PAEROA WTP – CHEMICAL FREE WASTE STREAMS

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ABSTRACT

In 2012 Harrison Grierson was commissioned to design the upgrade of the Paeroa Water Treatment Plant (WTP), with the objective of increasing the plant's capacity from 4.3 to 6.0 MLD and achieving compliance with the New Zealand Drinking Water Standards.

Constraints on the upgrade included the limited capacity of the existing sewer connection used to discharge washwater, and the heavily constrained site. The limited space made installing the equipment required to upscale the process design challenging, prohibiting installation of a clarifier, washwater handling and B-train access.

Given these constraints and the conditions of the raw water, the solution was developed around coagulant free membrane filtration, which only dosed coagulant during high color events. Reducing the volumes of coagulant used in the treatment removed the need for the B-train access and additional washwater handling. The upgrade of the plant also incorporated the first advanced oxidation UV peroxide plant commissioned in New Zealand, used to mitigate taste and odour.

This paper will discuss the design optimization process, consenting challenges for untreated washwater discharge and the collaboration of the structural and planning teams with the technology supplier required to develop this design solution.

KEYWORDS

Compliance, Environment, Discharge Consent, Reuse of Existing Infrastructure

1 INTRODUCTION

The Paeroa Water Treatment Plant (WTP) provides treated water to the community of Paeroa and the Ohinemuri Rural water supply. In addition to the residential Water Supply Scheme, the WTP also supplies water to the Silver Fern processing plant and the dairy farms in the area. The plant is therefore a key piece of infrastructure that has significant social and economic benefits for the Paeroa district.

The raw water for the WTP is taken from an intake in the Waitawheta River, immediately upstream of the confluence with the Ohinemuri River. The abstracted raw water is of variable quality due to the occurrence of algal blooms during summer periods and river freshes after rainfall events. The sediment that is washed into the river following a river fresh would typical result in a spike in turbidity, which is closely followed by elevated colour. The raw water is pumped from the intake to the Paeroa WTP 6.5 km away.

Prior to the upgrade, the existing treatment process consisted of coagulation followed by rapid sand filtration and chlorine disinfection. The filtration plant included three rapid gravity sand filters upstream of the clear water chlorine contact tank. The treated water would then be dosed with lime for pH adjustment before being gravity fed to the reservoir. The design capacity of the existing plant was 4.3 MLD, which was supplemented by the Ohunemuri Rural water supply during periods of peak demand.

The sludge handling system consisted of a sludge holding tank which received waste water from the filter backwash system and filter-to-waste operation. The sludge collected in the holding tanks was fed at a highly restricted rate into the sewer network to be processed at the Wastewater Treatment Plant (WwTP). The process flow diagram for the system is shown in Figure 1.

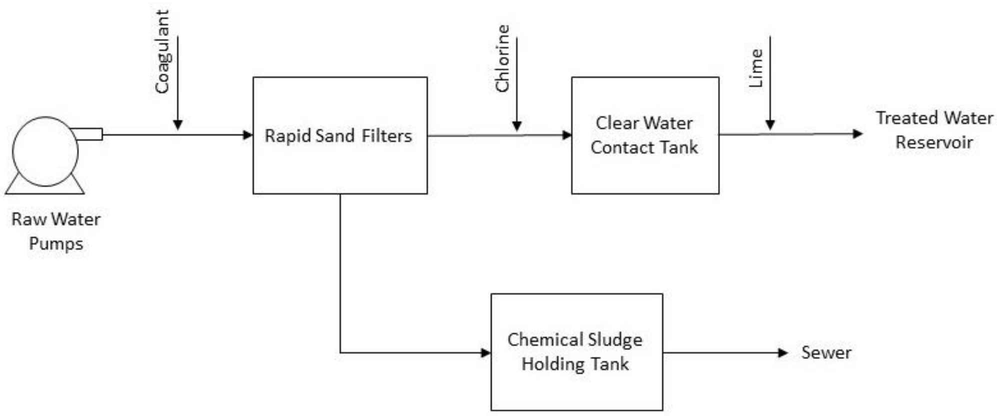

Figure 1: Treatment Process Prior to Upgrade

The upgrade of the WTP was necessitated by the inadequacy of the system to meet the predicted future water demand of the community and the compliance requirements of the DWSNZ. In addition, the previous treatment method of direct filtration was unable to cope with the intermittent high turbidity events and algal blooms associated with the raw water source, resulting in compliance transgressions, and taste and odour issues with the treated water supply.

2 DESIGN CONSIDERATIONS

The final solution for the upgrade was shaped around the following factors inherent to the existing site:

- The raw water quality;
- The limited access and site space;
- The limited capacity of the existing sewer connection;
- The large capacity of the treated water reservoir;
- And an existing stormwater connection to the Ohinemuri River.

The success of the upgrade come out of recognizing the limitations associated with site layout and the sewer capacity. These were mitigated by taking advantage of the opportunities provided by the raw water quality, large treated water reservoir and the existing stormwater connection. In this way the upgrade solution was able to make the most effective use of the existing infrastructure and reduce the cost of the overall project.

These constrains were considered in conjunction with Council's requirements for the project which included the flowing:

- Increasing the capacity of the plant to 6.0 MLD to meet the future water demand;
- Compliance with the Drinking Water Standards of New Zealand 2005 (revised 2008) and, in particular, to increase the WTP's disinfection to 4 log for protozoa;
- Upgrade of the ancillary components to enhance effective operation of the plants;
- Staged integration of the upgrades into the existing plant whilst maintaining the volume and quality water supply to the community; and
- A cost effective and practical solution to meet the upgrade requirements.

2.1 RAW WATER QUALITY

The most significant challenge was to provide a reliable treatment process that was able to treat the varying levels of turbidity and colour in the raw water.

Sampling of the raw water indicated that the majority of the influent was of good quality with average turbidity and colour levels less than 5.0 NTU and 5.0 Hazen respectively. However, following high rainfall events the turbidity of raw water would increase significantly reaching levels above 50 NTU. These spikes in turbidity typically last for less than a day, and are followed by a period of high colour, where the colour in the raw water reaches above 40 Hazen.

Due to their extremely fine nature, the particles that cause colour make them very difficult to treat without coagulation, which formed part of the existing treatment process. In spite of this, these events were still resulting in filter break though and causing compliance issues.

While these events are uncommon the significant change in the level of colour introduced the challenge of providing a consistent standard of treatment without over designing the system. A summary of the raw water turbidity is shown in Table 1.

Turbidity	Percentage Occurrence
Greater than 50 NTU	1%
Between 5 and 50 NTU	2%
Between 0 and 5 NTU	97%

Table 1: Raw Water Turbidity

In addition to the changes in turbidity and colour, the existing treatment process was unable to remove the organics introduced into the raw water as a result of the algal blooms, which were causing taste and odour issues in the treated water supply.

2.2 SITE SPACE AND ACCESS

The limitations of the site layout were a critical factor in the development of the upgrade design. As shown in Figure 2, the WTP site is very restricted with limited free space. This is further inhibited by the hilly topography making effective utilization of the available space challenging.

The access road into the plant is also restricted, particularly in the space available to turn a vehicle. The layout is unable to accommodate a B-train tanker used for chemical delivery.

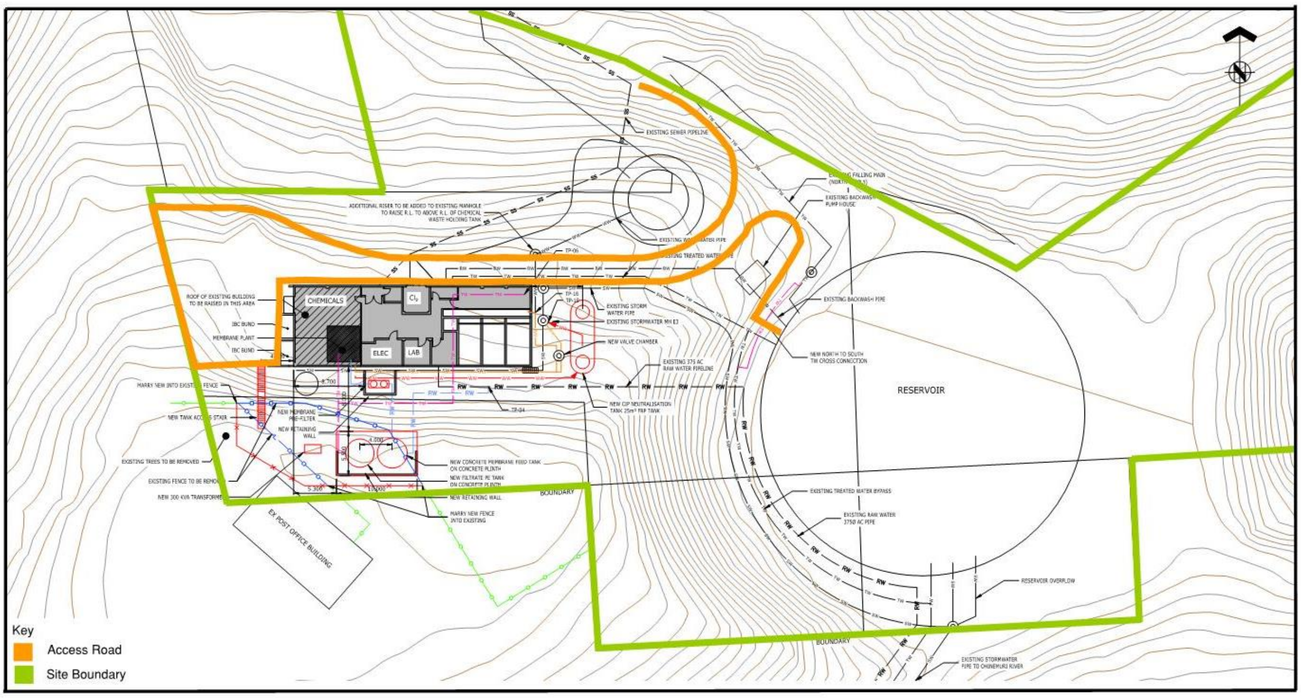

Figure 2: Paeroa WTP Layout

2.3 LIMITED CAPACITY OF THE SEWER CONNECTION

The waste streams produced during the treatment process also had to be carefully considered. This was a result of the limited capacity of the existing disposal system. The available discharge point to the WwTP is an onsite sewer connection. This infrastructure was already heavily strained under the existing treatment process due to the limited storage capacity of the sludge holding tank and flooding issues in the network. During periods of high flow the tank would overflow to the Ohinemuri River via a stormwater connection.

2.4 TREATED WATER STORAGE CAPACITY

The site had the advantage of an exceptionally large treated water reservoir. The existing reservoir has a storage volume of roughly 9,000 m^3, which equates to approximately two days of treated water supply for the community at the average water demand. This allowed for some flexibility when considering treatment options as the plant did not need to continually operate at its maximum throughput to meet the water supply demand.

2.5 EXISTING STORMWATER CONNECTION

Prior to the upgrade, the WTP was consented for discharge of stormwater runoff from the site to the Ohinemuri River. The stormwater runoff was untreated and discharged directly into an ephemeral wetland area which leads to the Ohinemuri River.

The capacity of this connection exceeded what was required for the stormwater discharge and thus could potentially be used for other purposes.

3 PROCESS SOLUTION

In considering upgrade options the initial direction was to try and develop a solution that was based on the existing treatment process.

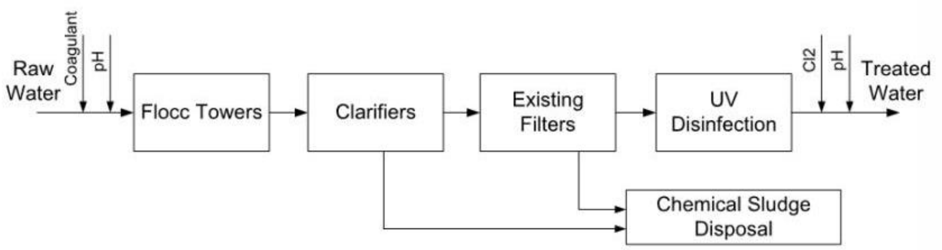

Figure 3: Concept Design Incorporating Existing Filters

As shown in the Figure 3, this process solution required continuous coagulant dosing and incorporated a clarifier in the treatment train. Reuse of the existing filters would also have required costly upgrades to facilitate the desired level of treatment automation.

The limitations of the site layout were a critical factor in trying to increase the capacity of the plant using the existing system. The required increase in flow meant that incorporating continuous coagulant dosing would require chemical delivery by a B-train tanker. Due the restricted site access this was not possible without significant adjustments to the layout. There was also no adequate space to install a clarifier on site. As a result extensive earth works would have been required to excavate a small hill side to create the necessary space.

In addition to the issues with the layout the waste streams produced by this treatment option far exceeded the capacity of the existing sludge handling system. The total volume of the sludge holding tank is 110 m^3, with a maximum discharge rate to the sewer of 17.6 m^3/hr.

Mass balance calculations were completed for eight operating scenarios to consider the sludge production at a range of inflow rates, turbidity and colour. Calculations based on the most extreme case of an inflow rate of 6.0 MLD with a turbidity of 100 NTU yielded a sludge flow of 530 m^3/d. As this exceeded the capacity of the existing sludge system, extensive upgrades would have been required to facilitate continuous coagulant dosing with the increased plant capacity. These upgrades would have required construction of sludge ponds.

This option was eliminated on the basis that it was not only restricted by the limitations of the site layout and sewer network, but it also did not take advantage of the opportunities presented by the good raw water quality, the large treated water reservoir and connection to the Ohinemuri River.

The critical factor in this was the variance of the raw water quality. The system presented in Figure 3, is essentially continually proving treatment for raw water conditions that occurred less than 1% of the time. As a result this solution used excessive amounts of unnecessary chemicals and thus unnecessarily increased the volume of the waste stream. This prompted investigation into solutions that reduced the chemical demand of the treatment process and as a result the amount of sludge sent to the sewer. With this as an objective direct filtration by membranes was introduced a potential treatment option.

The superior filtration achieved by the minute pore sizes in the membrane cells meant that direct filtration without coagulation was possible for the majority of the raw water conditions. Membrane filtration could also achieve the 4 log credits necessary for DWNZ compliance, without coagulation of the raw water.

As coagulation was not necessary to treat the raw water under normal conditions, this meant that the filter backwash water was chemical free for the majority of the plant's operation. Since the backwash water did not contain any chemicals it did not require further treatment at the WwTP, however this water still could not be sent to the sewer without causing network flooding.

Early consultation with Harrison Grierson's planning team indicated that the chemical free nature of the backwash water would allow for direct discharge to the environment. This allowed the existing stormwater connection to the Ohinemuri River to be incorporated into the upgrade design, with filter backwash water discharged directly to the water course when coagulant dosing is not required.

This treatment solution also provided the flexibility to directly dose coagulant upstream of the membrane feed tank during high colour events.

The process flow diagram of the upgraded system is shown in Figure 4 below.

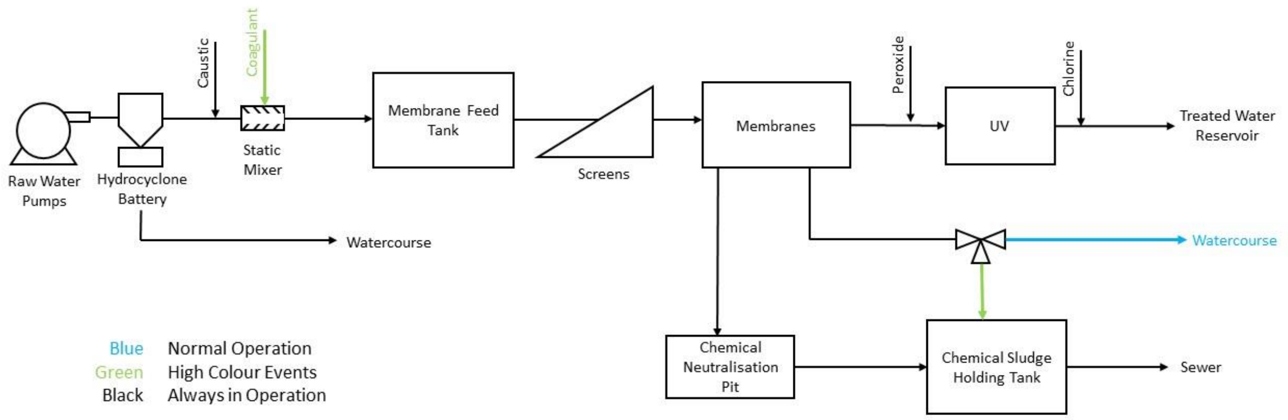

Figure 4: Post Upgrade Treatment Process

The system incorporated coagulating dosing upstream of the membrane feed tank to allow the plant to adapt the treatment process to changes in the raw water conditions. A colour meter included in the membrane package plant automatically initiates coagulant dosing to an inline static mixer when the raw water colour reading is above 10 Hazen. While coagulant is being dosed the plant flow rate is automatically reduced to 75%. An actuated valve to the chemical sludge holding tank opens and the valve on the discharge line to the Ohinemuri River closes. The limited sludge produced during this operation can be stored in the existing sludge tank, and sent to the sewer network at a reduced rate, as it had been prior to the upgrade. This was achievable due the large treated water reservoir which had sufficient capacity to meet the treated water demand during periods of reduced plant flow.

The treatment process also included a UV/peroxide system to treat the organic material causing the taste and odour issues through advanced oxidation. Again a contributing factor in selecting this system was that it is a zero waste process.

A hydrocyclone battery was included to mitigate the risk of damage to the membrane plant by larger sand particles during high turbidity events. The hydrocyclones were installed at the booster pump station on the raw water line to avoid the need to incorporate them on the WTP site. As this process is also chemical free, the hydrocyclones also discharge via the stormwater connection to the Ohinemuri River. The hydrocyclone battery is shown in Photograph 1.

Photograph 1 Hydrocyclones

4 DESIGN IMPLEMENTATION

The design process for the upgrade was based around recognizing the key design constraints and opportunities during the early stages of the project. The final upgrade design was developed over an extensive optioneering period that included input from Council and the Plant Operators, as well as the technology supplier and Harrison Grierson's planning and structural teams. A strong emphasis was placed on collaboration, where input was sought from the various parties during the early stages of the design.

Design meetings were held with the technology supplier, and process, planning and structural teams to ensure that all aspects of the design were considered and addressed during the concept phase. This was particularly important in the design considerations necessary to install the membranes at the WTP, and the consenting process.

4.1 SINGLE SOURCED MEMBRANE CONTRACT

Although membranes achieved the best treatment solution for the WTP, incorporating them into the existing layout also posed significant design challenges. As a result of this Harrison Grierson recognized the benefit of engaging the technology supplier early on the design process.

Masons Engineering had previously supplied Memcor membranes for the upgrade of the Kerepehi WTP, and thus they already had a good working relationship with Council. The Memcor product also had the benefit of being familiar to the Operators, and incorporating them in this upgrade would provide consistency between the plants.

Considering this Council was interested in single sourcing the membrane contract, and avoid the tendering process. Due to the high value of the contract a key issue with this was ensuring that commercial tension was retained. In order to fairly assess the prices provided by Masons for the Waihi and Paeroa WTPs Harrison Grierson was able to prepare comparative cost estimates based on industry experience with other plants of various sizes, this is shown in Figure 5. Based on this information Council awarded a single source contract to Masons.

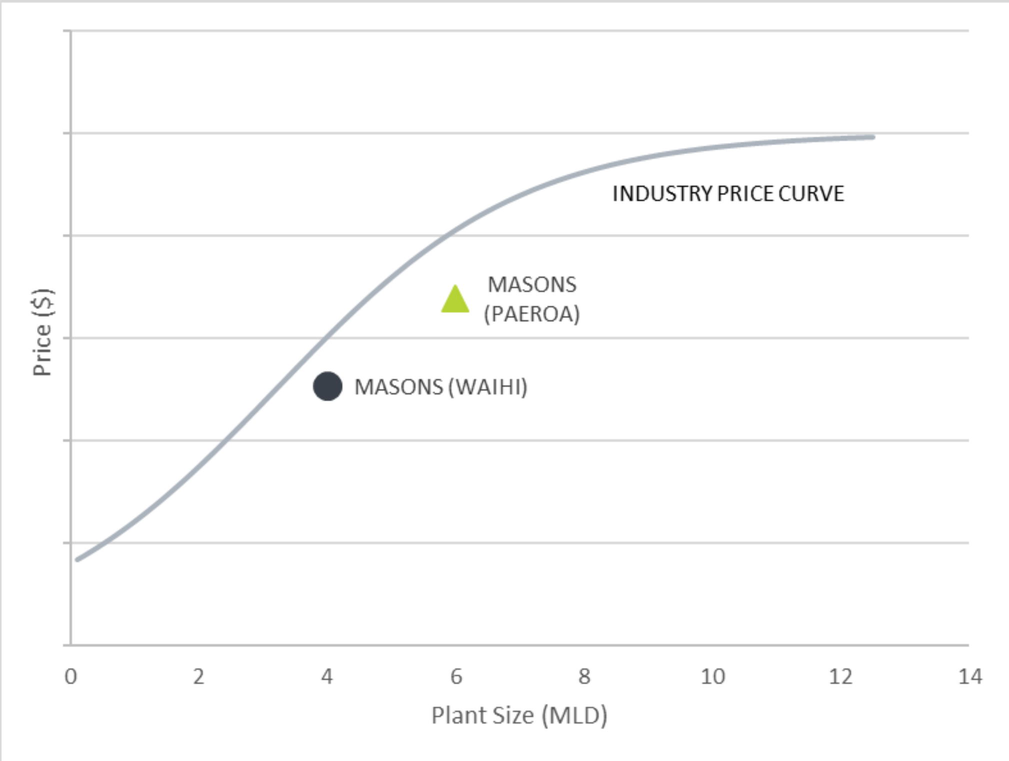

Figure 5: Membrane Pricing Guide

4.2 LAYOUT DESIGN

The major obstacle opposing the installation of a membrane plant was the constrained site space. In order to overcome this a collaborative approach with our in house structural team and the technology supplier was employed.

Masons was engaged during the optioneering process to provide input into the options assessment process. As a result of this collaboration, their expertise were incorporated into the process design and equipment installation. This was instrumental in overcoming the issue of finding adequate space onsite for a membrane plant. The operational requirements of the system were also taken into account, which involved a number design iterations regarding the platform arrangement around the membrane plant. This allowed the membrane cells to be lifted from the tanks for maintenance purposes.

Various options were considered for the building to house the membranes. This included construction of a new building. Due to the constrained layout finding the space for a new building would require the removal of a small hill at the back of the plant or demolition of half the existing WTP building. To avoid this it was decided that every attempt would be made to install the membrane plant in the existing WTP building.

In order to accommodate the membrane plant a number of structural modifications to the existing building were required. This included several iterations of the building design to facilitate the maintenance requirements of the system. In the original design the membrane tanks were covered by a single removable platform. The idea behind this design was that the cover would be removed from the appropriate tank by the Operator, and the cell lifted out, the cover would then be replaced and used as a work platform to complete the required maintenance. This design would have allowed the membranes to be installed within an existing space in the building without the need to remove any internal walls. The original platform design is shown in light blue in Figure 6.

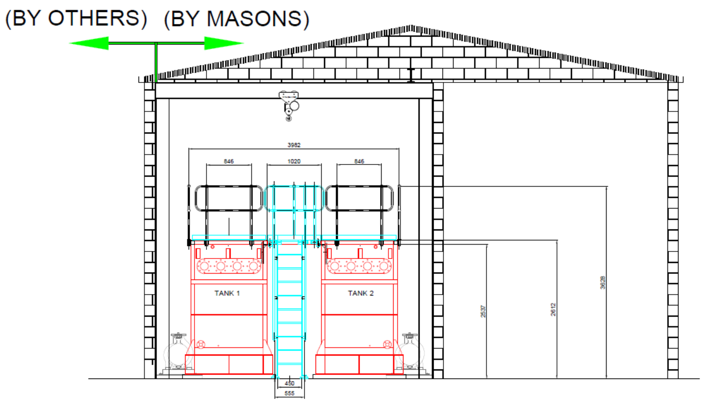

Figure 6 Original Membrane Platform Design

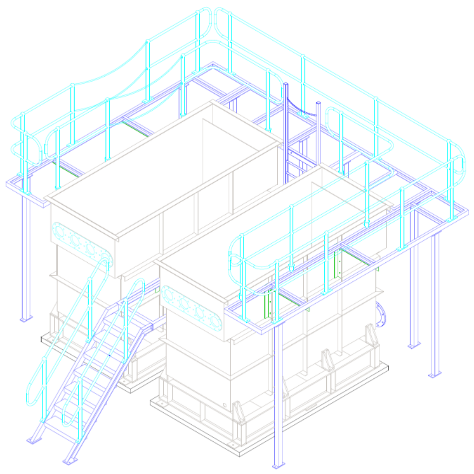

Figure 7 Final Membrane Platform Design

The design was later rejected due to the risks to the membranes of having Operators working over them on a regular basis. This risk was mitigated by removing the internal wall between the membrane and chemical rooms. This allowed the membranes to be lifted out of the tanks and lowered to a work area in the adjacent room. The work areas for the original and final design are shown in Figures 8 and 9 respectively. This design incorporated a platform around the membrane tanks shown in Figure 7.

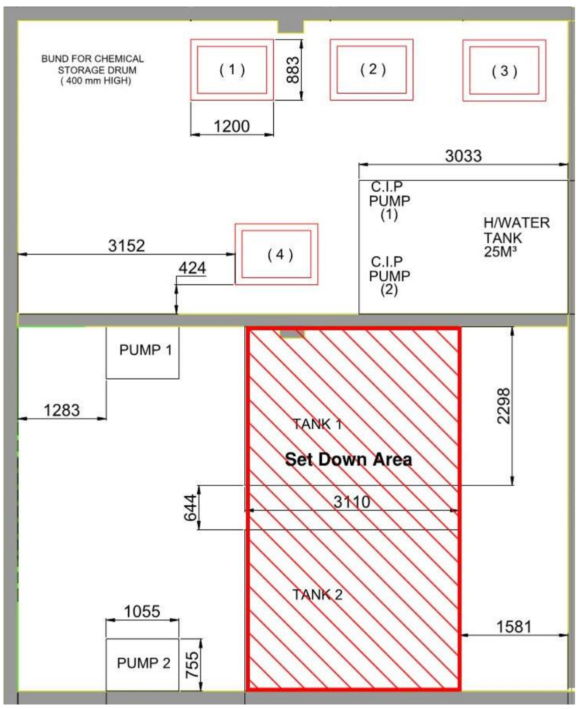

Figure 8 Original Layout

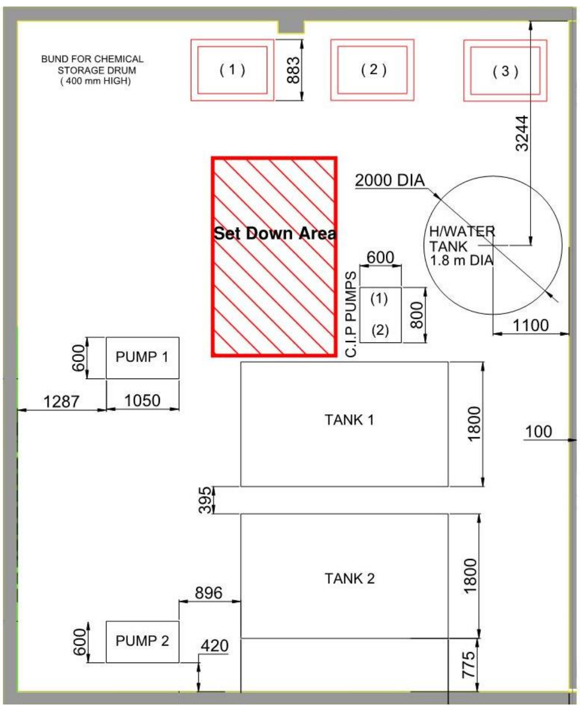

Figure 9 Final Layout

In order to accommodate the gantry crane to lift out the membrane cells, the roof of the building first had to be raised by 1.5 m, before being refitted. Additional modifications required to incorporate the final design included the removal of internal walls, and installation of new structural steel framing to provide the reinforcement required for earthquake compliance. Acoustic enclosures for the blowers and sound proofing for the building were also installed to reduce the noise level at the boundary to an acceptable level.

4.3 CONSENT APPLICATION

The discharge consent application for the WTP was based around the ability of the plant treat the majority of the raw water without using chemicals. The consent application proposed that the chemical free backwash water be directly discharged into the Ohinemuri River via the existing stormwater outfall in order to make the best use of the existing infrastructure.

The consent limits in the application were for a maximum volume of 600 m^3/d and an instantaneous flow rate of 111 m^3/hr. These limits took into account the various raw water conditions, however for the majority of the time the discharge volume was expected to be closer to 118 m^3/d.

As no chemicals are added during treatment, the only change to the raw water is a higher level of suspended solids in the discharge water. This in addition to the fact that the discharge water is taken from an intake point in the same catchment as the Ohinemuri River, meant that no treatment of the filter backwash water was necessary prior to discharge.

The solids loading due to the discharge of the filter back wash water is around 570 mg/L for 97% of the plants operation. Under these conditions the volume of water discharged is around 118 m^3/d, resulting in a total solids load of roughly 67 kg/d. This level of loading has no adverse effects on the Ohinemuri River.

5 BENEFITS OF DESIGN

Although challenging to implement, the use of membranes in the treatment process provided a range of benefits beyond their superior filtration capacity. Most of these stemmed from the coagulant free filtration.

A larger coagulant dosing plant would have required B-train access to the WTP, which was deemed infeasible in initial assessments. Further investigations looked at redirecting the traffic through the plant by incorporating an additional access point at the western end of the property. While this removed the need for a turning circle, construction of the new access point would have negatively impacted the neighboring properties and had significant cost implications.

Further cost savings were provided by removing the need for an upgrade of the sludge handling system. The initially proposed upgrades would have required construction of backwash water ponds on the bank of the Waitakaruru River. This would have had significant negative social and environmental impacts as a result of constructing sludge ponds on prime land between State Highway 2 and the river.

The solution also had a number of indirect social and environmental benefits. The reduced sludge production means that the raw water is used more efficiently and thus less water is required to meet the treated water demand of 6.0 MLD. The increase in efficiency had the added benefit of enabling the reuse of the existing raw water pumps, which would otherwise have to be upgraded to cope with the increased flow.

Additionally, the direct discharge of the backwash water to the Ohinemuri River provided a cultural benefit as the discharged water was returned to the same catchment as the source. This consideration is important for Iwi who have strong cultural beliefs against mixing water from different catchments.

6 CONCLUSION

The final project was completed to program and within budget. The solution met all of Council's requirements. In particular the plant is fully compliant with the DWSNZ, and the resource consent conditions. The installation of the UV peroxide system successfully treats 2-MIB and Geosmin, and as a result taste and odour is no longer an issue. This was achieved in a manner that was able to provide the best value for rate payers through effective use of the available infrastructure onsite, as well as indirect environmental benefits due to the chemical free filtration.

ACKNOWLEDGEMENTS

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