Wellington Water

Tuesday, 12 July 2022

OIA IRO-221

[redacted]
Email: [redacted]@fluoride.org.nz

Kia ora [redacted]

Official information request for the Greater Wellington Regional Council Review commissioned by Wellington Water.

I write regarding your official information request dated 18th March 2022 for the Greater Wellington Regional Council Review commissioned by Wellington Water.

Please see attached in our email response to you the report you have requested.

For further reference, the independent inquiry into the cessation of fluoride is available on our website, and you can find that report here: https://www.wellingtonwater.co.nz/your-water/drinking-water/fluoride-inquiry

You have the right to seek an investigation and review by the Ombudsman of this decision. Information about how to make a complaint is available at www.ombudsman.parliament.nz or freephone 0800 802 602.

Ngā mihi

[redacted]
Group Manager, Network Management Group
Wellington Water Ltd

GWRC Fluoride Facilities Review

PREPARED FOR WELLINGTON WATER | July 2022

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Stantec

Revision Schedule

Rev No.	Date	Description	Signature or Typed Name (documentation on file)			
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E	26/5/22	Updated following Project Team review	[redacted]	[redacted]	[redacted]	[redacted]
F	29/6/22	Updated following WWL Comments	[redacted]	[redacted]	[redacted]	[redacted]
G	4/7/22	Updated following WWL Comments	[redacted]	[redacted]	[redacted]	[redacted]

Quality Statement

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Since revisions A-C, Wellington Water's four water treatment plants' fluoridation systems have been inspected in more detail as part of a separate fluoridation upgrade project. As part of the separate project, containerised fluoridation systems are being designed and procured for Te Marua and Gear Island. Alternative solutions are being investigated for Waterloo and Wainuiomata to support continued fluoridation from these plants. Further details concerning those solutions are recorded in the separate project's documentation. Most of the details in this report from revisions A-C have remained unchanged.

This disclaimer shall apply notwithstanding that the report may be made available to Wellington Water and other persons for an application for permission or approval to fulfil a legal requirement.

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Executive Summary

Wellington Water operate fluoride dosing facilities at the four water treatment plants (WTPs) that supply the Wellington network: Te Marua, Waterloo, Wainuiomata and Gear Island. Te Marua, Waterloo and Wainuomata use sodium silicofluoride (SSF) powder, and Gear Island uses hydrofluorosilicic acid (HFA).

The fluoridation facilities have all experienced issues that have reduced the availability and reliability of fluoridation and the consistency of the treated water fluoride concentration. Wellington Water wish to improve the current performance of the fluoride dosing facilities, improve reliability and meet the required levels of service as described in legislation and the NZ Fluoridation Code of Practice.

The facilities had some common issues that contributed to poor performance, including the following:

- Poor powder quality (this has recently been addressed by changing supply to a Belgian product).
- Small mixing tanks, causing poor fluoride dose control, undissolved powder accumulating in the dosing line, excessive agitation and failures of the makeup water ballcocks.
- Manual bag emptying into powder hoppers which is a health and safety hazard and causes nylon strands from the bags to enter the dosing system (the nylon strands are no longer an issue as the new product comes in paper bags).
- Non-compliances with the Water New Zealand Code of Practice for Fluoridation of Drinking-Water Supplies in New Zealand (2014).
- The HFA fluoride system at the Gear Island WTP is at the end of their service lives and the tanks are in poor condition.

Long Term Solution

It is recommended that the facilities be replaced with new fluoridation systems that would address all of the current issues and, in addition, would comply with the NZ fluoridation code of practice.

This also provides an opportunity to change from powder (SSF) to bulk liquid (HFA) due to operational advantages.

As both options (SSF and HFA) have advantages and disadvantages across a range of aspects, a multi-criteria analysis (MCA) process is recommended for each site to decide which option is preferred, with input from stakeholders on assessment criteria, weightings and scoring. This approach provides a transparent and auditable process.

The 95th percentile Level 1 cost estimates for new SSF fluoride facilities are as follows:

Te Marua: $696,000

Waterloo: $696,000

Wainuiomata: $614,000

Gear Island: $614,000

The cost estimates are Level 1 and include a contingency of 40% and funding risk allowance of 60% in accordance with Wellington Water's cost estimation procedure.

The cost estimates were undertaken, without consideration of the wider aspects of the works that would be required at all of the plants, including items such as building repairs and significant modification, and were for high level discussion purposes only.

The cost of the Waterloo fluoride system includes for fluoridating the Wellington water supply that is currently fluoridated at Gear Island. If fluoridation of the Petone water supply is directed (made compulsory), then the existing fluoridation facility could be decommissioned. A smaller fluoridation facility dedicated to the Gear Island WTP would be required to fluoridate the Gear Island water supply for the periods when the Gear Island standby supply is used.

If fluoridation of Petone water remains optional and Wellington Water wish to continue supplying unfluoridated water to Petone, the Gear Island HFA facility should be replaced with a new system.

Short Term Improvements

In the meantime, the following improvements should be undertaken immediately to improve performance compliance with the NZ fluoridation code of practice. These are being address in a separate project.

1. Functional Description Review Against NZ Code of Practice / PLC Program Update

In a separate project, the fluoride functional descriptions are being reviewed against the NZ fluoridation code of practice to confirm compliance for lower, upper and emergency process limits; alarms and interlocks (non-resettable remotely). Where the functional descriptions do not meet the code of practice requirements, the PLC code should be updated.

2. Physical Improvement Works

The following improvement works should be undertaken as soon as practicable. These are being address in a separate project.

Te Marua

- Repair the treated water reservoir baffle curtains to prevent short circuiting.
- Implement a new containerised HFA fluoridation plant to replace the existing plant.

Gear Island

- Implement a new containerised HFA fluoridation plant to replace the existing plant.

Waterloo

- Implement recommendations being developed in a separate project to improve the fluoridation system's capacity for higher production rates, and relevant health and safety aspects.

Wainuiomata

- Implement recommendations being developed in a separate project to improve the fluoridation system's resilience.

3. Plant Performance Testing

With the new improved powder product (reduced caking) and following the improvement works listed above, the Waterloo and Wainuiomata fluoride systems should be in a position to be run for a two-week performance test. Following the two-week test period, the following aspects should be reviewed:

- Process control performance (fluoride concentration versus set point).
- Faults and issues.

This test will identify further short-term actions to improve process control and reliability.

1.0 INTRODUCTION

Wellington Water operates four fluoridation facilities, located at the four water treatment plants that supply the Wellington regional water supply network. Fluoride is added to the drinking water to help reduce the prevalence of tooth decay.

The fluoridation facilities have all experienced ongoing issues that have reduced the availability and reliability of fluoridation and the consistency of the treated water fluoride concentration. Due to these issues, the percentage of time that the fluoride dosing facilities have been operational is poor. Operational statistics for 2019 to 2020 are presented in Table 1.

Table 1 Wellington Water Treatment Fluoride Facilities – Reliability January 2019 – May 2020

Water Treatment Plant	Fraction of Time Fluoridation was Operational [1]
Te Marua	10-20%
Waterloo	30-40%
Wainuiomata	10-20%
Gear Island	55%

1. Data provided by WWL in project activity brief (August 2021).

The poor reliability illustrated in Table 1 is somewhat explained by the fact that because fluoridation is not a critical water safety requirement, issues are most easily dealt with by shutting down fluoridation systems, with rectification and reinstatement of fluoride dosing taking a lower priority than other more critical tasks. In this regard, shutting down a fluoride system is a good response to a failure as priorities should be with other more acute health critical systems.

Wellington Water wishes to improve the current poor reliability performance of fluoride dosing systems. They have commissioned Stantec to review the fluoride facilities and provide recommendations to achieve this target.

The Health (Fluoridation of Drinking Water) Amendment Bill was passed in November 2021. Since then, water suppliers are required to fluoridate a water supply if directed to do so by the Director-General of Health. Those already fluoridating will be required to continue to do so unless directed by the Director-General of Health to stop. This places more emphasis on reliability of fluoride dosing compared with the previous regime.

A useful reference guide in this review is the Code of Practice for Fluoridation of Drinking-Water Supplies in New Zealand (2014) published by the New Zealand Ministry of Health and Water New Zealand. This document outlines best practices for the design and operation of water fluoridation plants to ensure the safe and effective addition of fluoride to drinking-water supplies. Although compliance with this Code is not a legal requirement, water suppliers are encouraged to comply with the Code to ensure the safety of their consumers.

The objectives of this review are:

- Review the nature of historic failures of the fluoridation equipment at the four fluoridation facilities.
- Identify any common factors across the sites with respect to the failures.
- Review the design, operation, control and monitoring of the fluoride facilities with reference to the New Zealand Code of Practice for Fluoridation of Drinking-Water Supplies in New Zealand (2014).
- Produce a set of recommendations, including a high-level assessment and identification of benefits to procuring a common chemical dosing system for all sites.

2.0 FLUORIDE SYSTEM OVERVIEW

2.1 WATER SUPPLY AND DOSING LOCATIONS

Fluoride is dosed into the Wellington water supply at the four water treatment plants (WTPs):

- Te Marua WTP
- Waterloo WTP
- Wainuiomata WTP
- Gear Island WTP

The WTPs are all connected into a single regional network. Broadly speaking, Te Marua WTP supplies Upper Hutt, Porirua and the northern and western Wellington suburbs, and Waterloo, Gear Island and Wainuiomata WTPs supply Wainuiomata, Lower Hutt, and Wellington.

Since 1999, the Gear Island WTP has only been used as a standby facility and is typically only run on one or two days each month to maintain operational readiness. However, the Gear Island fluoride facility doses continuously into the treated water being provided to Wellington from the Waterloo WTP. This is to accommodate the non-fluoridated Petone supply zone.

A schematic of the water supply network showing the fluoride dosing locations is presented in Figure 1.

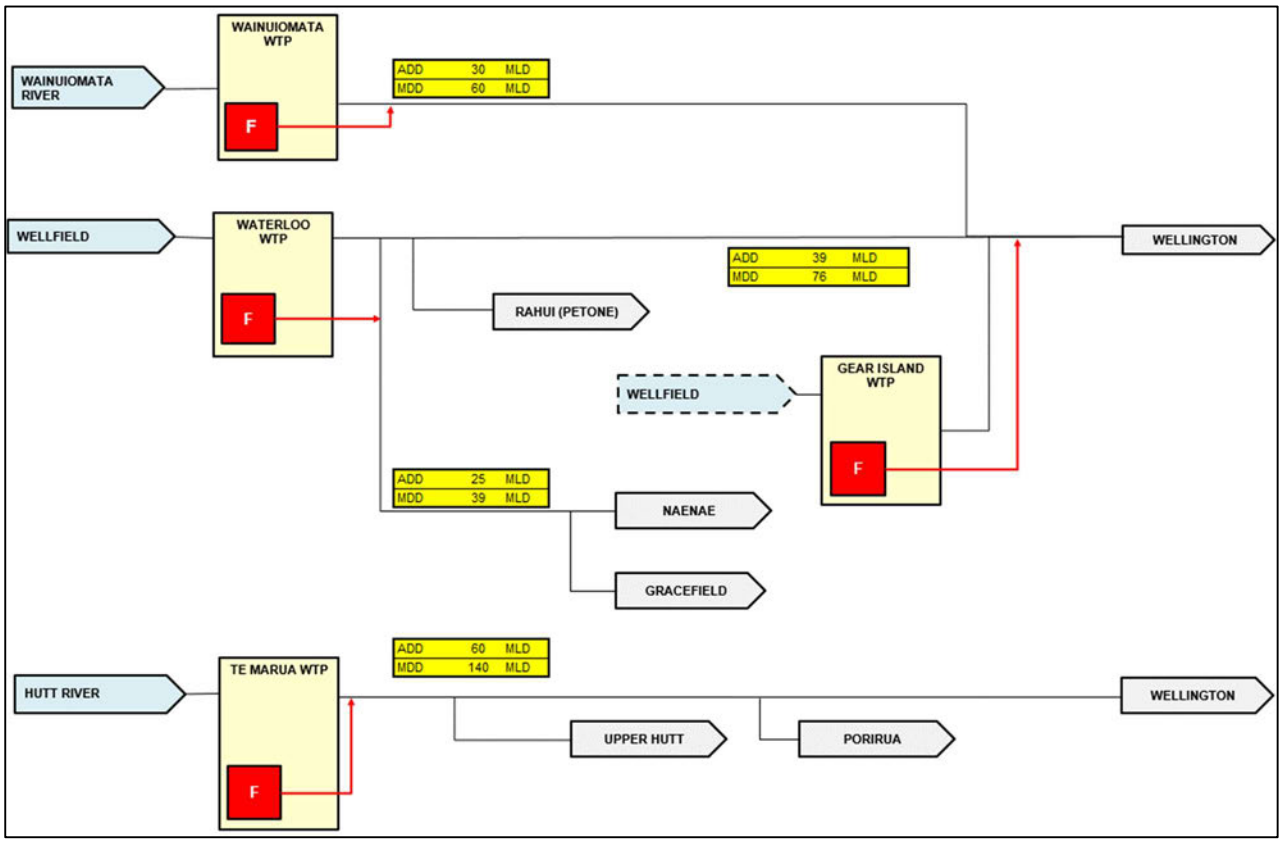

Figure 1 Greater Wellington Water Supply Fluoride Dosing Locations

2.2 FLUORIDE CHEMICALS USED

Three of the four fluoride dosing facilities use sodium silicofluoride (SSF) which is supplied as a powder in 25 kg bags. The Gear Island WTP uses hydrofluorosilicic acid (HFA) which is supplied by tankers as a bulk liquid.

Details of the chemicals used are presented in Table 2.

Table 2 Fluoride Chemicals Used in Wellington Regional Supply System

Chemical	Formula	Supplied Chemical Strength (w/w)	Supplied Chemical F Content (w/w)	Specific Gravity	WTPs Supplied
Sodium silicofluoride	Na_2SiF_6	99%	60%	n/a	• Te Marua • Waterloo • Wainuiomata
Hydrofluorosilicic acid	H_2SiF_6	20%	15.8%	1.19	• Gear Island

Sodium silicofluoride is manufactured overseas and imported to New Zealand by chemical suppliers. In previous years, a Belgian product was used. Afterwards, an alternative manufacturer of SSF was used in recent years, but the product quality was inferior to the Belgian product, resulting in powder handling issues. The powder arrived in the bags partially solidified and required breaking up. After reverting to the Belgian product in the Waterloo and Wainuiomata plants, these powder handling issues disappeared. The Te Marua fluoride system has remained offline since it was shut down.

Hydrofluorosilicic acid is manufactured in New Zealand and is a by-product of the superphosphate fertiliser manufacturing process. It is understood that there is a single manufacturer of HFA in New Zealand, namely Ballance, that supplies the whole country.

3.0 DESCRIPTION OF FLUORIDE FACILITIES

3.1 TE MARUA

3.1.1 System Overview

The Te Marua fluoride system was installed in 1986 at the same time as the water treatment plant (according to the Wellington Water asset database). The system is a constant flow, variable concentration system.

Fluoride solution is dosed into the treated water in the mixing chamber upstream of the treated water reservoir.

An online fluoride analyser measures the fluoride residual in the treated water reservoir. A second online analyser measures the fluoride residual at the treated water pump station approximately 1 km downstream of the reservoir. The analysers are not used for control of the dosing system but are used for annunciating alarms and for initiating automatic shutdowns on high fluoride concentration.

The fluoride dosing system consists of a bulk hopper (dry room), screw conveyor, day hopper (wet room), volumetric feeder, mixing tank, water make-up system and centrifugal dose pump.

Once per week, SSF powder from the 25 kg bags are manually loaded into the bulk hopper through the feed hatch located above the hopper. A dust extraction system is connected to the hopper.

The screw conveyor runs once per day to fill the day hopper, located above the volumetric feeder and mixing tank. The speed of the volumetric feeder is flow-paced to the plant's flow rate to achieve a treated water fluoride residual of 0.85 mg/L. The speed of the volumetric feeder can be adjusted by a multiplier available via SCADA (multiplier values between 0.8 and 1.8 can be selected). The volumetric feeder feeds dry powder into the mixing tank. The mixing tank is supplied with treated water via a water pipe fitted with a ballcock valve. This keeps the tank constantly full. An impeller in the tank provides the mixing energy for dissolved the SSF powder. The dosing pump (duty only) operates at fixed speed and delivers the fluoride solution to the dose point.

Figure 2 to Figure 6 illustrate the main elements of the fluoride system.

Figure 2 Te Marua WTP: SSF Powder Storage Hopper (note ladder and lack of handrail on platform)

Figure 3 Te Marua WTP: SSF Day Hopper (Behind Panel)

Figure 4 Te Marua WTP: Powder Feeder and Mixing Tank

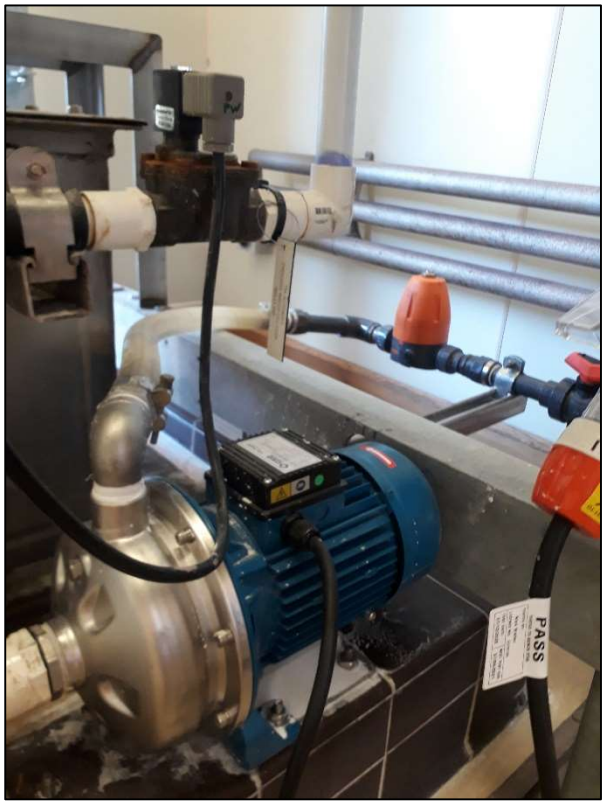

Figure 5 Te Marua WTP: Fluoride Dosing Pump

Figure 6 Te Marua WTP: Fluoride Dosing Point

A P&ID of the system is presented in Figure 7.

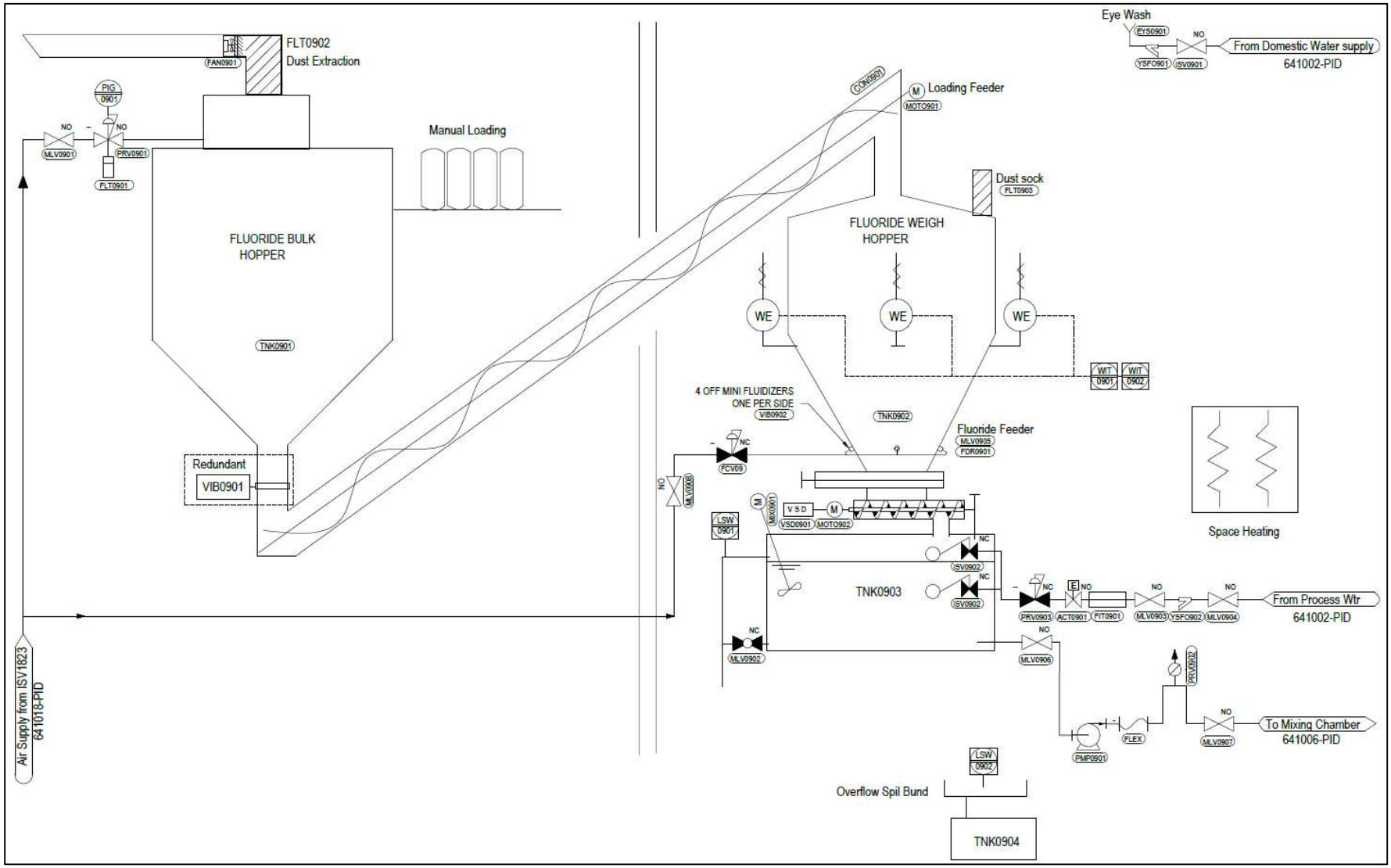

Figure 7 Te Marua WTP: Fluoride System P&ID

3.1.2 Process Design Parameters

Fluoride dosing process design parameters are presented in Table 3.

Table 3 Te Marua WTP Fluoride Process Parameters (Variable Concentration System)

Parameter	Unit	Value
Fluoride Dose		
Target treated water fluoride concentration	mg/L	0.85
Background fluoride concentration	mg/L	0.10
Fluoride dose into treated water	mg/L	0.75
Demand		
Treated water demand (average)	MLD	60
Treated water demand (maximum)	MLD	140
Powder Consumption		
SSF consumption (average)	kg/day	75
SSF consumption (maximum)	kg/day	175
SSF consumption (average)	kg/h	3.1
SSF consumption (maximum)	kg/h	7.3
Mixing Tank		
SSF solution concentration (maximum)	mg/L	2,000

3.1.3 Issues

The following issues with the Te Marua WTP fluoride system have been reported by Wellington Water operations staff or were observed during site investigations.

Treated Water Reservoir Short Circuiting

- There is short circuiting of treated water from the inlet to the outlet of the reservoir caused by a ripped baffle curtain. The short circuiting prevents a fluoride overdose being captured within the TWR. The baffle curtain issue is being addressed in a separate project.

Product Issues

- The handleability of the previous SSF product was inconsistent and difficult. The product often arrived as a solidified block and needed to be broken up, or was prone to compacting and bridging inside the hoppers. Fluidisers (using compressed air) were installed in the day hopper in 2019 for aiding with this issue. The fluidisers were not required when the Belgian product was previously used.
- Nylon strands from the SSF bags would sometimes make their way into the dosing system and cause blockages. A strainer was installed on the mixing tank outlet but was prone to blockages. The Belgian product comes in paper bags so the nylon strands should no longer be an issue.

Operability

- The absence of fixed handrails around the bag platform in the dry room presents a falling-from-height risk.
- Manually tipping the powder into the hopper is not recommended from a health and safety perspective in terms of airborne powder and muscle strain from handling multiple 25 kg bags. Most modern systems use a vacuum lance to transfer powder from the bags to the hopper.

- The dry feeder is reportedly undersized for providing the required fluoride dose at the peak plant production rates. While generally not an issue, it is a limitation for using the existing system longer-term.

Mixing Tank

- The mixing tank is small and there have been issues with excessive agitation and inconsistent dissolution of powder. This issue may be rectified with the Belgian SSF powder but the system has not yet been restarted with the new product.
- The ballcocks for the inlet water for maintaining the mixing tank volume reportedly require replacement every few months. While not considered a major operational issue, the timing of a failure may not be predictable
- The mixing tank mixer is too large for the mixing tank and must be operated on a timer for only a few seconds every minute to reduce damage to the ballcocks.

Dosing Hydraulics

- The delivery pump is a centrifugal pump across the plants, the model of which is standardised across the three plants. This is convenient for common spares, but the flow rate may not be appropriate for all plant flow rates.
- There is only one dosing pump. It is good practice, and according to the NZ Code of Practice, to have two dosing pumps (duty / standby).
- There is no pressure-sustaining valve on the dose line downstream of the dosing pump. There used to be one installed, but it was worn away and replaced with a manual isolation valve, which is manually throttled to provide backpressure to the pump.
- The treated water reservoir is lower than the fluoride room, meaning that syphoning of fluoride solution to the dose point can occur. A syphon-break valve is present which will ensure that the mixing tank is not syphoned to the reservoir. However, the dose line can still be syphoned as there is no pressure-sustaining valve and no auto-isolation valve at the dose point.

Additional Considerations

- The gaskets around the screw conveyor at the wall between the dry and wet rooms contain asbestos. This poses a risk should maintenance / dismantling take place on the screw conveyor.
- There is no dose line flowmeter for additional flow verification. Additional flow verification is required by the NZ Code of Practice.

3.2 WATERLOO

3.2.1 System Overview

The Waterloo fluoride system was installed in 1981 (according to the Wellington Water asset database). It was modified in 2001 at the same time as installing the plant at Gear Island.

The Waterloo WTP supplies Lower Hutt, Wainuiomata, and central, southern and eastern Wellington. The Waterloo fluoride dosing system operates as a constant concentration, variable flow system. Fluoride solution is dosed into a single dosing point in the Naenae supply pump discharge pipe. Another dosing point, in the Gracefield supply pump discharge pipe, is not used.

Two online analysers (duty / duty) measure the treated water fluoride concentration in the pumping main downstream of the dosing point. The analysers are not used for control of the dosing system but provide monitoring of fluoride concentration, annunciate alarms, and initiating automatic dosing shutdowns on high fluoride concentration.

There are two fluoride day tank recirculation pumps (duty / standby) which are multistage centrifugal water pumps; these pumps recirculate fluoride solution through the fluoride day tank to provide mixing of the tank contents. The fluoride dosing flow into the Naenae pumping main is supplied from the fluoride recirculation pipe via a modulating valve. This valve controls the dosing flow rate in response to the Naenae water supply flow meter, to maintain a constant fluoride dose into the water (mg/L).

The fluoride day tank is topped up regularly with batches of fluoride solution from the fluoride makeup system in the room next door. Each batch is around 4 – 5 m^3 in volume. When the level in the day tank reaches a batch makeup set point, the batching process starts. A volumetric powder feeder at the base of the day hopper feeds SSF powder into the fluoride mixing tank at a controlled rate proportional to the makeup water flow rate entering the mixing tank. At the same time, the fluoride transfer pump starts to transfer fluoride solution to the day tank. The mixing tank is kept full by ballcock valves connected to a treated water supply pipe. The fluoride transfer pump stops when the level in the day tank reaches the stop level. The mass of SSF powder added per batch is measured via load cells on the day hopper to calculate the solution strength.

Powder is transferred to the day hopper from a storage hopper directly above the day hopper, via a rotary valve. SSF powder is delivered to site in pallets of 25 kg bags. Once per week, between 200 and 400 kg of powder (8-16 x 25 kg bags) is emptied manually into the storage hopper via the feed hatch located above the hopper

Figure 8 to Figure 12 illustrates the main elements of the fluoride system.

Figure 8 Waterloo WTP: SSF Powder Feed Hatch (Storage Hopper below Floor)

Figure 9 Waterloo WTP: SSF Powder Storage Hopper (upper) and Day Hopper (lower)

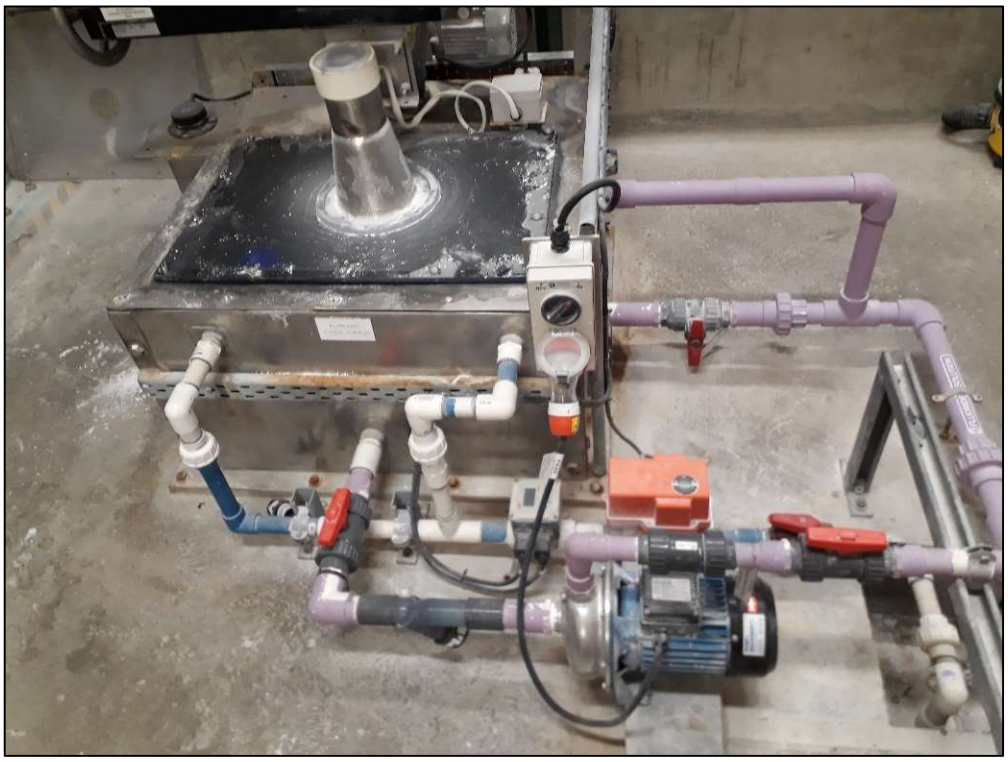

Figure 10 Waterloo WTP: SSF Mixing Tank and Transfer Pump

Figure 11 Waterloo WTP: SSF Day Tank

Figure 12 Waterloo WTP: Fluoride Dosing Pumps

A P&ID of the system is presented in Figure 13. The P&ID is being checked and updated as part of a separate project.

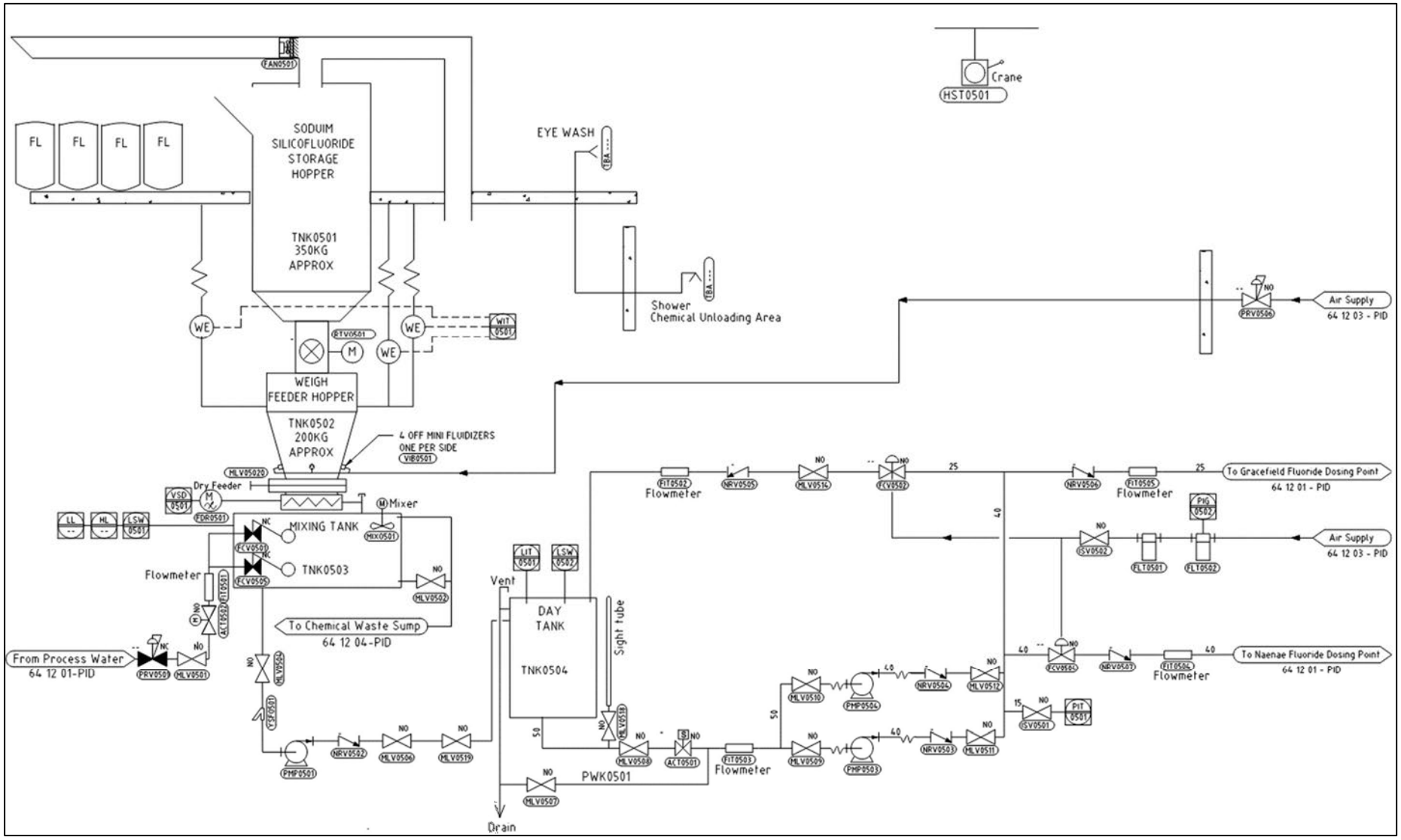

Figure 13 Waterloo WTP: Fluoride System P&ID

3.2.2 Process Design Parameters

Fluoride dosing process design parameters are presented in Table 4.

Table 4 Waterloo WTP Fluoride Process Parameters (Constant Concentration System)

Parameter	Units	Typical	Maximum
Fluoride Dose			
Target treated water fluoride concentration	mg/L	0.85	
Background fluoride concentration	mg/L	0.10	
Fluoride dose into treated water	mg/L	0.75	
Demand			
Fluoridated water demand	ML/d	11-60 [1]	120 [2]
Powder Consumption			
SSF consumption (daily)	kg/day	13-69	138
SSF consumption (hourly)	kg/h	0.6-3.1	6.3
Dry Capacities			
Bulk hopper	kg	350	
Bulk hopper storage time	d	5-28	2.5
Day hopper	kg	200	
Day hopper storage time	h	64-349	32
Dry feeder capacity	kg/h	7.7 [3]	
Wet Capacities			
Mixing tank capacity (live volume)	L	125	
SSF solution concentration	mg/L	500	
Batch size	m^3	4	
Batch make-up period	h	0.6-3.5	0.3
Day tank capacity (live volume)	m^3	12	
Day tank storage (full volume used)	h	1.9-10.5	1.0
Dose Rates			
Fluoride dosing flow rate	L/h	115-625	1,250

1. The typical demand is the current fluoridated production rate.
2. The maximum demand is the maximum that the Waterloo WTP can supply, including to Wellington. This includes fluoridated and unfluoridated demand and is included for reference in case the full production from the Waterloo WTP is required to be fluoridated in future.
3. This value is estimated as the dry feeder appears to be the same model as that installed in the Te Marua fluoride system.

3.2.3 Issues

The following issues with the Waterloo fluoride system have been reported by Wellington Water operations staff or were observed during site investigations.

Powder Handling

- The 25 kg bags are manually loaded into the loading hopper. The loading process poses risk to operators due to the heavy bags and the loading hopper and some exposure to dust.
- The manual tipping of powder into the hopper is not recommended from a health and safety perspective. Most modern systems use a vacuum lance to transfer powder from the bags to the hopper.
- The maximum day demand (including Wellington) uses 6 x 25 kg bags per day or 42 bags per week if demand is sustained for 7 days. A bulk bag (1,000 kg) system should be considered in future to save time in transferring powder to the storage hopper. This can be considered during detailed design if SSF is the preferred chemical option going forward (see Section 0).
- There are personnel access issues to the powder storeroom.
- The valley angles of the bulk hopper are too shallow. Powder sometimes built up in the hopper, requiring manual intervention to get it to transfer. This may have been due to the previous, lower quality product.
- The rotary valve below the bulk hopper sometimes had maintenance issues due to blocking. This may have been due to the previous, lower quality product.

Mixing Tank and Transfer Pump

- The batch makeup and transfer system design is such that the operators have to balance the transfer pump flow rate with the water supply rate by manually throttling the valve downstream of the transfer pump; otherwise the transfer pump draws down the level in the mixing tank.
- There is only one transfer pump (no standby unit).

Day Tank and Recirculation / Dosing Pumps

- The auto drain valve for the day tank is reportedly stuck and requires replacement.
- The day tank volume is reportedly insufficient at a dosed flow rate of 60 MLD, being drained down faster than batches can be made up.
- Multi-stage centrifugal pumps are used for both day tank recirculation and fluoride dosing, using a modulating valve to control the dosing flow rate off the recirculation line. Dedicated positive displacement dosing pumps (either diaphragm, progressive cavity or peristaltic) and a dedicated tank mixing system may provide better overall performance. This should be assessed in any upgrade options considered.

Fluoride Analysers

- There are two fluoride analysers (duty / duty). The analysers have daily automatic self-calibration which takes around one hour to complete. Having two analysers allows fluoride dosing to continue when one is offline for calibration. However, if the other analyser is down for maintenance, fluoride dosing is stopped until the calibration period is complete.
- The analysers reportedly consume too much chemical for the calibrations in comparison with other, differently branded analysers used by WWL.
- Reagents must be made up by operators. This is a time-consuming process that does not guarantee the quality of the reagent.

Fluoridation Policy

Future fluoridation policy will influence the future fluoride demand at the Waterloo WTP. If the Petone supply is required to be fluoridated, all water leaving the Waterloo WTP would need to be fluoridated. This would more than double the fluoride demand on the Waterloo WTP, requiring an upgrade in capacity.

To allow for this possibility, it is recommended that any upgrade works at the Waterloo WTP be designed assuming that all water leaving Waterloo WTP will be fluoridated in future.

3.3 WAINUIOMATA

3.3.1 System Overview

The Wainuiomata fluoride system was installed in 1964 (according to the Wellington Water asset database). The storage hopper and inclined screw conveyor were installed when the fluoride system was installed. The day hopper and volumetric screw feeder were replaced around 2000.

The Wainuiomata WTP supplies Wainuiomata and Wellington. As with the Te Marua WTP, the fluoride dosing system is a constant flow, variable concentration system. There is a single fluoride dosing pump that operates at a constant fixed speed. The fluoride dosing pump draws solution from the fluoride mixing tank, a small rectangular tank that sits directly below the SSF day hopper. The mixing tank is continuously topped up with treated water via a water pipe and ballcock valve. This keeps the tank full.

A volumetric feeder at the base of the SSF day hopper continuously feeds SSF powder into the mixing tank. The volumetric feeder speed is controlled automatically in response to the filtered water flow rate to maintain a constant fluoride dose, i.e. the dosed fluoride solution concentration varies in proportion to filtered water flow rate.

Powder is transferred to the day hopper from a storage hopper in the room next door, via an inclined screw conveyor.

SSF powder is delivered to site in pallets of 25 kg bags. Once per week, around 200 kg of powder (8 x 25 kg bags) is emptied manually into the storage hopper via the feed hatch located above the hopper.

Figure 14 to Figure 18 illustrates the main elements of the fluoride system.

Figure 14 Wainuiomata WTP: SSF Powder Storage Hopper Loading Hatch

Figure 15 Wainuiomata WTP: SSF Powder Day Hopper

Figure 16 Wainuiomata WTP: SSF Mixing Tank

Figure 17 Wainuiomata WTP: Fluoride Feeder and Dosing Pump

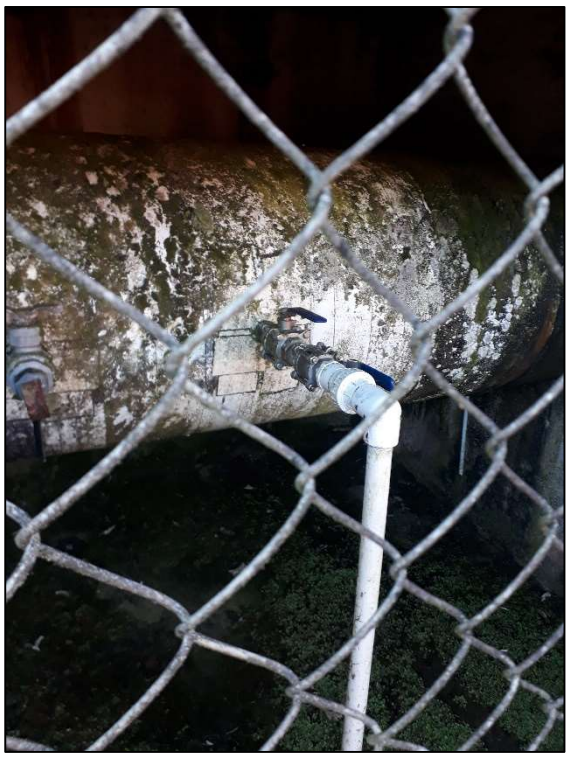

Figure 18 Wainuiomata WTP: Fluoride Dosing Point

A P&ID of the system is presented in Figure 19. The P&ID is being checked and updated as part of a separate project.

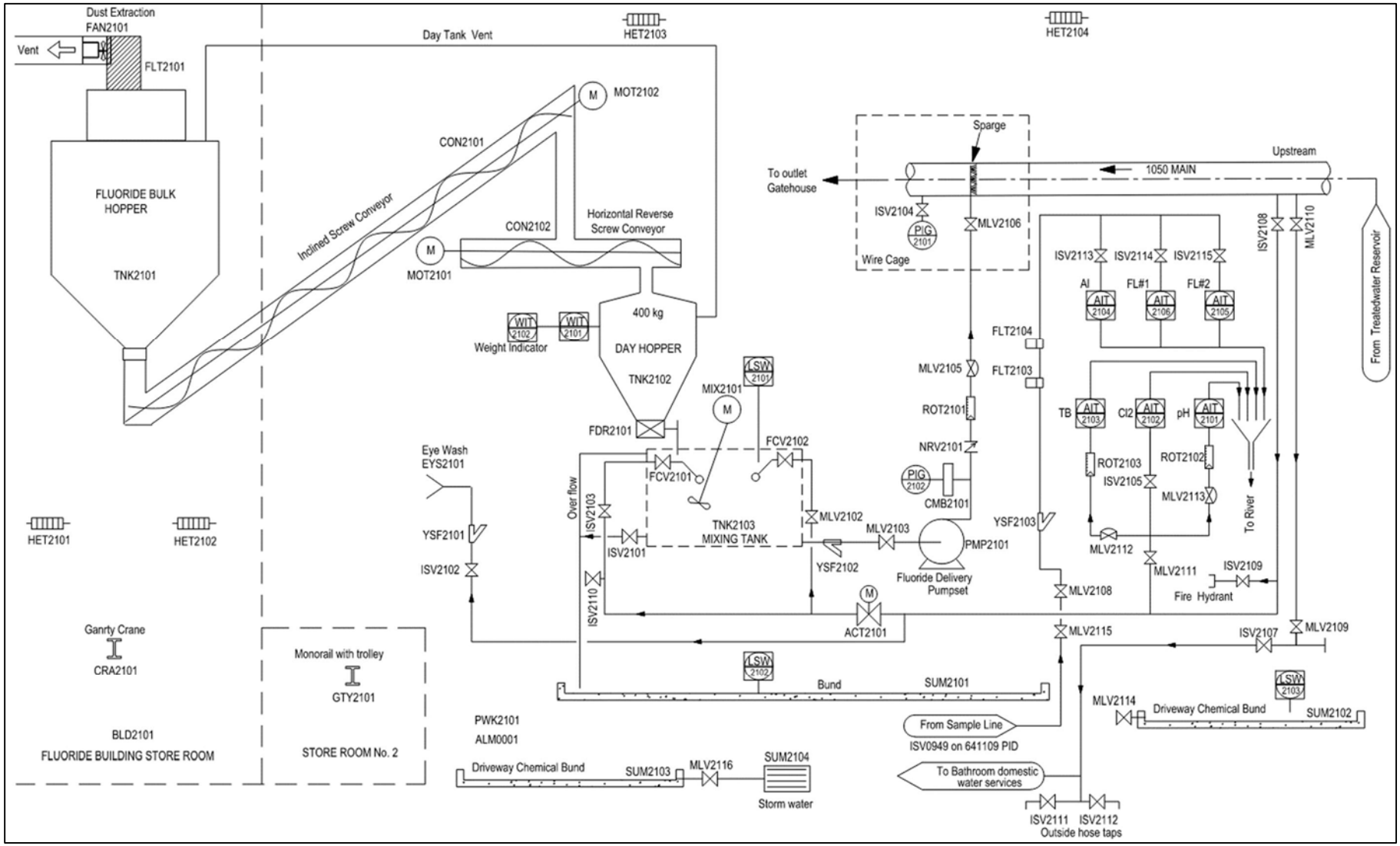

Figure 19 Wainuiomata WTP: Fluoride System P&ID

3.3.2 Process Design Parameters

Fluoride dosing process design parameters for Wainuiomata WTP are presented in Table 5.

Table 5 Wainuiomata WTP Fluoride Process Parameters (Variable Concentration System)

Parameter	Unit	Value
Fluoride Dose		
Target treated water fluoride concentration	mg/L	0.85
Background fluoride concentration	mg/L	0.10
Fluoride dose into treated water	mg/L	0.75
Demand		
Treated water demand (average)	MLD	30
Treated water demand (maximum)	MLD	60
Powder Consumption		
SSF consumption (average)	kg/day	38
SSF consumption (maximum)	kg/day	75
SSF consumption (average)	kg/h	1.6
SSF consumption (maximum)	kg/h	3.1
Mixing Tank		
SSF solution concentration (maximum)	mg/L	2,000

3.3.3 Issues

The following issues with the Wainuiomata fluoride system have been reported by Wellington Water operations staff or were observed during site investigations.

Powder Handling

- The same powder handling issues as Te Marua (see Section 3.1.3). These have been resolved since the Belgian product is now being used.
- The manual tipping of powder into the hopper is not recommended from a health and safety perspective. Most modern systems use a vacuum lance to transfer powder from the bags to the hopper to reduce exposure to dust.
- There is no access to the base of the powder transfer screw conveyor, and this is prone to blockage if the powder is allowed to sit in the base of the conveyor for a period of time. Therefore, the operators have to transfer all of the powder into the day hopper once they have tipped the bags into the conveyor. This limits the amount of powder that can be loaded into bulk hopper and results in more frequent bag transfers. This issue may have been resolved with the introduction of the Belgian product.
- The powder feeder uses a shaftless screw feeder, which is a different design to that used at Te Marua and Waterloo. The screw cannot meet fluoride set point during peak demand periods and cannot turn down to meet flows below 12 MLD. Therefore, fluoride dosing is switched off during low demand periods.

Mixing Tank

- There have been issues with excessive agitation and inconsistent dissolving performance in the mixing tank. These may have been resolved with the introduction of the Belgian product.

3.4 GEAR ISLAND

3.4.1 System Overview

The Gear Island WTP is used as a standby facility and is typically only run on one or two days each month, to maintain operational readiness. However, the Gear Island fluoride facility is intended to dose continuously into the Wellington water supply (to accommodate the non-fluoridated Petone supply zone supplied from Waterloo).

The fluoride facility at Gear Island was installed in 2001 but is no longer used due to health and safety, HSNO compliance and equipment condition issues. The facility used hydrofluorosilicic acid (HFA). There are four 2,500 L HDPE tanks and two diaphragm dosing pumps (duty / standby). The first and second tanks are hydraulically-linked and the third and fourth tanks are hydraulically-linked. HFA is replenished via bulk tanker delivery. The HFA can be directed to either pair of tanks by manually adjusting valve positions inside the building. All the equipment is located inside a bund. Two ventilation fans are activated manually when operators enter the HFA room ensure a good turnover of air in the HFA room.

HFA was dosed into the suction line of the carrier water booster pumps. The booster pumps draw carrier water from the 1050 mm main line via the Gear Island valve chamber and pump chlorinated and fluoridated water back into the main downstream of the draw-off point.

Because the water in the Wellington supply main at the Gear Island valve chamber normally consists of a mix of fluoridated water (from Wainuiomata WTP) and unfluoridated water (from Waterloo WTP) a calculation is performed in the control system to calculate the unfluoridated flow rate and required dose, which are used to control the dosing pump speed. Dosing will stop if the flow rate required for dosing is less than 2 ML/d.

Fluoride analysers (duty / duty) are used to ensure that the dose does not exceed safe limits. When one analyser is offline for calibration, the other one is used. The analysers are not used for control.

Figure 20 to Figure 22 show photos of the main elements of the fluoride system.

Figure 20 Gear Island WTP: HFA Tanker Delivery Connection Point (Centre)

Figure 21 Gear Island WTP: HFA Storage Tanks

Figure 22 Gear Island WTP: Fluoride Dosing Pumps

A P&ID of the system is presented in Figure 23. The P&ID is being checked and updated as part of a separate project.

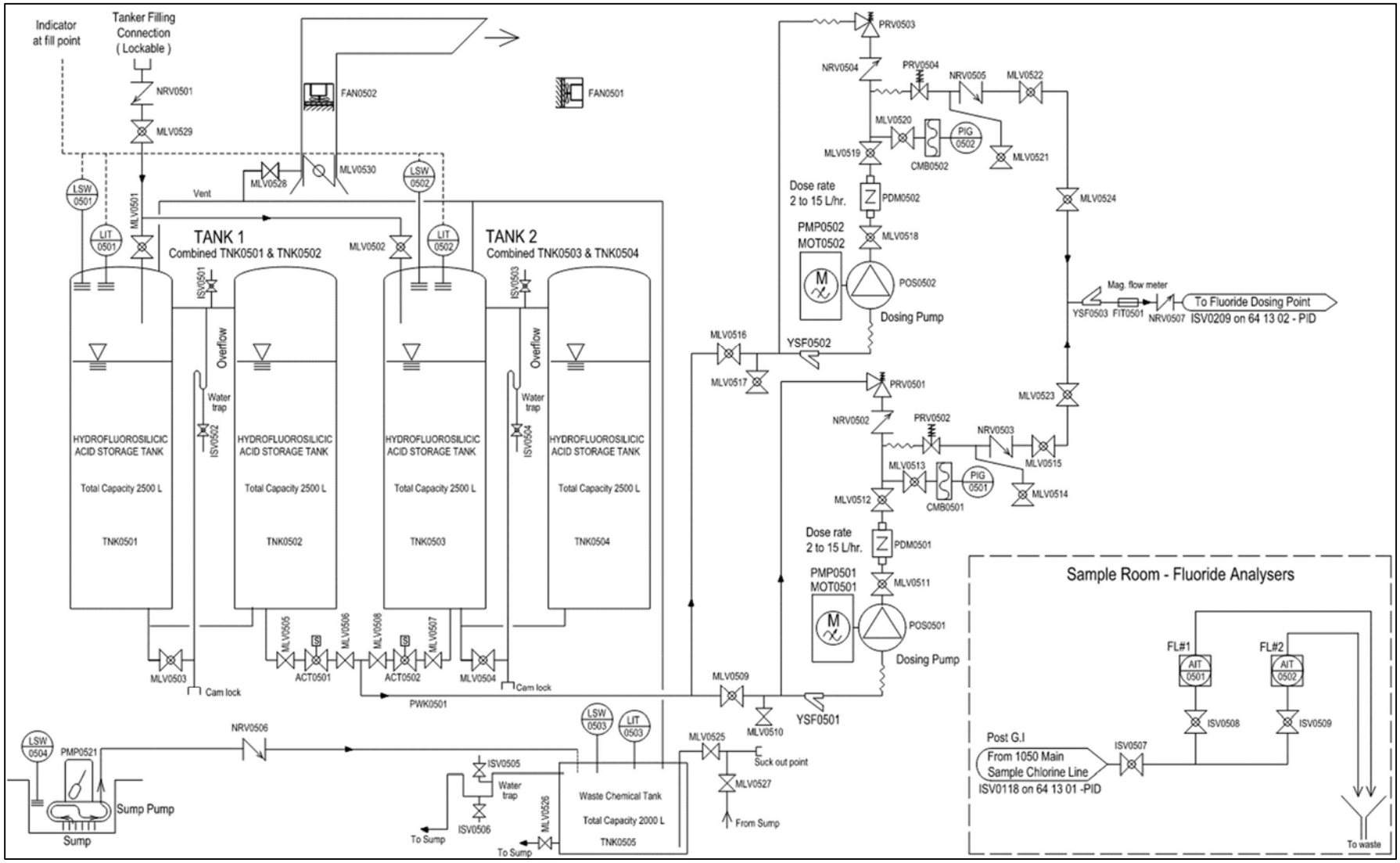

Figure 23 Gear Island WTP: Fluoride System P&ID

3.4.2 Process Design Parameters

Fluoride dosing process design parameters for Gear Island WTP are presented in Table 6.

Table 6 Gear Island WTP Fluoride Process Parameters (HFA System)

Parameter	Unit	Value
Fluoride Dose		
Target treated water fluoride concentration	mg/L	0.85
Background fluoride concentration	mg/L	0.10
Fluoride dose into treated water	mg/L	0.75
Demand		
Unfluoridated water demand (average)	MLD	39
Unfluoridated water demand (maximum)	MLD	76
HFA Consumption		
HFA consumption (average)	L/day	155
HFA consumption (maximum)	L/day	303
HFA consumption (average)	L/h	6.5
HFA consumption (maximum)	L/h	12.6

3.4.3 Issues

Health and Safety

- The operators have to enter the HFA bund to access the fluoride dosing pumps. This poses a health and safety risk if there is spillage in the bund.
- Plaster is pulling away from parts of the ceiling. While not a structural issue, the loose plaster poses a risk to operators in the room.

Asset Condition

- The equipment at the Gear Island fluoride facility is at the end of its service life and requires replacement. The tanks in particular are in poor condition.
- Ventilation of the room is activated manually on occasion. Ventilation should be continuous to maintain a good turnover of air under all conditions. However, as the system has not been running since November 2021, and the tanks do not have any residual HFA in them, this does not present a hazard.

Fluoridation Policy

- Future fluoridation policy will influence the decision on what to do with the Gear Island fluoride facility. If the Petone water supply is fluoridated in future, all water leaving the Waterloo WTP would be fluoridated and the Gear Island facility would be required for only the Gear Island bore water. Therefore, a smaller fluoridation plant at Gear Island may be required in future.

4.0 FLUORIDATION CODE OF PRACTICE

4.1 NEW ZEALAND CODE OF PRACTICE

The Water New Zealand Code of Practice for Fluoridation of Drinking-Water Supplies in New Zealand (2014) specifies good practice for the design and operation of water fluoridation plants to ensure the safe and effective addition of fluoride to drinking-water supplies. Although compliance with this Code is not a legal requirement, water suppliers are encouraged to comply with the Code to ensure the safety of their consumers. Compliance with the Code is also a way to provide increased public confidence.

The main purpose of the NZ Code of Practice is to ensure the safety of consumers and operators (i.e., maintain appropriate quality assurance procedures, avoid overdosing of fluoride, manage operational health and safety risks). The NZ Code of Practice provides a useful checklist for audit of current systems and compliance is considered mandatory for any new fluoride systems.

4.2 COMPLIANCE SUMMARY TABLE

Compliance of the fluoride facilities against the NZ Code of Practice has been assessed and is presented in Table 7.

Table 7 Wellington Fluoridation Facilities – 2014 NZ Fluoridation Code of Practice Compliance Assessment Summary

Item	Requirement	NZ CoP Section	2014 NZ CoP Compliance Assessment / Further Information Requirement			
			Te Marua	Waterloo	Wainuiomata	Gear Island
Chemical selection	Chemicals available for fluoridation are hydrofluorosilicic acid (H_2SiF_6), sodium fluoride (NaF) and sodium fluorosilicate/sodium silicofluoride (Na_2SiF_6)	4.1.2	✓ Sodium silicofluoride	✓ Sodium silicofluoride	✓ Sodium silicofluoride	✓ Hydrofluorosilicic acid
Target concentration of fluoride in water	Target concentration 0.7 – 1.0 mg/L. Historical records of raw water fluoride concentration to be analysed at an appropriate frequency for the expected variability and records kept.	4.1.3	✓	✓	✓	✓
Design control limits	• Operating target as determined in Section 4.1.3 • Operating range (≥95% of the time that the fluoridation plant is in operation) – within ± 0.15 of operating target • Lower action process limit – 0.6 mg/L • Upper action process limit – 1.2 mg/L • Emergency process limit – 1.5 mg/L	4.1.4 / Table 2	× No dosing; therefore, operating range is below lower action process limit ✓ Alarm levels and interlocks comply	? Review SCADA data for fluoride compliance ✓ Alarm levels and interlocks comply	? Review SCADA data for fluoride compliance ✓ Alarm levels and interlocks comply	× No dosing; therefore, operating range is below lower action process limit ✓ Alarm levels and interlocks comply
Automated operation of plant	Plant design must ensure dependable automatic operation with reliable stopping and starting of the system during plant shutdown and start-up.	4.1.5 d)	× Automatic operation but plant not running for requiring uptime	× Automatic operation but plant not running for requiring uptime	× Automatic operation but plant not running for requiring uptime	× Automatic operation but plant not running for requiring uptime
Alarms	The plant must have alarms (including after hours to duty operator) and automatic shutdowns for key process elements.	4.1.5 e)	✓	✓	✓	✓
Day tank / hopper	If a day tank (or hopper) is used: Fluoride transfer from the bu k tank (or hopper) to the day tank (or hopper) must occur nominally once in a 24-hour period. It must be equipped with either an online weight measurement device or an online level instrument that enables measurement of the quantity of fluoride used during each 24-hour period. The day tank must be sized for a maximum of 110% of the volume (or weight) required for the maximum capacity and target dose rate. If using fluorosilicic acid, the day tank must be vented to the outside atmosphere and all connections sealed to prevent corrosion of the equipment in the room, or 'clouding' of any windows and damage to any electrical panels. A water trap should be provided on the tank overflow. The building should also include appropriate levels of ventilation.	4.1.5 f) 4.1.6 c)	✓ Day hopper filled once per day ✓ Load cells on day hopper N/A	× Day hopper filled 1 to 2 times per day ✓ Load cells on day hopper ✓	? Confirm day hopper fill frequency. ✓ Load cells on day hopper. N/A	N/A No day tank (only bu k tanks) N/A N/A

Item	Requirement	NZ CoP Section	2014 NZ CoP Compliance Assessment / Further Information Requirement			
			Te Marua	Waterloo	Wainuiomata	Gear Island
Bulk tank	If a bulk tank is used it must be equipped with an online level indicator or instrument and an easily readable graduated volume scale to reduce the risk of overfilling. When fluorosilicic acid is used the tank level must be displayed at the delivery connection point for the bulk tanker supplier.	4.1.5 g)	N/A	N/A	N/A	✓ Online level indicator vis ble at tanker connection point
Flow-paced dosing	Fluoride dosing must be flow-paced based on the measured water flow into which the fluoride is being dosed. Typically dosing will be achieved through use of a suitable flow meter and variable speed metering pumps. A secondary flow-based control device (for example, a flow meter or flow sensing device such as a flow switch) should be provided as backup to the main flow meter (i.e. in series).	4.1.5 h)	✓ Variable conc., constant flow control ✓	✓Constant conc., variable flow control × No secondary device	✓ Variable conc., constant flow control × No secondary device	✓ ✓
Maximum dosing capacity	The maximum physical dosing capacity of the fluoridation chemical feeding equipment must be limited by design to a maximum value that is as close as practicable to the operating target dose rate at the maximum water flow rate. This maximum value should not exceed 110 per cent of the operating target dose rate at the maximum plant capacity. For metering pumps which have a manual stroke adjustment, the component of the dosing flow that is able to be changed by manual adjustment of the stroke is excluded from this requirement, as long as the stroke adjustment is locked in position and its maximum operating position is clearly marked.	4.1.5 i)	✓ Feeder capacity is 7.7 kg/h	× Day tank recirculation pumps used for dosing. Could overdose if control valve fails open.	✓ Powder feeder is undersized, which prevents overdosing	× Dose pump capacity is 25% larger than maximum
Failure of control system	The drinking-water supplier must ensure that upon failure of the control system, treated water exceeding the emergency process limit in Table 2 does not enter the drinking-water supply system. This fail-safe system would include metering pumps stopping and supply valves closing.	4.1.5 j)	× No control valve on dose line and dose line can syphon into treated water	✓ Control valve on dose line and dose line cannot syphon into treated water	? Need confirmation of control narrative	✓ No control valve on dose line but dose line cannot syphon into treated water
Duty/standby dosing pumps	Metering pumps should be in a duty/standby arrangement. A duty/assist arrangement is acceptable, however the additional risk of control malfunctions should be considered.	4.1.5 k)	× No metering pumps Single duty dosing pump	✓ Duty/standby pumps (but not metering pumps)	× No metering pumps Single duty dosing pump	✓ Duty/standby pumps

Item	Requirement	NZ CoP Section	2014 NZ CoP Compliance Assessment / Further Information Requirement			
			Te Marua	Waterloo	Wainuiomata	Gear Island
Dose monitoring	For water supply systems that serve more than 10,000 people, at least two of the three following Independent Checks must be used. If the water supply system serves 10,000 or fewer people, then at least one of the three Independent Checks is required.	4.1.6				
	1. Use of a day tank/hopper that can only be filled once a day and is equipped with an online device to measure its contents.		✓	✓	**?** Confirm day hopper fill frequency.	N/A
	2. Use of a fluoride measuring flow meter on the fluoride dosing line before the dosing point (only for (a) fluorosilicic acid, or (b) sodium fluoride from a saturator).		N/A	N/A	N/A	✓
	3. Fluoride concentration analyser on the drinking-water line after dosing point.		✓	✓	✓	✓
Water service off-takes	No drinking-water service within the plant or to consumers must be taken directly off the water line to which fluoride is dosed (upstream of fluoride analyser).	4.1.7 a)	✓	✓	✓	✓
Anti-siphonage, back-flow protection and pressure relief	Any water supply used for dissolving the fluoridating agent or as carry water must have a backflow prevention device fitted upstream of where the fluoridating agent is dissolved or diluted (such as mixing tanks), or injected (such as metering pumps). In some situations backflow prevention may be achieved simply through using an air gap.	4.1.7 b)	✓ Supply line enters from high level and there is an air gap	x Not shown on P&ID; air gap but backflow could occur when tank at high level	x No backflow-prevention device; air gap but backflow could occur when tank at high level	x No backflow-prevention device
Control equipment	It must be physically impossible for any component of the fluoridation feeding or control equipment to be manually plugged into standard electrical outlets for continuous operation if isolation of the power supply is used for the stop/start control of the dosing equipment. Any manual mode (or 'test') switch for the fluoridation chemical feeding equipment should not permit permanent selection (such as spring-loaded switches) and should return to the off position when released to prevent unattended manual operation. All key components of the fluoride dosing control system must be interlocked to ensure total fluoride dosing system shutdown in the event of failure of any individual equipment item and to ensure that the dosing system cannot operate unless water is flowing.	4.1.7 c)	✓	✓	**?** Need to review control equipment hardware and functionality.	✓
Corrosion and dust suppression	Corrosion prevention measures should be implemented for all fluoridation plants. Dust control measures should be implemented where sodium fluoride and sodium fluorosilicate are the agents used.	4.1.7 d)	✓ Dust control measure on bu k hopper	✓ Dust control measure on bulk hopper	✓ Dust control measure on bulk hopper	✓ Ventilation to atmosphere of tanks

Item	Requirement	NZ CoP Section	2014 NZ CoP Compliance Assessment / Further Information Requirement			
			Te Marua	Waterloo	Wainuiomata	Gear Island
Chemical delivery and quality assurance	The drinking-water supplier should ensure that the chemical supplier has a quality assurance system for the supply and delivery of the fluoridating agent to ensure its chemical purity, safe delivery and use. The quality assurance system should be implemented to manage all the factors associated with the specification, contract management, supply (including transportation), purity, storage, use and handling of fluoride compounds that could adversely impact upon the health and safety of staff, contractors and consumers. This quality assurance system should be included as part of the Water Safety Plan.	4.3.1	? Need to review Wellington Water chemical supply QA procedures	? Need to review Wellington Water chemical supply QA procedures	? Need to review Wellington Water chemical supply QA procedures	? Need to review Wellington Water chemical supply QA procedures
Bulk chemical storage	The drinking-water supplier should ensure that there is sufficient chemical available and readily access ble to ensure continuity of water fluoridation. The drinking-water supplier should document its assessment of storage requirements.	4.3.2	? Appears to be sufficient storage; however, storage requirements' documentation to be reviewed	? Appears to be sufficient storage; however, storage requirements' documentation to be reviewed	? Appears to be sufficient storage; however, storage requirements' documentation to be reviewed	? Appears to be sufficient storage; however, storage requirements' documentation to be reviewed
Bag loaders/Vacuum Loading Systems	Where a dry fluoridating agent is used, the design of the plant should minimise airborne dust and the need for manual handling. Where manual handling is necessary, it should be in accordance with the Code of Practice for Manual Handling and the Health and Safety at Work 2014.	4.3.3	✓	✓	✓	N/A
Chemical mixers	Fluoride solutions should be homogeneous, irrespective of preparation method. Mechanical mixers should be used for the preparation of sodium fluorosilicate solutions.	4.4.1	? Problematic product created some dissolution issues. However, system has not yet been restarted with Belgian product.	? Problematic product created some dissolution issues. These may have been resolved with the Belgian product – TBC.	? Problematic product created some dissolution issues. These may have been resolved with the Belgian product – TBC.	N/A
Metering pumps	Metering pumps must be able to accurately deliver the required flow rate, and be sized to operate at maximum output during the maximum flow that the treatment plant is designed to operate at. A safe method for calibrating dose rates must be available and maintained to ensure that the metering pumps are providing an accurate flow rate. Any risk of gravity flow or siphoning of the fluoride chemical through the metering pump must be prevented. Siphoning can be prevented through use of an anti-siphonage trap, air gap or similar. A loading valve (or alternative such as an air break) on the delivery side of the pump shall be provided if gravity flow from the metering pump is possible.	4.4.3	N/A (metering pumps not used) ✓ Anti-siphon trap installed	N/A (metering pumps not used) ✓ No risk of gravity flow or siphoning	N/A (metering pumps not used) ✓ No risk of gravity flow or siphoning	✓ ✓ No risk of gravity flow or siphoning

Item	Requirement	NZ CoP Section	2014 NZ CoP Compliance Assessment / Further Information Requirement			
			Te Marua	Waterloo	Wainuiomata	Gear Island
	Pressure relief on the delivery side of the pump or built into the metering pump must be provided. The pressure relieved at this point must be directed safely (e.g. back to the tank or bund).		N/A	N/A	N/A	N/A
Dry feeder systems	Dry feeder systems must ensure accurate delivery of the required volume or weight of fluoridation chemical for the quantity of water being treated and must be sized for the maximum flow of the treatment plant	4.4.4	✓ Powder feeder fitted with VSD	✓ Powder feeder fitted with VSD	× Shaftless screw feeder with limited turndown and insufficient capacity	N/A
Injection point	The location and detailing of the chemical injection point must: a) Provide homogenous mixing (minimum coefficient of variance of 0.95) of the chemical in the treated water (where necessary mixing devices should be used) before the first take off or sampling point b) Minimise loss of fluoride by precipitation with other chemicals (such as those containing calcium, aluminium and magnesium) or treatment processes (such as coagulation, filtration and pH correction), by dosing the fluoride following filtration and as far away as practicable after final pH correction if using lime c) Minimise the poss bility of siphonage and overfeeding d) Include provision of a sampling point following mixing e) Be located upstream of buffer storage of treated water f) Not allow any bypass or secondary pipework (or channel) into which the fluoride chemical will not be dosed (except for fire-fighting purposes or other non-potable water). g) Consider the impact of any recycle flow streams to avoid "double dosing".	4.4.5	? Confirm that analyser sample take-off point is upstream of reservoir following mixing chamber and not from the reservoir	✓ No perceived issues	✓ No perceived issues	✓ No perceived issues
Process control and instrumentation	In addition to the one or two Independent Checks, the following instrumentation must be provided: a) Flow meter on the process stream into which fluoride is being dosed. b) Level, pressure or weight indicators on bulk tank (or hopper). c) Alarm system to notify dosing abnormalities, particularly during unsupervised and after-hours periods. d) Reference bench-top fluoride analyser to verify the performance of the online unit required by Independent Check 3.	4.5	✓ × bulk hopper ✓ day hopper ✓ ? Check if benchtop analyser is provided	✓ × bu k hopper ✓ day hopper ✓ ? Check if benchtop analyser is provided	✓ × bulk hopper ✓ day hopper ✓ ? Check if benchtop analyser is provided	✓ ✓ ✓ ? Check if benchtop analyser is provided

Item	Requirement	NZ CoP Section	2014 NZ CoP Compliance Assessment / Further Information Requirement			
			Te Marua	Waterloo	Wainuiomata	Gear Island
	All online instruments must be calibrated in accordance the manufacturer's recommendations as to method and frequency.		? Review cal bration	? Review calibration	? Review calibration	? Review cal bration
Flow measurement	A flow meter must be provided to measure and communicate the water flow, and to pace the fluoride dosing equipment over the full water flow rate range. The metered flow must be truly representative of the flow into which the fluoride is dosed. The flow rate signal must be fed back from the meter to the fluoride dosing system to enable automatic adjustment of the fluoride dose rate. Use of electromagnetic flow meter or similar with an accuracy of ± 1 per cent over the complete range of flow is recommended. The accuracy must not exceed ± 3 per cent. The flow meter must be installed in accordance with the manufacturer's recommendations (particularly in relation to the length of straight pipe upstream and downstream of the meter).	4.5.1	✓	✓	✓	✓ Flow meters are used to determine the combined unfluoridated flow rate from Waterloo and Wainuiomata
Control and alarms	All dosing systems must be configured so as to be 'fail safe', that is, failure of a critical component automatically leads to the cessation of dosing and generation of an alarm. If it is not possible for the unit to fail safe, the PLC must be configured to ensure that fluoride will not be added to the water supply if a failure occurs. Loss of water to the online fluoride analyser must also generate an alarm. All alarms, including fluoride concentration alarms, where online instrumentation is installed must inform a resource capable of immediate response even after hours. Where dosing is stopped during automatic operation that is outside of the normal operating parameters of the plant (either manually or by shutdown alarms), dosing must not restart automatically without manual on-site intervention. Where automatic shutdown systems can be manually overridden (such as for maintenance purposes) any override events must be logged and the override facility configured such that the operator is aware that an override is activated (such as by the activation of a local or telemetry alarm). The operation of shutdown systems must be fully tested at least annually and the outcome of these tests recorded.	4.5.2	? Review functional description	? Review functional description	? Review functional description	? Review functional description
Plant security	The drinking-water supplier must control access to the fluoridation plant to prevent unauthorised access which will minimise the risk of anyone being injured. Appropriate signage must be provided to indicate the presence of the fluoridating agent, any electrical or OHS hazard, and any required personal protective clothing or equipment, and that authorised entry only is permitted. Access to the fluoridation plant should be restricted to authorised personnel through provision of a security locking system.	4.6	✓	✓	✓	✓

Item	Requirement	NZ CoP Section	2014 NZ CoP Compliance Assessment / Further Information Requirement			
			Te Marua	Waterloo	Wainuiomata	Gear Island
Monitoring of fluoride concentration in the raw water	The fluoride concentration in the raw water should be analysed at least annually, but preferably biannually in summer and in winter. Prior to design, more frequent monitoring is suggested. The sample must be analysed for fluoride at a Ministry of Health recognised laboratory (which will be IANZ accredited). The analysis must be done using the same method as descr bed in Section 4.1.6 for testing the fluoride concentration in drinking-water for Independent Check 3. The raw water fluoride concentration must be taken into account when designing and operating the fluoridation plant.	5.1.1	TBC	TBC	TBC	TBC
Quantity of fluoride dosed	Every 24 hours the mass of fluoride consumed by the plant (determined from the gross quantity of chemical used) must be calculated and divided by the volume of water that has passed the fluoride dosing point. This is another check of the average concentration dosed over each 24-hour period. Any inconsistencies must be investigated and remedial actions taken to bring the actual dose within the operating dose range (refer to Section 4.1.4).	5.1.2	✓	?	?	?
Monitoring of the treated water	DWSNZ requires that the drinking-water leaving the treatment plant is tested for fluoride with a weekly sampling frequency at minimum. DWSNZ specifies that there cannot be more than 13 days between samples. Alternatively, fluoride sampling may be carried out in the distribution zone. The sampling programme must be integrated into the Water Safety Plan under the DWSNZ for the drinking-water supplier and for any downstream water supplier receiving fluoridated water from the drinking-water supplier. The drinking-water supplier must have a procedure to investigate and rectify 0.15 mg/L or more discrepancies between the monitoring results and the fluoride concentration as determined from the quantity of fluoride dosed and the Independent Checks.	5.1.3	✓ Assume that sampling requirements of DWSNZ are met	✓ Assume that sampling requirements of DWSNZ are met	✓ Assume that sampling requirements of DWSNZ are me	✓ Assume that sampling requirements of DWSNZ are met.
Quality assurance	The quality assurance system must ensure the fluoridation process is adequately monitored and maintained such that any discrepancy, equipment reliability issue or unacceptable variability in the final fluoride concentration is readily identified and effectively rectified.	Section 5.2	x System is unreliable	x System is unreliable	x System is unreliable	x System is unreliable

Item	Requirement	NZ CoP Section	2014 NZ CoP Compliance Assessment / Further Information Requirement			
			Te Marua	Waterloo	Wainuiomata	Gear Island
Maintenance and Calibration	The drinking-water supplier should carry out monthly plant inspections at a minimum and record in writing the outcome of the inspections and any resultant actions. In some instances, the HAZOP may determine that a more rigorous plant inspection regime is required. Plant inspections will help ensure effective process control, determine whether equipment is operating normally and identify the need for maintenance. All equipment and instruments considered vital for process control must be maintained and calibrated regularly according to maintenance and calibration schedules documented or referenced to in the Operation & Maintenance Manual (see Section 6.3). Performance of metering pumps should be calibrated at least monthly by measuring the volume of solution pumped during a measured time interval.	Section 5.3	? Documentation and work orders to be reviewed	? Documentation and work orders to be reviewed	? Documentation and work orders to be reviewed	? Documentation and work orders to be reviewed
Operational Personnel	The drinking-water supplier must ensure that operational personnel (employees or contractors) are appropriately skilled and trained in the management and operation of the fluoridation plant, and that these competencies are maintained (and that this is documented in the Water Safety Plan). Operational personnel must have an adequate knowledge of the principles of fluoridation (including the risks), the type of plant or equipment and its operation and maintenance. A National Certificate in Water Treatment (Site Operator) - Level 4 (or equivalent), or preferably a National Diploma in Drinking Water - Water Treatment (Site Technician) - Level 5 (or equivalent) is recommended as a minimum qualification for operators of fluoridation plants.	Section 5.4	✓ Assume that operator training is provided	✓ Assume that operator training is provided	✓ Assume that operator training is provided	✓ Assume that operator training is provided
Occupational health and safety	Health and safety measures for consideration in the design and operation of a fluoridation plant include: a) Safety in Design to ensure a safe working environment and facilitate safe working practices b) Effective control measures are applied to mitigate risks as identified by the risk assessment c) Adequate training for plant operators about the specific hazards associated with the fluoridating agent d) Accessibility of the Material Safety Data Sheet (MSDS) for the fluoride chemical by maintaining the current MSDS in the Operation & Maintenance Manual, and providing a copy close to where the substance is used to enable reference to it by operators who handle the substance e) Pipework and tanks used for storage and distribution of fluoride chemicals comply with the relevant standards and are appropriately distinguishable (for example, colour coded and labelled) from other plant pipework	Section 5.5	? Health and safety measures not audited in this review	? Health and safety measures not audited in this review	? Health and safety measures not audited in this review	? Health and safety measures not audited in this review

Item	Requirement	NZ CoP Section	2014 NZ CoP Compliance Assessment / Further Information Requirement			
			Te Marua	Waterloo	Wainuiomata	Gear Island
	f) The installation and arrangement of the equipment to ensure that the handling and operation of the equipment meet workplace health and safety requirements g) Fluoridation equipment should be kept in a room or building separate from other water treatment plant equipment. h) Electrical control panels for the fluoridation plant are protected and should be located outside the fluoridation room i) The atmosphere of any areas where fluoridating agents are stored or used is safe for workers, and ventilation and dust extraction as appropriate is provided for the selected chemical j) Appropriate personal protective equipment and hand washing facilities are supplied and maintained by the drinking-water supplier at the fluoridation plant for mandatory operator use k) Emergency eyewash/showers are available where fluoridating agents are stored and handled l) Emergency skin treatment such as calcium gluconate gel or similar					
Spills and leaks	The drinking-water supplier must ensure the fluoridation plant and equipment is designed and operated to minimise the risk of fluoridating agent spills or leaks. Any spills or leaks must be contained and must not come into contact with or be stored with incompatible chemicals.	5.6.1	✓	✓	✓	✓
Waste disposal	The management or the disposal of waste containing fluoride must be in accordance with the Hazardous Substance and New Organisms (HSNO) Act 1996. Wastes include fluoride chemical and plant and equipment that have been in direct contact with fluoride chemical. The drinking-water supplier must document and implement an environmental waste disposal plan for fluoridating agent spills and leaks, contaminated fluoridating agent and fluoridating agent containers.	5.6.3	✓	✓	? Disposal procedure of empty bags to be reviewed	? Disposal procedure of waste chemical to be reviewed
Documentation	The following documents should be available: a) Design report b) Operation and Maintenance Manual c) Emergency Management Plan d) Commissioning records	6.	? Design report, O&M manual and emergency management plan present. Uncertainty around commissioning records.	? Design report, O&M manual and emergency management plan present. Uncertainty around commissioning records.	? Design report, O&M manual and emergency management plan present. Uncertainty around commissioning records.	? Design report, O&M manual and emergency management plan present. Uncertainty around commissioning records.

Item	Requirement	NZ CoP Section	2014 NZ CoP Compliance Assessment / Further Information Requirement			
			Te Marua	Waterloo	Wainuiomata	Gear Island
Record keeping	The drinking-water supplier should keep records verifying that the fluoride plant is managed and operated in accordance with this Code, and with DWSNZ and section 69ZD of the Health Act. The records must be maintained and made available for inspection upon request by the DWA. Records include: • Regular chemical analysis of fluoridating agent delivered • Regular analysis of concentration of fluoride in raw water • Plant and equipment cal bration certifications and maintenance data • Routine testing of critical alarms and corrective actions and outcomes of the system shutdown tests • Surveillance monitoring and audits records • Staff training records The drinking-water supplier must, at a minimum, also record the following parameters at the frequencies indicated: a) Continuously (minimum 5 minute interval records) as required by DWSNZ - Water flow - Online fluoride concentration (if Independent Check 3 is used) - Fluoride solution flow b) Daily - The volume of water treated - The quantity of fluoride added to the water - The level or weight of the day tank prior to and after refilling or the volume of fluoride solution used (if a level sensor or load cell is fitted to the day tank for Independent Check 1) - The stock of fluoride on hand - The results of fluoride analysis of the samples of water taken from the treated water at the intervals required - Average fluoride concentration each day on the basis of the online analyser records (if Independent Check 3 is used) - Average fluoride concentration each day on the basis of the loss of mass or volume in the day tank (if using Independent Check 1) - A reconciliation of each of the Independent Checks c) Weekly - Results from weekly sampling for fluoride content in the treated water	6.5	? Record keeping to be reviewed Online measurements present for fluoride concentration, fluoride dosed, water treated and hopper weight Fluoride stock recorded	? Record keeping to be reviewed Online measurements present for fluoride concentration, fluoride dosed, water treated and hopper weight Fluoride stock recorded	? Record keeping to be reviewed Online measurements present for fluoride concentration, fluoride dosed, water treated and hopper weight Fluoride stock recorded	? Record keeping to be reviewed Online measurements present for fluoride concentration, fluoride dosed, fluoride flow rate, water treated and tank levels

Item	Requirement	NZ CoP Section	2014 NZ CoP Compliance Assessment / Further Information Requirement			
			Te Marua	Waterloo	Wainuiomata	Gear Island
Annual reporting	Water suppliers should provide the DWA with a report each year of their fluoridation systems. The annual report should include information required to demonstrate that the fluoride P2 compliance criteria within the DWSNZ has been achieved for the July - June period, and: The annual average, minimum and maximum fluoride concentration at each fluoridation plant The annual average, minimum and maximum fluoride concentration from the weekly samples in the water sampling localities, including a summary of any missed samples A summary of incidents and emergencies that were reported during the year A summary of the fluoridation process and chemicals used at each fluoridation plant (including any fluoridation plants operated by others that feed into that water supply being reported on)	7.1	? Check if annual fluoridation report is produced	? Check if annual fluoridation report is produced	? Check if annual fluoridation report is produced	? Check if annual fluoridation report is produced
Notification requirements	The DWA must be notified of emergency and exceptional situations as described in Table 3. If the fluoride concentration in the drinking-water is less than the lower action process limit for a continuous period of >72 hours, it is not mandatory that the DWA be notified but it is encouraged. Fluoride concentration in drinking-water supplied in a water sampling locality exceeds or may exceed 1.5 mg/L. Notify the DWA Immediately, investigate the cause of the exceedance and take appropriate action. See DWSNZ for more information. Fluoride concentration measured at the fluoridation plant exceeds 1.5 mg/L, however, does not enter the drinking-water supply. This does not require a mandatory notification but the DWA should be notified. In addition, an internal investigation into the cause of the incident should be carried out and action should be undertaken and documented. Fluoride concentration in drinking-water supplied is less than the lower action process limit for a continuous period of >72 hours. This does not require a mandatory notification but the DWA should be notified. If the rolling annual average fluoride concentration of drinking-water in a water supply has exceeded, or is expected to exceed, 1.0 mg/L in each quarterly compliance period. The DWA should be notified.	7.2	x Fluoride concentration in drinking water is regularly less than lower action process limit due to dosing system downtime	x Fluoride concentration in drinking water is regularly less than lower action process limit due to dosing system downtime	x Fluoride concentration in drinking water is regularly less than lower action process limit due to dosing system downtime	x Fluoride concentration in drinking water is regularly less than lower action process limit due to dosing system downtime

5.0 SUMMARY

5.1 COMMON ISSUES

The main common issues with the fluoride facilities are summarised below.

- **Poor powder quality**

  Poor powder quality was a significant cause of system downtime until the powder supply was changed to a Belgian product. This proves the importance of sourcing high quality product, even if it comes with a higher price. The previous powder had serious caking and bridging issues and caused high operator intervention and regular shutdowns due to blockages in the powder handling operation.

- **Mixing tanks**

  Mixing has been an issue due to the problematic product being used along with the mixing tank size and agitation energy applied. Since the powder has been replaced with the Belgian product, it appears that mixing issues have been resolved at Waterloo and Wainuiomata.

  The mixing tank at Te Marua and Wainuiomata is also used as the dosing tank. This may result in undissolved powder being present during times of sustained higher production rates. A separate day tank is used at Waterloo (which was an upgrade to the original plant). A day tank ensures that a consistent mixing configuration is present in the dedicated mixing tank under all batching conditions.

- **Manual bag handling**

  All three powder plants require manually lifting the bags and emptying them into the bulk / loading hopper. This is a health and safety hazard to operators in terms of muscle strain and dust exposure. Most modern systems use a vacuum lance to transfer powder from the bags to the hopper thereby avoiding handling the bags.

- **No standby fluoride dosing pump**

  Dedicated duty / standby dosing pumps are not present at Te Marua and Wainuiomata.

- **Fluoride Analyser Auto Calibration**

  If one of the two analysers is down for maintenance and the other analyser is in auto calibration mode, fluoride dosing is stopped until the online analyser has completed its calibration. This is performed to avoid dosing during the daily analyser self-calibration period. This contributes to fluoride dosing system downtime.

5.2 SITE SPECIFIC ISSUES

In addition to the above common issues, site-specific issues are summarised below. Note that at the time of this report's revision E update, the Te Marua and Gear Island fluoride dosing systems are in the process of being replaced with containerised solutions (separate project).

Te Marua

- Short-circuiting in the treated water reservoir due to damage to the baffle curtain. This is being resolved in a separate project.

Waterloo

- The fluoride dosing system is reportedly unable to sustain dosing at higher production rates.
- Dedicated metering pumps (diaphragm or progressive cavity) and a dedicated mixing system may provide more process control for the current system. The metering pumps should be provided with a calibration cylinder to allow regular pump calibration.

Wainuiomata

- Powder feeder screw is not appropriate for all production rates. It does not provide the required turndown nor can it sustain the required dose at peak capacity.
- No access to bottom of day hopper feed screw conveyor to allow maintenance.

Gear Island

- The operators have to enter the HFA bund to access the fluoride dosing pumps. This poses a health and safety risk if there is spillage in the bund.
- The equipment at the Gear Island fluoride facility is at the end of its service life and requires replacement. The tanks in particular are in poor condition.
- Future use depends on fluoridation policy for Petone (different fluoride system may be required if Petone is fluoridated).

6.0 AVAILABLE FLUORIDE DOSING TECHNOLOGY

6.1 SODIUM SILICOFLUORIDE SYSTEMS

Sodium silicofluoride is generally used at medium to large plants, such as the Wellington Water facilities, as the chemical cost is lower than sodium fluoride. Modern facilities comprise the following elements.

Powder Loading

Powder loading is either by a vacuum lance for 25 kg bags (typically for plants below 40 MLD) or a 1,000 kg bulk bag unloader (plants greater than 40 MLD).

In both cases, dust is extracted by a vacuum fan and captured by a water trap prior to discharge to atmosphere.

Powder Makeup

Powder is stored inside a hopper which sits on load cells to monitor powder consumption. A powder feeder at the base of the hopper feeds the powder into the solution tank where it is mixed with makeup water in batches.

The solution tank is divided into two sections by an overflow baffle. The first section, the mixing tank, is equipped with a top-mounted slow speed stirrer and is sized to retain the solution for a minimum of 10 minutes to completely dissolve the powder into solution prior to overflowing into the dosing tank. The water level in the mixing tank is maintained at the overflow level at all times by the baffle.

The second section of the tank is the dosing tank. The level in the dosing tank fluctuates between batch start (low level) and batch stop (high level). When the batch start level is reached, a solenoid valve on the makeup water pipe opens to allow makeup water into the mixing tank. At the same time, the powder feeder starts, to transfer a set mass of powder into the mixing tank.

Dosing Pumps

Dosing pumps transfer the fluoride solution from the dosing tank to the dosing point. The dosing pumps are always positive displacement pumps, and for SSF can be either diaphragm, progressive cavity or peristaltic depending on the flow rate. Positive displacement dosing pumps provide better dose control as they are not affected by water pressure at the dosing point.

The dosing pumps operate continuously, and the batch makeup system operates on start and stop levels in the dosing tank as described above.

Control Philosophy

Either of two control philosophies can be used to control SSF dosing systems:

- **Variable concentration, constant transfer.** The mechanical feeder speed varies to produce variable solution strength proportional to the treated water flow rate to maintain the fluoride dose set point (mg/L). The dosing pumps operate at fixed speed to transfer the solution into the water.
- **Constant concentration, variable transfer.** The mechanical feeder speed is fixed to produce constant solution strength. The dosing pumps operate at variable speed proportional to the treated water plant flow rate to maintain the fluoride dose set point (mg/L).

Figure 24 shows an isometric drawing of a recently installed SSF dosing system at Obanvale in New South Wales, Australia (25 MLD capacity).

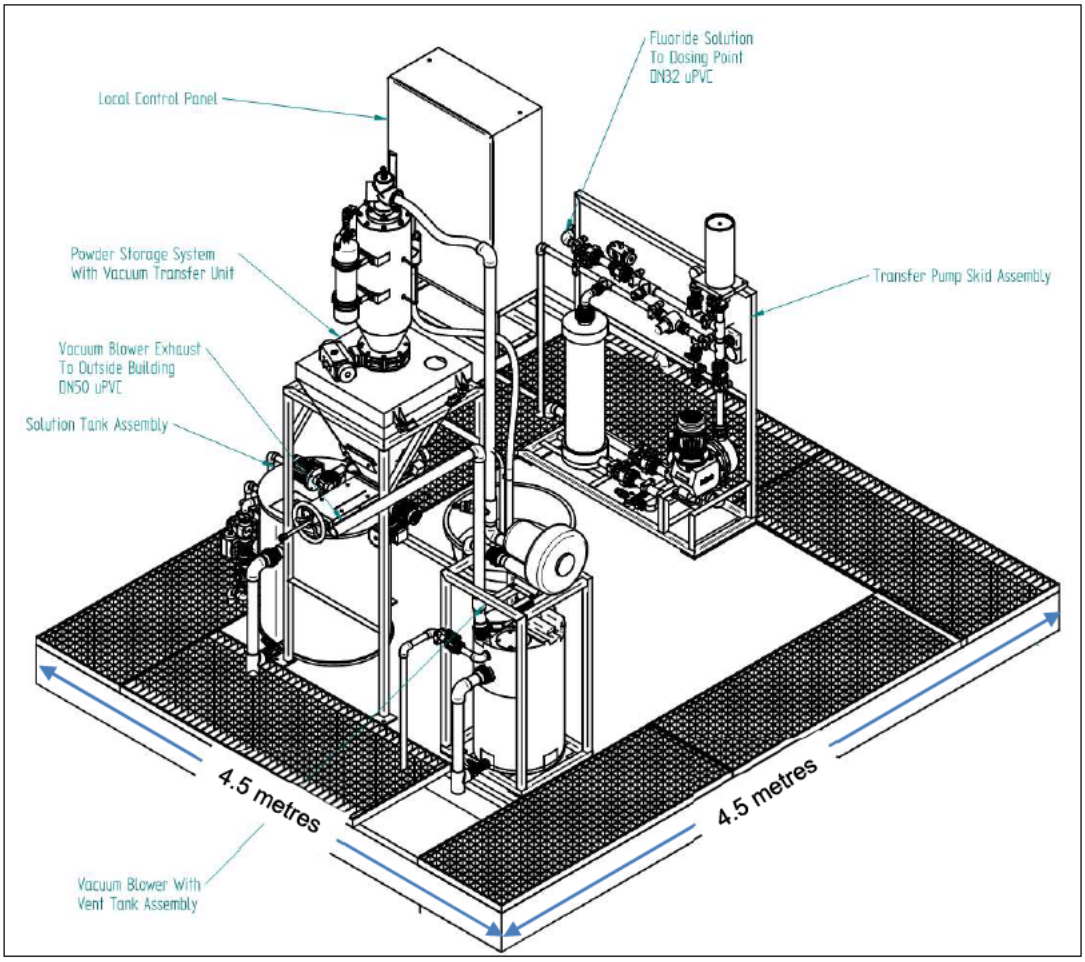

Figure 24 Obanvale WTP SSF Dosing Skid – 25 MLD Water Demand (ProMinent)

6.2 SODIUM FLUORIDE SYSTEMS

The alternative powder to sodium silicofluoride is sodium fluoride. These systems are more commonly used in smaller plants (up to around 15 MLD) as they have a lower capital cost and are simpler to operate than the SSF systems. For larger plants such as the Wellington WTPs the lower chemical cost of the SSF systems makes them more economic.

The sodium fluoride systems are constant concentration, variable transfer systems. Sodium fluoride has a reliable saturation solubility of 4.05%. By keeping excess sodium fluoride powder in a dissolving tank, a constant 4.05% saturated solution is maintained. This makes the sodium fluoride systems a lot simpler to operate than the SSF systems.

Due to the higher chemical costs, switching to sodium fluoride is not recommended for the Wellington WTPs.

6.3 HYDROFLUOROSILICIC ACID SYSTEMS

Hydrofluorosilicic acid (HFA) systems avoid powder handling and makeup equipment and are therefore simpler, essentially comprising tanker delivery facility, bulk storage tanks, day tanks and dosing skids.

HFA is extremely corrosive, and facilities must be designed with appropriate safety provisions and adequate forced air ventilation to avoid corrosion of building surfaces and equipment.

6.4 RECOMMENDATIONS

The two viable fluoride chemical options are sodium silicofluoride (SSF) and hydrofluorosilicic acid (HFA) as sodium fluoride is uneconomic at the sizes of plant considered. SSF does not produce corrosive vapour but does result in airborne dust. In addition, there are fewer sources of HFA product than of SSF powder, and therefore there is a greater product supply chain risk with HFA than for SSF.

As this report recommends that the existing fluoridation systems be replaced with new systems (see Section 8), there is an opportunity to change from SSF to HFA if this will provide cost savings and/or non-financial advantages over SSF.

As both options have advantages and disadvantages across a range of aspects, a multi-criteria analysis (MCA) process is recommended to decide which options is preferred, with input from stakeholders on assessment criteria, weightings and scoring. This will provide a transparent and auditable process to allow the project to progress to design.

An MCA assessment of the fluoride chemicals is beyond the scope of this report. For the purposes of this report, SSF powder package plants have been assumed for capital cost estimate purposes.

7.0 COST ESTIMATES

Preliminary sizing and Level 1 capital cost estimates for new SSF fluoride dosing facilities are provided in Table 8. Budget price estimates for SSF makeup and dosing package plants were obtained from Chemfeed NZ Ltd who are agents for ProMinent, a major supplier of fluoride dosing equipment in both New Zealand and Australia.

As discussed in the previous section, a cost comparison between SSF and HFA system was not part of the scope of this review; a full multi-criteria assessment (MCA) between SSF and HFA is recommended to take into account financial and non-financial aspects. Table 8 provides the basis for the cost estimates.

Table 8 GWRC SSF Fluoride Facilities: Level 1 Preliminary Sizing and Cost Estimates

Parameter	Unit	Te Marua	Waterloo	Wainuiomata	Gear Island
Maximum daily demand	MLD	140	120	60	80
Fluoride dose	mg/L	0.75	0.75	0.75	0.75
Max daily SSF consumption	kg/d	175	150	75	100
Day hopper volume	Litres	140	120	60	80
Max SSF feed rate	kg/h	7.3	6.3	3.1	4.2
Solution SSF concentration	%	0.20	0.20	0.20	0.20
Max dosing pump flow rate	Lpm	61	52	26	35
Mixing tank volume	Litres	600	500	260	350
Cost Estimate					
Package plant supply		170,000	170,000	150,000	150,000
Install & commissioning	10%	17,000	17,000	15,000	15,000
Enabling works	25%	43,000	43,000	38,000	38,000
Engineering fees	20%	46,000	46,000	41,000	41,000
Prelim & General	15%	35,000	35,000	30,000	30,000
Base Estimate		**311,000**	**311,000**	**274,000**	**274,000**
Contingency	40%	124,000	124,000	110,000	110,000
Expected Estimate		**435,000**	**435,000**	**384,000**	**384,000**
Funding Risk	60%	261,000	261,000	230,000	230,000
95th Percentile Estimate		**696,000**	**696,000**	**614,000**	**614,000**

8.0 RECOMMENDATIONS

8.1 IMMEDIATE IMPROVEMENTS (WITHIN ONE YEAR)

It is reasonable to assume that relacing the existing dosing systems will take up to two years, factoring in budget approvals, design, and procurement etc. In the meantime the following measures should be undertaken immediately to improve the reliability and safety of the current systems:

1. Functional Description Review Against NZ Code of Practice/ PLC Program Update

The fluoride functional descriptions should be reviewed against the NZ fluoridation code of practice alarm and reporting requirements to check compliance for lower, upper and emergency process limits; alarms and interlocks (non-resettable remotely). Where the functional descriptions do not meet the code of practice requirements, the PLC code should be updated.

The following changes should be included at a minimum in any PLC code update:

- Update the PLC code to automatically pause fluoride dosing on loss of analyser signal for self-calibration, and restart on resumption of analyser signal (no alarm raised as this is not a fault but routine operation). This will avoid the need for the operators to shut down fluoride dosing if only one analyser is available.
- Update the PLC code to automatically calculate the 24-hour mass of fluoride consumed (kg) at midnight every day, based on the day hopper load cell data. The PLC should then divide this figure by the 24-hour totalised volume of water treated over the same period to provide the daily average fluoride dose.

Note that at the time of this report's revision E update, this review was performed as part of a separate project.

2. Physical Improvement Works

The following improvement works should be undertaken as soon as practicable. Note that at the time of this report's revision E update, the Te Marua and Gear Island fluoride dosing systems are in the process of being replaced with containerised solutions (separate project).

Te Marua

- Repair the treated water reservoir baffle curtains to prevent short circuiting.
- A new containerised fluoride dosing system to replace the existing system is being designed as part of a separate project.

Waterloo

- Improve the capacity of the system for sustainable operation at higher production rates.

Wainuiomata

- Replace the shaftless fluoride powder feeder with a model similar to those at Te Marua and Waterloo if there is still a problem with feeder dose control after switching to the improved SSF powder product.

Gear Island

- A new containerised fluoride dosing system to replace the existing system is being designed as part of a separate project.

3. Plant Performance Test

With the new improved powder product (reduced caking) and following the improvement works listed above, the fluoride systems should be in a position to be run for a two-week performance test. Following the two-week test period the following aspects should be reviewed:

- Process control performance (fluoride concentration versus set point)
- Faults and issues.

This test will identify further actions to improve process control and reliability.

8.2 MEDIUM TERM IMPROVEMENTS (WITHIN TWO YEARS)

Multi Criteria Assessment of SSF versus HFA

The two fluoride chemical alternatives each have advantages and disadvantages, therefore a multi-criteria analysis (MCA) process is recommended to decide which option is preferred, with input from stakeholders on assessment criteria, weightings and scoring. This will provide a transparent and auditable process to allow the project to progress to design. An MCA process would consider aspects such as:

- Life cost (net present value of capex plus opex)
- Physical arrangement and space constraints
- Health and safety risks
- Supply risks

New Fluoridation Plants (Waterloo and Wainuiomata)

Given the difficulty of retrofitting new mixing tanks and dosing equipment into the existing fluoride plants, and the number of other issues that require addressing, it is recommended to replace all of the SSF facilities with complete new package plants designed to meet the NZ Code of Practice. This would provide the greatest probability of success by reducing the interfaces of new plant with existing plant and making it easier to obtain performance guarantees for the overall system. Existing fluoride equipment can be removed prior to the new package plants installed.

Physical site constraints will affect the detailed pipework and equipment layout design of each package plant however these issues can be resolved by the package plant contractor.

It is recommended that the new package plants be provided with their own local control panels, linked to the WW SCADA system for remote operation and monitoring. The local control panels allow the equipment to be fully tested prior to shipment, reduces system integration and programming time and ensure that the new system control functionality meets the requirements NZ Code of Practice.

Te Marua and Gear Island

At the time of this report's revision E update, the Te Marua and Gear Island fluoride dosing systems are in the process of being replaced with containerised solutions (separate project). These are intended to be short-term solutions to be replaced with long-term solutions at a later stage. The designs for the long-term solutions are to take into account fluoridation policy (Gear Island) and the long-term upgrade of the Te Marua WTP.

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