Apex Water

PRELIMINARY DESIGN REPORT

FULTON HOGAN LAND DEVELOPMENT WATER AND WASTEWATER TREATMENT FOR CONSENTING

AUGUST 2026

REVISION 3

DOCUMENT DETAILS

Client:	Fulton Hogan Land Development
Project Number:	240806
Revision:	3
Date:	13/08/26

REVISION HISTORY

Rev.	Date	Description	Originated	Reviewed	Approved
0	30/06/26	Issued for internal review	N Fong	M Savage	R Upton-Birdsall
1	03/07/26	Issued for client review	N Fong	M Savage	R Upton-Birdsall
2	10/08/26	Issued for client submission	N Fong	M Savage	R Upton-Birdsall
3	13/08/26	Minor updates included	N Fong	M Savage	R Upton-Birdsall

EXECUTIVE SUMMARY

Milldale North (Stages 14-17) is a land development project comprising approximately 231ha of land held across various records of title at Milldale, Wainui. The site is located to the north of the existing and consented Milldale development, extending further north towards Upper Orewa Road. To support the planning and consenting stages of this development, Apex Water has been engaged to provide water and wastewater design services for private on-site treatment.

A need was identified for a new Water Treatment Plant (WTP) capable of meeting a peak demand of 1,300 m^3/day, and a new Wastewater Treatment Plant (WWTP) capable of treating a peak wastewater production of 780 m^3/day.

The proposed WWTP will employ a hybrid biological nutrient removal system, combining advanced processes to produce exceptionally high-quality permeate. The treatment train will include a four-stage Bardenpho activated sludge process, a Membrane Aerated Biofilm Reactor (MABR), and hollow-fibre ultrafiltration membranes. Once fully established, this system is designed to treat wastewater to an extremely high standard, producing permeate of a quality among the highest achieved by any WWTP in New Zealand.

The discharge of treated wastewater shall be directed to a constructed wetland for further nutrient polishing. Residuals (wastewater) produced by the potable WTP shall be directed to the WWTP for treatment.

An options assessment was undertaken to determine suitable treatment technologies for the reliable treatment of potable water. Cartridge filters, Ultra Filtration (UF) membranes, and multi-media filters have been identified as suitable treatment processes to meet the requirements of the Drinking Water Standards for New Zealand based on initial source water monitoring. Final technology selection shall be confirmed based on ongoing sampling and analysis during the detailed design stages of the project.

This report outlines the proposed wastewater and drinking water treatment systems, including the design of the wastewater treatment process, the drinking water treatment process, and the associated infrastructure.

CONTENTS

STATEMENT OF QUALIFICATIONS AND EXPERIENCE

Author: Nuobelle Fong

My full name is Nuobelle Fong.

I am a Process Engineer at Apex Water. I hold a Bachelor of Engineering (Honours) in Chemical and Materials Engineering and have seven years of professional experience in the fields of water and wastewater treatment, including treatment plant operations, process design, and asset management. My experience includes the preparation of technical assessments and reports, design and commissioning of water and wastewater treatment systems, and supporting the operations and maintenance of treatment assets.

I have been engaged by Fulton Hogan Land Development Limited (FHLD) (the Applicant) to undertake an assessment of Water and Wastewater Treatment Plant design associated with the Milldale Stages 14-17 project and to prepare this report in support of the substantive application under the Fast-track Approvals Act 2024 (FTAA).

While this is not an Environment Court proceeding, I confirm that I have prepared this assessment in accordance with the applicable professional and ethical obligations of my profession and that the opinions expressed are within my area of expertise.

Reviewer: Matt Savage

My full name is Dr. Matthew John Savage.

I am a Principal Engineer and founder of Apex Water. I hold a Doctorate in Chemical and Process Engineering specialising in Wastewater Treatment. I am a chartered professional engineer with Engineering New Zealand and a chartered member of the international Institute of Chemical Engineers. I have over 25 years' experience in wastewater treatment plant design.

Apex Water designs, constructs and operates drinking water and wastewater treatment plants at a similar scale to those required to service the proposed development detailed in this application.

I recently prepared assessments of environmental effects for the treatment and discharge of wastewater from a 1200 house subdivision at Karaka North Village to a level suitable for discharge to land and to water via land. This treatment plant is now complete and awaiting construction of houses in order to commence operation.

I have been engaged by the Applicant to undertake an assessment of the Water and Wastewater Treatment Plant design associated with the Milldale Stages 14-17 project and to prepare this report in support of the substantive application under the FTAA.

While this is not an Environment Court proceeding, I confirm that I have prepared this assessment in accordance with the applicable professional and ethical obligations of my profession and that the opinions expressed are within my area of expertise.

Approver: Rebecca Upton-Birdsall

My full name is Rebecca Upton-Birdsall.

I am the Engineering Manager at Apex Water Ltd. I hold a Bachelor of Engineering (Honours) in Chemical and Materials Engineering and have approximately 14 years' professional experience in the fields of drinking water and wastewater treatment. My experience includes the planning, process design, commissioning and optimisation of municipal and industrial water and wastewater treatment plants, together with contract administration, technical management and operational integration. I have led the design and commissioning of numerous treatment facilities throughout New Zealand, including membrane water treatment plants, biological nutrient removal systems, membrane bioreactors (MBRs), advanced disinfection systems and associated treatment infrastructure.

I have been engaged by the Applicant to undertake an assessment of the Water and Wastewater Treatment Plant design associated with the Milldale Stages 14-17 project and to prepare this report in support of the substantive application under the FTAA.

While this is not an Environment Court proceeding, I confirm that I have prepared this assessment in accordance with the applicable professional and ethical obligations of my profession and that the opinions expressed are within my area of expertise.

1. INTRODUCTION

This report has been prepared in support of the substantive application for the Milldale Stages 14-17 Project under the Fast-track Approvals Act 2024 (FTAA).

The Project relates to approximately 231ha of land centred around Wainui Road in Wainui, Auckland. The proposal provides for a comprehensively planned urban development including residential neighbourhoods, a supporting commercial node, transport and servicing infrastructure, open space, wetland and ecological restoration, and associated enabling works.

The application seeks approvals necessary to facilitate the staged development of the Project, including a suite of resource consents required under the FTAA framework.

The substantive application is supported by a comprehensive set of technical assessments and plans addressing the environmental, servicing and infrastructure matters associated with the proposal. This report should be read alongside the Planning Report and the appended technical reports and drawings lodged in support of the substantive application.

2. PURPOSE AND SCOPE

This report addresses matters relating to the wastewater discharge consent (to land and surface water) and drinking water supply associated with the Project proposal. It seeks to

- assess the proposed wastewater treatment, disposal and discharge strategy, including options for discharge to land and surface water;
- assess the proposed drinking water supply, treatment process and compliance with relevant drinking water requirements;
- evaluate the suitability of the proposed treatment processes and supporting infrastructure;
- consider potential environmental effects associated with the proposed wastewater systems;

This report has been prepared having regard to the relevant statutory and technical framework applicable to the proposal, including:

- Water Services (Drinking Water Standards for New Zealand) Regulations 2022 (DWSNZ);
- Drinking Water Quality Assurance Rules 2022 (Revised 2024) (DWQAR);
- Auckland Council Guideline Document GD2021/006 – On-site Wastewater Management in the Auckland Region (GD06)*;
- Auckland Council Code of Practice for Land Development and Subdivision (CoP)

* GD2021/006 provides useful guidance and design benchmarks, however, it is explicitly intended for on-site wastewater systems up to 3 m^3/day and is therefore not directly applicable to the scale of the wastewater scheme proposed for Milldale Stages 14-17. Accordingly, it has been used as a reference only.

LIMITATIONS

The opinions, conclusions and recommendations in this report are based on conditions encountered and information provided at the date of preparation of the report. Apex has no responsibility or obligation to update this report to account for events or changes occurring after the date the report was prepared. While referred to, the design and performance of any polishing wetlands utilised on the wastewater discharge fall outside the scope of this report. The opinions, conclusions and recommendations in this report are based on assumptions made by Apex noted in this report.

3. SITE DESCRIPTION

The site comprises approximately 231ha of land located to the north of the existing Milldale development. The site comprises two distinct areas:

- Residential subdivision area to the south of the Ōrewa river (shown in red in Figure 1); and
- Te Korowai o Maraeariki to the north of the Ōrewa river (shown in orange in Figure 1).

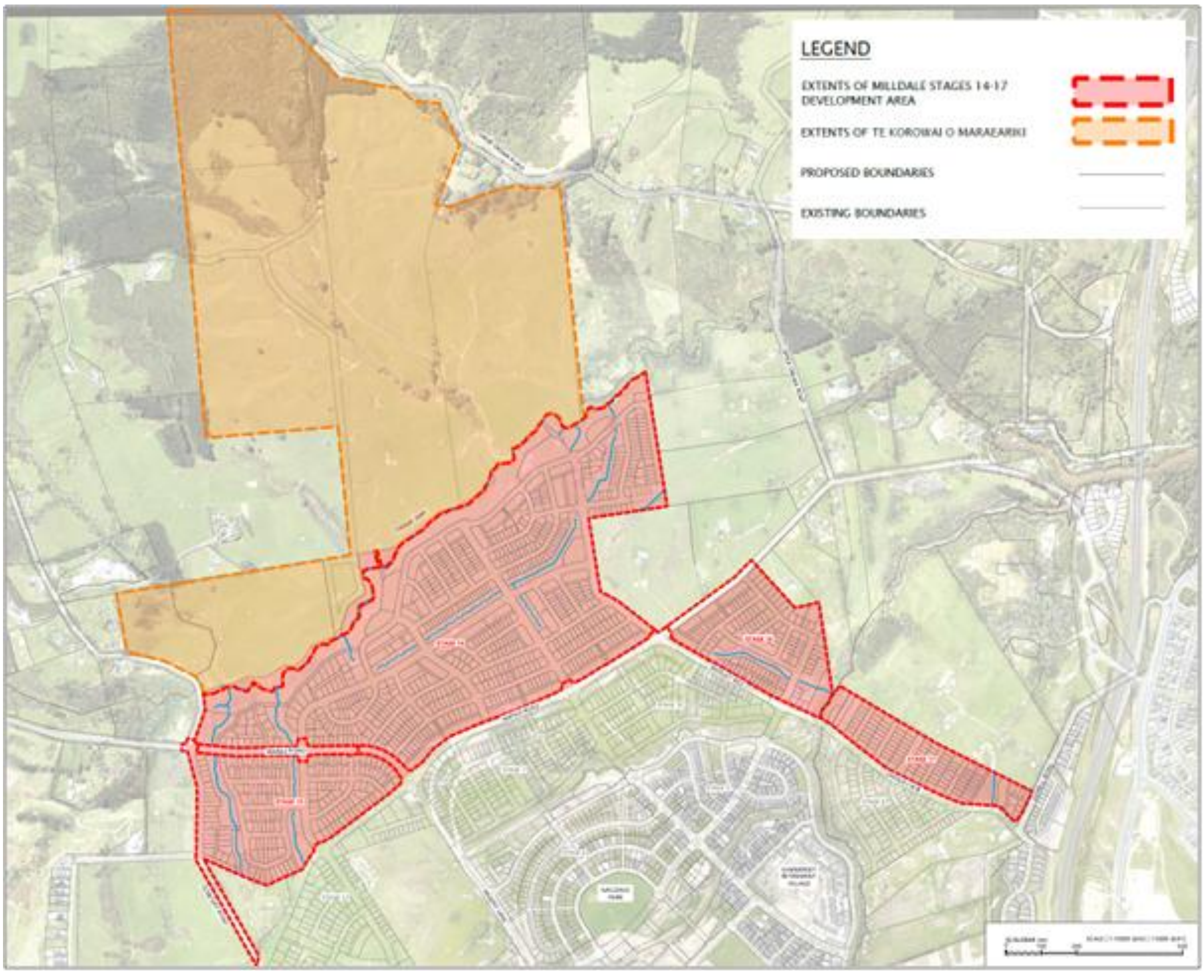

Figure 1: Site location plan

The proposed residential subdivision area is located within the Future Urban Zone under the Auckland Unitary Plan (AUP). This part of the site is characterised by gently undulating to rolling pasture, with several streams, natural wetlands, constructed ponds and artificial drains traversing the area.

Te Korowai o Maraeariki is located to the north of the Ōrewa river and is zoned Rural Production under the AUP. This area is characterised by more undulating to steep terrain, with a series of ridgelines separated by incised gullies extending from the Ōrewa River. The land is predominantly managed pasture interspersed with streams and natural wetlands, together with pine plantations, exotic vegetation and gorse scrub. Relatively large areas of indigenous vegetation are also present, including a Significant Ecological Area – Terrestrial Overlay in the north-western portion of the site.

There is existing water, stormwater and wastewater infrastructure surrounding the site as a result of the extensive development within previous Milldale Stages. However, the site itself is not currently serviced in terms of supply and infrastructure. The surrounding roading network has been progressively developed in accordance with the staging of the Milldale development.

The surrounding area is now substantially developed. Milldale Stages 1 to 6 are complete, while Stage 7 is well advanced, with subdivision completed for Stages 7A–7C and construction of Stage 7D anticipated to commence in early 2027. Separate consents for the Stage 8 and 9 enabling works and subdivision were granted in 2024, with the associated offset and construction works now complete. The Milldale Local Centre has also been constructed, together with associated roads, accessways and drainage reserves. Community infrastructure within the surrounding area includes Ahutoetoe Primary School, two early childhood education centres and the Summerset retirement village. Beyond the urban extent of Milldale, the site adjoins a number of rural residential properties.

Further detail regarding the site, surrounding environment and planning framework is provided within the Planning Report and technical reports appended to the application.

4. THE PROPOSAL

The Milldale Stages 14-17 project seeks approvals for an urban development on the site. The proposal provides for 1,401 dwellings across a range of housing typologies and densities. To assess supporting infrastructure, a yield of 1,425 dwellings has been conservatively assumed. In addition, the proposal includes provision for a small commercial area, transport infrastructure, servicing and stormwater infrastructure, subdivision, earthworks, stream works, and neighbourhood parks. To the north of the Ōrewa river within Te Korowai o Maraeariki, the project includes private water and wastewater infrastructure, ecological restoration, as well as walking and cycling trails to enhance recreation and amenity.

Development of the Project will require a suite of approvals under the FTAA, including resource consents associated with subdivision, land use activities, bulk earthworks, infrastructure works, stream works, water take, diversion and discharge; along with NES for contamination and freshwater.

The aspects of the proposal relevant to this report include:

- Proposed drinking water supply source, treatment process and distribution infrastructure.
- Proposed wastewater treatment process, including the MABR-MBR treatment systems.
- Proposed wastewater disposal strategy, including discharge to the constructed wetland.
- Assessment of treatment process performance and compliance with relevant drinking water and wastewater quality requirements.
- Sizing for the principal treatments and proposed site layout.

A full description of the proposal is provided in the Planning Report and technical reports and drawings appended to the substantive application and should be read in conjunction with this report.

5. TREATMENT SYSTEM OVERVIEW

To service the development, a 1,300 m^3/day WTP and a 780 m^3/day WWTP are proposed to meet peak daily flow requirements. During preliminary design, multiple treatment options were evaluated to identify technologies offering the best balance of reliability, treatment performance, and scalability.

5.1 WASTEWATER TREATMENT

The proposed wastewater treatment system will utilise a hybrid Biological Nutrient Removal (BNR) process with a semi-modular configuration able to be easily expanded as the development grows. The biological process tanks will follow a four-stage Bardenpho layout, integrating Membrane Aerated Biofilm Reactor (MABR) technology and Ultrafiltration (MBR) membranes to achieve enhanced nutrient removal and solids separation.

Discharges from the treatment plant compound shall comprise:

- The discharge of MABR-MBR permeate (treated wastewater)
- The discharge of treated air from portions of the wastewater treatment process (e.g. odour control device discharge)
- The removal of dewatered sludge and screenings from site by truck

Year round discharge of MBR permeate to a constructed wetland is proposed to manage discharge streams in consideration of both preservation of the receiving environment and Te Mana o te Wai, allowing average daily flow of 660m^3 and a peak wet weather discharge flow of 780 m^3/day.

5.2 WATER TREATMENT

The water treatment system will utilise cartridge filters, Ultra Filtration (UF) membranes, and multi-media filters along with UV disinfection and chlorination to produce drinking water that meets or exceeds the requirement of the Drinking Water Standards for New Zealand. Residuals from the WTP shall be directed to the WWTP for further treatment prior to discharge. The final treatment configuration will be confirmed during detailed design, with infrastructure sizing presented in this report sufficient to accommodate both options for consenting purposes.

6. WATER TREATMENT PLANT

6.1 WATER DEMAND

The anticipated potable water demand of the development has been established by the client's Civil consultants, Woods (Bear, 2026), and with reference to the Auckland Council Code of Practice for Land Development and Subdivision – Chapter 6: Water (Watercare Services, 2021). It is understood that this demand calculation is separate to the network design calculations, and takes into consideration water savings implementations, in the form of dual flush low flow toilets. It should also be noted that the required raw water supply calculation includes a 95% treated water production yield to account for waste produced by the treatment process, as recommended by Apex. Table 1 below shows a summary of the raw and treated water flows expected for a development of this size.

Table 1: Milldale Stages 14-17 water demand

Treated Water Parameter	**Unit**	**Value**
Average Daily Demand	m^3/day	836
Average Instantaneous Flow	L/s	9.7
Peak Daily Demand	m^3/day	1254
Peak Instantaneous Demand	L/s	14.5
Raw Water Parameter	**Unit**	**Value**
Average Daily Demand	m^3/day	880
Average Instantaneous Flow	L/s	10.2
Peak Daily Demand	m^3/day	1320
Peak Instantaneous Demand	L/s	36.1

The WTP provides for treatment of water from two different potential sources, enabling a combined groundwater and surface water take approach. Based on the above required demands, an assessment of the groundwater (Williamson J. , 2026) and surface water potential (Tasca & Williamson, 2026) was carried out by the client's hydrologists, Williamson Water & Land Advisory (WWLA), who recommended the following take volumes from the proposed sources:

Groundwater Supply (m^3/day)	***Surface Water Supply (m^3/day)***
455	425

6.2 RAW WATER QUALITY

The groundwater feed to the plant is to be supplied by an new bore and the surface water feed is to be supplied by raw water storage reservoir fed from the Orewa River. A summary of the routine water profile results is demonstrated by Table 2 below. The groundwater sample was collected from an existing bore on the site following bore step testing and the surface water sample was collected immediately upstream of the proposed surface water take location. The values indicated in red in the following table indicate where raw water results exceed the Drinking Water Standards New Zealand (DWSNZ) Maximum Acceptable Values (MAV) (New Zealand Government, 2022) and those in orange are indicative of exceeding recommended level of Drinking Water Quality Assurance Rules Aesthetic Values (AV) (Taumata Arowai, 2022).

Table 2: Drinking Water Source Quality

Determinand	**Bore (mg/L)**	**Stream (mg/L)**
Escherichia coli		4100
Arsenic	0.0011	0.0011
Boron	0.25	0.053
Chloride	32	23
Colour	10	44
Copper	0.00092	0.0026
Fluoride	0.2	0.06
Hardness	2.5	32
Lead	0.00018	0.00041
Manganese	0.0107	0.037
Mercury		0.00011
Nitrate, short-term	0.002	0.37
Nitrite, short-term	0.002	0.004
Nitrate and nitrite	0.002	0.38
Iron	0.52	0.98
pH	9.7	6.3
Sodium	105	16.1
Sulphate	4.9	11.2
Temperature		20
Total Dissolved Solids	250	119
Turbidity	11.5	23
Zinc	2.3	0.0044
Electrical Conductivity	43	15.4
Alkalinity	165	23
Langelier Index	0.3	-2.2
Bicarbonate	135	28
Calcium	0.96	8
Magnesium	0.02	2.9
Potassium	0.25	2.6
Temperature	20	20
Total Phosphorus		0.087
Reactive Silica	11.4	10.1
Silicon		4.7

6.3 OPTIONS ASSESSMENT

As seen in the analytical results above, each water supply source differs in quality and thus requires different raw water conditioning processes and tailored filtration methods.

6.3.1 GROUNDWATER TREATMENT

While there are no exceedances of DWSNZ's MAVs, the bore sample results show 4 determinands that are over the limit of Taumata Arowai's AVs. Iron, pH, turbidity, and zinc, which exceed the AVs of 0.3 mg/L, pH 8.5, 5 NTU, and 1.5 mg/L, respectively.

WWLA has noted in their assessment of the bore that increasing the casing depth is likely to significantly reduce iron concentrations. Additionally, the high turbidity in this sample was found to be inconsistent with typical bore water which WWLA has attributed to metal precipitants as indicated by the elevated iron concentrations. The actual turbidity is assumed to be low to mid-range (< 1 – 5 NTU).

A method of filtration will be required to remove the residual inert solids, silt, clay, bacteria, aquatic organisms (primarily protozoan cysts), and insoluble metals that are present in the water and require reduction in concentration. Our experience indicates that cartridge filtration and multi-media filtration can be considered to treat this bore source. Should the assumption that the turbidity of the bore is still high despite improvements to iron concentrations, then the alternative filter system proposed for the surface water take would be capable of filtering the more contaminated bore water – significantly mitigating this risk.

CARTRIDGE FILTRATION

Cartridge filters are comprised of a housing typically containing multiple cartridges that are made of pleated material. Raw water is passed through the cartridges from the inside to the outside, removing particulate impurities by trapping them on the outside of the pleats as they pass through. Pressure differential is measured across the filter to monitor the accumulation of contaminants on the cartridge. Cartridges cannot be regenerated with cleaning like other types of filters, so the pressure differential setpoint is used to indicate a replacement is required. Consequently, cartridge filters are not recommended when there is high turbidity loading in the raw water. The raw water solids will blind the cartridge filters, obstruct flow and necessitating replacement at a frequency that is uneconomical. If the raw water turbidity is above 5 NTU, cartridge filter blinding will occur within a matter of minutes. Cartridge filters are disposable and replacement of them is manual, leading to a very expensive and time-consuming solution if solids removal is required. Apex's high flow cartridge filters are validated to provide 3 log credits of disinfection which, along with UV is suitable for treating bore water.

Figure 2: Duty / standby cartridge filter units (Motueka WTP)

MULTI-MEDIA FILTRATION WITH GREENSAND MEDIA

Multi-media filters remove particulate impurities by passing conditioned raw water through beds of porous media of differing particle sizes. Additionally, a layer of greensand media is utilised to specifically remove iron and manganese. The raw water delivered to the filters is first treated by a process called raw water conditioning, in which chemicals are added and given enough time to react, prior to filtration. An acid and a coagulant/flocculant are added into an inline static mixer, to create the rapid mixing energy and uniform chemical distribution required for adequate pH control and coagulation prior to the flocculation. Pre-chlorination prior to the greensand media is also required to enable filtration of iron. The filtration stage then removes the floc formed during conditioning, resulting in near-total solids capture.

Like cartridge filters, pressure differential is measured across the media to determine filter media clogging or variations in the plant flow. However, unlike cartridge filters, multi-media filters are typically backwashed once a day or if high pressure differential or high turbidity is detected. The generation of dirty backwash water is a key limitation of multi-media filters as it reduces the net yield of treated water and produces a waste stream requiring appropriate management and discharge. The filters are backwashed one at a time due to the high flow of treated water required and subsequent wastewater produced. The plant will be designed to capture the dirty backwash water along with analyser drains and other waste streams from the WTP in a sump and pumped to the WWTP for further treatment.

6.3.2 SURFACE WATER TREATMENT

The river sample result showed only one determinand, E-coli, that was above the DWSNZ's MAV of <1 in 100mL of sample. Furthermore, the colour, iron, pH, and turbidity results were also in exceedance of Taumata Arowai's Aesthetic Values (AV). An Ultra-filtration Membrane treatment is recommended as they have a higher operational limit for water sources with high turbidity, 5+ NTU, commonly seen in surface water and provide a higher level of pathogen removal than cartridge filters.

ULTRA-FILTRATION MEMBRANES

Ultrafiltration (UF) membranes act as physical barrier that removes particles, bacteria, and other contaminants from the water. This proposed treatment system begins with a coarse strainer to protect the membranes and then a raw water conditioning process, similar to the conventional direct filtration described previously. It is then pumped through the membrane system, which allows clean water to pass through while trapping unwanted material above the membrane pore size of around 0.02 µm. Because the membrane pores are extremely small (in the order of 25 times smaller than an individual bacteria), the system produces consistently high-quality water even when the raw water quality changes. This makes membrane systems particularly effective during storm events when water quality can deteriorate rapidly.

Figure 3: Example of UF Membranes

Over time, particles can build up on the membrane surface and reduce performance. To prevent this, the system automatically performs regular backwashing during which clean water is pumped backwards through the membranes to remove accumulated solids. Once a day, the system will also perform a Chemically Enhanced Backwash (CEB) which incorporates cleaning chemicals (typically Sodium Hypochlorite (NaOCl, Hypo) or Citric Acid) into a backwash.

Although regular backwashing removes most solids from the membrane surface, some material gradually accumulates over time and reduces membrane performance. To manage this, the system performs routine Maintenance Cleans (MC). This process uses a low-strength cleaning solution to remove deposits before they become significant. Maintenance Cleans are automatically scheduled to occur during periods of low water demand.

Over time, some fouling cannot be removed through routine Maintenance Cleans. Recovery Cleans (RC) are more intensive cleaning procedures designed to restore membrane performance and extend membrane life. This process uses heated water, stronger cleaning solutions, and longer durations than a MC.

In both recovery and maintenance cleans, the cleaning solution is prepared in a dedicated Clean-in-Place (CIP) tank and circulated through the membrane system using a CIP pump.

The two cleaning chemicals typically used are:

- Sodium hypochlorite to remove organic material such as biological growth.
- Citric or Sulphuric acid to remove inorganic deposits and mineral scale.

Sodium hypochlorite cleans are typically carried out daily, while a citric acid clean is typically undertaken once per week. The control system can alert operators when a Recovery Clean is recommended. However, the operator is responsible for selecting the appropriate cleaning chemical and scheduling the cleaning activity. With regular backwashing and cleaning, UF membrane systems provide a reliable and robust treatment barrier capable of producing high-quality drinking water from a wide range of source waters.

As explained above, UF membranes provide excellent removal of suspended solids, microorganisms, and oxidised metals, however, they are sensitive to fouling from accumulated solids, biological growth, and mineral scaling. These systems typically require additional infrastructure, including automated backwashing systems, chemical cleaning facilities, and ongoing operator oversight. Compared with conventional filtration processes, membrane plants generally have higher capital and operating costs and greater operational complexity.

It should be noted that the water quality results indicate a high concentration of iron which can cause fouling of the membranes. This is a risk we would address as follows:

- Raw water storage pond aerated to oxidise iron and encourage settling of precipitate and other solids.
- Membrane selection would be driven by the most robust option for dealing with elevated iron.
- Membrane cleaning systems would be established based on risk of elevated iron and associated fouling.

The raw water reservoir will introduce an environment for algal growth. To mitigate this, we would recommend aeration, ultrasonic algae prevention, and considered reservoir design to enable maintenance. Should no ultrafiltration membrane be found to be suitable for the raw water quality, a conventional treatment process incorporating coagulation and clarification could be adopted. The preferred treatment approach will be confirmed during the detailed design phase.

MULTI-MEDIA FILTRATION WITH GREENSAND MEDIA

As covered in previous sections, greensand media is effective at removing dissolved iron and manganese. While oxidation within the pond and subsequent UF membranes are expected to remove the majority of iron precipitates, a greensand filter may be included as a polishing step to remove any residual dissolved iron and help achieve consistently low iron concentrations in the treated water. The requirement for greensand filtration will be confirmed as part of the detailed design process based on additional sampling.

RESIDUALS SYSTEM

Light residuals generated by the treatment process, including UF membrane concentrate and filter backwash wastewater, are collected in a thickener feed tank, which provides temporary storage and flow equalisation prior to solids thickening. A thickener feed pump will then transfer the residuals to the lamella thickener conditioning tank.

Within the conditioning tank, polymer is dosed and mixed with the residuals to promote floc formation prior to clarification. The conditioned wastewater then flows into the lamella plate thickener, where suspended solids settle and are concentrated to approximately 2–5% dry solids. The clarified overflow is discharged to a recycle water tank, from which it is returned to the treatment process via the recycle water pump.

6.3.3 COMBINED TREATMENT TRAIN

As both sources benefit from multi-media filtration, it is proposed that the two streams be combined following their respective raw water conditioning and primary treatment processes, prior to multi-media filtration. The combined flow will then pass through the multi-media filters before undergoing UV disinfection and chlorination.

ULTRAVIOLET (UV) LIGHT DISINFECTION

The main unit process of the water treatment plant will be ultraviolet (UV) disinfection. It addresses both bacterial and 3.0 log protozoal treatment requirements. Immersed in water within a protective sleeve, the UV lamps emit UV radiation to inactivate micro-organisms by damaging the organism's DNA, therefore rendering to unable to reproduce and infect. It should be noted that inactivated micro-organisms (and other particles) are not removed from the water by UV disinfection.

The UV's effectiveness, or reduction equivalent dose, is determined by the combination of radiation intensity and time of exposure. A key factor in the radiation intensity received by the water is the UV transmittance (UVT) of the water, a measure of how much UV is absorbed by the water as UV waves pass through it. The lower the UV transmittance, the more UV light is required to achieve the same dose. The UV reactors are validated using the USEPA UV disinfection guidance manual and each UV will provide a reduction equivalent dose of 40 mJ/cm^2, operating as duty / standby. Each unit has a dedicated local control panel, measuring UV intensity (UVI) and providing information regarding the system's running condition (i.e. wipers running, warning alarms and critical alarms).

The UV's controller uses UVT and flowrate to calculate the UV dose applied. The power output to the UV lamps is changed to ensure the dose remains above 40 mJ/cm^2.

To ensure compliance is met, the following sampling is continuously monitored:

- Flowrate
- Turbidity of the water entering the UV reactor
- UVT of the water entering or existing the UV reactor

Figure 4: Duty / standby UV disinfection units (Karaka Village North WTP)

6.3.4 DRINKING WATER COMPLIANCE

All WTP's, such as Milldale Stages 14-17, are required to comply with Water Services (Drinking Water Standards for New Zealand (DWSNZ)) Regulations 2022 and Drinking Water Quality Assurance Rules 2022 (DWQAR) (Taumata Arowai, 2022). It is also highly recommended to future-proof new builds so that they are compliant with likely future requirements. Some key requirements to be considered alongside the options assessment are discussed in the following sections.

PROTOZOA LOG CREDIT TREATMENT REQUIREMENTS

Log credit refers to logarithmic reduction of protozoa and is used in water treatment to represent an order of magnitude removal of contaminants (e.g. 4-Log = 99.99% reduction). As Milldale Stages 14-17 is proposed to have a dual raw water source, the plant will likely require 4-6 log credits. Raw Water Conditioning upstream of direct filtration gives 2.5 log credits, USEPA approved UF Membranes typically give 4.0 log credits and compliant UV technology gives 3 log protozoan inactivation credits. Therefore, the proposed groundwater treatment and surface water treatment will achieve a minimum of 5.5 log credits and 7 log credits, respectively.

MEMBRANE COMPLIANCE & MEMBRANE INTEGRITY TESTS (MIT)

Compliance with the membrane system is to ensure the membranes' integrity is not breached. This is done by two methods. A continuous measurement of permeate turbidity to provide continuous integrity testing, and membrane integrity testing in the form of an automated pressure decay test, performed daily to further confirm compliance.

Pressure Decay Testing (PDT), involves filling the membrane with pressurised air and holding for a period of time. If the pressure drops faster than a set rate, the membrane fibers are considered to be compromised and the 4-log removal is not being met. Remedial action must then be taken. The test will be automated and scheduled for a time of low production demand, as the membrane train must be taken out of normal operation. The test will always occur after a backwash sequence, but prior to the forward flush. Should any non-conformity be registered, the Operators would be required to find the offending module(s) and isolate these from the system. Production would be able to continue at a reduced capacity until the modules are repaired or replaced.

CHLORINE COMPLIANCE

Chlorine compliance is maintained by use of two free available chlorine (FAC) analysers in a set point trim arrangement and always maintaining a minimum of 1 hour supply within the reservoir to ensure contact time is maintained. Treated water leaving the plant is chlorinated and measured for FAC, pH and turbidity to meet the requirements of section 4.10.1 of the DWQAR.

RESERVOIR BAFFLING FACTOR

Reservoirs should be suitably sized to allow for a baffling factor, sometimes called a short-circuiting factor to ensure suitable hydraulic retention time and therefore disinfection. Additionally, sufficient reservoir volume must be allocated for Firewater storage.

6.4 WATER TREATMENT SELECTION

Apex has high confidence that a direct filtration and UF membrane-based water treatment process will meet the drinking water quality requirements. The suitability of each technology has been assessed, and each option can be employed to effectively remove each contaminant from the raw water stream. The infrastructure provided for in this design report shall allow provision for both treatment processes to be adopted while working within the structures and building footprint provided.

A process flow diagram of the proposed treatment process can be seen in Figure 5 below.

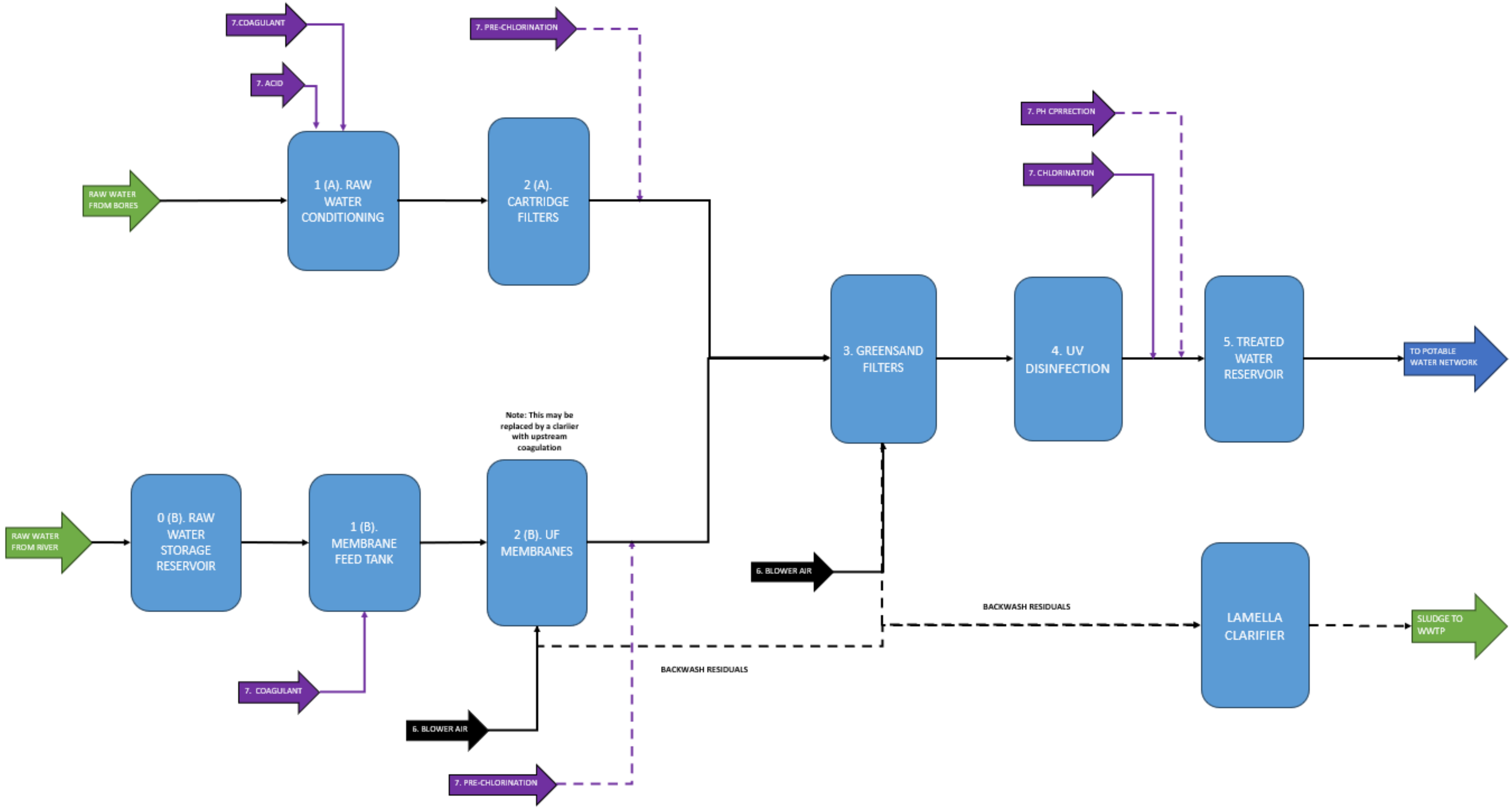

Figure 5: Proposed WTP process flow diagram

Each of the assessed treatment technologies have their own advantages and limitations and a full assessment of these in the context of the overall project shall be carried out during the detailed design process. Whichever core technology is employed, the water treatment plant will also include disinfection of the water utilising UV and chlorination to meet the level of disinfection log-credits required for this source water under DWSNZ. It is also recommended that the Client undergoes further testing of water sources prior to final selection of the water treatment plant processes.

6.4.1 CHEMICAL SYSTEMS

Table 3: Summary of chemical consumption for the proposed plant

Chemical	**Purpose**	**Approx. Consumption**
Sulphuric Acid (9%)	pH control of groundwater feed to the water treatment plant and membrane cleans to remove inorganic deposits and mineral scale.	150 L/week
Polyaluminium Chloride (23%)	Coagulation/flocculation of raw water feed to the water treatment plant.	430 L/week
Sodium Hypochlorite (13%)	Disinfection of drinking water via FAC residual, membrane cleans to remove organic material, and if required, oxidation of metal precipitates.	150 L/week
Sodium Hydroxide (30%)	pH control of treated water and membrane clean neutralisation.	50 L/week
Sodium Bisulphate (SBS) (23%)	Dechlorination of waste residuals.	0.5 L/week

6.5 TREATED WATER RESERVOIR

A treated water reservoir has been included to provide buffering for peak demand flows and resilience to the supply network. This reservoir has been sized by the client's civil consultants, Woods, with consideration to the required daily demand and any firewater requirements. Information supporting the sizing of this reservoir can be found in documentation supporting the substantive application.

7. WASTEWATER TREATMENT PLANT

7.1 LOADING

The anticipated wastewater loading has been established in consultation with the client's civil consultants, Woods, with reference to the Auckland Council Code of Practice for Land Development and Subdivision – Chapter 5: Wastewater (Watercare, 2021). The code of practice details what allowances should be made per dwelling when determining wastewater flows generated from different sized dwellings within new housing developments. Using the information provided within the Code of Practice and the development size provided by Woods, a wastewater model has been developed. The wastewater flow assessment also takes into account the water-saving measures incorporated into the development. The resulting reduction in average water demand has been carried through to the wastewater flow assessment, as these water-use reductions are expected to be reflected in the average wastewater discharge received at the WWTP. Table 4 below outlines information related to the wastewater loading on the proposed treatment plant. The WTP waste flows have been developed by Apex based on an assumed 95% recovery from the drinking water treatment process.

Table 4: Recommended design wastewater flows

Parameter	**Unit**	**Value**
Peaking Factor	-	1.2
Design Flow	m^3/d	613
Instantaneous Design Flow	L/s	7.1
Peak Wet Weather Flow	m^3/d	736
Instantaneous Design Flow	L/s	8.5
Water Treatment Plant Waste Flow (at average demand)	m^3/d	47

7.2 PEAKING – INFILTRATION AND INGRESS

Stages 14-17 of the Milldale development will be serviced by a low-pressure sewer network, which conveys wastewater to the treatment plant through a network of sealed, pressurised rising mains. Each property will be equipped with an individual collection tank and pump station.

Compared to conventional gravity sewer networks, low-pressure sewer systems substantially reduce peak hydraulic loading by minimising infiltration and inflow (I&I). Because the network is sealed and pressurised, there is limited opportunity for groundwater infiltration or stormwater ingress. This effectively decouples wastewater flows from rainfall events and reduces wet-weather flow variability.

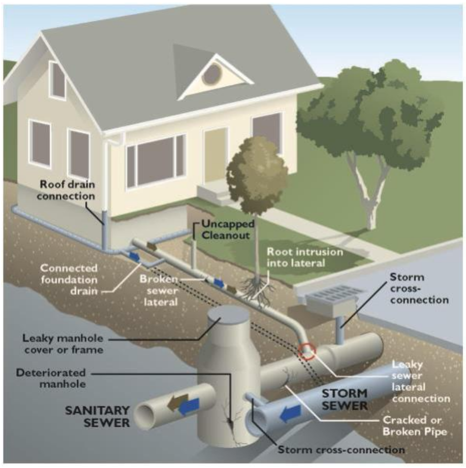

Figure 6: Sources of Infiltration and Inflow in a conventional gravity sewer network (GHD Limited, 2015)

In contrast, gravity sewer networks are susceptible to infiltration through damaged or defective pipework and inflow from surface sources such as stormwater misconnections, damaged manholes, and maintenance access points. As a result, wet-weather flows in conventional gravity systems can significantly exceed average dry weather flows (ADWF). The Auckland Council Code of Practice for New Land Development – Chapter 6: Wastewater specifies a peaking factor of 6.7 × ADWF for the design of conventional gravity wastewater networks.

Wastewater generation within the development is expected to vary both daily and seasonally. While the low-pressure sewer network substantially reduces weather-related peaking, the WWTP must still accommodate normal diurnal flow variations and residual peak flow events.

To manage these fluctuations, the WWTP incorporates an upstream balance tank that provides flow equalisation. The balance tank temporarily accumulates excess inflow during peak periods and releases it for treatment at a controlled rate. This decouples the treatment process from short-term hydraulic peaks and allows the WWTP to be designed based on average operating flows rather than instantaneous peak flows.

Previous experience from comparable developments utilising low-pressure sewer systems show that a peaking factor of 1.2 to be appropriately conservative for this application.

An example of a balance tank incorporated into a membrane bioreactor treatment plant recently designed and constructed by Apex Water is shown in Figure 7 below.

Figure 7: Karaka North WWTP flow balancing tank for MBR process

7.3 RAW WASTEWATER QUALITY

The wastewater stream entering the plant comprises primarily of domestic sources with a small commercial area. In staged developments, it is common for the strength of sewage to be higher when there are fewer connections, gradually reaching a more typical sewage strength as the development expands.

A summary of guidance values used for wastewater strength is presented in Table 4 below. These values presented follow the Auckland Regional Council Guidance Document GD06 (Chen & Roberts, 2021) as well as real world historical data obtained from the similar sized Clarks Beach community.

Table 5: Expected wastewater strengths

Influent Concentrations	**Guidance Document GD06**	**Clarks Beach**	
		Median	95th Percentile
COD	-	550	1,100
COD-filtered	-	200	332
BOD	250 - 350	270	420
TSS	300 - 400	-	-
TKN	-	65	94
NH_4-N	-	48	65
NH_3	Varies	-	-
NO_3	<1	-	-
TN	Varies	-	-
PO_4	10 - 30	-	-
TP	-	10	13
Faecal coliforms	10^8 - 10^{10}		

The WWTP has been designed using wastewater quality data collected from a community similar in size and character to the proposed development. This information is considered more representative of the expected wastewater characteristics and provides a conservative basis for treatment plant design. The plant has been designed to accommodate wastewater that is stronger than average and to continue meeting discharge requirements during periods when wastewater quality varies. Wastewater composition can change over time as the development grows and occupancy patterns change. In particular, the balance between nutrients and organic matter can vary, which can affect the efficiency of the biological treatment process.

To provide flexibility under a wide range of operating conditions, the treatment plant includes provision for the addition of a supplementary carbon source, such as acetic acid, if required. This allows the treatment process to be optimised should wastewater characteristics differ from those anticipated during the design phase, helping to maintain consistent treatment performance and compliance with discharge requirements.

7.4 EXISTING SURFACE WATER QUALITY

Ecological assessments undertaken by Viridis, have identified the receiving environment at Milldale North as sensitive and already subject to ecological stress, necessitating a high level of nutrient removal within the treatment process. A full ecological report and wastewater discharge assessment, prepared by Viridis (Good & Allen, Milldale North Wastewater Discharge: Downstream Water Quality Effects and Treatment Implications, 2026), is included in the supporting documentation for the substantive application and provides a detailed assessment of the existing in-stream physicochemical conditions and ecological health. This requirement is corroborated by hydrological investigations completed by WWLA (Tasca & Williamson, 2026).

These conditions support the proposed discharge of treated wastewater to a constructed wetland. As per WWLA's assessment, the cascading wetland system will provide approximately 8–9 days of hydraulic retention time, providing further polishing of the treated wastewater prior to discharge to the receiving environment. This system and its effects are discussed further in Viridis and WWLA's assessments.

7.5 OPTIONS ASSESSMENT

The suitability of various treatment systems currently in operation throughout New Zealand have been assessed for the Milldale Stages 14-17. It should be noted that in this case, the condition of the receiving environment is the limiting factor in technology selection, requiring a treatment process capable of removing all but trace levels of nutrients and other contaminants. The list of suitable treatment process capable of achieving the required level of nutrient removal, as assessed in this report are shown below.

- Membrane Bioreactor (MBR)
- Hybrid Membrane Aerated Biofilm Reactor with Tertiary Membrane Treatment (MABR-MBR)

These are all biological wastewater treatment processes that employ bacteria to facilitate the removal of organic contaminants and nutrients from the wastewater.

Based on the need for robustness and flexibility, and the limitations imposed by the receiving environment, an MABR-MBR hybrid biological process was identified as the most suitable option for this Wastewater Treatment Plant.

MEMBRANE BIOREACTOR (MBR)

A Membrane Bioreactor (MBR) is an advanced wastewater treatment process that combines biological treatment with membrane filtration. The biological treatment process uses naturally occurring microorganisms to break down contaminants in the wastewater, while the membranes provide a physical barrier that removes suspended solids, bacteria, and other pathogens.

The result is a very high-quality treated effluent that is clear, low in suspended solids, and suitable for discharge or water reuse applications. MBR systems are capable of producing consistently high-quality treated water, even when wastewater flows and characteristics vary over time. Treated water from Apex-designed MBR plants routinely achieves extremely low bacterial concentrations, often with no detectable E. coli present in treated water samples.

MBR technology is widely regarded as one of the most effective wastewater treatment processes currently available. Compared with conventional treatment systems, it produces a higher quality effluent, requires a smaller footprint, and provides greater resilience to changes in wastewater quality and flow.

An example of an MBR treatment plant designed and constructed by Apex Water for Watercare at Meremere is shown below.

Figure 8: MBR treatment plant designed and built by Apex for Watercare

For the Milldale Stages 14-17 development, the MBR represents the preferred treatment technology due to its ability to consistently achieve a high-quality effluent with very low suspended solids concentrations. This makes it particularly well suited to the proposed discharge and water reuse objectives while providing a robust and future-proof treatment solution.

The MBR represents the best available technology, delivering a clear effluent of low suspended solids content (generally <4mg/L even with an allowance of breakage of some filtration membranes), making it ideal for the proposed discharge and reuse applications. The key benefits of MBR technology for this application are shown in Table 6.

Table 6: Benefits of MBR technology

Benefit	**Description**
Reliability	The MBR process is well established and utilised in new wastewater treatment processes in New Zealand. Its reliability is well demonstrated with Apex Water having designed and built numerous such plants for public and private clients through the country including Watercare.
Compact Process	As the submerged membranes act as a physical barrier, the suspended biomass can be present a very high concentrations allowing very efficient treatment in a compact footprint.
Process Flexibility	The MBR process can be operated to handle varying wastewater strengths including high strength wastewater.
Membrane Filtration	The membrane filtration step prevents bacteria from entering the treated water, producing exceptionally clear low turbidity permeate. This clear permeate is well suited to further treatment i.e. UV disinfection, chlorination, or Reverse Osmosis (RO).

Figure 9 provides an example of above ground concrete membrane tanks at a membrane bioreactor treatment plant that has been designed and built by Apex Water for an industrial client in New Zealand.

Figure 9: Apex MBR membrane tank

HYBRID MEMBRANE AERATED BIOREACTOR AND MEMBRANE BIOREACTOR (MABR-MBR HYBRID)

The Membrane Aerated Bioreactor (MABR) is a more recent modification of the activated sludge process employing gas permeable membranes that provide extremely efficient aeration and a growth surface for biofilm. Because diffusion of oxygen through the membrane is up to 10 times more energy efficient than traditional aeration systems, biological treatment can be achieved in MABRs at a lower power consumption than conventional wastewater systems. Furthermore, the counter diffusion of oxygen and nutrients through a biofilm enables simultaneous nitrification-denitrification within the MABR tank. When compared to other treatment technologies, the MABR process requires a smaller footprint (i.e., smaller tanks) and uses less aeration energy to achieve the same level of nitrification, which often constitutes one of the largest operational expenses of a traditional treatment plant.

As a standalone process, the MABR produces effluent with a total solids concentration comparable to that produced by conventional activated sludge processes. Unless coupled with a membrane or other process to effectively separate and remove bulk solids from the treated wastewater, the treated effluent quality would be unsuitable for further tertiary disinfection (such as ultraviolet disinfection) or discharge to a sensitive environment. Incorporating MABR technology into an MBR process results in a highly effective nutrient removal system that occupies less space, operates more robustly, and efficiently produces effluent of an extremely high quality.

The MABR process is considered a modified activated sludge process and therefore can often be applied to enhance the performance of treatment systems based on the same process (e.g. Activated Sludge or MBR). For reasons noted above, integrating MABR technology into these processes can deliver a number of benefits, including improved performance, a reduced plant footprint, and lower operating (OPEX) costs. An image of MABR modules awaiting installation is shown in Figure 10 below.

Figure 10: Example of OxyMem type MABR modules prior to installation inside tank. Each module houses gas

The key benefits of MABR-MBR technology for this application are shown in Table 7 below.

Table 7: Benefits of Hybrid MABR-MBR technology

Benefit	**Description**
MBR Benefits	As the treatment process incorporates MBR into the treatment train, the same benefits are present as detailed above
Waste Production	The high efficiency of the biofilm produces less waste biomass for the same treatment, meaning waste activated sludge (WAS) volumes are reduced.
Operational Cost	Lower energy consumption, sludge production and chemical dosing requirements result in lower operational and disposal costs.
Scalable and Modular	The treatment process is easily scaled and can be designed to easily accommodate both modular implementation and future expansion. The treatment process is so compact and efficient that at some scales modular, offsite construction is viable.
Energy Efficient	The MABR technology can offer better environmental performance when measured against other conventional treatment processes.

Figure 11 below demonstrates a hybrid MABR / MBR treatment plant with almost ten times the capacity of the proposed installation designed and constructed by Apex Water for Watercare.

Figure 11: Raglan WWTP

7.6 TREATMENT PROCESS SELECTION

A multi-criteria assessment was undertaken internally by a group of experienced engineers to evaluate each option against a range of technical, operational, environmental, and commercial criteria. The assessed parameters are Performance, Future Proofing, Operability, Constructability, Social and Environmental Impact and Resilience and Process Resilience. For each of these parameters, the recommended Membrane Aerated Biofilm Reactor and Ultra filtration MBR membranes has been compared to the most common traditional treatment solution which consists of a 4-stage Bardenpho activated sludge treatment process.

Table 8 below details the different processes considered, with Option 1 being the recommended selection.

Table 8: Multi Criteria Assessment on Treatment Processes Considered

			Base Option 1 MABR + MBR		**Option 2 Bardenpho MBR**		**Option 3 MABR Alone**	
Category	Criteria	Weighting	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Performance	Treated Effluent Quality (suitable for Surface Water)	20%	0	0	0	0	-2	-0.4
	Reliability & Robustness	10%	0	0	-1	-0.1	-2	-0.2
Future Proofing	Phased Construction & Future Upgradability	10%	0	0	-1	-0.1	-1	-0.1
	Relocatable / Suitability for Interim plant	10%	0	0	-1	-0.1	0	0
Operability	Ease of operation	7.5%	0	0	-1	-0.075	-1	-0.075
	Process safety	7.5%	0	0	0	0	0	0
Constructability	Ease of implementation	5%	0	0	0.5	0.025	0.5	0.025
Social and Environmental Impact	Amenity impacts (noise, odour etc)	5%	0	0	0	0	0	0
	GHG emissions	5%	0	0	-0.50	-0.025	1	0.05
Resilience	Process stability under peak flow	5%	0	0	-0.5	-0.025	0	0
	Process stability under future load conditions	5%	0	0	-0.5	-0.025	0	0
Financial	Indicative capital cost	5%	0	0	1	0.05	1	0.05
	Relative operating cost	5%	0	0	-1	-0.05	0	0
Total Option Score				0		-0.775		-1.35
Rank				1		2		3

Score	Description
-2	Much Worse
-1	Moderately Worse
0	Same as Base Option 1
1	Moderately Better
2	Much Better

7.6.1 DISADVANTAGES OF MABR-MBR-RO HYBRID SYSTEM

As is the case with any process technology, the MABR-MBR hybrid system does present some limitations and disadvantages. The disadvantages associated with the treatment process are well defined and through process design can be largely mitigated. The disadvantages of the MABR-MBR system include:

Table 9: Limitations of MBR Treatment Processes

Limitation	**Description**
Flow	The membranes that provide the physical barrier between the treated wastewater and the bacteria / sewage also provide a physical limit to the total flow that the plant can handle. The surface area available for filtration, the level of membrane fouling blocking liquid flow, and the physical pressure limitations of membranes all contribute to providing a hydraulic upper limit to a membrane treatment process. On systems with large peak flows, mitigation measures (such as flow balancing, use of low-pressure sewer, or oversizing MBR membranes) need to be implemented to handle these peaks.
Membrane Fouling	The blocking of membrane pores over a period of operation due to the accumulation of organic fouling or deposition of inorganic scaling restricts flow through the membrane. While Membrane fouling presents one of the largest operational complications with MBR technology, well established automated cleaning of the membranes to remove these blockages largely mitigates this risk. Cleaning processes must be performed proactively and controlled in accordance with good operational practices to ensure process performance and integrity of the membranes is maintained.
RO Retentate	One issue that needs to be addressed in the use of RO filtration, is the disposal of the concentrated retentate stream, comprising contaminants that cannot pass through the membrane. Depending on the RO treatment train design, this could produce a waste stream of approximately 10 - 30% of the total volume fed to it (depending on raw water quality and type of RO membrane). While this represents an operational constraint, it is worth noting that the retentate stream that will result from the proposed plant is still of a high enough quality that there are various viable applications for reuse of this treated waste stream by irrigation around the development.

7.6.2 EXPECTED WASTEWATER QUALITY

The resulting treated effluent quality from the MABR-MBR hybrid system is of such a high quality that by the World Health Organization (WHO) Standards, it meets the requirements for bathing water quality and Queensland guidelines for Class A recycled water without further treatment processes. At similar sites using this treatment processes, it is not uncommon to have undetectable levels of *E. coli* bacteria in the discharge (e.g., <1 CFU per 100mL).

From a practical perspective and to allow for any minor leaks or damage to membranes, MBRs are often designed to achieve a treated water quality of <4 *E. coli*/100mL. Following this with UV would also deactivate almost all viruses from the wastewater. Table 10 below presents the expected treated effluent quality.

Table 10: Expected treated effluent quality

Parameter		**Proposed Treated Water Quality Median**	**Literature Derived Stormwater Runoff Quality (Williamson R. B., 1993)**	**Consent Discharge Limits for Karaka North (1250 Lots)**	**Watercare Consent Limits for Direct Discharge to Ocean from Clark's Beach**
$cBOD_5$	mg/L	5	8	5	5
TSS	mg/L	4	170	4	5
TN	mg/L	5	2.5	5	5
TP	mg/L	2	42	2	Not limited
AMM-N	mg/L	2	0.1	2	2
E. coli	MPN/ 100mL	<4	<1	<4	UV treatment required but no E. *coli* limit specified

PREVALENCE OF MABR-MBR SYSTEMS IN THE AUCKLAND REGION

Over the past decade, most new sewage plants within the Auckland Region and surrounding area are MBRs. These include Pukekohe, Warkworth, Clarks Beach, Waiheke, and Karaka North. In the Waiheke Island application, due to the nature, occupancy and diet over the holiday periods, the wastewater can be unusually strong with peaks up to ten times as strong as typical sewage. Despite this, the system has regularly demonstrated treated wastewater quality as shown in Table 11 below.

Table 11: Proven treated effluent quality from MBR

Parameter	**Concentration**
Total Nitrogen (mg/L)	< 10 (Typically < 5 for most MBRs)
cBOD5 (mg/L)	< 2
Total Suspended Solids (mg/L)	< 1
E.coli (CFU/100mL)	< 1

The implementation of MABR processes has been much more recent within New Zealand, due to the relatively new nature of this problem, and the tendency of New Zealand municipalities to await substantial proof of reliability and successful implementation off sure before adopting new technologies.

In New Zealand, Watercare has been instrumental in the uptake of MABR technology, with the Te Kauwhata WWTP (operational since 2023) being the first full scale example in New Zealand. This plant is designed to treat wastewater flows to reliably achieve the quality shown in Table 12 below.

Table 12: Performance of Hybrid MABR-MBR system

Parameter	**Concentration**
Average Flowrate (m^3/day)	1,500
Peak Flowrate (m^3/day)	2,000
cBOD5 (mg/L)	10
Total Nitrogen (mg/L)	5
Total Suspended Solids (mg/L)	<5

Based on proven success at Te Kauwhata WwTP, Watercare has further installed MABR upgrades with the support of Apex Water in Raglan and Meremere and are currently implementing further upgrades to Clark's Beach with the same technology. Construction is also underway for new hybrid MABR-MBR plants in Ngaaruawaahia, Te Kauwhata, Huntly, and, and Manapouri.

7.6.3 TREATMENT TRAIN

A simplified process flow diagram of the MABR-MBR hybrid treatment train is illustrated in Figure 12 below.

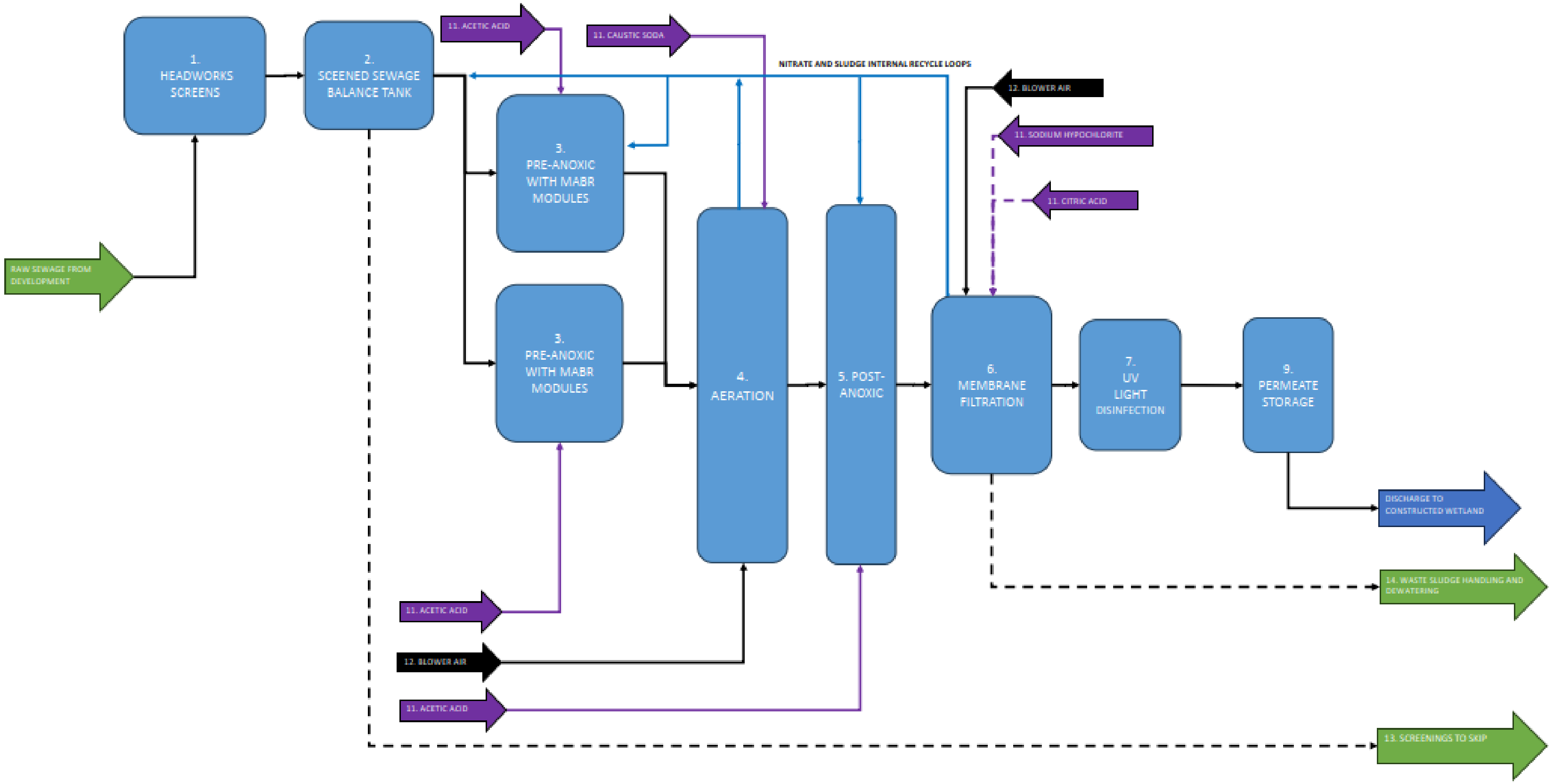

Figure 12: Proposed WWTP process flow diagram

This system is characterized by the following unit processes on the main flow path,

1. Headwork Screening – These screen bulk solids out of the raw sewage to protect the downstream process.
2. Flow Balancing – A tank which buffers peak flows of screened sewage.
3. Pre-Anoxic Tank(s) – The first stage and heart of the biological process housing the MABR modules.
4. Aeration Tank – Dissolved oxygen is pumped into this tank to feed the biological process.
5. Post Anoxic Tank – The second stage and polishing step of the biological process.
6. Membrane Tank – The filtration step of the process, where bulk solids, bacteria and most viruses are filtered out of the wastewater.
7. UV Disinfection – The UV disinfection step where most remaining bacteria or viruses are deactivated through exposure to ultraviolet light.
8. Permeate Storage – Where permeate (fully treated wastewater) is stored prior to discharge
9. Discharge System – Treated wastewater is discharged to a constructed wetland.

Ancillary or other unit processes on minor flow paths may not be shown on the simplified process flow diagram below, but include:

1. Activated Sludge is periodically wasted and stored in the Waste Activated Sludge (WAS) tanks to maintain the required levels of biological activity.
2. WAS is dewatered typically using a centrifuge for discharge and removal as a dry cake. Polymer flocculant is dosed to improve the dewatering performance.
3. Aeration blowers feed high volume and medium pressure air to the MABR gas transfer membranes and the aeration tank.
4. Acetic acid is dosed as a supplementary carbon source to provide food to the biological process.
5. Sodium hydroxide is dosed to manage the pH of the treatment process. The biological process consumes alkalinity, decreasing the pH of the wastewater which if not managed negatively impacts biological activity.
6. Aluminium Sulphate is dosed to sequester phosphorous out of solution for removal.
7. Citric Acid is used to remove inorganic scaling from the membrane surfaces through a Clean-in-Place (CIP) process.
8. Sodium hypochlorite is used to remove organic fouling from the membrane surfaces through a CIP process.
9. Headworks screenings are collected in a skip for removal to landfill.
10. Dewatered sludge is collected in a skip for removal to landfill.

11. An odour treatment system collects air from the headworks, sludge systems and other potential odour sources and treats to remove odour before discharge to atmosphere.

7.6.4 BIOWIN MODELLING

Biological modelling of the treatment process has been carried out making use of Biological Modelling software. This design step is critical to both confirming the technology selection is appropriate for the wastewater volumetric and nutrient loading expected, but also in providing input to the planning and consenting of the overall project site.

The biological modelling process is carried out on Biowin software which is a tool that ties together the biological, chemical and physical process models. Through the production and optimisation of the model, the discharge quality can be determined for a range of flow scenarios which allows a sensitivity analysis to be carried out on the proposed design to determine its suitability and stability under a range of influent flows and strengths.

One of the other key outputs of this stage of the design process includes bulk sizing of the unit processes which allows for a preliminary layout of the site including:

- Bulk dimensions of the treatment plant building – Planning and land use considerations.
- Bulk dimensions of the treatment plant biological reactor tanks – Planning and land use considerations.
- Volumetric consumption of the ancillary chemicals – Planning, land-use and hazardous substance considerations.
- Site layout, permeable and impermeable surface make-up –Planning, land use, hazardous substances and industrial and trade related activities considerations.
- Site layout – Noise generation, attenuation, vehicle movements, air discharges and operational ergonomics of the site (planning, land-use, traffic and discharge to air considerations).

An overview of the BioWin model as visualised from the computer is illustrated in Figure 13 below. The following subsections provide further details of the plant design.

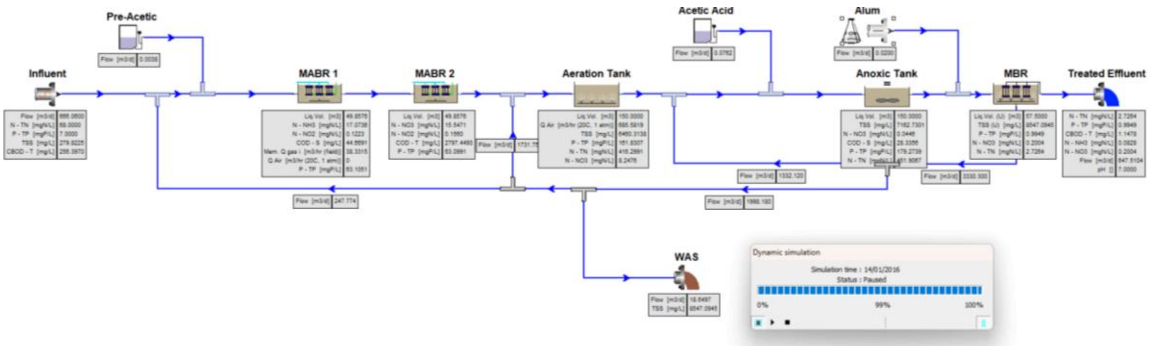

Figure 13: Biowin modelling overview

7.6.5 MAIN UNIT PROCESSES

The proposed WWTP incorporates a series of physical, biological, and chemical treatment processes designed to reliably produce a high-quality effluent suitable for discharge to the receiving environment.

HEADWORKS SCREENING AND GRIT REMOVAL

Wastewater collected from the development is conveyed to the treatment plant where it first passes through a screening and grit removal system. Fine screens remove larger solids, such as wipes, plastics, and other debris, while the grit removal process separates sand and other abrasive inorganic materials. Removing these materials at the beginning of the treatment process protects downstream equipment from wear, reduces maintenance requirements, and improves overall plant reliability.

The collected screenings and grit are dewatered and stored in sealed bins prior to removal from site by a licensed contractor. This process also assists with odour control and housekeeping within the treatment plant. To reduce operational complexity the screens are elevated to enable the screened sewage to flow under gravity through the screens and into the rest of the process.

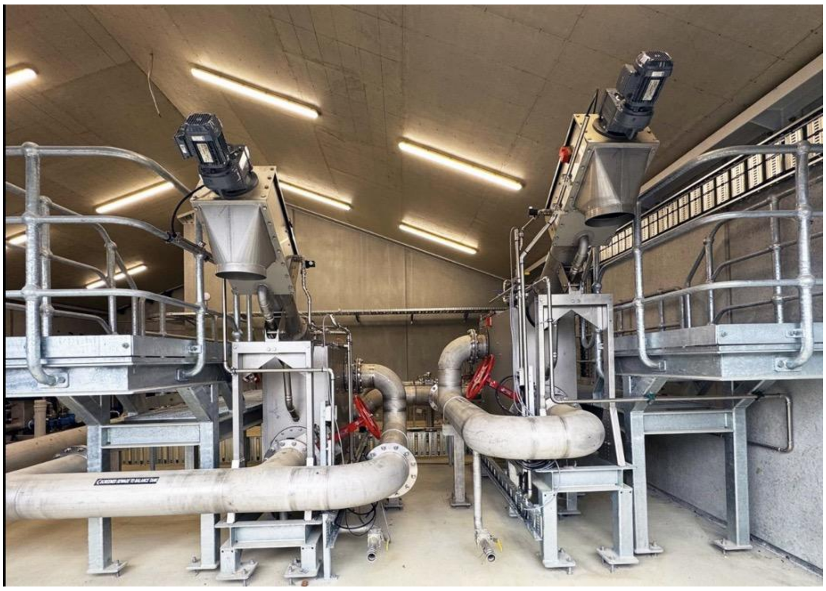

Figure 14: Fine and Coarse Inlet Screens at a treatment plant designed and built by Apex Water

BIOLOGICAL NUTRIENT REMOVAL

Following screening, the wastewater enters a series of biological treatment tanks where naturally occurring microorganisms consume dissolved organic contaminants and nutrients. The treatment process includes both anoxic and aerobic zones, enabling the efficient removal of nitrogen compounds through biological nitrification and denitrification processes.

The pre-anoxic treatment stage incorporates Membrane Aerated Biofilm Reactor (MABR) technology, which improves nitrogen removal efficiency by delivering oxygen directly to specialised bacteria growing on membrane surfaces. This allows high rates of nutrient removal within a compact footprint while reducing energy consumption compared to conventional treatment processes.

AERATION

The wastewater then enters the aeration tank, where fine bubble diffusers supply oxygen to support the biological treatment process. In this stage, microorganisms further reduce organic contaminants and convert residual ammonia into nitrate. Continuous monitoring and automatic control of dissolved oxygen levels ensure stable treatment performance while minimising energy consumption and the discharge of offensive odour.

Figure 15: Operating aeration tank (Large Blue Tank)

POST-ANOXIC TREATMENT

Following aeration, the nitrate-rich wastewater enters the post-anoxic tank, where naturally occurring bacteria remove any remaining nitrogen from the wastewater. This final biological treatment stage helps achieve the low nitrogen concentrations required for discharge.

Where additional nitrogen removal is required, a supplementary carbon source in the form of acetic acid may be added to support the treatment process. Phosphorus is removed by dosing aluminium sulphate (alum), which converts dissolved phosphorus into solid particles. These particles are subsequently captured by the membrane filtration system and removed from the process with the waste sludge. Together, the post-anoxic treatment process and chemical dosing systems ensures the treated wastewater consistently achieves the required discharge standards.

MEMBRANE BIOREACTOR (MBR)

The core treatment process is a Membrane Bioreactor (MBR), which combines conventional activated sludge treatment with membrane filtration. The membranes act as a physical barrier, separating treated water from suspended solids, bacteria, and other microorganisms.

Unlike conventional gravity clarifiers, membrane filtration produces a consistently high-quality effluent with very low suspended solids concentrations and extremely low bacterial counts. Treated water from MBR systems commonly contains less than 5 *E.coli* per 100 mL, with many facilities regularly achieving non-detectable levels.

The membrane system is continuously cleaned through air scouring and periodic automated cleaning cycles to maintain performance. The membranes also enable the biological process to operate at higher biomass concentrations than conventional treatment systems, resulting in improved treatment efficiency in a smaller overall plant footprint.

UV DISINFECTION

As an additional treatment barrier, the filtered effluent passes through a UV disinfection system. Ultraviolet light damages the DNA of microorganisms, preventing them from reproducing and providing further protection against pathogens.

The UV system incorporates multiple lamps, automatic cleaning systems, online monitoring, and fault alarms to ensure reliable operation. The combination of membrane filtration and UV disinfection provides multiple independent barriers to microbial contamination of the receiving environment.

PERMEATE STORAGE AND INTERNAL REUSE

The permeate produced by the plant is of such a high quality that it can be beneficially re-used within the wastewater treatment plant as process water. The inlet screens run through an automated cleaning process requiring high pressure water to be sprayed internally to dislodge and clear accumulated solids. It is proposed that permeate is used in this application and any other cleaning applications on site where there is no risk of potable, non-potable cross-over.

SLUDGE MANAGEMENT

A by-product of the biological treatment process is waste activated sludge, consisting primarily of excess microorganisms generated during treatment. To maintain stable operation, a portion of this biomass is regularly removed from the system.

The waste sludge is transferred to dedicated storage tanks where it thickens prior to mechanical dewatering. A centrifuge is used to increase the solids concentration and reduce the volume of sludge requiring off-site disposal. The dewatered sludge is collected in covered 7.5 m^3 skip bins and removed from site by a specialist contractor for disposal at an appropriately licensed facility. At full design flow, the skip is expected to require emptying up to twice per month.

All sludge handling and dewatering equipment is enclosed within the treatment plant building and connected to the odour management system, minimising potential impacts on neighbouring properties.

CHEMICAL SYSTEMS

The plant will incorporate the chemical systems detailed in Table 13 below.

Table 13: Chemical system for the proposed WWTP

Chemical	**Purpose / Details**	**Dose Point**	**Approx. Consumption**
Acetic acid (49%)	Provides a carbon source for nitrogen removal.	Post Anoxic	150 L/day
Caustic soda (30%)	Provides pH adjustment as required. The biological reactions can consume all alkalinity available, dropping the pH into a range that is harmful to the bacteria.	Aeration tanks	50 L/day
Aluminium sulphate	Precipitates out phosphorus as it can be filtered out by the MBR system. Note, the addition of aluminium sulphate does increase the MBR cleaning requirements.	Anoxic tank 2	40L/day
Sodium hypochlorite (13%)	Utilised for membrane CIP to remove organic fouling on the membranes	MBR tanks	100 L/month
Citric acid	Utilised for membrane CIP to remove inorganic scaling from the membranes	MBR tanks	100L/month

7.7 DISCHARGE OPTIONS

7.7.1 PROPOSED DISCHARGE PATHWAY

Due to the nature and quality of the receiving environment, it is proposed that all treated wastewater is discharged to a constructed wetland. The proposed discharge volumes under the summer low-flow, median-flow and peak wet-weather operating scenarios, modelled by WWLA, are summarised in the following table.

Table 14: Wetland discharge flows (James & Williamson, 2026)

Scenario	**Wetland Discharge Volume from Surface Runoff (m3/day)**	**Wetland Discharge Volume from Groundwater (m3/day)**
1. Low Instream Flowrates – Mean Average Low Flow (MALF) – summer	484	44
2. Median In Stream Flowrates (Average Condition)	595	44
3. Peak In Stream Flowrates (Peak Wet Weather)	850	44

A summary of the treatment discharge pathway can be seen in Figure *16* below.

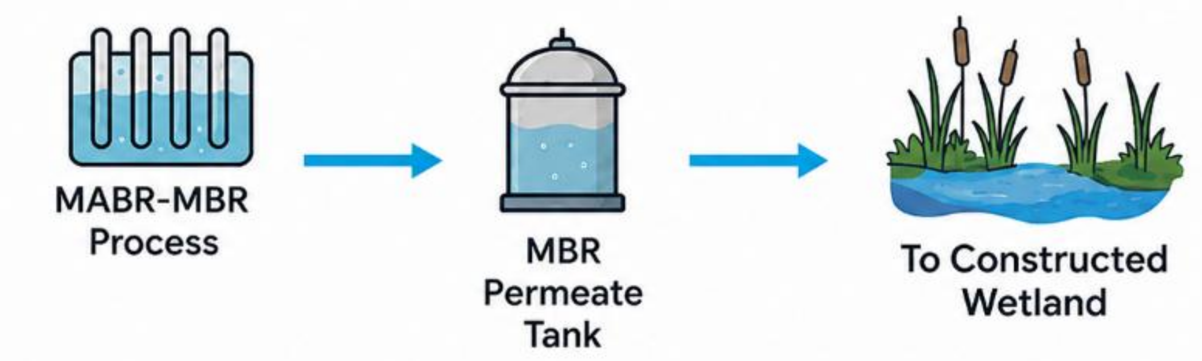

Figure 16: Proposed Discharge pathway

7.7.2 EFFECTS OF DISCHARGE ON SURFACE WATER QUALITY

WWLA has undertaken an assessment of the expected wastewater quality after treatment by the constructed wetland. A summary of their results is outlined in the table below.

Table 15: Expected Discharge Quality

	Influent Concentrations to the Wetland	**Expected Outflow Concentrations from the Wetland (James & Williamson, 2026)**
TN (mg/L)	5	0.75
TP (mg/L)	2	0.06
cBOD5 (mg/L)	5	2.75
TSS	4	4

Based on the above quality, an assessment of environmental effects from the treated wastewater discharge has been carried out by Viridis (Good & Allen, 2026) to support this consent application. The assessment has considered how the wastewater discharge would impact the quality of these receiving environments under three different scenarios. In their report, Viridis states that:

"*Overall, the proposed discharge is predicted to result in only small changes to selected water-quality parameters, while maintaining the compliance NPS-FM bands for toxicity and DRP enrichment. Although some ANZG physicochemical DGVs are exceeded, these values indicate departure from reference-site conditions rather than direct adverse-effect thresholds. Provided the treated wastewater quality specified by WWLA* (James & Williamson, 2026) *is consistently achieved, effects on receiving-water quality are therefore assessed as low.*"

7.7.3 WASTEWATER ENVIRONMENTAL PERFORMANCE STANDARDS 2025

The New Zealand government has recently passed into legislation the Water Services (Wastewater Environmental Performance Standards) Regulations 2025 (New Zealand Government, 2025). These standards, whilst applicable only to local authorities or local authorities derived organisations provide a simplified consenting pathway by setting out discharge quality standards that treated wastewater discharges must meet for a range of receiving environments. It also requires that for an application to discharge wastewater into a river, a dilution class must be specified. In the case of the proposed Milldale Stages 14-17 WWTP, the wastewater discharge will fall into the dilution class of Very Low Dilution in all scenarios. Despite this, the proposed discharge quality meets the required quality standards for all the parameters detailed by a significant margin. Table 16 below provides a comparison between the proposed treated wastewater discharge quality that will be provided by the constructed wetland and the limits detailed in the standards.

Table 16: Discharge quality comparison

Constituent	**Concentration Limit (very low dilution class)**	**Proposed Treated Water Quality Median (James & Williamson, 2026)**
TN (mg/L)	4	0.75
AMM-N (mg/L)	*1*	<0.002
TP (mg/L)	0.5	0.06
E.coli (CFU/100mL)	*130*	<1
$cBOD_5$ (mg/L)	5 *10*	2.75
TSS (mg/L)	5 *10*	4

Underline: Annual median concentration that must not be exceeded

Italicised: Concentration measured as a 90th percentile that must not be exceeded

The results above highlight the treatment quality that is proposed resulting in a discharge higher in quality than what would be required for a local authority designing, building and operating the same treatment plant on the same site.

7.8 ODOUR MANAGEMENT

7.8.1 ODOUR SOURCES

Wastewater has the potential to generate offensive odours. Odour from raw sewage is primarily generated through the decomposition of organic matter by microorganisms in the wastewater. When raw sewage enters the wastewater network, it contains a variety of organic materials, such as food waste, human waste, oils, and other substances. Due to the lack of external sources of oxygen any latent dissolved oxygen with the raw sewage is quickly consumed leaving the breakdown of sewage to occur in anaerobic (oxygen-deprived) conditions.

As organic material decomposes, it produces several gases, some of which are responsible for the foul odour. These gases include:

1. Hydrogen Sulphide (H_2S) – Often described as having a rotten egg smell, hydrogen sulphide is produced when sulphur compounds in organic matter are broken down by anaerobic bacteria.
2. Ammonia (NH_3) – Ammonia is produced from the breakdown of nitrogen-containing compounds found in human waste and other organic material. It has a sharp, pungent odour.
3. Methane (CH_4) – Methane is a colourless, odourless gas, but it can be associated with raw sewage due to the overall decomposition process.

The generation of odour is intensified by long residence times in conveyancing networks, which is compounded by poor ventilation or stagnant conditions. Effective sewage treatment, aeration, and proper system design are essential in controlling and mitigating these odours. While mitigation of the conditions which lead to the generation of offensive odours is not possible in the network leading to the treatment plant, they can be controlled through the treatment steps. Table 17 identifies the potential sources of offensive odours and the mitigations, or treatment proposed to ensure the emission of the these to the surrounding environment is avoided.

Table 17: Sources of odour and its mitigations

Process	**Potential Odour Source**	**Mitigation Measure**
Influent Balance Tank	High potential to generate odour	Because it receives raw sewage and the level in this tank is constantly changing, the balance tank will be covered and the air from the headspace of this tank will be ducted to an odour treatment system for odour treatment before being released to the environment.
Headworks Screens	Potential of the raw sewage and screenings in this system to release offensive odours due to anaerobic decomposition in the conveyancing network feeding the plant.	The system (including screening bins) is fully enclosed and connected to the odour extraction network. The main site odour extraction network maintains a negative pressure on the headworks system that ensures any odour is captured and transferred to the odour control unit for treatment prior to discharge. Uncontrolled odour emission should be negligible during normal operations.
Pre-Anoxic Tank	Raw screened sewage is fed into this tank.	Continuous recycle flow from the aeration tank, providing large quantities of nitrate rich water, and preventing anaerobic conditions from developing. The Oxidation-Reduction potential of the contents of this tank is continuously monitored which allows the contents to be monitored for generation of anaerobic conditions.
Aerobic Tanks	Anaerobic conditions from overloading or aeration equipment failure can generate offensive odour.	The aeration tanks are fitted with fine bubble diffusers to efficiently transfer oxygen from the air into the water. By maintaining a positive level of dissolved oxygen in the aeration tank, odour emissions are minimised meaning that this tank does not need to be covered. Blowers, which supply air, will have a backup emergency power supply. Standby blowers available onsite.
Post-Anoxic Tanks	Anaerobic conditions from overloading or aeration equipment failure can generate offensive odour	Low contaminant concentrations and continuous supply of nitrate to this anoxic tank, combined with its short hydraulic residence times prevents anaerobic conditions from developing.

Process	Potential Odour Source	Mitigation Measure
MBR Tanks	Anaerobic conditions from overloading or aeration equipment failure can generate offensive odour.	The membranes in these tanks are continuously cleaned by scouring with air. The contents of this tank have already had almost all dissolved contaminants (e.g. organic load and nutrients) removed by previous steps in the process. Therefore, the membrane tanks have a high concentration of dissolved oxygen in them. These factors combine to mitigate the risk of the membrane tanks generating offensive odours.
Waste Activated Sludge (WAS) Dewatering and Storage	Contains sludge which has a high risk of releasing offensive odour.	The WAS tanks are fully enclosed and connected to the odour extraction and treatment network. The WAS is aerated to maintain conditions which mitigate the formation of offensive odours. The sludge dewatering plant is fully enclosed and connected directly to the odour removal and treatment system. It is also housed in a building separately connected to the odour extraction and treatment network.

7.8.2 ODOUR CONTROL UNITS

As odour formation within the incoming wastewater network cannot be controlled, dedicated infrastructure is required to capture and treat odorous air within the treatment facility. An odour control unit (OCU) is employed to remove or neutralise odorous compounds and other contaminants from extracted air. Air is typically drawn from enclosed areas with the highest odour potential, such as inlet works, sludge storage tanks, skips, dewatering systems, and sumps. Table 18 provides an overview of the odour control technologies assessed for this development.

Table 18: Odour control unit comparison

Technology	**Operation**	**Advantages**	**Disadvantages**
Biofilter	Uses aerobic bacteria growing on a bed of bark chips to oxidise contaminants such as hydrogen sulphide (the primary offensive odour compound from sewage). Air is extracted from plant odour sources by fan and passed through the bed of bark prior to being discharged to air.	Well-established technology. Low capital and operating cost.	Treatment can fail if the moisture and pH of the bark bed is not kept within the optimum range. Larger biofilters can be prone to short-circuiting. Larger biofilters can produce a plume of ‘bark’ scented air from passing high volumes of air (generally considered inoffensive but can be quite noticeable on neighbouring properties).
Carbon scrubber	Uses an activated carbon pallet bed. Odour causing compounds are adsorbed onto the activated carbon pallets and thereby removed from the air stream. The carbon pallets can also be doped with sodium hydroxide, which significantly increases the ability of the carbon to remove and neutralise acidic gasses, such as hydrogen sulphide from sewage and sludge.	System relies on physical adsorption, so is more robust and reliable than biological oxidation.	Higher capital and operating costs than a biofilter. Carbon bed requires replacing every one to three years.
Multistage chemical scrubber	Uses product specific bed(s) to remove contaminants.	Able to tailor removal to specific pollutants.	Complex system. High capital and operating costs. More suitable for industrial sites where specific gaseous pollutants are targeted in conjunction with dust or other particulate matter.

7.8.3 SELECTION OF ODOUR CONTROL UNIT

Based on the assessment of odour control technologies presented in Table 18, a carbon scrubber has been identified as the preferred system. This selection is supported by its proven reliability, effective performance, and operational simplicity, as well as the ease with which the system can be designed, installed, and maintained.

Figure 17: Activated Carbon odour control unit at Karaka North WWTP

7.9 OPERATION INTO SERVICE

The commissioning of biological nutrient reduction processes can be complex, requiring expert technical oversight from personnel experienced in both their design and operation. With the core nutrient reduction process being biologically driven, a sufficient concentration of biomass (bacteria) is necessary to consume the contaminants present in the raw wastewater. The generation of biomass requires the controlled introduction of wastewater, supplementary food sources and maintaining conditions suitable for growth.

Based on Apex's experience, it typically takes up to two months, or potentially longer after the initial receipt of wastewater to develop adequate biomass in a seeded and supplementary fed biological treatment process. The exact time required will depend on several factors.

Biomass within wastewater treatment processes thrives under optimal conditions. If these conditions are disturbed, the biological processes may underperform, become stressed, or even fail to effectively remove nutrients from the wastewater. During commissioning, operational adjustments will be made to ensure the correct conditions are maintained to support healthy biomass and promote its growth.

Several factors can influence the health of the biomass, including:

- Insufficient organic matter (carbon-based contaminants) in the raw wastewater to sustain existing biomass and allow for growth. This should not be an issue for this site as wastewater is drawn from an existing network servicing a mature catchment.
- Excessive organic matter in the raw wastewater relative to the available biomass. This will need to be managed carefully during the early stages of commissioning.
- Insufficient alkalinity to support required nutrient reduction levels. These will be monitored, and supplementary alkalinity shall be dosed into the system.
- Insufficient dissolved oxygen concentration to support biological processes.
- Inappropriate biomass average residence time within the system, either too high or too low. This will be tightly monitored and controlled and is the key to ensuring the correct level of treatment

Due to the staged and modular nature of the proposed biological treatment process, an increase in plant capacity through future upgrades will require additional engineering oversight to ensure the process can support increased flows and nutrient loading.

8. RISK ASSESSMENT

A preliminary risk assessment has been undertaken to identify risks relevant to the design, operation, and maintenance of the proposed treatment systems. Also included are the mitigation measures proposed to manage or minimise these risks. The identified risks are summarised in Table 19.

Table 19: General risks and mitigations

Risk	**Potential Consequence**	**Mitigation**
	DESIGN	
Odour generation (WWTP)	Community complaints	Provide covered process units where appropriate, ventilation, odour control units, and adequate separation distances. An odour assessment has been completed by Air Matters based on the proposed treatment system covered in this report.
Noise generation	Community complaints and non-compliance with noise limits	Select low-noise equipment, provide acoustic treatment where required, minimise operation of high-noise equipment where practicable or limit to certain times of the day, and consider site layout to reduce noise impacts at sensitive receivers. A noise assessment has been completed by Styles Acoustics based on the proposed treatment system covered in this report.
Discharge non-compliance	Resource consent breach, community complaints	Incorporate multiple treatment barriers to minimise potential effects on the receiving environment. Provision of duty/standby equipment, buffer storage capacity, automated control systems, and continuous online monitoring. An assessment on the effects of the receiving environment (surface water) has been completed by Viridis.
Drinking water quality non-compliance	Failure to comply with the Drinking Water Standards for New Zealand	Design a multi-barrier treatment process with appropriate redundancy, monitoring, alarms, and contingency measures to ensure compliance.
Chemical storage and handling	Chemical spills, incompatible chemical reactions, operator safety risks, environmental contamination, and interruption to treatment processes	Design chemical storage and dosing systems in accordance with relevant standards, provide bunding and spill containment, separate incompatible chemicals, incorporate ventilation and emergency safety equipment, and provide adequate storage capacity to maintain treatment during supply interruptions. A hazardous substances analysis has been completed by WWLA based on the proposed treatment system covered in this report.

Risk	Potential Consequence	Mitigation
Flooding	Damage to infrastructure and service interruption	Locate the site outside the 1% Annual Exceedance Probability (AEP) floodplain, and incorporate site drainage and flood resilience measures into the design.
Seismic design requirements	Increased construction costs, design complexity, or changes to the preferred treatment option if higher seismic Importance Levels are required.	Confirm the seismic Importance Level (e.g. IL2 for buildings and IL3 for treated water reservoirs, where applicable) during detailed design and incorporate seismic design requirements into the structural design.
Geotechnical conditions	Unforeseen ground conditions resulting in increased foundation costs, construction delays, or design changes.	Undertake a geotechnical investigation to confirm ground conditions, groundwater levels, and foundation requirements prior to detailed design. An assessment on geotechnical conditions of the proposed site location has been completed by Gibb Ritchie based on the proposed treatment system covered in this report.
Survey and existing services	Design conflicts, utility strikes, or insufficient site area resulting in redesign or construction delays.	Undertake a detailed topographic and cadastral survey, including identification of existing underground and overhead services, to inform the detailed design and confirm site constraints and boundaries.
	OPERATIONS AND MAINTENANCE	
Equipment reliability	Plant downtime, reduced treatment capacity, and service interruptions	Provide duty/standby equipment for critical processes, redundancy, and bypass arrangements where appropriate.
Power supply interruption	Loss of treatment capability, supply interruptions	Provide standby generation or emergency power for critical systems and fail-safe control philosophy.
Chemical dosing failure	Poor treatment performance or water quality exceedances	Install duty/standby dosing systems, storage alarms, bunding, and online monitoring.
Instrumentation or control system failure	Loss of process control	Provide redundant instrumentation for critical parameters, alarms, manual override capability, and robust SCADA architecture.
Membrane or filter fouling	Reduced production capacity and increased maintenance	Provide suitable pretreatment, cleaning systems, and operational monitoring.
Asset deterioration	Reduced reliability and increased lifecycle costs	Select durable materials and equipment with appropriate design life and implement a planned preventative maintenance programme.
Discharge non-compliance	Environmental contamination	Robust design, O&M manual and SOP documentation, trained operators
Noise generation	Community disturbance, complaints and non-compliance with noise limits.	Keep acoustic enclosures and doors closed, minimise operation of high-noise equipment outside normal hours where practicable, maintain rotating equipment to prevent excessive noise and monitor compliance with consent noise limits.

9. PROPOSED SITE LAYOUT

The water and wastewater treatment facilities are to be located within a compound surrounded by security fencing to exclude non-operational personnel. The site shall allow provision for all access requirements from operational vehicles and personnel for servicing the facility. The following sections of the report cover the visual aspects of the site, make-up of the compound and details on the main structures to be located on the site.

WATER TREATMENT PLANT CONSIDERATIONS

The water and wastewater treatment plant are proposed to be co-located within the northern area of the site. There will be a clear separation between the core infrastructure which separates the two treatment processes with any potable water storage or handling kept as far away as practicable from any sewage storage or handling. Chemical dosing infrastructure common to both plants is proposed to be located near the bulk tanker load out bay. Figure 18 below highlights the separation between water and wastewater infrastructure on the site with reference to the prevailing wind blowing from the south-west.

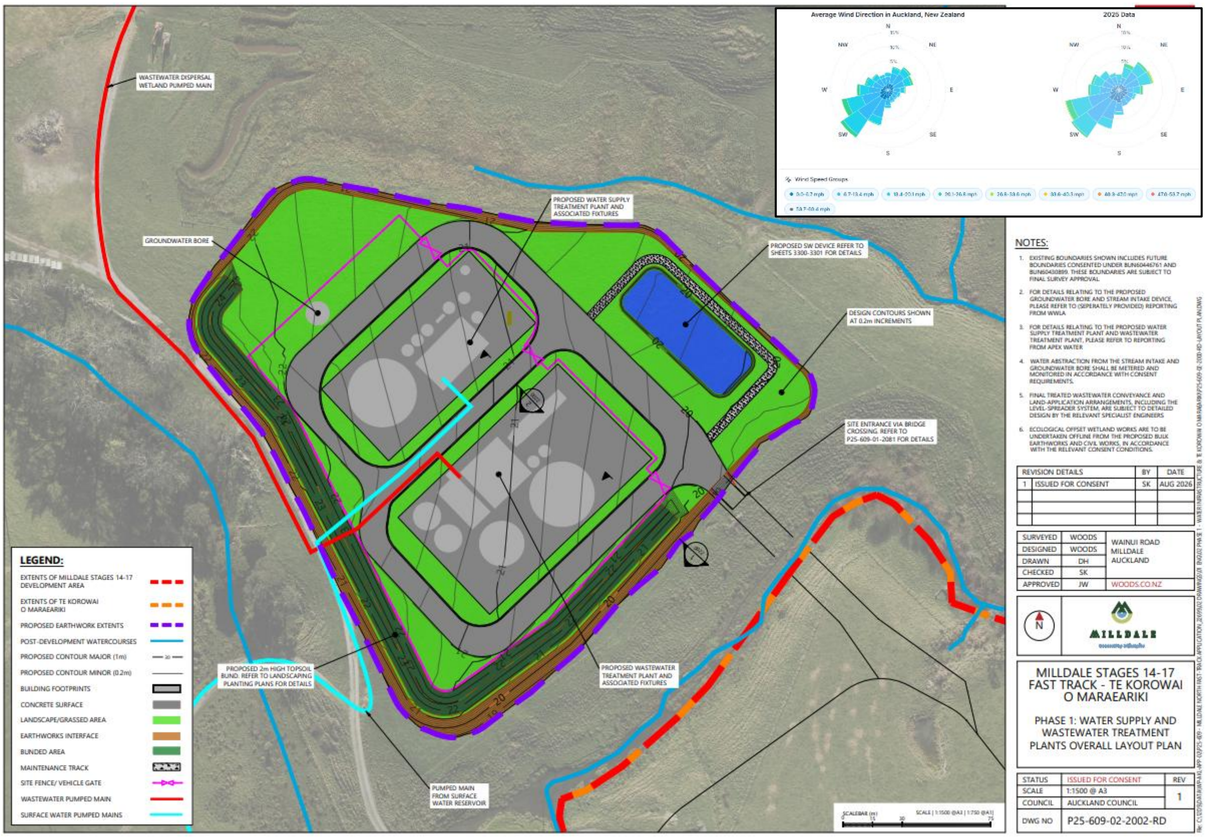

Figure 18: Site layout overview

During the detailed design process and as a requirement of becoming a registered water supplier, a water safety plan and source water risk assessment must be conducted. This process will be carried out alongside the detailed design of the treatment plant allowing for design and operational considerations surrounding the colocation of the treatment plants to be appropriately captured and actioned.

9.1 SITE OVERVIEW

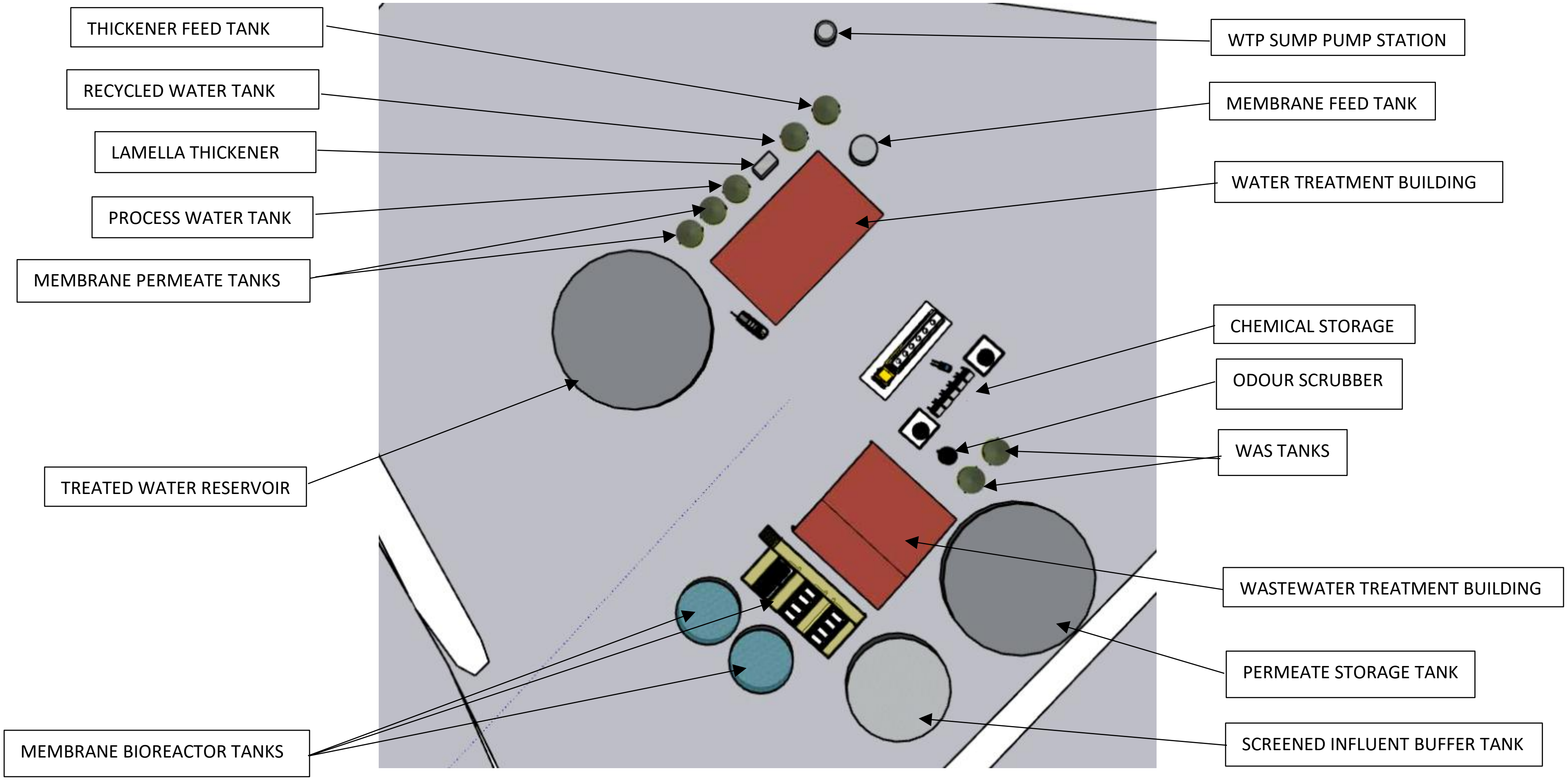

Figure 19: Proposed site layout

VISUAL RENDERS

Architectural renders of the proposed wastewater treatment plant and the associated structures can be seen in Figure 20**Error! Reference source not found.** to Figure 21 below.

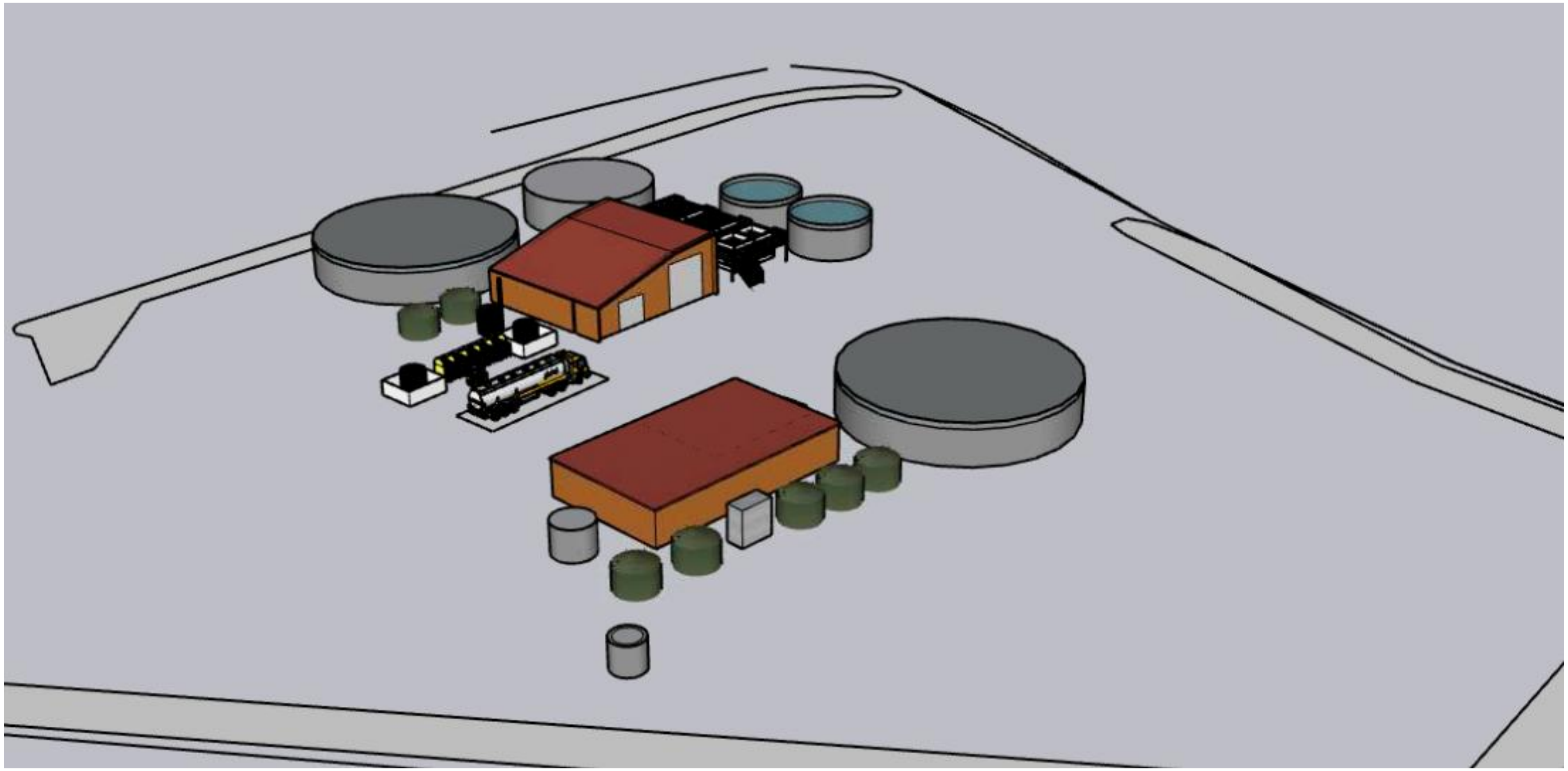

Figure 20: Northern outlook

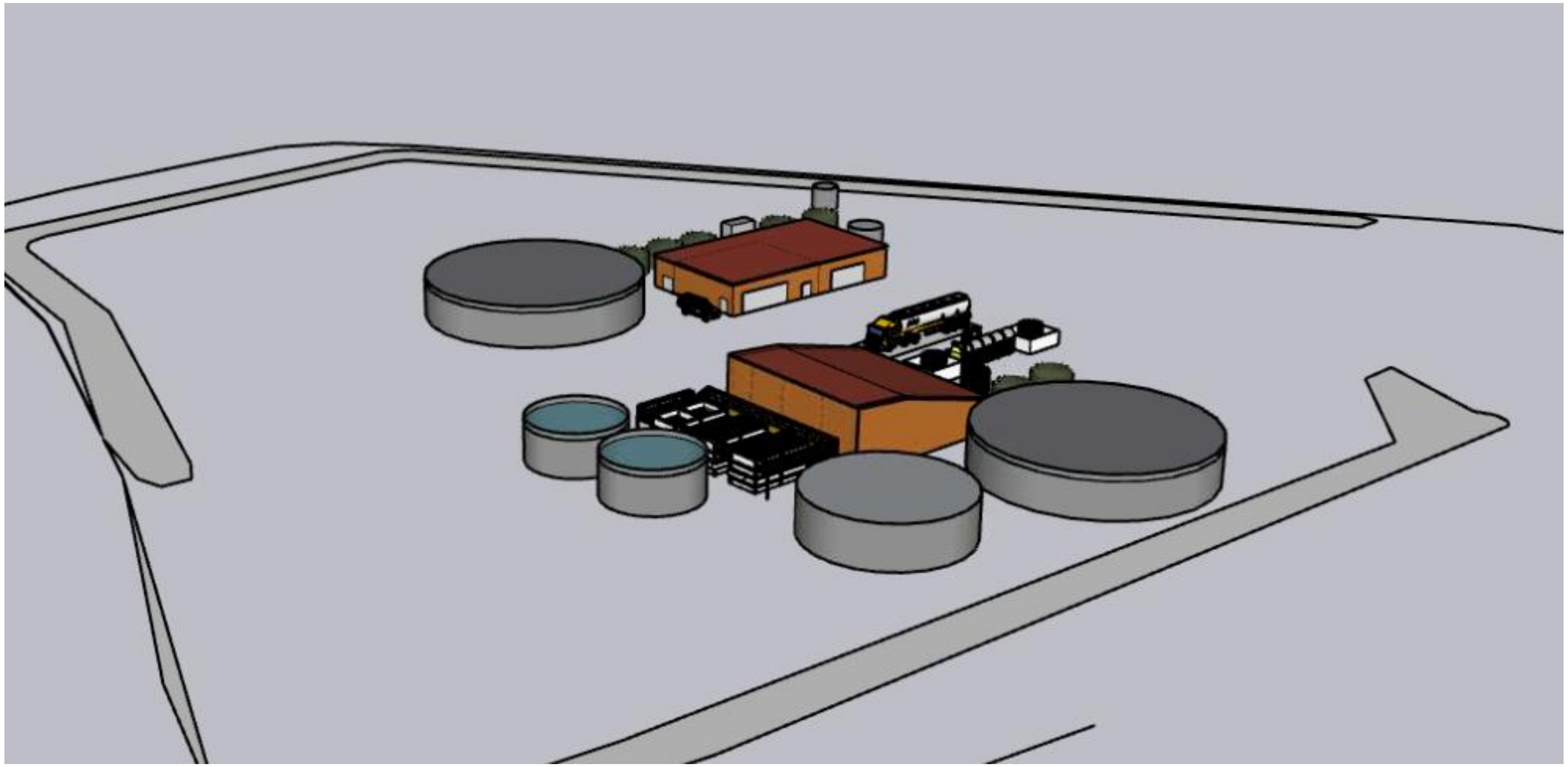

Figure 21: Southern outlook

SURFACE MAKEUP

An area of approximately 16,014 m^2 has been allocated to the treatment plant and associated infrastructure. Based on the proposed site layout, the approximate breakdown of the site coverage between impermeable surfaces including structures and permeable or landscaped areas is shown in Table 20 below.

Table 20: Surface makeup

Type of Surface	Area (m^2)
Hard surfaces (Impermeable, including roads & structures)	10,121
Landscaped (Permeable)	5,893
Total	16,014

9.2 WASTEWATER TREATMENT PLANT STRUCTURES

TREATMENT PLANT BUILDING

This building contains key equipment such as the headworks screens and dewatering system. In the context of the broader development, and the proximity of the proposed treatment plant to residential lots, noisy equipment shall be located within the treatment plant building which shall be constructed of material appropriate to the required level of noise attenuation. Alongside the key items of process equipment located within the treatment plant building, general site facilities such as the control room, toilets, and other site amenities shall be housed with separate partitions within the building. The general configuration of the proposed wastewater treatment plant building can be seen below in the figure below.

Housing equipment indoors also helps to mitigate odour emissions. This is coupled with the direct extraction of vapours from equipment handling sewage. Additionally, the entire treatment plant hall where much of the equipment can be found will be extracted to the odour scrubbing system.

Ventilation air shall be allowed into the building via sound attenuating louvres designed to minimise noise escape whilst providing minimal restriction to air passage, allowing large volume of air into the building as will be required by the odour extraction and aeration systems. The proposed wastewater treatment plant building can be seen in the figure below.

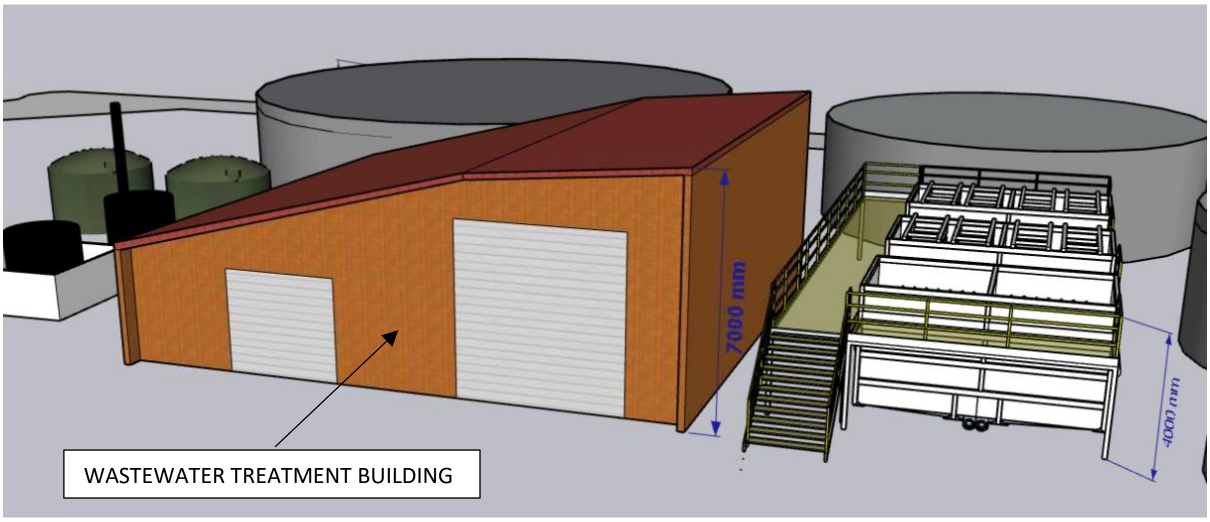

Figure 22: WWTP building visual impact

SCREENED INFLUENT BUFFER TANK AND PERMEATE TANK

The balance tank and permeate (treated wastewater) tank shall consist of sealed tanks up to a height of 4.2 m. The balance tank shall be sealed and vented to the odour scrubber system and shall be operated at a low level. The purpose of the balance tank is to buffer peak flows. The proposed balance tank can be seen in Figure 23 below.

The permeate tank is used to buffer treated wastewater discharges. By providing a large capacity for the buffering of flow, the proportion of flows discharged to land can be maximised by holding back discharges when discharge conditions are unfavourable.

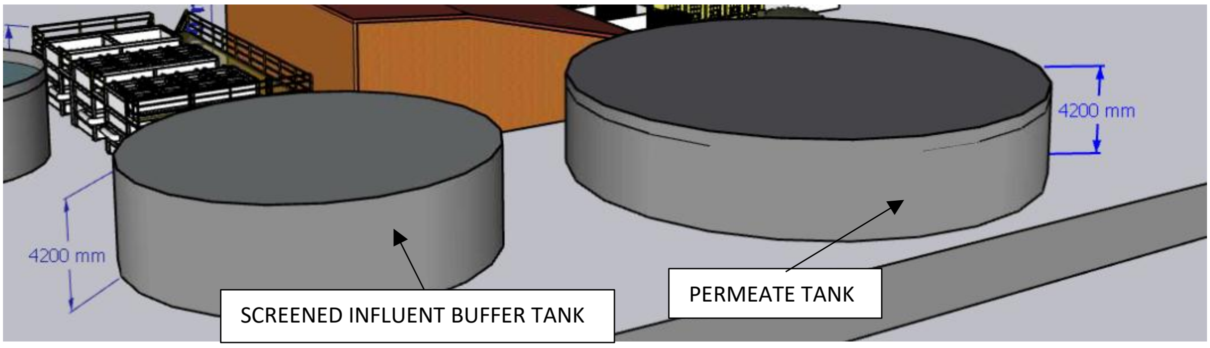

Figure 23: WWTP tanks visual impact

MEMBRANE BIOREACTOR

The biological process which is central to the treatment train consists of a series of modular, semi-relocatable tanks. These tanks house critical process equipment, such as the MABR modules and membranes, mixers, aeration equipment and are sized to provide the retention times and provide the required conditions for biological treatment.

The screened sewage passed through this process producing a very high quality permeate. The Pre-Anoxic, Post-Anoxic, the MABR modules and hollow fibre membranes housed within these are modular and can be installed in stages to suit load received by the treatment plant as the development grows. A simple render of the proposed wastewater treatment tanks can be seen in Figure 24 below.

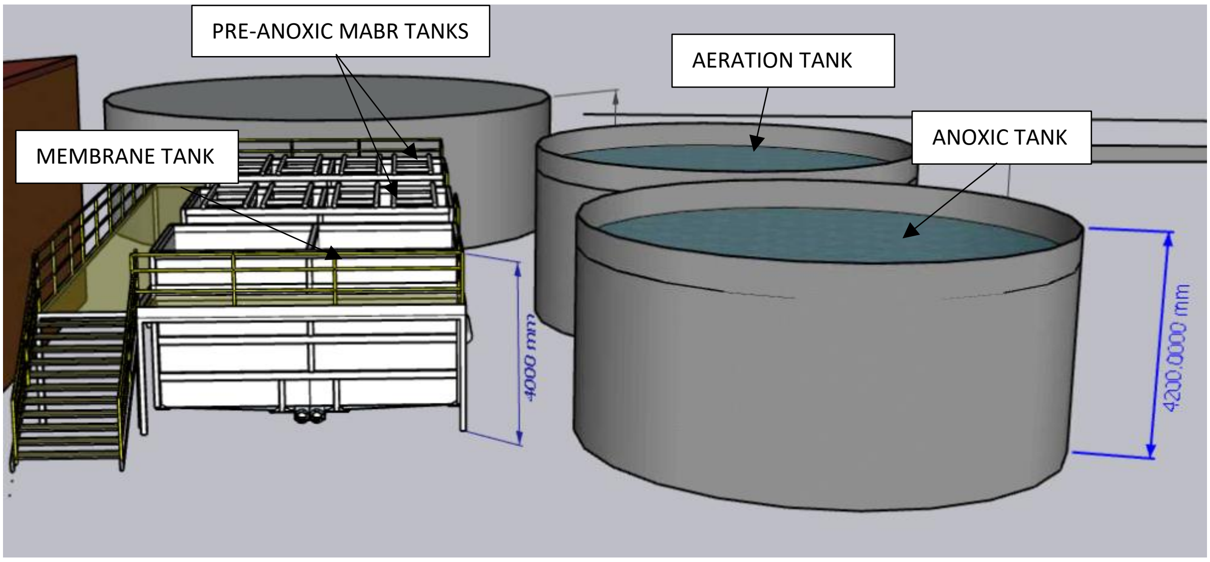

Figure 24: WWTP biological treatment process visual impact

OTHER STRUCTURES AND TANKS

The site comprises of several other ancillary features which do not make up the treatment process, but service it and the site. These include:

- The overall site apron generally consisting of an impermeable surface providing vehicle access, parking and housing stormwater diversion and handling.
- The chemical load out bay, an area separated from the overall site's stormwater system consisting of an impermeable surface constructed to allow for deliveries of the chemicals used within the treatment process while minimizing any risk to the environment or personnel from spills.
- Waste Activated Sludge (WAS) tanks, consisting of two up-to 30m^3 polyethylene tanks used for the settling of WAS which is a biproduct of the treatment process.
- Chemical storage tanks – consisting of two high density polyethylene storage tanks up-to 10m^3 in volume. These two tanks will hold solutions of Sodium hydroxide and Acetic acid required in the treatment process.
- Intermediate Bulk Storage Bunds, consisting of 6no. relocatable covered bunds, used for the storage of bulk packaged chemicals which are delivered in 1000L containers. These chemicals include Aluminium Sulphate, Sodium hypochlorite and Citric acid.
- Odour scrubber tanks and equipment typically consisting of a carbon vessel and vent stack used to draw-off and treat air from potentially odour generating areas in the process.

9.3 WATER TREATMENT PLANT STRUCTURES

TREATMENT PLANT BUILDING

The plant room for the water treatment plant can be seen in Figure 25 below. Inside this building, the main treatment process, chemical storage, and the pump skid feeding the reticulated network.

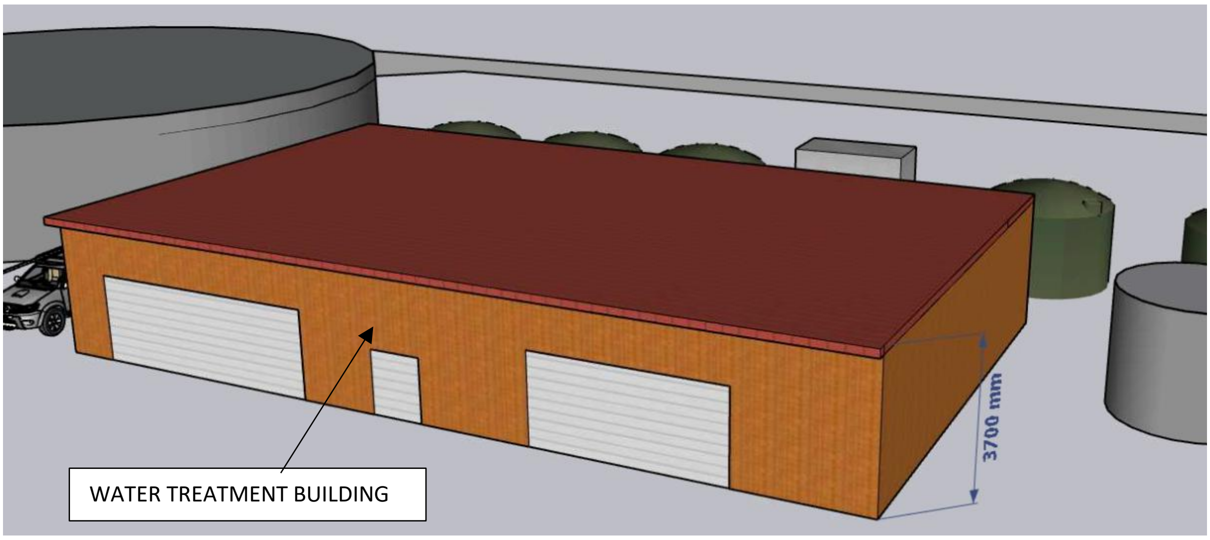

Figure 25: WTP building visual impact

TREATED WATER RESERVOIR

The treated water reservoir of approximately 1.8ML shall be located in the location shown in Figure 26 below. This tank shall be sized to ensure stages 14-17 of the development have a resilient supply of drinking water, as well as allowance for firefighting measures. Large structures such as the treated water reservoir will be screened by landscaping to minimise its visibility and integrate it with the surrounding environment.

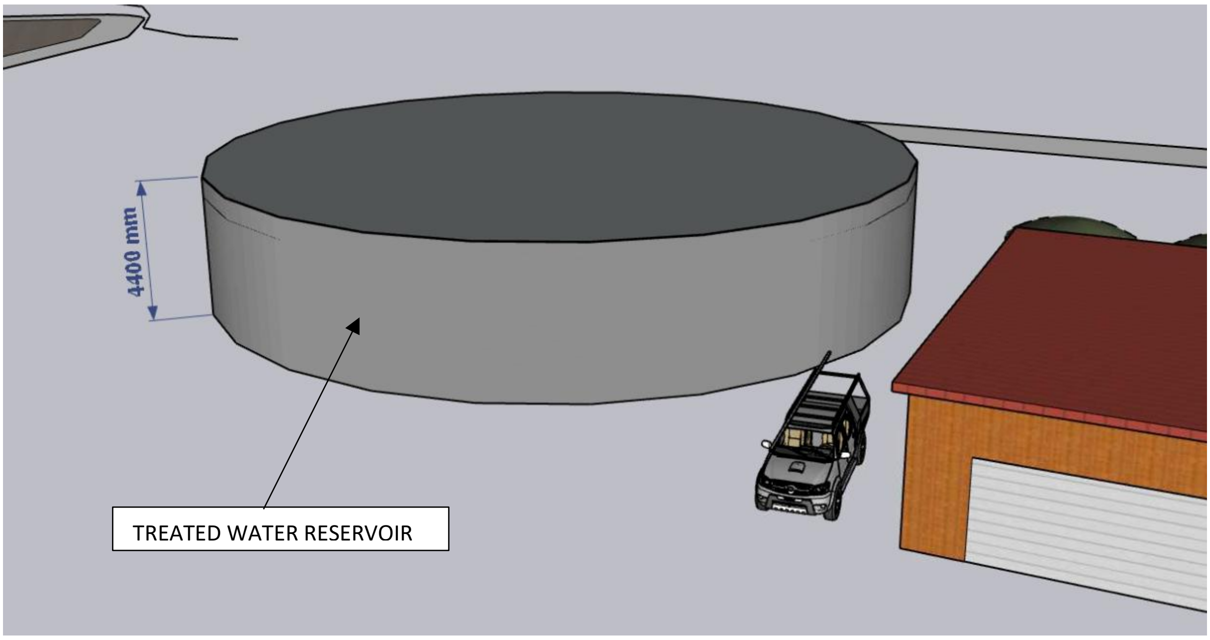

Figure 26: WTP reservoir visual impact

OTHER STRUCTURES AND TANKS

The site comprises of several other ancillary features which do not make up the treatment process, but service it and the site. These include:

- The overall site apron generally consisting of an impermeable surface providing vehicle access, parking and housing stormwater diversion and handling.

- The chemical load out bay, an area separated from the overall site's stormwater system consisting of an impermeable surface constructed to allow for deliveries of the chemicals used within the treatment process while minimizing any risk to the environment or personnel from spills.
- Membrane Feed Tank, consisting of a 30m^3 polyethylene tank used for the raw water conditioning of the surface water source. Fed by the raw water storage basin and pumped to the treatment building.
- Membrane Permeate Tanks, consisting of two up-to 30m^3 polyethylene tanks that receive UF membrane permeate dosed with super chlorinated water and caustic soda. The clear water tanks provide critical contact time for the chlorine dosing.
- Waste Residuals System consisting of a thickener feed tank, lamella thickener, recycled water tank, and site sump pump station. Fed by the residuals of the UF membrane concentrate and backwash systems inside the treatment plant building. The thickener feed tank pumps to the lamella thickener from which clarified residual water overflows into the recycled water tank. Thickened sludge from the lamella thickener is sent to the WWTP via the site sump pumps and the recycled water is returned to the start of the WTP.
- Process Water Tank consisting of a 30m^3 polyethylene tank that receives treated water to be used for backwashing systems of the membranes and filters.

10. REFERENCES

Bear, M. (2026). *Milldale North - Water Demands Sensitivity Study*. Woods.

Chen, Z., & Roberts, G. S. (2021). *On-site Wastewater Management in the Auckland Region. Auckland Council Guideline Document, GD2021/006*. Auckland Council.

Environment Protection and Heritage Council; Natural Resource Management Ministerial Council; Australian Health Ministers' Conference. (2006). *Australian guidelines for water recycling: Managing health and environmental risks (Phase 1)*. *National Water Quality Management Strategy*.

GHD Limited. (2015). *Infiltration & Inflow*. Wellington: Water New Zealand.

Good, A. (2026). *Assessment of Surface Water Quality Effects*.

Good, A., & Allen, G. (2026). *Milldale North Wastewater Discharge: Downstream Water Quality Effects and Treatment Implications*. Viridis Environmental Consultants.

Hunt, O., Walker, K., O.Neill, E., & Brockbank, T. (2021). *Wastewater Disposal and the NPS-FM 2020: What does the future look like?* Water New Zealand.

James, B. (2026). *WWLA Report Milldale Stage 14-17 Soil Infiltration Testing*. WWLA.

James, B., & Williamson, J. (2026). *Treated Water Cascading Wetland*.

Kirk, S. (2026). *Milldale North Fast Track Water Infrastructure*. Woods.

Kirk, S. (2026). *Proposed Disposal Fields, Offset Wetlands and Water Infrastructure Sites*. Woods.

New Zealand Government. (2022). *Water Services (Drinking Water Standards for New Zealand) Regulations 2022*.

New Zealand Government. (2025). *Water Services (Wastewater Environmental Performance Standards) Regulations 2025*.

NIWA. (2022). *Constructed Wetland Practicioner Guide - Design and Performance Estimates*. New Zealand: DairyNZ Ltd.

Tasca, B., & Williamson, J. (2026). *Milldale North - Surface Water Potential for Community Water Supply*. WWLA.

Taumata Arowai. (2022). *Aesthetic Values for Drinking Water Notice 2022*.

Taumata Arowai. (2022). *Drinking Water Quality Assurance Rules 2022*.

Watercare. (2021, November 29). *How we calculate charges*. Retrieved from Watercare: https://www.watercare.co.nz/Manage-account/Our-charges/How-we-calculate-our-charges

Watercare Services. (2021). *Water and Wastewater Code of Practice for Land Development and Subdivision*.

Williamson, J. (2026). *Bore Step Testing*. WWLA.

Williamson, R. B. (1993). *Urban Runoff Data Book: A Manual for the Preliminary Evaluation of Urban Stormwater Impacts on Water Quality*. Hamilton, New Zealand: Water Quality Centre, Ecosystems Division, National Institute of Water and Atmospheric Research, 1993.