PUTTING OPERATORS FIRST: INSIGHTS FROM WAIĀRI'S DESIGN JOURNEY.

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ABSTRACT

Tauranga City Council (TCC) commissioned its new Waiāri Water Treatment Plant (WTP), with water first being delivered to customers in December 2022. The WTP has a 30 ML/d capacity with a future design capacity of 60 ML/d using coagulation, clarification, membrane filtration and disinfection (sodium hypochlorite). The WTP is also a zero liquid discharge facility with all liquids either recycled or physically removed from site, a process rarely used in New Zealand. The WTP design had a strong emphasis on putting the operator first by considering health and safety, operations team visibility and movements, segregation of visitors, plant and chemical areas, maintenance activities and site tours. This approach, led to a facility where the operations team have a modern working environment, excellent visibility and control of areas, and a reduced need for PPE.

This paper outlines the collaborative approach to the design of the Waiāri WTP by TCC and Beca to provide a safe and operable facility. This paper discusses the key factors to success through the design process including:

- Creation of facility design principles before pen was put to paper, as a rule book for designers
- Bringing in operations experience and requirements early
- The value of visiting other sites with the operations team and learning from others experience.
- Understanding core operational tasks, and health and safety to inform design and layouts.
- Understanding and applying resilience from the operations teams' experience to manage expectations of a water supplier.
- Considering and segregating chemicals
- Managing noise and heat
- The value of traditional safety in design and HAZOP processes
- The use of 3D design and virtual reality for design reviews
- The value of a 3D model during construction

This paper then discusses the operational and maintenance context on how the design thinking has carried through into an operational facility, including:

- The safety of reduced noise: Hearing protection not required, except for specific areas (centrifuge and generator buildings)
- Reduced PPE requirements in operational areas compared to TCC's existing WTPs.
- A site where access and maintenance of equipment can be completed from ground level or an adjacent scissor lift.
- Reducing confined spaces and ladders to a minimum
- Clear access ways for maintenance
- Clear sight lines from key operational facilities
- Separation of plant and visitor areas

The result of this process has resulted in a safe and operable facility in an operator-centric layout that can be applied to future facility layouts where the operations teams' safety, security and control of visitors and contractors is improved.

KEYWORDS

Health and Safety, Layout, Design, Water Treatment

PRESENTER PROFILE

Rodney has been in the water industry for 16 years and has been involved with the Waiāri Water Scheme when the design process was kicked off in 2016 and has been a key player right through to its operation today. Rodney is the current Water Treatment Manager for TCC.

Scott has worked in operations, planning and consulting in the water industry. Scott was the process lead for Waiāri and brought a wealth of skills and experience in both process design and treatment operations. Scott was also the technical commissioning lead, ensuring safe water was provided to the community.

INTRODUCTION

Tauranga City Council (TCC) commissioned its new Waiāri Water Treatment Plant (WTP), with water first being delivered to customers in December 2022. The WTP has a 20 ML/d capacity with a future design capacity of 60 ML/d using coagulation, clarification, membrane filtration and disinfection (sodium hypochlorite).

The WTP is also a zero liquid discharge facility with all liquids either recycled or physically removed from site, a process rarely used in New Zealand. The WTP design had a strong emphasis on putting the operator first by considering health and safety, operations team visibility and movements, segregation of visitors, plant and chemical areas, maintenance activities and site tours. This approach, led to a facility where the operations team have a modern working environment, excellent visibility and control of areas, and a reduced need for PPE.

This paper outlines the collaborative approach to the design of the Waiāri WTP by TCC and Beca to provide a safe and operable facility.

PUTTING THE OPERATIONS FIRST REQUIRES HAVING OPERATIONS IN THE ROOM

An obvious statement, but not always done as well as it should be. The people who run the plant know their own preferences, what annoyances there are; experience that can often be missing in a design office. For example, a large pipe might get a designer excited when it's the instrument panel that matters to an operator!

The next step is to create an open environment where wānanga is welcomed – to challenge the thinking of others and sometimes agree to disagree. Someone needs to play the role of a moderator, and ideally this person has both design and operations experience.

LEARN FROM OTHERS

The Tauranga City operations team and the Beca design lead visited numerous sites to see other similar plants and even a membrane manufacturing facility. The amount of knowledge from discussing and sharing stories with the operators on these sites led to fundamental decisions being made that would shape the direction of the future plant.

The knowledge of other water utilities particularly around the less obvious nuances and challenges shared by other operations teams was invaluable.

Often consultants can be heard speaking a different language to an operator and the value of having different operations teams giving tours and discussing openly what they have learnt over the years should be considered for all future water infrastructure upgrades. Some of the key themes that came out of these site visits and discussions were:

- The value of remote access from suppliers.
- The appropriateness of support agreements, and tailoring these to the client's membrane experience
- The simplicity of making process changes to setpoints and/or controls, and not having black box software
- Having all controls on a single PLC
- Preferences around different valve manufacturers – noting that valves on the membranes need to have an airtight seal and can quickly rack up 1,000,000 actuations.
- Challenges/preferences with proprietary equipment
- Distribution of chemical cleaning across individual membranes
- Where noise is generated and minimising it where possible
- How each manufacturer completes membrane repairs
- Location of the CIP system in the centre of the rack layout
- Maximising the use of gravity flow and minimising the need for pumping.
- Providing clear traffic flows for on-site movements and deliveries.

FACILITY DESIGN PRINCIPLES

We workshopped the key generic requirements and created a playbook for designers to apply, from large scale items such as minimising confined spaces to smaller details such as the weight and orientation of equipment. The key elements of these are:

- Design out confined spaces and provide safe access.
- Minimise noise levels.
- Specify high efficiency electrical equipment
- Piping, valving and equipment location and accessibility.
- Purpose built chemical systems where safety and operability are the core component.
- Efficient and effective general access and site layout
- Sustainability and energy efficiency
- Providing a working environment that is great to be a part of

These guiding principles allowed all designers in a multi-disciplinary project to understand and apply design requirements and preferences from the start. It's much easier to start right, than try to change something at a safety in design session!

These design principles are a key success factor in the completed plant. Some of these approaches were achieved at only minor, or minimal associated costs. The development of these was effectively the first safety in design session – before pen was put to paper. This allowed key requirements to be considered and included in the development of the initial plant design, and with these details covered early traditional safety in design (SiD) and hazard and operability (HAZOP) studies could have a wider focus on more of the finer points of the design. This staged approach of getting these design principles embedded early in the project set the safety and operability project culture from day one.

The site has been designed such that there are no routine activities that require anyone to enter a confined space or work at height. The attention to safety has resulted in a facility that TCC are able to welcome the public on tours and not be handing out PPE to everyone to allow them to walk through the door.

Photograph 1: An example of removing a confined space.

A TYPICAL OPERATORS DAY AND SAFETY INFORMS A LAYOUT

A collaborative approach to the site layout was completed to provide a functional layout that suited and met day to day operations. The main control room location was considered to provide clear sightlines to the main access, segregated access from operational areas, and visibility of key areas of plant. The final amenity layout provides:

- An operational area, segregated from any public areas by swipe card access including:
    - A control room with visibility to the main entrance and through the main areas of the WTP
    - An adjacent lab and analyser room, where key instrumentation and testing can be completed centrally to the operational hub.
    - An office area for operations staff to work.
    - Bathrooms, shower, locker, and a wellness room to enable rest during the "all-nighters."
    - Access into the plant operational areas
- A public access area with swipe card access at the main door providing,
    - A disabled bathroom
    - A large meeting room with a view to the membrane area

- A north facing staff/lunchroom and outdoor seating area that allows staff to disconnect from the work environment during their breaks.

Figure 1 below shows a cut through of the amenity area design.

Figure 1: Section views of the Amenity Area design

The operating plant was then developed in conjunction to consider:

- Segregation of chemical areas, with all storage tanks in a roofed area with external access only. Chemical dosing pumps are located inside the process building in cabinets mounted on a wall backing onto the bulk chemical storage area. Dosing cabinet are fitted with clear doors and have safety glasses storage adjacent.
- Fencing and security gates to control access to all operational areas of the WTP.
- Provides sightlines from the control room, and through large areas of the plant to improve communications during maintenance activities.
- Segregation of the membrane hall from the other plant areas and creating a clean area demarcation. Placing the dewatering area in a separate building with significant attention to noise attenuation and the ability to maintain and clean any spills.
- Site tours and a route to see the WTP in a logical fashion. Considering someone in a wheelchair being able to tour the site, considers wider and flatter accessways are perfect for maintenance activities.
- Having noise generating equipment in its own space (placing the hearing protection around the equipment, rather than requiring individuals to wear it).
- Vehicle access for maintenance, chemical deliveries, and removal of liquid and solid waste, including how solids bins are moving and stacked up on site to minimise double handling.
- The operations team requirement of double isolation from pressurized systems. This required additional valving on the inlet to each membrane rack but allows for safe maintenance in future. The membrane contractor also noted how useful the valves were to complete their system commissioning. By including clear and logical isolation to key equipment it takes the guess work out of future maintenance and providing a true zero energy environment to work in.

A 3D cut-out of the WTP main building area design is provided in Figure 1 below, with the overall site shown in *Figure 2*

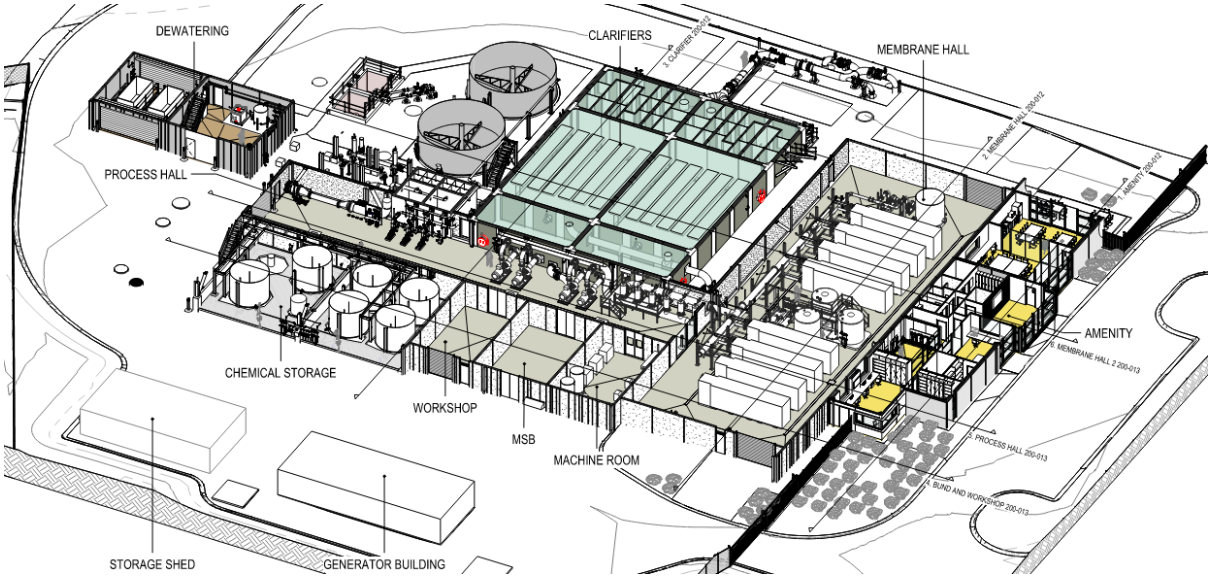


Figure 2: Section view of the WTP design

Photograph 2: Waiāri WTP

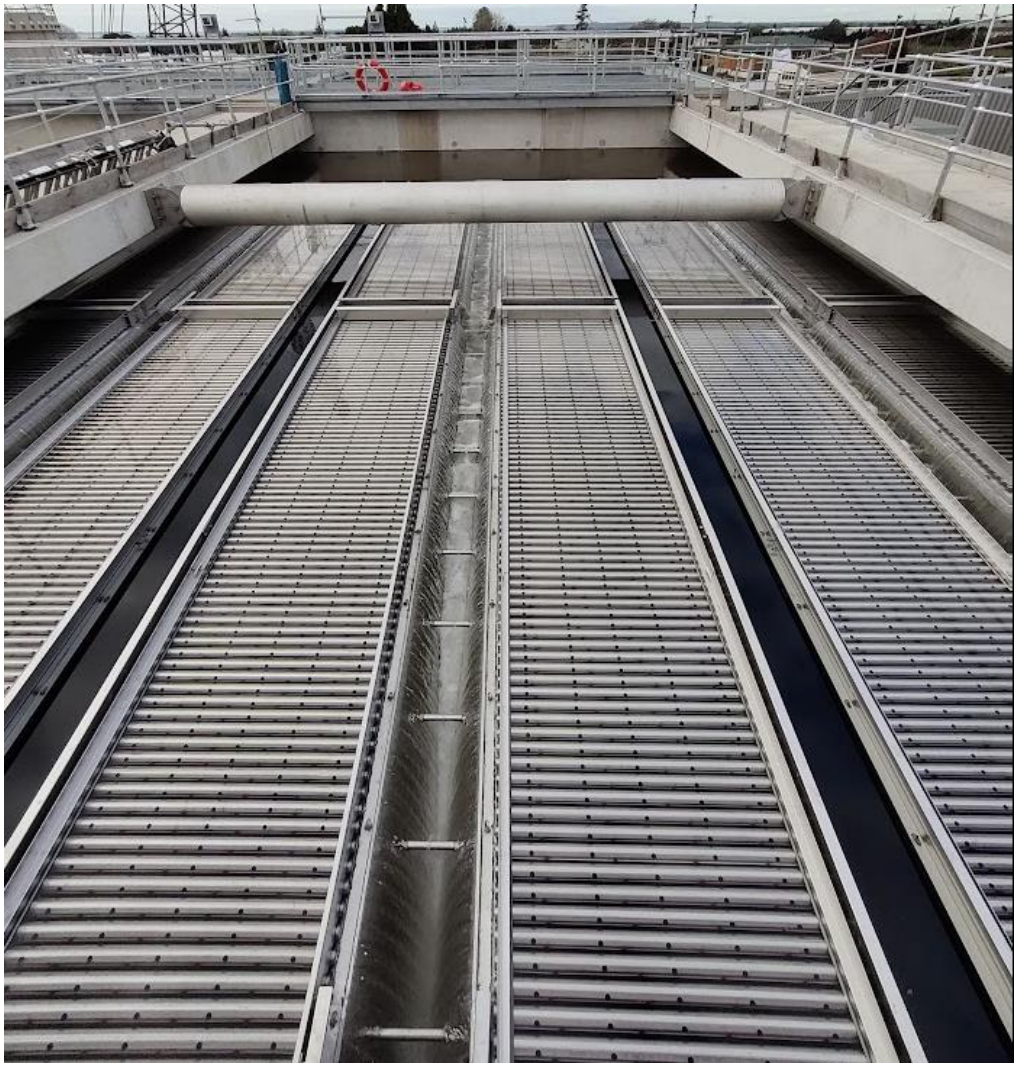
Photograph 3: Double isolation of pressure systems

THE MEANING OF RESILIENCE

Because equipment can run up to a certain limit doesn't mean that it will comfortably operate at that limit. In a Waiāri context, the water source is from a stream with some farming and forestry in the catchment where the stream flow reacts quickly to rainfall and bring high loads of solids and organics past the intake (effectively turning the source into chocolate milk).

When these rainfall events occur, often after hours, there may be only one or two staff available to operate TCC's three water treatment plants and a reticulation system. This means that at times when a plant is running at its limit, there are also likely to be other areas that require urgent care.

An operator needs to assess the situation across their area(s) of responsibility and then prioritise works that address matters that pose the most risk to the public. This often means that a treatment plant is left to run under its own automated controls during such events.



Photograph 4: Waiāri WTP Clarifier - an example of resilience

This was strongly reinforced by the operations team during the design of the WTP and as such a clarification process was included in the design, to reduce the solids load on the membrane process.

While an additional capital cost, it means that the WTP is able to operate with a much lower risk profile through these events. Under normal operation this has the added benefit that the membrane operation sees lower solids, meaning that pressures across membranes are reduced, reducing pumping costs, and cleaning frequency may be decreased and membrane life therefore increased.

Because the source water quality can change so quickly, feed forward coagulant dosing is required to make the treatment process function well to maintain process control and remove organics from the source water. There are many different approaches to achieving this within the water industry, but they all rely on the reliability and repeatability of the water quality instrumentation, and also an understanding of the water source with regard to coagulant dose rates under varying water quality conditions. The control and learning of the third-party algorithm is still to be optimised to achieve a hands-off approach to coagulation control.

NOISE AND HEAT

The best way to reduce noise and heat is to not create it in the first place.

Providing aftermarket acoustic enclosures often means that you are wrapping heat generating equipment in a blanket and creating an overheating risk. Most modern equipment for WTPs can operate less than 80 dBa, as this is largely the case at Waiāri. Specifying noise limits on equipment and requiring larger and slower rotating equipment means that earmuffs can be left behind for most of an operator's working week. This equipment can add a bit of a cost premium, but this is often quickly offset when you consider the alternative of additional noise management within the site. You also have happier operators, and typically lower maintenance and energy costs. Sometimes it's hard to know if the Waiāri WTP is running or not!

Some larger equipment will still generate noise and requires management. For Waiāri, the standby generators and the dewatering centrifuge were accepted to have elevated noise levels. These units are also better suited to be housed in their own spaces away from the main plant areas, with management of their rooms having an acoustic rating. With high ventilation requirements, specific acoustic ventilation was required to reduce noise to meet the strict requirements of the site. Although not meeting requirements for hearing protection, the air compressors were also placed in a dedicated machine room where waste heat is removed and sent externally or into the membrane hall. What this has meant is that operators are able to have a normal conversation in the main plant areas, providing improved communications and a lower health and safety risk during maintenance activities.

Photograph 5: Noise management

Managing waste heat was also considered. Large variable speed drives can generate approximately 2 to 3% of the total motor load, and when pumps are over 300kW, this quickly adds up. Direct air cooled VSDs with intake and discharges external to the building was used for the raw water pumps and membrane feed pumps, significantly reducing the heat load into the electrical rooms, resulting in smaller heat pump cooling requirements.

Adding a small amount of insulation in the roof reduced the ventilation fan size by a factor of 4 primarily due to reduced solar gain.

CONDENSATION

Stainless steel pipework will sweat a lot, particularly during warmer humid periods. This was considered in the design and location of floor drains being below pipe racks where practical.

The ventilation system controls are also configured to operate during working hours, based on temperature, and continuously throughout the summer period to reduce the potential for condensation and higher humidity environments.

NATURAL LIGHT AND FRESH AIR

Everyone feels happier in a workplace where there is natural light and fresh air. The Waiāri plant and amenity areas have high level windows with electric actuators to allow for natural ventilation and to bring in natural light.

Chemical dosing cabinets have forced ventilation such that the inside of the cabinet is under negative pressure, with any vapours being discharged externally. This reduces the risk of chemical fumes in the cabinets, and reduces the potential for corrosion of equipment (mechanical and electrical) within the cabinet – something that has been experienced at other sites.

EMBRACING THE DIGITAL WORLD

There are multiple digital tools available for design, with the use of 3D models, virtual reality and augmented reality becoming more and more commonplace in the water industry.

The Waiāri was designed in 3D from the beginning which required coordination to set things up across multiple different design models, but once this was completed, the benefits were immediately and the race for space began. Clashes and interfaces were obvious, and a designer could proactively resolve these prior to picking these up during a later cross discipline design review. 3D design is the industry standard now, but typically with the production of 2D drawings from the model to build from.

Virtual reality (VR) was also used for design coordination reviews and client reviews of the proposed WTP. The real benefit of this is the element of perspective, where you can understand the scale and height of some elements, the available space for maintenance, and even the slope of paved surfaces. Using this to identify design snags was a great advantage, significantly reducing review time, and also picking up on details difficult to notice in a drawing or 3D model. We found over

200 items within 2 hours (with designers able to see a screen of what the VR headset is showing).

Having operators, maintenance, engineering staff and managers looking through the VR system also identified a lot of items where things could be fine-tuned for simpler maintenance or operation.

AN OPERATOR'S PERSPECTIVE

To be part of a project that keeps the end users in mind, has been like a breath of fresh air. By including operations in the decision making helps to move you closer to delivering a project that is not just fit for purpose but is also safer, simpler to operate, and a nice environment to work in.

An environment that is safe to work in, quiet, warm, and clean, helps to keep our teams feeling appreciated and improves commitment to resolving challenges that invariably occur in a project of this size and nature.

Photograph 6: Clear sightlines in the WTP

We all like working in a nice environment and our operations teams are no different. The days of a portacom and a kettle being good enough is a thing of the past and the future lies in considering the personal amenity value of a modern working environment. At Waiāri, the coffee machine, BBQ and sun-soaked outdoor seating is certainly appreciated.

Treatment Plants are the life blood of any city and are often taken for granted. The Waiāri has been designed and built in a way that not only cares for the people working there but cares for an entire community.

Through the collaboration with Beca, TCC Operations and drawing on other leaders in our industry, we have created an iconic piece of infrastructure that will serve our community well into the future.

CONCLUSIONS

By including operations in the decision making helps to move you closer to delivering a project that is not just fit for purpose but is also more resilient, safer, simpler to operate and maintain, and a nice environment to work in.

Starting with safety in design prior to design by discussing and agreeing the fundamental design principles allows the layout and design to be progressed on the right path, reserving traditional safety in design and HAZOP sessions to focus on the finer points of the design. This staged/continuous approach to safety and operability provided significant benefits for the Waiāri WTP for the operations and maintenance staff, and is something that should be considered on all facility design projects moving forward.

ACKNOWLEDGEMENTS

All of those involved in the Waiāri Water Supply Scheme.