HATEA PUMP STATION AND HIGH RATE STORM TREATMENT PLANT

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ABSTRACT

This paper discusses the novel approach that Whangarei District Council is taking to address the problem of overflows at their Hatea Pump Station.

A 1000m^3 storage tank was designed, which will also operate as a high rate clarifier and UV reactor to treat the effluent that overflows during high flow events. Since increased pump station capacity would overload the network downstream during high flow events, "off-loading" at this location is considered the preferred mitigation measure. The sewerage network model predicts eight events per annum when the capacity of the pump station is insufficient. The designed tank will reduce the quantity of discharges to approximately two events per year, and will also significantly increase the quality of the discharge.

The design includes screens and chemical dosing, but unlike conventional treatment and screening facilities, no sludge or screening handling facilities are required. All screenings are retained in the "day to day" pump station and all sludge is washed into the "day to day" pump station after the storage tank has been used. In this way both construction and operation costs of the treatment facility are low compared to a conventional treatment plant of similar capacity.

KEYWORDS

storm flow, high rate, treatment, inflow, infiltration, pump station, Hatea, Whangarei, overflow, UV disinfection

1 INTRODUCTION

1.1 THE SITE

Hatea Pump Station is located on the north western side of Whangarei City on Whareora Road, next to the Hatea River. This pump station receives wastewater predominantly from the Tikipunga catchment and serves about 2,300 properties. The site is low lying, resulting in the area of the pump station being flooded about four times a year.

Whangarei itself is located at the upper end of the highly valued Whangarei Harbour with its great fishing spots and Cockle beds. Sewage overflows, whether due to infiltration and inflow caused by storm events or due to mechanical failure, have a great impact on recreational activities in and around the harbour.

Whangarei District Council (WDC) made a commitment in 2010 to significantly reduce the quantity and impact of sewerage overflows into the Whangarei Harbour. To achieve this Okara Park Pump Station, which used to be the place of the most frequent overflows, was significantly upgraded. The second most important asset to address was Hatea Pump Station.

1.2 THE EXISTING PUMP STATION

The existing pump station has a capacity of approximately 80 l/s, with current dry weather flows ranging from 5-20 l/s. The setup consisted of a wet well with adjacent underground valve chamber, and an above ground Motor Control Centre (MCC). From the pump station wastewater was pumped through a 423m DN250mm rising main to the Mill Rd trunk sewer, which sits 28m higher.

During storm conditions discharge from the sewer network into the pump station increases to up to 250 l/s, causing Hatea Pump Station to overflow into the nearby Hatea River. The pump station itself becomes flooded during heavy storm events. Field data shows that the existing Hatea Pump Station spills on average six times a year due to storm events, each time releasing between 200m^3 – 3,000m^3 of highly diluted untreated sewage into the Hatea River. Operational issues with the facility can result in further 2-3 spills each year, at much smaller quantities (up to 500m^3) but at significantly higher concentrations. These spills have a significant negative effect on the environment locally, impact on the water quality of the Whangarei Harbour with associated health risks and negative publicity for Whangarei District Council.

Figure 1- The existing Hatea Pump Station

2 OPTIONS

Conventional solutions for similar problems involve the provision of emergency storage or upgrades to the pump station and associated pipe network.

2.1 EMERGENCY STORAGE

Whangarei District Council commissioned Opus International Consultants initially to investigate options for the provision of either 1800m^{3}or 2500m^{3}emergency storage at the existing pump station. The report then evaluated options for the provision of gravity fed in-ground storage. The idea of an above ground tank was briefly discussed at this stage. Such a tank would have to be filled by pumping, creating the risk of overflows during power outages. For this reason the idea was not further evaluated.

In the initial report two potential locations for emergency storage were investigated. A site north of Whareora Rd, adjacent to the existing pump station, was identified as being better suited. The only other location in the vicinity large enough to accommodate a tank of the required size was lower lying, very confined in regard to potential construction works, as well as being located in an esplanade reserve.

Figure 2- Site adjacent to existing pump station which was selected for the new emergency storage tank

At this stage the first results of the Whangarei sewerage modelling report prepared by AWT became available. AWT had simulated several scenarios for the catchment upstream of Hatea Pump Station in order to determine the required size for an emergency storage tank that would eliminate wet weather overflows from the site. The model predicted a required storage in excess of 10,000m^3.

Construction of a tank this size would not only have been uneconomic, but it also would have been too large for this site.

2.2 PUMP STATION UPGRADE

Hatea Pump Station is connected to the Whangarei Wastewater Treatment Plant by approximately 8km of rising mains and trunk sewers.

Upgrading the pump station to a capacity of 250l/s, and raising it above flood level would be relatively simple and also inexpensive way to solve the overflow problems at Hatea. However, the whole Whangarei trunk sewer network downstream would also require upgrading. The existing network operates close to capacity, and a number of overflow points spill during heavy storm events. The Whangarei Wastewater Treatment Plant would also need significant upgrades to cope with the additional storm flows.

Initial order of magnitude estimates, undertaken by the Whangarei District Council, indicated costs in the order of $18m for this option.

2.3 STORM FLOW TREATMENT

In recent years, where complete prevention of wastewater overflows is not possible, the treatment of storm flows has become more and more of an issue for local councils, due to a greater awareness of the environmental impacts and associated public health risks of overflows. Specialised providers such as Veolia provide package type solution such has the Actiflo™ high-rate clarifier system. When Whangarei District Council started to investigate possible solutions, it was clear that some form of treatment was worth exploring.

The initial concept developed by the Whangarei District Council proposed the construction of an emergency storage tank to provide 12hr dry weather flow capacity. This is also a prerequisite for the application for discharge consent (whether treated or untreated) under the Northern Regional Council (NRC) Regional Water and Soil Plan (RWSP).

Since this would not stop overflows completely, the concept also included a high rate clarification process, such as the above mentioned Actiflo™ system, in about 2014. The last stage planned for the site was the addition of a UV treatment system for the disinfection of overflows. This would have required additional pumping, either into or out of the tank, as well as other infrastructure to link the separate assets. Since this solution was very expensive it was planned to stretch its implementation out over several financial years.

2.4 A MULTIFUNCTIONAL APPROACH

While Opus was completing that investigation for the provision of emergency storage, we also discussed with the client what other options might produce the desired outcome in a more efficient and economic way. One idea was to see if a storage tank could be utilized as a kind of clarifier. Also, if the pump station were to be built at the end of the storage tank then no additional pumping would be required. A new pump station in this location could easily be connected to the existing switchboard for power and to the existing rising mains. An additional length of about 40m of gravity pipeline would be required into the pump station. The pumps would have approximately 2m extra static head, which would have minimal effect on pump performance of new pumps.

The approach finally developed would see a new pump station being built as part of a large structure, which also includes mechanical screening, chemical dosing facilities, 1,000m^3 emergency storage tank/clarifier, a set of labyrinth weirs to decant surface water, a UV pumping station and finally UV treatment reactors to disinfect the effluent before being discharged into rock beds adjacent to the Hatea River. Chemical storage and the motor control centre will be located in a control building on top of the structure.

The new pump station will operate autonomously in a duty/standby configuration. If incoming flows exceed the capacity of the pump station, thus causing the wet well level to rise, it will overflow via a mechanical screen into the 1,000m^3 emergency storage tank. As flow enters the tank it will be dosed with a chemical coagulant to assist the settlement of the suspended material.

If the storm event stops before the tank is filled then the tank will be drained by gravity back to the pump station and pumped away in the conventional way. If the tank fills to capacity the settled wastewater will overflow from the surface via labyrinth weirs and discharge into a second pump station. This second station will pump the flow through UV reactors prior to discharge to the Hatea River.

3 THE HATEA STATION

3.1 PROCESS

Any new pump station or treatment plant in this location has to operate unmanned, other than weekly inspections and visits after a storm event. The site will be remotely monitored by a telemetry system. Under normal operation wastewater will flow by gravity into the wet well, causing the level in the well to rise. At a fixed level one of three submersible pumps will start and pump the sewage into the existing rising main.

The pump speed will ramp up and down in relation to the difference in level between actual level and a set point. As the flow into the station increases, such as in wet weather, the wet well level will rise, causing the assist pump to start. The pumps will be limited to a maximum flow rate or speed, so as not to overload the downstream pipework.

Pumped flow and wet well level will be monitored; if the inflow exceeds the maximum pump rate the level will rise in the wet well until it starts to overflow into the 1000m^3 storage tank. The screen motor will start at a set wet well level. After a set period, or when a set level in the tank is reached, a chemical dosing pump will start and pump coagulant into the screened wastewater.

The tank will continue to fill while the flow into the pump station exceeds the maximum pump rate. Once the tank is full the screened and now settled effluent will flow over labyrinth weirs into the UV pump chamber. The clarified effluent will then rise in the UV pump wet well and at a set level one of two UV pumps will start at minimum speed, followed by the two ultraviolet light (UV) reactors. Effluent will be re-circulated back into the UV pump wet well by a recirculation pipe which is controlled by an actuated valve. A circulation time of two minutes is required while the UV lamps warm up before the flow is discharged to the rock beds.

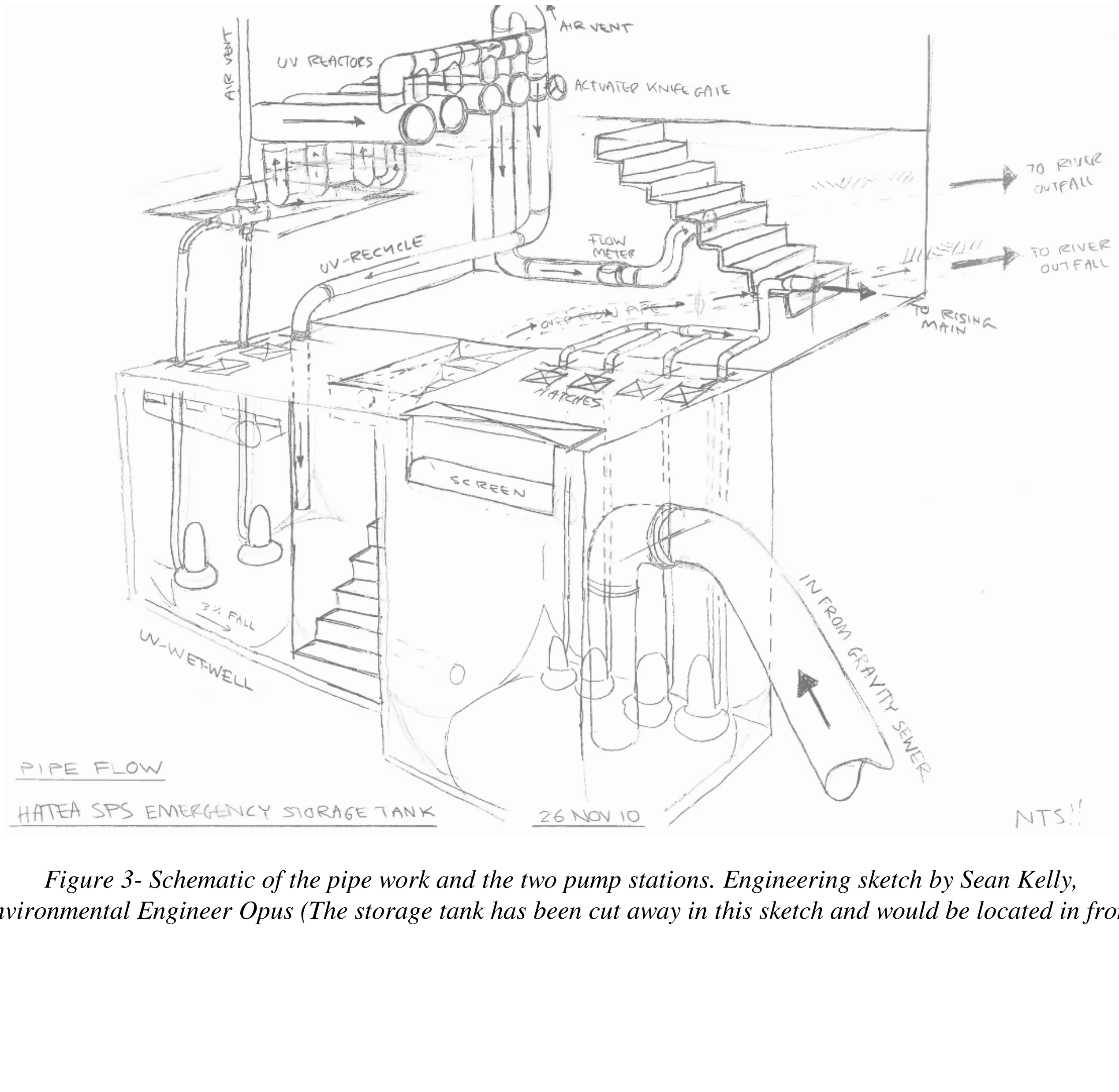

Figure 3- Schematic of the pipe work and the two pump stations. Engineering sketch by Sean Kelly, Environmental Engineer Opus (The storage tank has been cut away in this sketch and would be located in front)

As the influent flow rate reduces the UV pump will ramp down. If the level in the UV chamber drops below a set point and the pump is at a minimum speed the recirculation valve will open and the effluent will start re-circulating. When the level in the UV wet well gets below a minimum set-point the UV system will stop followed by the UV pumps.

Actuated valves will open which will allow the effluent in the storage tank and the UV well to drain back into the sewage pump station. UV pump station, UV reactors and the tank will be washed down with potable water after the event.

3.2 DESIGN FLOWS

During the investigation phase Whangarei District Council highlighted the fact that the trunk sewer main to which Hatea Pump Station was discharging was already at capacity during storm events even without the regular flows from the pump station. The model results showed that the Kamo catchment upstream of the Hatea discharge point produced flows of up to 183 l/s during heavy storm events.

These flows could easily be diverted to Hatea Pump Station during extreme storm events by simple provision of 400m of gravity sewer main (refer Figure 4). This would in turn significantly reduce the loading on the downstream trunk sewer network and alleviate overflows from the Butterfactory Lane manhole, another frequent overflow point. The storage tank and treatment facility has therefore been designed for larger flows which could occur, if peak flows from Kamo catchment are diverted to it.

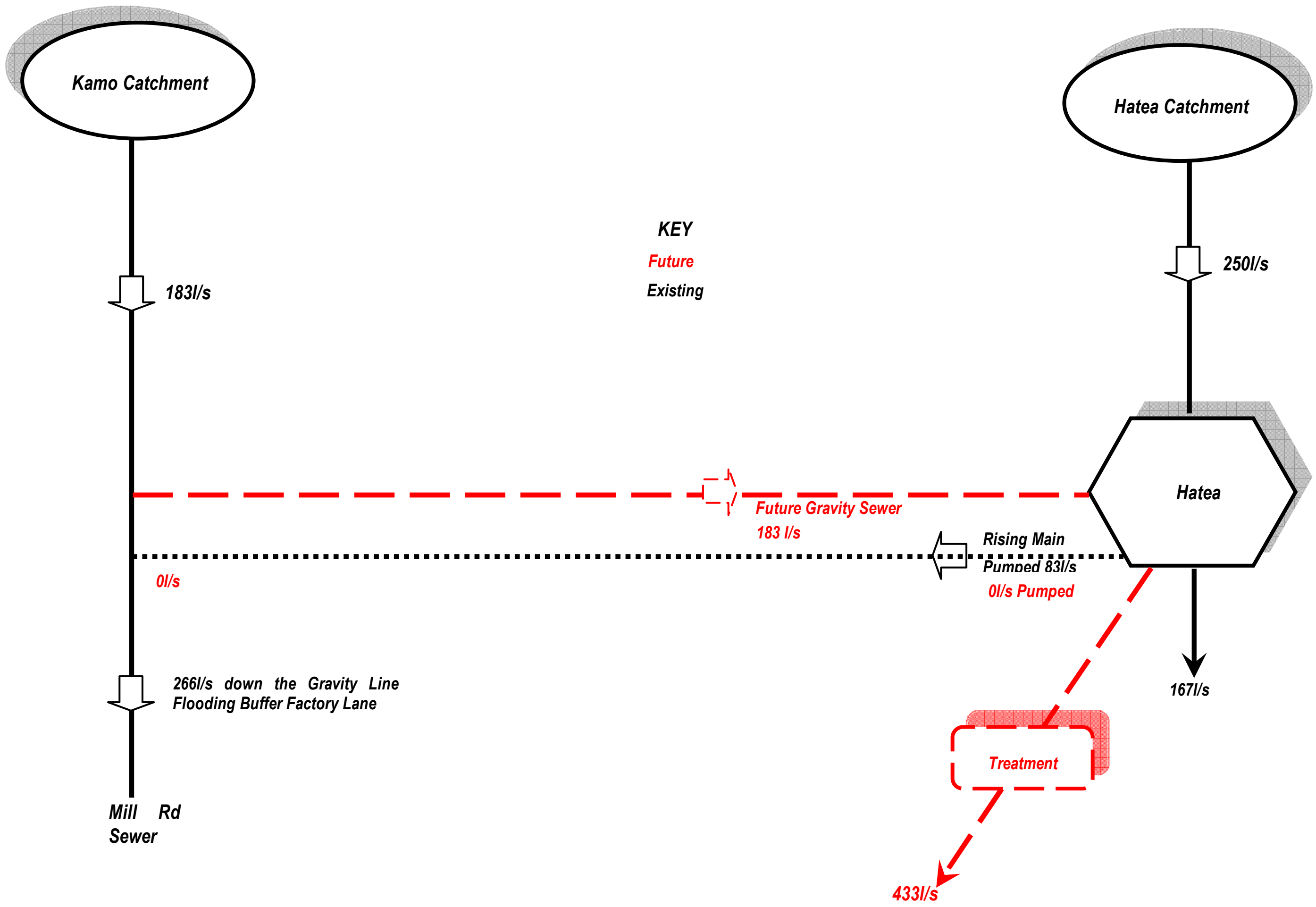

Figure 4- Flow schematic for potential flow diversion during extreme storm events

3.3 THE TANK DESIGN

In the event that the pumps are unable to cope with the inflow, the water will rise in the wet well until it overflows through the screen into the tank. After dosing with coagulant the wastewater will flow through the storage tank and solids will settle over the length of the tank. In order to optimize this process the rectangular clarifier is narrow and long. Using a "U" shape made of two long and narrow bays, 40 metres long and 5 metres wide, with a centre concrete wall the tank achieves a ratio of 16:1.

To determine the most suitable size for the tank, the frequency of future overflows had to be taken into consideration, as well as the minimum size for the provision of 12hr emergency storage and finally the loading rate for the clarifier at its design flow of 433l/s.

3.3.1 FREQUENCY OF OVERFLOWS

Table 1 is an extract from the WDC Sewage Spills Records from January 2009 through to June 2011 listing the spill events that have occurred at the Hatea SPS. The last column shows the expected result if the emergency storage tank and treatment system had been in place.

Table 1- Record of Historic Spills

Date	Spill Volume (m3)	Reason For Spill	Result if upgrade was in place
05/03/2009	<1,000	Heavy Rain	No Spill
01/05/2009	<1,000	Heavy Rain	No Spill
06/05/2009	450	Operational Issue	No Spill
26/05/2009	480	Heavy Rain	No Spill
10/06/2009	<1,000	Heavy Rain	No Spill
11/07/2009	1,000	Heavy Rain	No Spill
30/10/2009	120	Power Failure	No Spill
04/02/2010	20	Power Failure	No Spill
21/05/2010	< 3000	Heavy Rain	<2,000m3 of treated
24/05/2010	1,500	Heavy Rain	500m3 of treated
01/06/2010	< 2,000	Heavy Rain	<1,000m3 of treated
04/07/2010	600	Heavy Rain	No Spill
04/08/2010	200	Heavy Rain	No Spill
23/01/2011	300	Heavy Rain	No Spill
28/01/2011	<2,000	Heavy Rain	<1,000m3 of treated
24/03/2011	<15	Power Failure	No Spill
09/04/2011	<100	Power Failure	No Spill
02/05/2011	<900	Heavy Rain	No Spill

From this table it can be seen that over the 30 month period, a 1000m^3 emergency storage tank would have reduced the total number of spill events from 18 to 4, and the total spill volume during this period would have been reduced from approximately 8,500m^3 to 4,500m^3.

3.3.2 MINIMUM 12HR EMERGENCY STORAGE

The model of the Whangarei sewer network for the "high growth" option in 2041 developed by AWT suggests a required storage size of 734m^3 (~800m^3) to meet the 12hrs ADWF[1]. A 1000m^3 tank would provide greater than 15 hours of storage and would virtually eliminate overflows in the event of equipment or power failure. This is a vast improvement compared to the existing storage capacity of 20 minutes.

3.3.3 CLARIFIER LOADING RATE

For the hydraulic loading rate the WEF "Clarifier Design 2nd Edition Handbook" (page 73) states, that for chemically enhanced primary treatment (CEPT), i.e. where wastewater is chemically coagulated before clarification, *'U.S. EPA (1975a) 2m/h at average flow to 4m/hr at peak flows for CEPT with lime addition'*. This equates to 48m/day to 96m/day. WDC indicated that a rate of up to 95m/day be used.

[1] Average Dry Weather Flow

Hydraulic Loading Rate = Q/ Clarification Area
Re-arranging gives **Clarification Area = Q / hydraulic loading rate**
Flow Q in m³/day
Clarification Area in m²
Hydraulic Loading Rate in m/day
Maximum flow Hatea + Kamo combined, Q=433 l/s = 433 l/s x 86,400 s/day x 1m³/1000 l = 37,411 m³/day

For the Hatea scheme, data from a pilot trialling undertaken for “Napier Chemically Assisted Primary Archive” was used. The inflows for the Napier example was dosed with a coagulant and flocculants, however for the Hatea scheme the inflows will have coagulation only. The following hydraulic rate was supplied for the Napier scheme:

At ADWF, rate = 1.7 m/hr
At PWWF, rate = 3.7 m/hr = 88.8 m/day

The minimal required clarification area using the WDC loading rate would be

$$37411/95 = 394 \text{ m}^2$$

Using hydraulic rate of 88.8m/day, gives a clarification area of

$$37411/ 88.8= 421 \text{ m}^2$$

A tank volume of 1000m^3 was chosen which at an average water depth of 2.4m, provides a horizontal clarification area at the bottom of the tanks of 420m² (42 x 10m internal).

3.4 THE TANK COMPONENTS

Figure 5- Model of the valve chamber above both wet wells

3.4.1 THE NEW DAY TO DAY PUMP STATION

This new pump station will replace the existing Hatea Pump Station. With about 95m^3 of wet well volume it will house three Flygt pumps. The normal dry weather flows will vary between 5-20 l/s depending on the time of the day. The pumps chosen are two 100mm pumps (duty/standby) Flygt NP3171.181 (53-274-00-1070) 22kw and one 150mm pump Flygt NP3301.180 (53-454-00-1150) 70kw. The design capacity of the pump station is 85 l/s discharging into a 280mm OD SDR17 PN10 PE pipeline which is joined up with the existing 250mm rising main.

Figure 6 – Model of the "day to day" wet well with inlet pipe, pumps and mechanical screen

3.4.2 MECHANICAL SCREENING

The mechanical screening system will remove all solid material in the sewage greater than 5mm as it flows from the wet well into the tank. A special Huber ROK2 screen has been chosen, as this is one of the few models operating in an up-flow direction. The mechanical self-cleaning screen will operate automatically to remove solid material, which will simply drop back into the main pump station and be conveyed to the Whangarei WWTP. The screen is equipped with an automatic reversing functionality to avoid blockages. In case of power failure the effluent will automatically flow over the top of the screen into the tank without screening.

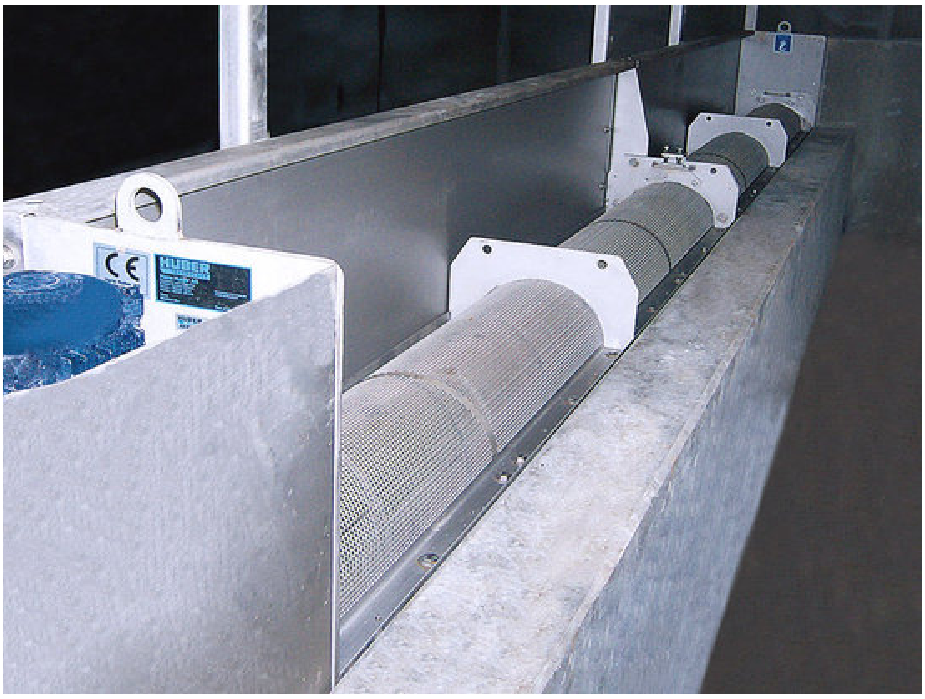

Figure 7- Proposed Huber ROK2 screen

3.4.3 CHEMICAL DOSING

A chemical coagulant will be sprayed into the wastewater as it passes over a weir to the storage tank via an automatic dosing system. The chemical dose rate will be controlled by a variable speed pump, which will deliver a varying quantity of chemical proportional entering the flow to the tank.

Jar testing on samples of wastewater spilled from the Hatea SPS during storm events has indicated that Poly Aluminium Chloride (PACl) is likely to enhance settlement of suspended solid material in the storage tank to improve performance of the UV disinfection equipment. Results from this testing have indicated that the ultra violet transmittance achieved in the effluent leaving the clarifier/ tank is likely to enable good performance of the UV disinfection equipment.

The proposed PACl chemical is a common chemical used in potable water treatment and wastewater treatment to aid settlement of suspended material while minimising sludge production with minimal risk to the receiving environment. The low level of sludge anticipated in the storage tank will be washed to the main pump station and conveyed to the WWTP after the storm event has passed. Further, a shelf life of several years makes this chemical well suited for this application.

3.4.4 DECANTERS

After clarification in the storage tank the wastewater has to pass into the UV pump station. Since the solids are settling to the bottom of the tank, the aim is to 'decant' the "clean water" off the top. However, water overflowing a weir or similar structure at a high velocity creates a significant up-flow in the water body. This up-flow would potentially be capable of pulling up the sludge blanket from the bottom of the tank.

In order to minimize the up-flow velocities a long weir length in the form of four 20m long double sided labyrinth weirs was provided. These weirs will consist of 300x300mm stainless steel troughs, hanging from the ceiling of the tank, into which the wastewater overflows. Fat and other floating solids will be held back by a stainless steel baffle.

The total weir length had been determined using a weir loading rate of 400 m^3/m/day (4.63 l/m/s) adapted from the same Napier example used for the clarifier. For the Hatea tank a flow of 433 l/s would require a minimum weir length of 433/4.63=94m. The labyrinth weirs designed have a total length of 160m which is a conservative approach.

Figure 8- Test sample for the decanters

3.4.5 ULTRAVIOLET DISINFECTION

When the chemical testing was undertaken on the storm samples taken from the Hatea Pump Station, the supernatant of these tests was also tested for transmittance, suspended solids and bacteriophage. The results were then used together with the expected flow information to design the UV treatment plant. A transmittance of 66% and 15mg/l suspended solids was achieved in the tests and a transmittance of 50-60% with 20mg/l SS was used for the design of the UV's. Based on this influent quality and a peak design flow of 433l/s, the UV reactors were designed to provide a minimum UV dosage of 40mJ/m^2. The ultimate stage design comprises four high rate UV reactors, of which only two will be installed at this stage to reflect the actual expected inflow of 170l/s.

Figure 9- Model of the control room with UV reactors

Figure 10- UV reactors at the WEDECO factory in Germany

3.4.6 UV PUMP STATION

The UV pump station itself would have been a very straight forward design for a pump station with a maximum flow of 433l/s, but the UV reactors and the general operation of the tank added some complexity due to

- The UV reactors require a “warm up” time of 2-3 minutes before they reach full capacity. Before this no discharge should take place.
- During operation the reactors have to maintain a certain minimum flow, as they will overheat otherwise
- Frequent on/off operation of the reactors will shorten the life of the UV lights. Therefore the reactors have to be able to operate continuously even during minimal discharges from the tank.
- The UV reactors (and the UV pump station) might not be used for up to 18 months between events. Bacteria in the effluent will form a slime layer around the lamps, which will reduce their capacity. Therefore a regular cleaning cycle needs to be introduced.

To address these problems, the discharge pipe from the UV reactors was looped back into the UV wet well. Once the wet well in the UV pump station reaches a certain level, one pump will start to cycle the effluent through the UV reactors and back into the wet well, giving the reactors time to warm up. As the water continues to rise, an actuated valve will close, slowly forcing the water to overflow into the discharge pipe leading to the rock bed. With this method it is expected to be possible to maintain even minimal discharge rates.

The pumps chosen are two 300mm pumps (duty/assist) Flygt NP3202.180 (53-614-00-6010) 37kw to deliver the required maximum capacity of 433 l/s. The pipe work in the UV pump station also makes provision for the two Wedeco LBX750 UV reactors which are not being installed at this stage.

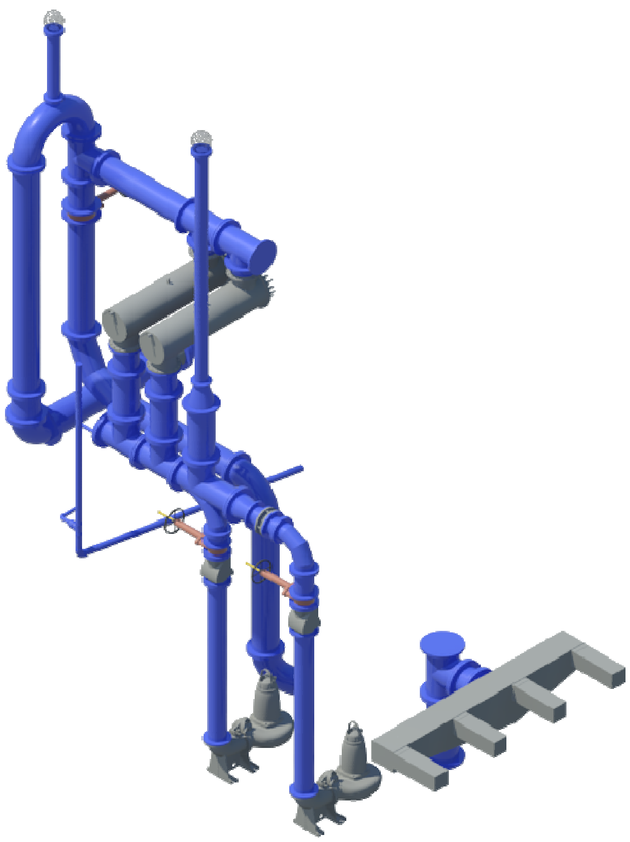

Figure 11- Model of the UV pump station pipe work with decanters (cut away), inlet pipe, pumps, UC reactors and circulation pipe work

3.4.7 MOTOR CONTROL CENTRE AND CHEMICAL STORAGE

In its ultimate stage the motor control centre has to provide space for the control cabinets of the telemetry and PLC's, for up to six variable speed drives and five control centres for the four UV reactors. Sufficient space has to be provided for the maintenance of the pumps and other equipment, as well as for all UV reactors, including clear zones to maintain the UV reactors. There also has to be a chemical storage room for the PAC1. All this has to be located above flood level.

For this reason a rather large control building was designed on top of the tank.

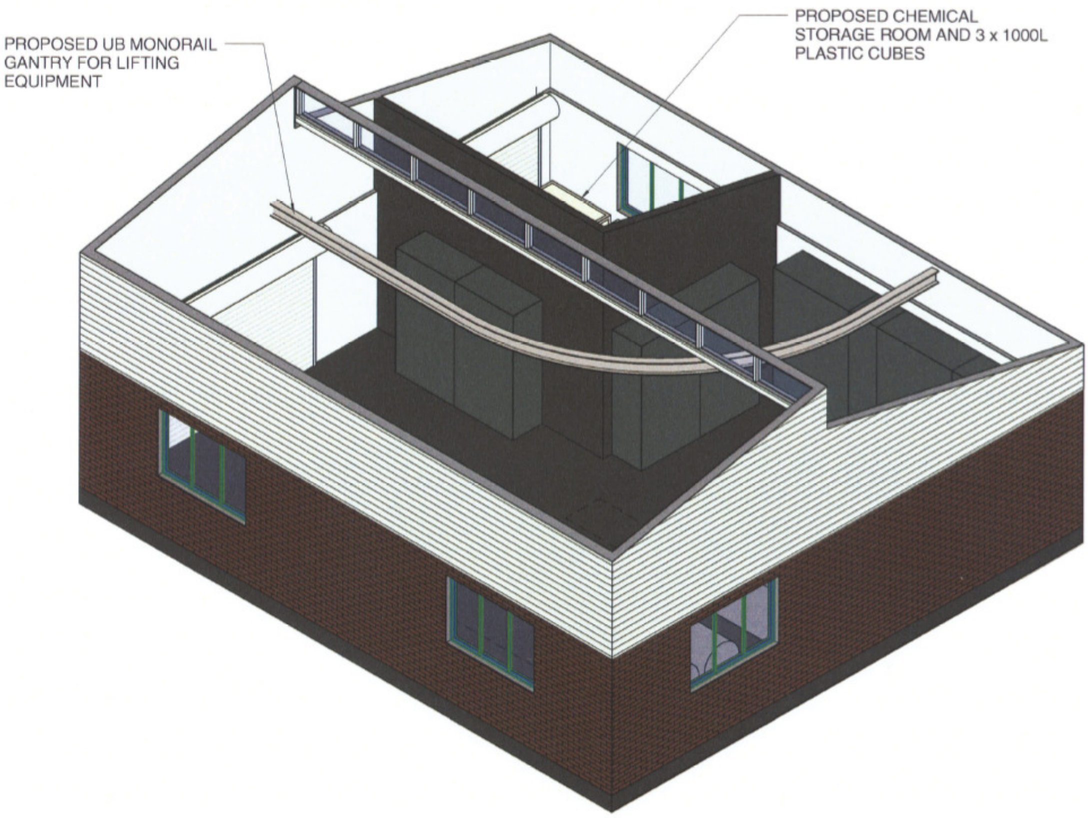

Figure 12 – Control building with chemical storage

3.4.8 OUTFALL STRUCTURE

Once the clarified effluent has been pumped through the UV disinfection system, it is finally discharged into rock beds. A gabion wall will be built on the east river bank to dissipate outlet flow to earth, rather than direct to Water. This design aspect is to provide mitigation of effects upon iwi cultural and spiritual values. The gabion wall will be 1 m high and 12 m long.

3.4.9 ODOUR CONTROL

Occasionally, there have been complaints about foul odours from the pump station by local residents. This was also emphasized in public consultation undertaken during early stages of the design. To address this concern, the design includes a bio filter that has been sized using the ARC guideline to ensure that no offensive or objectionable odour will be detectable from the boundary of the property.

3.5 TREATMENT PERFORMANCE

3.5.1 BACKGROUND WATER QUALITY

The water quality of the Hatea River is monitored by the Northland Regional Council as part of their bathing water quality programme. The results give a reasonably consistent picture of the level of E.coli bacteria in the Hatea River outside of major storm events. Removing outlying results (3,000+), which are likely to have been influenced by other events, the average E.coli level for the 2 sites during dry weather is 588 MPN/100ml at

Whangarei Falls (upstream) and 574 MPN/100ml at Mair Park (downstream). This level is believed to provide an indication of the background concentration of E.coli (97w) in the Hatea River during dry weather.

Limited historical data of water quality in the Hatea River during storm events is available. To provide some indication of water quality during these events, WDC has undertaken sampling and analysis during recent storm events which is presented in the following tables.

Table 2 - Hatea River water quality samples

Storm Event 2nd May 2011		Above Whangarei Falls	400m upstream of the Pump Station	Opposite Sewer Pump station	Downstream of the Pump Station	Hatea SPS Overflow
Ammonia Nitrogen	mg/l	0.92	1.00	1.12	1.00	3.50
E coli (97w)	MPN/100ml	6,867	24,196	48,840	15,650	1,046,200
Oxygen Demand	mg/l	<10	<10	<10	<10	42
Solids Suspended	mg/l	87	71	106	80	52

3.5.2 DISCHARGE QUALITY

As mentioned in the previous section, current spill events at the Hatea Pump Station result in a discharge concentration of E.coli in the order of 1,000,000 MPN/100ml. Analysis has indicated that once the upgrade is in place, during peak storm events when the capacity of the storage tank is exceeded, the concentration of E.coli in the treated discharge to the Hatea River is expected to be less than 1,000 MPN/100ml.

Table 3- Estimated disinfection targets for storm water discharges from Hatea Pump Station

Target Influent Parameters					**Target Influent Parameters**			
Flow	TSS	UVT	UV Dose	E.coli inlet	Estimated E.coli Outlet	Log Reduction	Estimated E.coli Outlet	Log Reduction
[l/s]	[mg/l]	[%]	[mJ/cm²]	[CFU/100ml]	[CFU/100 ml @ 80%ile]		[CFU/100 ml @ 95%ile]	
170	20	60	75	2,500,000	250	4	1,000	3.4
250	20	60	51	2,500,000	1,000	3	5,000	2.7
170	20	50	57	2,500,000	500	4	2,000	3.1
170	20	50	57	500,000	200	3	500	3
170	20	40	44	2,500,000	5,000	3	10,000	2.4
170	30	50	57	2,500,000	1,000	3	5,000	2.7

Table 3 lists a number of estimates for the bacteriophage loading in the effluent from the finished system prepared by Wedeco. This is based on the treatment using two of their LBX750 UV reactors. These estimates are based on conservative values based on our testing and also on the background water quality during storm events ranges that varies from 6,000-24,000. It is expected that the new system will make a significant improvement on the current situation. Environmental impacts from the discharges during storm events after the implementation of the system are considered to be negligible.

4 CONCLUSIONS

The Hatea storage tank is a novel approach to the problem of pump station overflows. While other options would have been feasible in this situation, they would have been more expensive or the outcomes would have been less desirable.

Each of the designs elements is well established and has been used many times before. The screen, rectangular clarifiers, UV treatment, chemical dosing - all these things have a track record of good performance. The novelty of the design lies in the way those proven methods have been combined to find a near ideal solution for a given problem.

Thinking outside the box and the application of engineering knowledge in a new way has resulted in a solution that is more economic by providing the same or better outcomes compared with other solution. This is not to say that this design could readily be applied all over the country in other locations. The Hatea storage tank was designed for a unique set of circumstances in a unique location. And whilst it is likely that this approach can be successfully applied in other locations this has to be determined on a case by case basis.

ACKNOWLEDGEMENTS

I would like to express my gratitude to the Whangarei District Council, especially to Andrew Carvell, for having the trust in Opus to develop this interesting and challenging project together with us. It has been and exhilarating experience to work collaboratively on this innovative design.

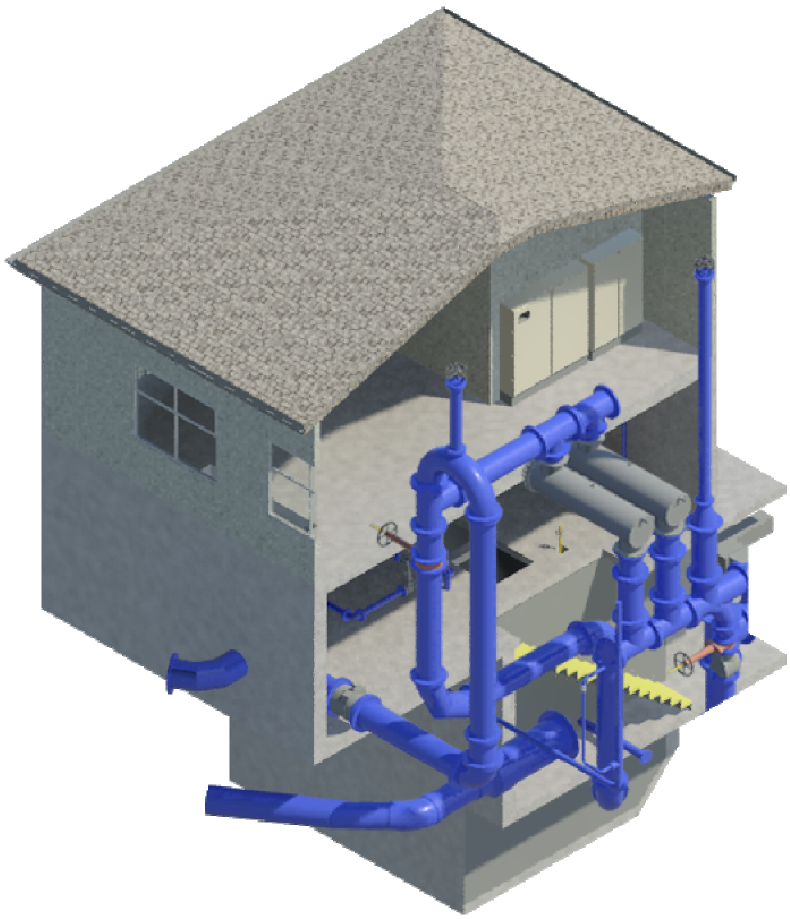

Figure 13- Cut away model of the Control room building and valve chamber underneath with pipe work