to events associated with the trunk mains. ■ Increased chlorine demand. ■ Large scaled complaints
Required actions:	■ Take microbiological samples to check compliance with *DWSNZ:2005*. If results indicate a transgression follow procedure as set out in Figure 4.2 of *DWSNZ:2005*. ■ If chemical contamination is suspected, monitor concentrations of the suspected determinand and follow the requirements of Section 8.4 of *DWSNZ:2005*. ■ Determine the reason for water loss and leakage, repair and plan for long-term preventive measures. ■ Review flushing records and pipework repairs in the area of the repair to confirm all sections of the pipework would have been flushed, and flush again. ■ Monitor chlorine residuals and increase residual to make sure more than 0.2 mg/L FAC reaches all parts of the distribution system. ■ Confirm that all procedures for pipe repair including crew repair procedures were followed. ■ Review laboratory results and take further samples. ■ Record cause of system failure. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Water Asset Engineer.

9.14 D2.3 Distribution - Operation

Event – Contamination enters the distribution system	
Indicators:	■ Inability to maintain a chlorine residual when one can normally be maintained. ■ In 100 ml samples of water from the reservoir, *E. coli* is continually detectable or is present at elevated levels (more than 10 per 100 mL). ■ Widespread complaints of taste and odour from consumers. ■ Widespread levels of illness in the community. ■ Turbidity fluctuations and levels greater than that in water leaving the treatment plant.
Required actions:	■ Follow the actions given in Figure 4.2 of the *DWSNZ:2005*. ■ Identify the reason for the failure and rectify. ■ Record cause of system failure and steps taken to correct. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Water Asset Engineer.

9.15 D2.4 Distribution – Backflow prevention

Event – Backflow into the distribution system occurs	
Indicators:	■ Complaints of discoloured, tasting or smelling water coming from taps. ■ Backflow incident reported by industry. ■ Reports of illness in parts of the community. ■ Inability to maintain disinfectant residual in parts of the distribution system. ■ *E. coli* or coliforms found in the distribution system
Required actions:	■ Notify the MOH, and in consultation warn consumers in the affected area not to draw water until further notice. If necessary, provide another source of potable water until water of acceptable quality can again be supplied. ■ Identify the source of the backflow incident, and isolate until a backflow prevention device can be fitted, or the one already installed can be made operational. ■ Drain and flush the affected part of the distribution system, considering the need to flush with elevated chlorine concentrations if the incident may have involved microbiological contaminants. (Consultation with the Regional Council will probably be required with regard to disposal of the flushed water.) ■ Monitor an appropriate determinand in the affected area to determine the successive of the contingency measures, and notify consumers, when the supply is safe to use, that they will need to flush their taps until good quality water an again be drawn. ■ Record cause of system failure and steps taken to correct. ■ Modify Water Safety Plan and Backflow Prevention Policy if necessary.
Responsibility:	■ Water Asset Engineer.

9.16 P2 Treated water transmission

Event – High levels of contamination enter a trunk main	
Indicators:	■ Unexplained water loss or observed damage. ■ Observed problems with air valves. ■ Mains break. ■ Pressure drops. ■ Elevated turbidity, microbiological counts or chemical determinand concentrations. ■ Incidents of illness suspected of being linked to events associated with the trunk mains. ■ Increased chlorine demand.
Required actions:	■ Take microbiological samples to check compliance with *DWSNZ:2005*. If results indicate a transgression follow procedure as set out in Figure 4.2 *DWSNZ:2005.* ■ If chemical contamination is suspected, monitor concentrations of the suspected determinand and follow the requirements of Section 8.4 of *DWSNZ:2005.* ■ Determine the reason for water loss and leakage, repair and plan for long term preventative measures. ■ Review flushing records and pipework repairs in the area of the repair to confirm all sections of the pipework would have been flushed, and flush again. ■ Monitor chlorine residuals and increase residual to ensure an FAC residual of more than 0.2 mg/L is achieved throughout the distribution system. ■ Confirm that proper work practices for pipe repair were followed. ■ Review laboratory results and take further samples. ■ Record cause of system failure. ■ Modify Water Safety Plan if necessary.
Responsibility:	■ Water Asset Engineer.

9.17 G1 General training

Event –	
Indicators:	■ Incidents as a result of operation error.
Required actions:	■ Refreshment training.
Responsibility:	■ Civil Works Supervisor and Senior Treatment Plant Supervisor.

9.18 G2 General Monitoring

Event – Poor quality assurance and/or quality control for monitoring	
Indicators:	■ Too many errors detected during audits or surveillance. ■ Too many process control failures. ■ Too many outliers shown by inter-lab quality control studies. ■ Repeated unexplained compliance test failures (FAC/*E. coli*).
Required actions:	■ Full audit of quality procedures. ■ Identify and resolve deficiencies in equipment/methods/staff training. ■ Identify all analysis records that may have been adversely affected. ■ Inform the Medical Officer of Health (MOH) if compliance tests may have been affected. ■ Once the cause of the poor performance has been identified, correct it. ■ Record the reason for the failure and the steps taken to rectify. ■ Modify the water safety plan if necessary.
Responsibility:	■ Water Asset Engineer.

9.19 Post event debrief

A post event debrief should be carried out following any of the risk events identified in this Section.

The debrief should include a review of the following:

- Whether the indicators are clear enough to reflect the event;
- Whether the judgement and decisions for actions were timely and correct;
- Whether the corrective actions were effective;
- Gap identification and any improvements required.

The findings from the debrief should be used to update the WSP.

10 Water Safety Plan Performance Assessment

The Water Safety Plan should be reviewed every five years to ensure the plan is current. The Water Asset Engineer is responsible for the review process. The review process will involve:

- Checking that roles and responsibilities are still valid.
- Reviewing the operation of the water supply by:
  - Checking compliance with the Drinking Water Standards for New Zealand;
  - Reviewing incident records and learning lessons from the incident;
  - Checking whether any problems have been found during routine checks and maintenance.
- Reviewing progress for improvements and updating schedule with new improvements identified as a result of incidents occurring.
- Addressing new or altered risks arising from modification, additions or changes made to the supply.
- Reviewing monitoring and maintenance responsibilities.
- Checking personnel changes and that new staff are aware of the Water Safety Plan.

Appendix A

Risk Information Tables

Appendix B

Bore Information

Component	Designed & Current Capacity	Description	Operation	Year Built
Papaioea Park Bore No.1	250m^3/hr for about 16m of drawdown. 15 m^3/hr (current) (Now standby pump)	The bore is 130m deep with a static artesian head of 5.36m. The bore services the Milson and Hospital area. This bore has flow and pressure control and is now only used as a standby bore.	8 hrs/month	1965
Papaioea Park Bore No.2	380m^3/hr 250m^3/hr (current)	This bore is 347m deep and has a positive static water level of 43.88m. This bore operates in the same manner as the old bore utilising surface pumps.	12-16 hrs/day	2001
Roberts Line Bore No.1	250-m^3/hr (max) for 30m of drawdown. Currently 103m^3/hr	This bore is 130m deep and services the Kelvin Grove area (bore redeveloped in 1996). This bore is now used as a standby bore.	8 hrs/month	1984
Roberts Line Bore No. 2	500m^3/hr 330m^3/hr (current)	The bore is 206m deep with a positive static head of 14.78m.	Up to 24hrs/day	2004
Takaro Bore	450m^3/hr for 11m of drawdown	The bore is a 300mm diameter bore with 8m of screen.	10 hrs/day	1965
Keith Street Bore	380m^3/hr (design) 180m^3/hr (current)	The bore is 257m deep. There are surface centrifugal pumps used to boost the pressure. This bore has flow and pressure control. (redeveloped in 2002 and 2005).	8 hrs/day	1998
Ashhurst Bore	165m^3/hr	This is a 300mm diameter bore that is 83m deep.	6-10 hrs/day	1991
Bunnythorpe Bore	600m^3/day	This is a 150mm diameter bore that is 201m deep.	Up to 24 hrs/day	1996
Longburn Bore	250m^3/day	This is a 80mm diameter bore that is 171m deep	Up to 24 hrs/day	1985