GWE
CONSULTING ENGINEERS

WASTEWATER RETICULATION AND WWTP CONCEPT DESIGN

110 Jack Lachlan Drive Beachlands, Auckland

BEACHLANDS SOUTH LIMITED PARTNERSHIP

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Creative Thinking | Better Environments

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EXECUTIVE SUMMARY

Beachlands South Limited Partnership (BSLP) has engaged GWE Consulting Limited (GWE) to develop a concept design for the reticulation and wastewater treatment plant (WWTP) to service the proposed Beachlands South private plan change (PPC) area which will rezone approximately 307 hectares of land from Rural Countryside Living to a series of live zones (LZ) and an area of future urban zone (FUZ).

As part of the process, GWE undertook an options assessment to determine viable options, taking into account site-specific factors including:

- General site topography
- Receiving environments
- Potential for staging
- Operational complexity and reliability
- Ease of construction
- Technologies that are well recognised within NZ and consistent with current and emerging best practice technologies

A low-pressure sewer system (LPSS) was determined to be the preferred reticulation option for the development as it provided substantial benefits over alternative reticulation methods due to its suitability for catchments with varying topography and the nature of its installation/construction minimising inflow and infiltration (I&I) related flows. LPSS systems have been successfully used in a number of developments across New Zealand, with the design, construction and maintenance of the system well understood within the New Zealand wastewater industry.

A high-level assessment of the available wastewater treatment options was undertaken, including a review of the existing Beachlands-Maraetai WWTP. The WWTP was identified to currently have insufficient capacity to service the proposed LZ PPC area development, with no existing plans for an expansion, thus a standalone treatment option was pursued for the PPC.

However, there is a potential opportunity to provide a combined wastewater solution for both the PPC area development and Beachlands as a whole. This would require further discussions with Watercare Services Limited (Watercare) to achieve this possible outcome.

A membrane bioreactor (MBR) treatment plant was identified to be the most viable wastewater treatment option to service the development. MBR treatment systems are able to reliably provide a high degree of contaminant removal, including nutrients and are expected to outperform alternative treatment technologies while maintaining a small footprint. MBR's are a maturing, robust and well understood technology that is increasingly being employed across NZ and accepted by Watercare where best-practice treatment is required, particularly for discharges to sensitive receiving environments.

A high-level assessment of suitable wastewater disposal options was also undertaken. There are a number of feasible wastewater disposal options for the PPC area, including the disposal of treated wastewater to land or disposal to a permanent stream in the western catchment and subsequently to the coastal marine area.

A summary of the proposed options is provided below. Each of the options are considered to be feasible.

1. Tertiary polishing wetland near the existing ponds on the 9-hole golf course and disposal over the 9-hole golf course land and part of the FUZ land.
2. Tertiary polishing wetland at the head of the western gully followed by discharge into the permanent stream in the western gully and subsequently to the coastal marine area.

Based on the identified key factors, options analysis and site-specific constraints, the PPC can be viably serviced for wastewater through the solutions identified in this report and no constraints have been identified that would suggest the land within the PPC area is not suitable for urbanisation.

The PPC also includes a standard that requires adequate water supply and wastewater infrastructure to be provided at the time of time subdivision or development. This standard ensures development will not progress without the necessary wastewater infrastructure. This provision is supported and is considered the most appropriate method to ensure the wastewater treatment and disposal requirements of future occupants of the precinct are coordinated with development and provided when needed.

GWE will undertake specific detailed design of the preferred option when applying for the wastewater resource consent. This will include:

- Undertaking further investigations and confirming the preferred wastewater disposal route. Undertake preliminary engineering design for all wastewater infrastructure elements, an assessment of environmental effects and associated stakeholder engagement.
- Preparing consent application documents and lodge for the required consents (discharge to water, land and air).
- Undertaking detailed design for all wastewater infrastructure aspects, refine CAPEX/OPEX costs and continue to undertake key stakeholder consultation.

1 INTRODUCTION

This report has been prepared in support of the Proposed Private Plan Change (PPC) by Beachlands South Limited Partnership (BSLP) to rezone approximately 307 hectares of Rural Countryside Living zoned land to a series of live zones (LZ) and an area of future urban zoning (FUZ).

The part of the PPC area owned and controlled by BSLP, comprises of approximately 255 hectares of coastal land made up of the Formosa Golf Resort (110 Jack Lachlan Drive) and rural-residential properties (620 and 712 Whitford-Maraetai Road). The PPC area does not have any current public drinking water or wastewater servicing.

The development is proposed to be undertaken in seven stages, with the final design horizon (including the land to be zoned future urban under the PPC) understood to be 3,810 housing unit equivalents (HUEs) with additional minor commercial, community, employment areas, school, a hotel and mixed-use developments.

BSLP has engaged GWE Consulting Limited (GWE) to carry out a high-level options assessment and develop a concept design for the reticulation and wastewater treatment plant (WWTP) to service the proposed Beachlands South PPC area.

The nominated options and design for the reticulation and WWTP will focus on solutions that are robust and proven within a New Zealand context. The design, approach and philosophy of the overall reticulation and treatment system, in conjunction with assessments undertaken by others, including an ecological assessment, are expected to ensure the effects of the wastewater discharge are less than minor.

2 SCOPE OF WORK

GWE's scope of work includes the following:

- Determine wastewater design flow volumes and provide a high-level characterisation of influent raw wastewater.
- An assessment of suitable wastewater reticulation models for the proposed development.
- An assessment of centralised and decentralised wastewater management strategies.
- An assessment of the suitable wastewater treatment options, including high-level site-specific concept design of GWE's recommended option.
- Concept design validation.
- Indicative effluent quality requirements based on the proposed discharge route(s).
- Specialist and technical reports and input into the plan change application.
- Assessment suitable secondary/tertiary treatment options and develop PFD's, site layouts and sizing.

The following items are outside the scope of our engagement:

- Assessment of Environmental Effects (AEE) and ecological assessments for any future resource consents.
- Stakeholder and community consultation.
- Topographical and geotechnical surveys and assessments.
- Cost estimates.
- Distribution and pumpstation calculation and analysis.
- Consents and permits.

3 EXISTING ENVIRONMENT

3.1 Project Location

The Beachlands South PPC area comprises of approximately 307 hectares of coastal land largely made up of the Formosa Golf Resort (110 Jack Lachlan Drive) and rural-residential properties (620 and 712 Whitford-Maraetai Road). The other properties within the PPC area are generally lifestyle blocks with single residential dwellings.

The PPC area is located on the southern side of Jack Lachlan Drive and adjoins the thriving community of Beachlands, to the north. Refer to Figure 1 for a locality plan.

Topography across the site is variable but generally gently slopes towards the coastal edge before sloping steeply, over a low scarp, towards the CMA. The overall Beachlands South PPC area catchment contains a number of tributaries which generally flow towards the coastline.

Figure 1: Locality Plan – Beachlands South Overall Development Area

3.2 Background

3.2.1 Surrounding Area

The wider environment covers the Beachlands and Maraetai areas.

Beachlands is a coastal village located east of the existing Manukau urban areas and was established in the 1920s. Development in the area increased in the following years due to its proximity to several beaches and bays.

Maraetai is a town located to the east of Beachlands and is similar in nature to the Beachlands Village area in terms of its coastal context.

Historical developments in the Beachlands area are largely characterised by grid-based roading layouts, low-density character with typically rectangular shaped allotments and minimal rear site development.

More recent development in the area includes the Beachlands 1 Precinct development (covering 122 ha of land between the Beachlands Village area and Jack Lachlan Drive).

3.2.2 Existing Wastewater Servicing – Beachlands-Maraetai WWTP

The existing Beachlands and Maraetai areas, including the Beachlands 1 Precinct development are serviced by the Beachlands-Maraetai wastewater treatment plant (WWTP). The WWTP is located at 100 Okaroro Drive, Beachlands; approximately 3 km from the Beachlands PPC area.

The Beachlands WWTP is designed to cater for a population of 10,000 people, with the associated discharge consent limit being 2,800 m^3/day, understood to expire in 2025. The WWTP utilises an activated sludge process with biological nutrient removal (BNR) capacity (a 4-stage Bardenpho process) with filtration and UV disinfection. Treated effluent is discharged into the Te Puru Stream.

GWE understands the Beachlands WWTP currently services over 9,100 persons, close to its design capacity. Watercare has not identified any plans for an upgrade to the capacity of the Beachlands WWTP thus it currently cannot service the proposed Beachlands South PPC area development within the short-term horizon. However, it is expected that investigations into future capacity upgrades will occur prior to the consent renewal as it is projected the area currently serviced by the WWTP will continue to develop, necessitating an upgrade.

4 PROPOSED DEVELOPMENT

4.1 Site Plan and Description

The development of the PPC area will proceed in multiple stages. Each Stage is detailed in the structure and precinct plans prepared by JASMAX[1]. The PPC provides for the live zoning and future urban zoning.

The development will comprise a mix of housing types including 5/6-storey apartments, 3-storey walk-up apartments, 2-storey terraced housing (narrow, large and detached), stand-alone houses (medium, large and extra-large), live-work units, retirement villas and apartments as well as light industrial development. In addition, there will be a school, hotel, golf, commercial offices and retail. The details for both the LZ and FUZ are provided in the table below.

Table 1: Development Details

HOUSE TYPE	UNITARY PLAN ZONE	HOUSEHOLD UNIT EQUIVALENT (HUE) LIVE ZONE (TOTAL)	HOUSEHOLD UNIT EQUIVALENT (HUE) FUTURE URBAN ZONE (CUMULATIVE TOTAL)*	TYPICAL FOOTPRINT / ROOF AREA (m2)
5/6-storey lifted apartments	THAB	1,139	1,139	936
3-storey walk-up apartments	Mixed Housing Urban	432	452	528
2-storey terraced housing – narrow lots	Mixed Housing Urban	223	223	49.5
2-storey terraced housing – larger lots	Mixed Housing Urban	334	409	78
2-storey zero-lot or duplex housing	Mixed Housing Urban	328	565	96
Standalone houses – medium	Mixed Housing Urban	191	386	120
Standalone houses – large	Mixed Housing Urban	77	404	180
Standalone houses – extra large	Large Lot Residential	-	38	300
Live-work units		28	28	49.5
Retirement villas		71	71	180
Retirement apartments		25	2	528
Light industrial (112 m^2)		70	70	
HUE's Total		**2,918**	**3,810**	
Other Uses				

[1] Structure & Precinct Plans

HOUSE TYPE	UNITARY PLAN ZONE	HOUSEHOLD UNIT EQUIVALENT (HUE) LIVE ZONE (TOTAL)	HOUSEHOLD UNIT EQUIVALENT (HUE) FUTURE URBAN ZONE (CUMULATIVE TOTAL)*	TYPICAL FOOTPRINT / ROOF AREA (m2)
Golf (100 people)				
Hotel (300 guests, 30 staff)				
School (1000 students, 150 teachers)				3,000
F&B (micro-brewery, restaurant, wine bar, multi-purpose pavilion)				1,810
Retail				2,515
Metromarket				1,800
Innovation Hub and Commercial				5,095
Service / Light Industry (600 people)				

Note:
**The HUE's totals are cumulative with the Live Zone, therefore there are no additional 5/6 storey lifted apartments within the Future Urban Zone, only 20 3-storey walk ups, etc.*

The final development horizon (including the land to be zoned future urban) is understood to be 3,810 HUE's based on the plans provided to GWE. For the purposes of wastewater design, GWE have adopted a final design horizon of 4,000 HUEs.

An additional wastewater flow allowance of 15% has been allowed to cover commercial, community and mixed-use development, including schools and village/neighbourhood centres.

5 WASTEWATER RETICULATION OPTIONS

5.1 Options Considered

A number of reticulation options were evaluated for the Beachlands South PPC area including:

- Conventional Gravity Sewer System
- Septic Tank Effluent Pumping/Gravity (STEP/STEG)
- Vacuum Sewer System
- Low Pressure Sewer System (LPS)

The options were evaluated based on a series of site-specific key factors (refer to Section 5.5).

5.2 Conventional Gravity Sewer

Conventional gravity sewer (CGS) systems utilise elevational differences to transfer wastewater. CGS systems are well documented and are the most common method of sewage reticulation in New Zealand and worldwide.

CGS systems are typically simple, reliable and are well understood by regulatory and government agencies. However, owing to their nature as a gravity system, larger pipe sizes are needed in comparison to alternative reticulation options. Specific engineering design attention is required in relation to the pipework slope requirements to ensure adequate flow (and flushing velocities) are provided for. CGS systems also require manholes at intersections, changes in grade, direction and at regular intervals (typically 100-150 m).

The installation of the larger gravity mains can be challenging, requiring extensive temporary works and larger machinery. Trenchless installation options may not be suitable where short lengths of pipework are required between manholes.

CGS systems can require deep excavations to ensure the required slope is maintained and varying topography can require a number sewage pumpstations, significantly increasing the cost of the overall reticulation network. Owing to the general overall topography of the Beachlands South PPC area, it is expected that a number of pumpstations would be required for a CGS system.

CGS systems do not offer any form of treatment prior to a wastewater treatment plant (WWTP) and can suffer from significant infiltration and inflow (I&I) induced flows, particularly on-lot I&I which can be difficult to identify and resolve. I&I flows in CGS systems require substantial peaking factors to be adopted in design when compared to alternative reticulation systems. I&I flows can substantially increase the demands on treatment infrastructure, increasing WWTP sizing requirements and thus costs and can potentially lead to non-compliances due to overflows.

Overall, a CGS system is expected to be unsuitable for the Beachland’s PPC area due to the potential I&I and overall topography of the PPC area when compared with alternative reticulation options

Table 2 summarises the CGS system.

Table 2: CGS Summary

PROS	CONS
Well understood by regulatory authorities and the NZ wastewater industry.	Significant I&I requiring substantially larger unit processes at the WWTP, increasing the costs and footprint of the WWTP.
Lower on-lot requirements. No requirement for on-lot pump out of tanks etc.	Requires a number of pumpstations to transfer effluent to the WWTP, significantly increasing costs.
Power outages will not affect individual lots (although the operation of the pumpstations can be affected if no back-up/generator is provided).	Higher potential for non-compliances during periods of very high I&I related inflows.

PROS	CONS
Very reliable with minimal overall power requirements.	Substantially larger pipe sizes in comparison to pressure-based reticulation options significantly increases costs.
Fewer overall components within the reticulation system.	The general topography in the area can necessitate installations at substantial depths, significantly increasing the complexity of construction (due to dewatering requirements, trench stability etc.). Breakages can be difficult and expensive to repair.
No public education necessary to ensure blockages or maintenance problems are avoided.	Exfiltration/leaks within the reticulation (due to ground movement or accidental damage) may go unnoticed for long periods of time.
	Longer hydraulic retention times (HRTs), especially in the earlier phases of the development leading to a greater risk of odour and hydrogen sulphide generation & corrosion.
	Can potentially constrain the location of the WWTP

5.3 Pressure Sewer Systems

Pressure sewer reticulation networks typically utilise HDPE pipework with fusion welded connections, significantly reducing I&I flows and reducing the sizing requirements and demands on downstream infrastructure. The alignment and grading requirements of the sewer main can be relaxed and it can more closely follow the topography of the area. This also provides additional flexibility in siting the WWTP facility as it is less dependent on its final elevation.

Pipes can also be installed within shallow, narrow trenches (typically 600mm below ground level (bgl)) to reduce construction costs and prevent issues with crossing other services including stormwater, power and communications services. For staged developments, pressure sewer systems typically offer lower upfront capital costs.

As wastewater can remain within the overall pressure system for extended periods of time, waste can become septic, potentially leading to odours and hydrogen sulphide (H_2S) induced corrosion at the early stages of development (for concrete and any cast iron structures). However, it is noted that in a staged development, a gravity sewer is likely to encounter the same issue as the system must be installed to handle the final development horizon flows, resulting in long retention times in the reticulation network during the initial development stages. This can be managed and minimised through the use of activated carbon filters (common in NZ) and the selection of suitable materials (HDPE/PVC) for reticulation infrastructure.

5.3.1 STEP/STEG

STEP/STEG systems consist of a concrete, plastic or fibreglass tank that acts as a septic tank, with effluent either pumped (STEP) or transferred under gravity where possible (STEG). Each household requires a STEP/STEG tank, which requires periodic desludging, often every 3 to 5 years depending on tank sizing and solids accumulation. The tanks also include emergency storage, providing sufficient time for emergency works in the event of an issue.

STEP/STEG systems can significantly reduce outlet $cBOD_5$, TSS and O&G concentrations, reducing the potential for clogging within the rising main.

Due to the reduced contaminant load entering into the downstream WWTP, key unit processes including primary sedimentation can potentially be reduced or removed. However, the removal of carbon ($cBOD_5$) can compromise biological nutrient removal processes (particularly nitrogen as it is not reduced in any appreciable quantity within the STEP tank) as it can affect the Carbon:Nitrogen ratio (C:N), likely requiring the WWTP to dose supplementary carbon (typically molasses or methanol) into the wastewater prior to secondary treatment.

Owing to the potential discharge routes and the demands imposed under the current regulatory framework, the Beachland's South WWTP is expected to be required to achieve a high degree of nutrient removal (both nitrogen and phosphorus). As such, a STEP system is not expected to be optimal given its removal of carbon prior to the WWTP.

Table 3 summarises the STEP system.

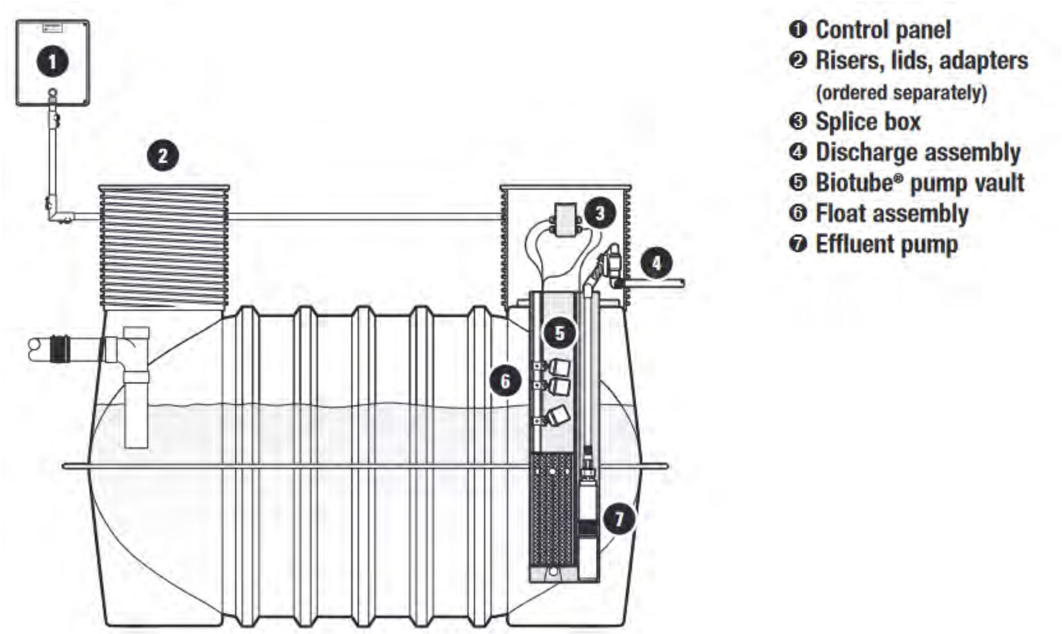


Figure 2: Standard STEP Tank Components

Source: Orenco ProSTEP Installation Manual

Table 3: STEP Summary

PROS	CONS
Little/no I&I related flows, substantially reducing the required unit process sizing of the WWTP & associated costs.	Higher on-lot requirements. STEP tanks require periodic desludging (every 3-5 years). Neglecting this requirement can adversely affect the operation of the on-lot unit.

PROS	CONS
Not expected to require any pumpstations to transfer effluent to the WWTP.	A STEP reticulation system removes a substantial amount of carbon which is required for treatment processes at the WWTP.
Significantly smaller reticulation pipe sizes and fewer manholes required in comparison to a gravity option.	Power outages may affect individual lots (although 24 hours emergency storage is provided within the STEP tanks)
Significantly less reliant on the topography in an area, providing flexibility in siting the WWTP.	Some education of the general public required to ensure blockages or maintenance issues are resolved.
Material and trenching costs are substantially lower than gravity options as the pipe size and depth requirements are reduced. Substantially cheaper to install in areas with high groundwater.	More components within the reticulation system.
Generally lower HRTs can assist with reducing the potential for odour problems.	
Generally a very reliable system.	
Utilised in a number of developments across NZ.	

5.3.2 Low Pressure Sewer

Similar to STEP/STEG systems, a low-pressure sewer system (LPSS) utilises on-site pump chambers at each property. However, LPSS's have significantly smaller chambers as they do not provide any primary treatment and instead utilise grinder pumps to transfer wastewater. These pumps grind the household wastewater into a slurry and pump it into the sewer main.

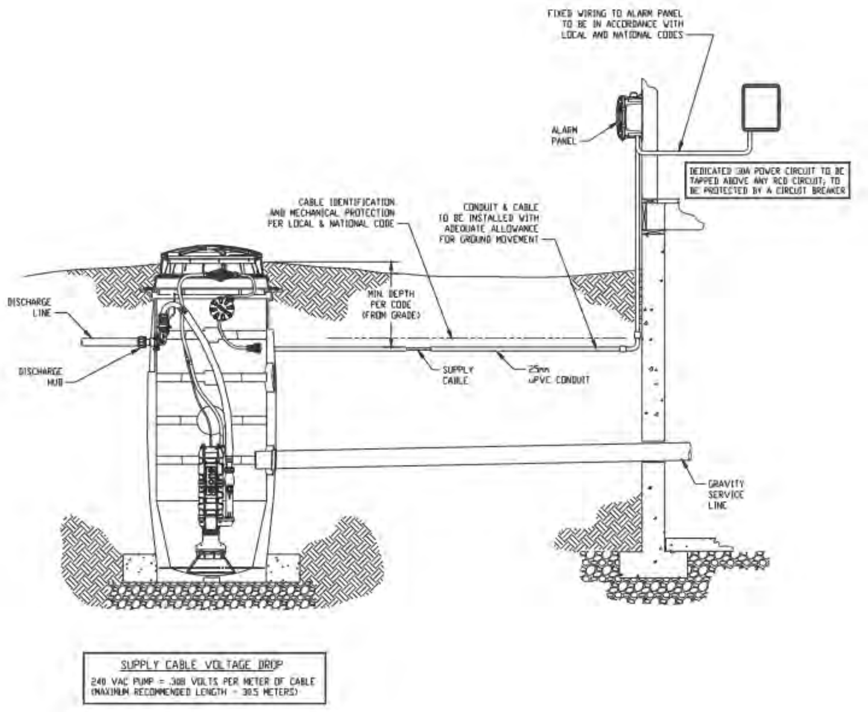


Figure 3: Typical LPSS Chamber Installation

Source: E/One Sewer Systems Installation Manual

Table 4 summarises the LPS system.

Table 4: LPS Summary

PROS	CONS
Little/no I&I related flows, substantially reducing the required unit process sizing of the WWTP & associated costs.	Higher on-lot requirements.
Not expected to require any pumpstations to transfer effluent to the WWTP.	Power outages may affect individual lots (although 24 hours emergency storage is provided within the on-lot tanks)
Significantly smaller reticulation pipe sizes and fewer manholes required in comparison to a gravity option.	Some education of the general public required to ensure blockages or maintenance issues are resolved.
Significantly less reliant on the topography in an area, providing flexibility in siting the WWTP.	More components within the reticulation system.
Material and trenching costs are substantially lower than gravity options as the pipe size and depth requirements are reduced. Substantially cheaper to install in areas with high groundwater.	Typically higher power requirements than a STEP system owing to the use of a grinder pump.
Generally lower HRTs can assist with reducing the potential for odour problems.	
Generally a very reliable system. Grinder pumps are more rugged than STEP pumps.	
Utilised in a number of developments across NZ.	
Potential for "smart" pressure sewer capability that enables remote control, assists with managing diurnal flows, trend analysis, monitoring and can alert service providers in the event of an issue.	

5.4 Vacuum Sewer Systems

With vacuum sewer systems, wastewater from each dwelling flows into a sump. Once a sufficient level of waste is received, wastewater is transferred under a vacuum into the sewer main. The vacuum mains are typically laid in a 'saw tooth' profile, with the vacuum itself generated by a vacuum pump station. I&I flows are generally negligible with vacuum systems when constructed with fusion welded HDPE (or similar materials).

The retention times in vacuum sewers is typically lower than alternative reticulation options, lowering the potential for waste to become septic (leading to odours and corrosion within the network).

However, owing to their nature, vacuum systems are heavily limited in terms of their permissible hydraulic lifts and are generally not suitable to service catchments containing large elevation differences, being mostly suitable to flat or slightly sloping sites.

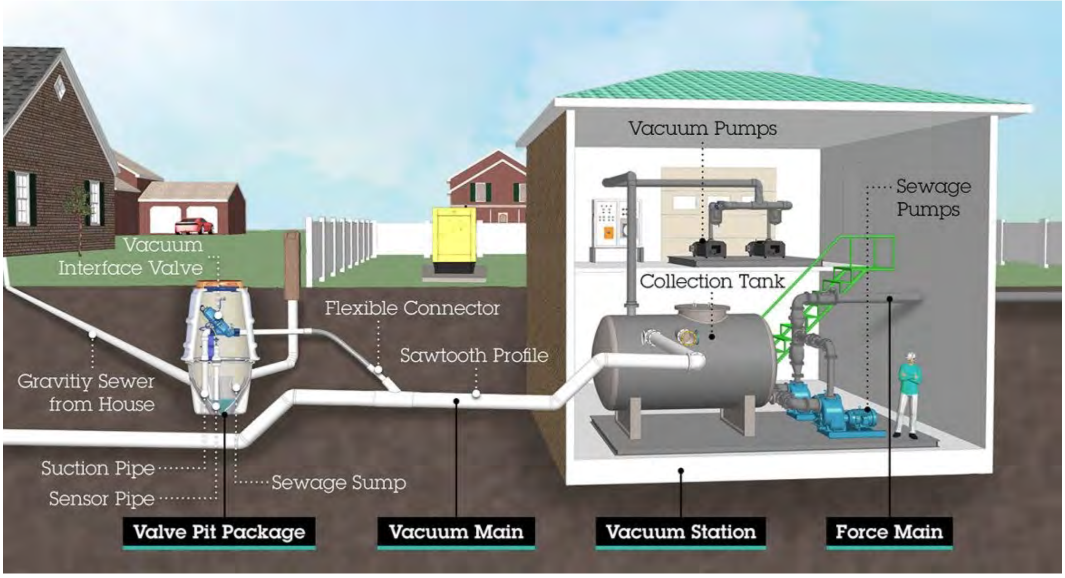


Figure 4: Typical Vacuum Sewer System

Source: Quality Site Work Manufacturer Spotlight - Airvac Vacuum Sewer Systems

Table 5 summarises the vacuum sewer system.

Table 5: Vacuum Sewer Summary

PROS	CONS
Utilised within a number of developments across NZ.	Highly reliant on the catchment's topography. The Beachland's PCC area contains varying topography and is generally unsuitable to enable a cost-effective vacuum sewer system.
Power outages will not affect individual lots (although the operation of the vacuum pumpstations can be affected if no back-up/generator is provided).	Operated differently to pressure and gravity systems, requiring specific training.
Minimal I&I, reducing demands on downstream wastewater infrastructure.	Strict construction tolerances required to ensure the system performs as intended.
Breakages in the pipe will cause infiltration into the reticulation network, rather than leakages.	
Material and trenching costs are substantially lower than gravity options as the pipe size and depth requirements are reduced. Substantially cheaper to install in areas with high groundwater.	
Generally lower HRTs can assist with reducing the potential for odour problems.	
Generally a reliable system.	

5.5 Preferred Reticulation Option

Options were evaluated on the basis of specific key factors to the Beachlands South PPC area including:

- General Site Topography
- Potential for Staging
- Operational Complexity and Reliability
- Requirement for Separate Pumpstations
- Potential for Infiltration and Inflow (I&I)
- Municipality Perception (Watercare Services Limited) – Potential for Vested Assets
- Expected WWTP Process Units
- Flexibility and Constraints on the Viable Locations for the WWTP(s)
- Existing Local and Wider Area Reticulation Models

Owing to the varying topography across the overall catchment, a pressurised reticulation solution was determined to have significant advantages over the alternatives.

The potential discharge routes and receiving environment (Refer to Section 10.0) is expected to require the provision of best practice treatment, including substantial nutrient removal. As such, pressurised reticulation options including STEP which reduce elements necessary for biological nutrient removal, namely carbon, were discounted.

An LPS reticulation solution was therefore determined to be the most practical option based on the identified characteristics, key factors and the proposed membrane bioreactor (MBR) WWTP (Refer to Section 7.2.4).

6 LOW PRESSURE SEWER SYSTEM

6.1 On-Lot Equipment

An LPS system requires the following equipment to be installed on each lot:

- Pump chamber including discharge grinder pump, valves and control system – the tank is located on the property owner's land, with the control panel typically located within the dwelling.
- Pressure sewer boundary kit including isolation valve and non-return valve. This equipment is normally installed at the same time as water/power/communications is provided.

Pump chambers are to be sized to suit the on-lot development, with several standard chamber volumes available. Commercial or industrial lots may require multiple chambers or a custom chamber to be installed.

6.2 Reticulation Concept Design

The concept design of the LPS reticulation will be undertaken at a later date as part of the work required for the overall master plan by GWE Consulting Ltd utilising E/One (or similar) pressure sewer technology, widely used throughout New Zealand. The concept design will primarily focus on the sizing of the reticulation sewer mains, with preliminary and detailed design to cover laterals and on-lot connections.

The reticulation system will be divided into zones, with isolating valves provided at boundaries to enable individual pipework sections to be isolated for maintenance/repairs. End of line flushing points and scour valves will be provided to ensure maintenance can be carried out.

A high-level assessment of the Beachland's South PPC area has identified that intermediate pump-stations are not required as the elevation changes and distances are expected to be serviceable without additional reticulation pump-stations although this will be re-assessed in subsequent design and consenting stages. A concept layout for the scheme has been provided in Appendix A.

The LPS reticulation system can also incorporate smart controllers which can provide on-line monitoring and control of the network, potentially reducing instantaneous peaks flows transferred to the WWTP. This can be further investigated during subsequent design stages.

7 WASTEWATER TREATMENT OPTIONS

7.1 Beachlands-Maraetai WWTP

As identified in Section 3.2.3, the existing Watercare Beachlands-Maraetai WWTP is operating close to its design capacity (10,000 persons) and Watercare have not identified any current plans to upgrade/expand the WWTP to allow for additional connections.

A high-level assessment using an allowance of 3.0 persons per HUE identifies that the Beachlands-Maraetai WWTP is currently suitable for approximately 3,300 HUEs.

The proposed Beachlands South PPC live zone and future urban zone provides 2,918 and 3,810 HUEs (excluding commercial etc. development), respectively and would represent a substantial increase in demand, well outside the current capacity of the Beachlands-Maraetai WWTP.

As such, an independent wastewater treatment option was pursued for the live zone. However, it is noted that an expansion to the Watercare Beachlands-Maraetai WWTP to accommodate the flows from the Beachlands South PPC area is expected to be feasible but would require discussions and negotiations with Watercare.

7.1.1 Expansion to the Beachlands-Maraetai WWTP

The Beachlands-Maraetai WWTP is a BNR based WWTP with tertiary filtration and disinfection. An expansion to the WWTP to accommodate the flows from the Beachlands South PPC area could involve the installation of a parallel BNR based treatment process or the installation of a more modern treatment process e.g. MBR.

7.2 Centralised and Decentralised Options

A centralised wastewater treatment solution is characterised by a single large-scale WWTP, capable of servicing the entire development catchment.

A decentralised wastewater treatment solution is characterised by a series of smaller, individual WWTPs, each serving a specific area of the development.

A centralised WWTP is proposed for the Beachlands South PPC area to ensure a single coherent solution that is consistent with modern best practice wastewater treatment technology.

7.3 Wastewater Treatment Options Considered

Similar to the reticulation options assessment, GWE evaluated the available treatment options on the basis of specific key factors to the Beachlands South PPC area including:

- Ease of construction
- Operational complexity
- Reliability
- Potential for staged upgrades
- Ability to meet stringent current and potential future effluent quality targets (long-term discharge security)
- Use of technologies that are common within a NZ context and consistent with current and emerging technologies

GWE evaluated a number of WWTP treatment train process options including:

- Sequential Batch Reactor (SBR) based WWTP
- Conventional Modified Ludzack-Ettinger (MLE) based WWTP
- Membrane Bioreactor (MBR) based WWTP

NOTE - An oxidation pond based WWTP, while widely used across NZ, was discounted on the basis of its size requirements, poor treatment performance relative to alternative options and potential for nuisance effects e.g. odour.

7.3.1 SBR Based WWTP

An SBR system utilises an activated sludge treatment process consisting of a series of stages within a single reactor tank. SBR systems are commonly employed within New Zealand to treat municipal and industrial wastewater streams e.g. Morrinsville WWTP and Waiouru WWTP.

SBR systems operate on a time controlled cyclic mode, which typically involve the following stages:

1. Fill
2. Aerate/React
3. Settle

4. Decant
5. Idle

SBR systems are characterised as providing significant operational flexibility, high nutrient removal, smaller footprints (as the system does not require secondary settlement tanks) and tolerance of shock loads (hydraulic and organic loads).

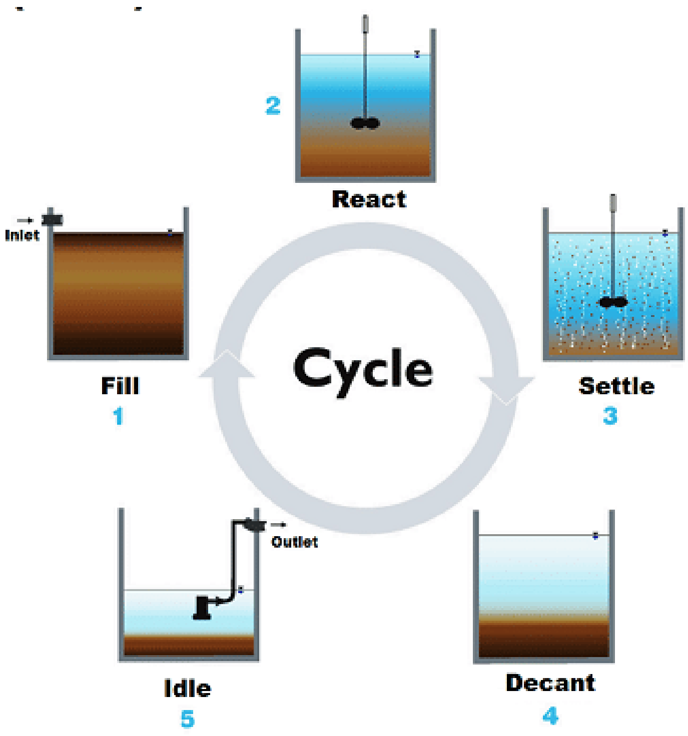


Figure 5: SBR Cycles

Source: Engineering for Change

7.3.2 Conventional MLE Based WWTP

The MLE process is a modification of the conventional activated sludge process where an anoxic zone is located prior to an aerobic zone, with an internal recycle employed to target nutrient removal (nitrogen).

Conventional MLE processes require a secondary clarifier/settlement tank to separate the solids from the treated wastewater prior to further treatment in downstream unit processes.

A conventional MLE system will provide a high level of treatment and reliability but will have a larger footprint in comparison to alternative treatment options and may generate larger volumes of sludge. Examples of MLE based WWTPs within NZ include the Queenstown WWTP and Rosedale WWTP.

7.3.3 MBR System

Membrane Bioreactors (MBRs) have become increasingly common in New Zealand over the past 20 years for use in wastewater treatment.

MBR systems generally utilise membranes (typically microfiltration or ultrafiltration membranes) submerged within an aerated biological treatment tank to treat wastewater. The membranes act as a filter to remove solids and therefore eliminates the need for secondary settlement tanks.

MBR WWTP's are increasingly being used to treat wastewater streams due to its ability to provide a very high degree of treatment, overall reliability, compact design relative to alternative treatment options and generally lower sludge production. MBR's are widely understood to be a robust and reliable treatment process within NZ and are generally recognised as the best practice option for wastewater treatment.

Examples of MBR WWTPs within NZ include the Rotoiti-Rotoma WWTP, Warkworth WWTP, Clarks Beach WWTP and Te Aroha WWTP.

Figure 6: Flat Sheet Membranes Utilised in an MBR

Source: Apex Environmental

7.3.4 Preferred Option

Owing to the expected effluent quality requirements and the potential receiving environments (Refer to Section 10.0), an MBR WWTP was considered the most viable option, noting that MBR WWTPs are commonly employed across NZ where a discharge to a sensitive receiving environment is required e.g. Matiatia, Clarks Beach, Helensville (however, all of these examples of MBR upgrades/retrofits to existing technologies).

SBR and conventional MLE based WWTPs can achieve substantial contaminant reductions with tertiary treatment processes. However, these treatment processes are not expected to reliably provide the same degree of treatment as an MBR WWTP.

Future (short and long term) regulatory changes are also expected to impose greater demands on WWTP's, with effluent quality limits expected to tighten in future. An MBR WWTP is expected to provide long term discharge security for the development as the process is robust and is capable of achieving stringent discharge standards, particularly in regard to microbiological contaminant removal. An MBR WWTP can also be upgraded in future to achieve more stringent limits without comparatively large capital expenditure or re-design.

Treatment systems that facilitate straightforward expansions to accommodate future wastewater volumes are preferred in order to accommodate the staging of the proposed development. The MBR process train is highly modular, with new membrane units and process tanks able to be added to enable an efficient increase to the throughput of the plant.

MBR WWTP's are also expected to have a smaller footprint in comparison to alternative treatment technologies as they can operate at higher biomass concentrations, enabling smaller process tanks.

Overall, in order to meet the key drivers for the development, including enabling the proposed staging, achieving regulatory acceptance and meeting the expected stringent effluent quality limits, an MBR WWTP is recommended.

8 WWTP BASIS OF DESIGN

Wastewater flows and loads from the Beachlands South PPC area have been derived based on housing unit equivalent (HUE) data provided by BSLP. The development is understood to occur across seven stages, with a final residential HUE design horizon of approximately 4,000 HUEs. An additional allowance of 15% has been included to cover commercial, community and mixed-use development.

The reticulation system will be developed in accordance with the stages. However, GWE propose the WWTP is staged as follows:

1. All civil and structural elements for the final design horizon to be designed and constructed at the live zoning stage.
2. Mechanical items, including membranes and blowers, to be installed across two stages.

This is proposed to ensure an efficient delivery of infrastructure to the PPC area.

GWE proposes the mechanical items to be staged as follows:

1. Live Zone (LZ) (Stage 1) – Approximately 2,900 HUEs
2. Future Urban Zone (FUZ) (Stage 2) – Approximately 4,000 (including Stages 1 & 2) HUEs (Final Design Horizon)

8.1 Flows

Watercare Services Limited (Watercare) standards identify a per capita flow allowance of 225 litres/person/day as the recommended design basis to determine flows from residential dwellings. However, given that the proposed development is expected to have limited potable water resources and that full water conservation devices will be utilised on all outlets, a reduced per capita flow of 150 litres/person/day has been adopted as the design basis for residential dwellings. A 150 litres/person/day per capita flow is within commonly accepted design rates of 130 – 220 litres/person/day.

As per Watercare standards, a residential occupancy of 3.0 persons/HUE was adopted. An additional conservative allowance of 15% was included to cover commercial, community and mixed-use developments. As the reticulation network will utilise an LPS system, I&I flows into the network are expected to be minimal.

Table 6 outlines the anticipated flows the development that have been utilised for sizing the process units at the WWTP.

Table 6: Beachlands South - Anticipated Flows

STAGE	HUE	DESIGN FLOW[1,2]
Stage 1[3]	2,900	1,500
Stage 2	4,000	2,100

Notes:

[1]Includes an allowance of 15% for commercial, community and mixed-use developments.

[2]All flows in m^3/d.

[3]Utilised for staging the mechanical elements only. Civil/structural elements are undertaken on the basis of the final design horizon (Stage 2).

The wastewater flows identified in Table 6 above are expected to be marginally above the water supply demands for the development modelled by GWE (with water use expected to be approximately equal to wastewater generation), however, this will allow for some minor I&I and variation in inflows.

8.2 Contaminant Loads

Contaminant concentrations from the residential development is expected to be in line with standard domestic strength wastewater. GWE have assumed that the wastewater from the commercial developments will have a waste strength of approximately three times that of the domestic sources.

Raw influent contaminant concentrations have been assessed for the following key parameters:

- Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)
- Total Suspended Solids (TSS)
- Total Nitrogen (TN)
- Total Phosphorus (TP)

A high-level mass balance has been undertaken to determine the expected combined stream wastewater characteristics (Refer to Table 7). The associated loads (Refer to Table 8) utilised in the concept design have also been determined to assist with staging the mechanical elements of the WWTP.

Table 7: Beachlands South - Anticipated Contaminant Concentrations

PARAMETER	RAW DOMESTIC WASTEWATER	RAW COMMERCIAL WASTEWATER	RAW COMBINED STREAM
5-Day Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	250	750	320
Total Suspended Solids (TSS)	300	900	380
Total Nitrogen (TN)	50	150	65
Total Phosphorus (TP)	30	90	40

Note:

[1]All concentrations in mg/L

Table 8: Beachlands South - Anticipated Loads

PARAMETER	STAGE 1	STAGE 2
5-Day Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	480	660
Total Suspended Solids (TSS)	570	790
Total Nitrogen (TN)	95	135
Total Phosphorus (TP)	60	80

Note:
[1]All loads in kg/d

8.3 Target Effluent Quality

While the AEE (prepared by others) is expected to inform the final effluent quality requirements, GWE have undertaken an assessment of the expected requirements for the proposed receiving environment options (Refer to Section 10.0). Effluent quality limits are expected to be derived from the potential effects on a number of different elements, including overall water quality, ecology and cultural values.

Table 9 outlines the expected average effluent quality targets the WWTP would be expected to reliably achieve under a discharge consent and are in-line with current best practice.

Table 9: Beachlands South – Anticipated Average Effluent Quality Requirements

PARAMETER	RAW COMBINED INFLUENT	TREATED EFFLUENT (AVERAGE)	95TH PERCENTILE	REMOVAL % (AVERAGE)
5-Day Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	320	10	15	97%
Total Suspended Solids (TSS)	380	10	15	97%
Total Nitrogen (TN)	65	5	10	92%
Total Phosphorus (TP)	40	1	3	97%
Faecal Coliforms (FC)	>$1x10^8$ CFU/100 mL	<10 CFU/100 mL	<50 CFU/100 mL	>99%

Note:
[1]All concentrations in mg/L unless otherwise stated.

GWE expects that an MBR WWTP will be capable of achieving the limits identified in Table 9 with the use of chemical dosing, including supplementary carbon dosing for TN removal and aluminium sulphate (or similar) for TP removal.

8.3.1 Auckland WWTP Discharges

A high-level review of Watercare WWTP's that discharge effluent to water has been undertaken to contextualise key parameters for the target effluent quality for the WWTP servicing the proposed Beachlands South PPC Area.

Table 10 identifies effluent quality limits for various WWTPs within the Auckland region and compares it to the proposed limits for the WWTP servicing the Beachlands South PPC area.

Table 10: Auckland WWTP Consent Limits Review

PARAMETER	BOD	TSS	NH3	TN	RP[3]	TP	FC
Pukekohe WWTP	<12[4]	<18[4]	<10[4]	-	-	<8[3]	<1,000 CFU/100 mL[4]
Mangere WWTP	<15	<15	<3[5] <5[5]	35	<9	-	>99% disinfection
Beachlands-Maraetai WWTP	<15[4]	<15[4]	<4[6] <5[6]	-	<5[4]	-	<14 CFU/100 mL
Helensville WWTP	<20	<20	<20	-	-	-	<50 CFU/100 mL
Clarks Beach WWTP	<10	<15	<10	-	-	-	<14 CFU/100 mL
Beachlands South PPC Area WWTP	**<10**	**<10**	**-**	**<5**	**-**	**1**	**<50 CFU/100 mL**

Notes:
[1]All values in mg/L unless otherwise stated.
[2]All values are mean or median limits unless otherwise stated.
[3]Reactive phosphorus
[4]90th percentile
[5]<6 mg/L December–March, <15 mg/L otherwise.
[6]95th percentile, <4 November–April, <5 mg/L otherwise.

The proposed effluent quality (refer to Section 8.3) generally meets or exceeds the effluent quality limits for other WWTPs within the Auckland region and is in line with best practice treatment.

9 WWTP CONCEPT DESIGN

GWE have undertaken a high-level concept design for the Beachlands South MBR WWTP to achieve the effluent concentrations identified in Table 9. Detailed process design will be required in later stages to confirm the WWTP unit process sizing.

9.1 WWTP Summary

The MBR WWTP is expected to have the following key unit processes:

1. Headworks - Screening (Staged to 0.5 mm) and Grit Removal
2. Flow Balancing Tank
3. MBR Process utilising 4-Stage Barndenpho (Alternative configurations, including MLE, can be investigated in subsequent design stages)
    a. Stage 1 – Primary Anoxic Tank

   b. Stage 2 – Aeration Tank
   c. Stage 3 – Secondary Anoxic Tank
   d. Stage 4 – Membrane Tank
   e. Permeate Tank
4. UV Disinfection
5. Chemical Dosing
   a. Carbon (Required for denitrification)
   b. Caustic (Alkalinity)
   c. Alum (Chemical phosphorus removal)
   d. Hypochlorite and Citric Acid (Membrane cleaning)
   e. Polymer (Sludge Thickening)
6. Sludge Storage and Thickening
7. Odour Control

A high-level concept layout and process flow diagram (PFD) for the WWTP is provided in Appendix B.

No primary treatment has been specified for the proposed plant as it would generate a separate sludge stream. Furthermore, the removal of carbon within a primary stage would be detrimental to the overall WWTP process by potentially compromising nutrient removal.

The overall design approach, particularly regarding redundancy and process unit selection, will be done in general accordance with Watercare's standards.

9.2 Headworks

Screening and grit removal will be required in order to remove rags and other screenings prior to key WWTP processes. Specific consideration for the WWTP headworks during subsequent design phases will be required to ensure sufficient protection is provided for the membranes and aeration system (diffusers) due to their sensitivity to grit and other objects including hair and lint.

Two-staged screening (with final aperture size to be 0.5 mm) and a vortex grit removal chamber (or similar) is proposed and will be confirmed in latter design stages. The process units will be located within a building, with the air extracted and sent to the odour treatment system to prevent odorous discharges.

Screenings & grit will be collected, washed, compacted and dewatered prior to being taken for disposal off-site.

9.3 Flow Balancing

Flow balancing is required to reduce the sizing requirements of key process units and ensure the diurnal and instantaneous flow peaks can be accommodated within the

WWTP. While the pressure reticulation system proposed for the Beachlands development is expected to have significantly lower peak instantaneous flows when compared to traditional gravity reticulation systems, flow balancing/equalisation is recommended to ensure flows to the process units can be managed.

The flow balancing tanks have been sized on the basis of 18 hours hydraulic retention times (HRT), however, a significant amount of storage is expected to be reserved for accommodating the following (approximately 6 hours HRT):

- Power and equipment failure.
- Emergency storage
- Significant maintenance tasks requiring partial plant shutdown.

The balance tanks are proposed to be buried, with the head space connected to the odour treatment system to prevent odorous discharges.

9.4 Concept Process Sizing

GWE have undertaken concept level sizing for the key process units of the MBR WWTP. A Bardenpho based process, utilising a series of anoxic and aeration tanks, has been chosen to ensure the MBR is capable of achieving the proposed effluent quality limits, particularly in regards to the nutrient levels (TN/TP).

Indicative sizing of the key process tanks has been undertaken on the basis of standard hydraulic retention times (HRT). Detailed process design will be required to confirm the final reactor sizes.

9.4.1 Process Tank Sizing

The indicative sizing for key process units based on the final design horizon and expected contaminant load is as follows (Design flow of 2,100 m^3/d):

Table 11: Beachlands South WWTP - High Level Concept Sizing

PROCESS UNIT	HRT (HRS)	TOTAL VOLUME (m^3)[1]
Flow Balancing Tank	18	1,600
MBR PROCESS – PARALLEL TREATMENT TRAINS		
MBR – Primary Anoxic Tank	3	270
MBR – Aeration Tank	8	700
MBR – Secondary Anoxic Tank	3	270
MBR – Membrane Tank[2]	2	180

Notes:
[1]Total volume to be evenly split across two parallel MBR process treatment trains
[2]Membrane installation to be staged as noted in Section 8.

Two parallel MBR process treatment trains will be installed due to the following:

- To enable one treatment train to be taken offline to ensure treatment is not compromised during periods of low flow (due to inadequate flow/nutrient loadings to the WWTP).

- To provide a degree of redundancy in the event of an emergency.
- To enable maintenance tasks to be carried out without shutting down the WWTP.
- To enable toxic-shock loads to be handled/contained within a single reactor, with biomass from the other reactor used to re-seed it in the event of biomass die off, preventing extended shutdowns due to inadequate biomass availability.

A small permeate tank will provide minor flow balancing for the UV & discharge (400 m^3, approx. 4 hours HRT), if required.

9.5 UV Disinfection

When well designed and operated, MBR WWTP's can achieve high removal rates of faecal coliform bacteria and is expected to meet the standard threshold for disinfection (FC <200 CFU/100 mL). However, GWE expect a post-membrane disinfection treatment step will be required to ensure both regulatory and cultural acceptance. As such, a UV disinfection system is expected to be required.

9.6 Chemical Dosing

In order to optimise the treatment process and to achieve the required effluent quality, a number of standard wastewater treatment chemical additives are expected to be required. Subsequent design stages (and process design) will inform the required dose rates and specific storage requirements.

9.6.1 Carbon

In order to achieve the required level of nitrogen removal, an additional carbon source is expected to be required. GWE expect a standard carbon source in the form of acetic acid, ethanol, molasses or liquid sugar can be utilised at the WWTP site. Carbon can be dosed into the primary anoxic tank to ensure the parameters for denitrification are optimised.

9.6.2 Caustic/Soda Ash

Caustic soda or soda ash may be required in order to ensure sufficient alkalinity is present in the wastewater for the required biological treatment processes. If required, it can be dosed into the aeration tank to maintain the required pH.

9.6.3 Alum

The primary method of TP reduction will be through chemical addition (alum) as optimising simultaneous biological TN and TP removal is not expected to be cost effective or have the ability to get to the required limits for discharged TP. Alum can be dosed into the primary anoxic tank. The phosphate precipitate will be removed along with the biological sludge.

9.6.4 Hypochlorite and Citric Acid

Membrane clean in place (CIP) chemicals are expected to include sodium hypochlorite and citric acid. The dosing requirements will be specified by the membrane supplier.

The primary purpose of membrane CIP is to restore membrane permeability and remove foulants that cannot be removed through automated backwash (physical) cleaning cycles.

Sodium hypochlorite will assist with removing biological growths/organic fouling on the membranes while citric acid is used to remove inorganic contaminant build-up. Membrane CIP occurs in-situ, with typically one-train isolated and cleaned at a time.

9.6.5 Polymer

Polymer may be required in order to improve the sludge thickening capabilities of the WWTP. Polymer assists in flocculating solids and improves the thickening process.

The polymer (if required) will be chosen as part of the detailed design process. Refinements to polymer selection are expected to occur as part of commissioning (once sludge is produced and polymer selection can be reviewed/tested).

9.7 Sludge Storage and Thickening

The production of sludge from the biological treatment processes will need to be removed from the WWTP.

Waste activated sludge (WAS) will be pumped to the WAS storage tanks and then into the dewatering building where it will be thickened using a gravity belt thickener (or similar technology) to reduce the volume of sludge required to be taken off-site for disposal. The thickening process units will be located within a building, with the air extracted and sent to the odour treatment system to prevent odorous discharges.

The disposal of sludge off-site will minimise potential odour emissions from the WWTP site.

9.8 Odour Management and Buffer Distance

Provision will be made for the collection and treatment of objectionable odour generated at the WWTP site.

The WWTP is expected to have several sources of odour including the following:

- Headworks Area
- Flow Buffering Tanks
- Sludge Storage and Thickening Area

At the concept stage, GWE have provisioned for an odour treatment system, expected to be comprised of a biological scrubber-based system (or similar technology). Key odour producing process areas (headworks and sludge storage and thickening) are proposed to be contained within a single building to enable odorous discharges to be captured and diverted to the odour treatment system. The specific design considerations, including the required air extraction rates, will be determined in subsequent design stages.

The flow balancing tanks are proposed to be buried, with the head space plumbed to the odour treatment system and operated under negative pressure. Open tanks would require substantial buffer distances to be provided.

The MBR process tanks are not expected to be a significant source of odour (when operated as intended) and as such, odour treatment has not been provisioned for the tanks. It is also noted the MBR tanks are expected to be sited towards the rear of the WWTP.

A buffer distance between the WWTP and any residential development is expected to be required in order to minimise any potential nuisance effects on neighbours, including noise and odour. This can be addressed at the resource consent stage for the WWTP.

9.9 Visual Intrusion

A number of items at the WWTP, including buildings, structures and tanks, have the potential to create adverse visual effects.

Process tanks will have a maximum height/depth of 6 m and will be partially buried/buried where possible. Sludge and chemical tanks will have a maximum height of 8 m. The external appearance of structures and buildings will be designed to minimise any adverse visual impacts and will be similar in scale to development anticipated within the precinct.

9.10 WWTP Location

9.10.1 Selection Considerations

Generally, the following principles are considered when siting a WWTP:

- Elevation.
  - WWTP's are preferred to be located at lower elevations to minimise the requirements for pumping.
- Proximity to potential discharge locations.
- Isolation from residential areas.
- General land use of the surrounding area.
- Susceptibility of a site to flooding.
- Sufficient area to enable an expansion to the WWTP.
- General access to the area (to enable chemical deliveries or removal of sludge).
- Proximity to drinking water sources.

9.10.2 Proposed Location

The factors identified in Section 9.10.1 were utilised to determine a suitable location for the WWTP, with the location shown in Figure 7.

The chosen location for the WWTP is bounded on three sides by areas of native bush (areas of ecological significance) and is located a sufficient distance away from proposed residential areas, minimising the potential for adverse nuisance effects.

Additional screen planting will be undertaken to assist with integrating the WWTP area into the surrounding landscape and to provide further visual screening.

The identified site is located in an area where existing ground levels are estimated to be approximately 35-40 m RL and is expected to be suitable for on-lot pumping across the overall catchment. The WWTP will be located outside of the 1% annual exceedance probability (AEP) floodplain.

The chosen area is expected to be sufficient to provide for the required WWTP size and enables further expansion, if required. The WWTP site is located in close proximity to the development's primary arterial road, ensuring the site can be accessed without issue.

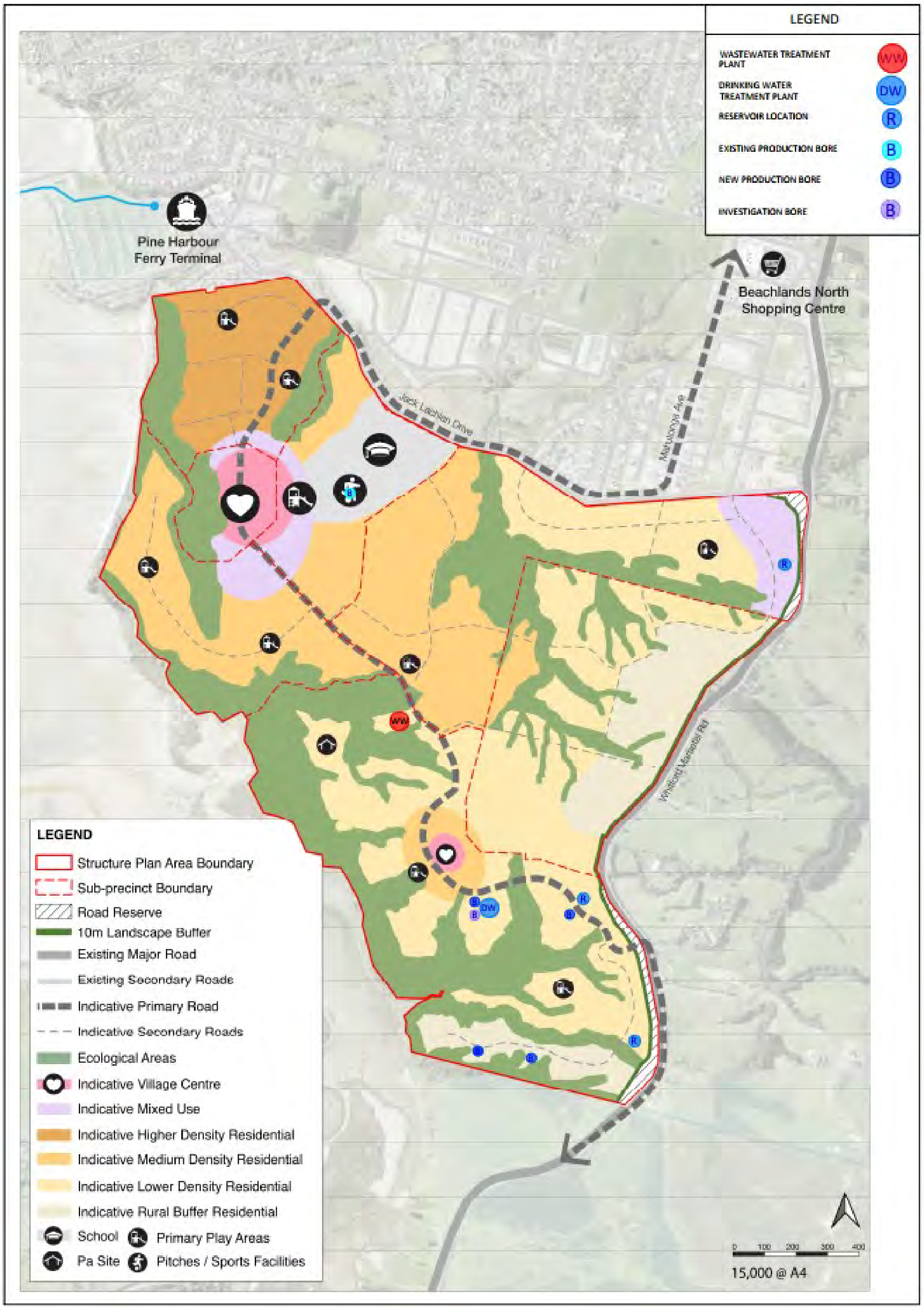


Figure 7: Water and Wastewater Infrastructure Concept Plan

9.11 Noise

At the concept stage, the significant sources of noise at the WWTP, including the blowers and dewatering equipment, are to be contained within buildings. Any building containing mechanical equipment that can generate high levels of noise will require specialised acoustic building design to ensure the required noise limits (dB) can be met. This can be addressed at the resource consent stage.

Mechanical equipment including dry-mounted pumps will be provided with an acoustic cover or similar noise attenuating device if required.

9.12 Operations and Maintenance

Standard operations and maintenance (O&M) tasks are expected to be carried out by on-site WWTP operators including:

- General consent compliance work including monitoring flows and carrying out basic on-site testing to verify the operational performance of the WWTP.
- Monitoring WWTP parameters and alarms.
- General preventative maintenance including cleaning process units and UV bulb replacements.
- General corrective maintenance.
- Monitoring and ordering supplies (e.g. chemicals, spare parts etc.)

It is expected the WWTP will require a full-time staff-member to carry out the required standard tasks.

All key mechanical equipment will be in a duty/standby arrangement to permit maintenance without affecting the WWTP's operation.

Infrequent, large scale maintenance tasks, including the replacement of the membranes (expected to be required every 8-10 years) will require the membrane supplier or specialist contractor's to be engaged to carry out the works. These tasks will involve significant expenditure and will need to be annualised and included in the operational expenditure costs for the WWTP. Specific consideration in the design of the WWTP, including access requirements and sufficient space for manoeuvring large plant will also be required to ensure the tasks can be completed efficiently.

10 DISCHARGE ROUTE OPTIONS

10.1 Disposal Options

While an evaluation of the available disposal options is outside GWE's scope for this plan change report, a high-level assessment of has been carried out, involving the following options:

1. Tertiary polishing wetlands near the existing ponds on the golf course and disposal over the 9-hole golf course land and part of the FUZ land.

2. Tertiary polishing wetlands at the head of the western gully followed by discharge into the permanent stream in the western gully and subsequently to the coastal marine area.
3. Connection to the Watercare network

10.2 Option 1 – Land Disposal to the 9-hole Golf Course and FUZ Land

A centralised WWTP with disposal to a pressure compensating dripper irrigation (PCDI) system or similar alternative land disposal method has been investigated as an option.

PCDI wastewater disposal is common activity within Auckland and New Zealand. Large scale PCDI disposal schemes in New Zealand include the Kinloch Golf Course irrigation scheme and the Omaha Flats WWTP disposal. Further to this, there are a number of smaller subdivisions within NZ that are located outside of council reticulation service areas which utilise a centralised WWTP, with the disposal of treated effluent to a PCDI field including Opito Bay and Ongare Point.

A land disposal option would require extensive land areas as it would need to cover the peak flow at a disposal rate that would not result in adverse effects, including runoff to sensitive areas including freshwater and marine receiving environments or ponding, particularly during the wetter winter months.

GWE have investigated an option to dispose of wastewater generated by the LZ development (Stage 1 – Refer to Table 6) in land that is to be zoned FUZ and the 9-hole golf course area. Refer to Appendix C for a high-level site plan identifying potentially suitable irrigation areas (9-hole golf course and FUZ area accounting for standard separation distances within the Auckland region). As shown on the site plan, sufficient area is available for a land disposal system to service the LZ.

The FUZ land will be retained as a predominately greenfield area during the live zone development as it can only be developed once rezoned from FUZ to live zonings via a future plan change process. Therefore the FUZ land can be utilised to dispose of wastewater. Provided the disposal is managed in accordance with best practice, no adverse effects on the area are expected to arise due to the irrigation activity.

In order to permit develop the FUZ development land in the future, an alternative discharge option would need to be investigated and consented. However, this would not be required for approximately 12 years (after the build out of the live zoned land).

Effluent from the MBR system is expected to have very low levels of nutrients (Refer to Section 8.3), well beyond the requirements of a land disposal system. While also not required for land disposal, a series of polishing wetlands is proposed to provide additional reductions in nutrients. A vertical flow wetland (VFW) followed by a surface flow wetland (SFW) is proposed to further polish the MBR treated wastewater. Concept sizing of the VFW and SFW has been undertaken by Tokin & Taylor Limited (T+T) (Refer to Appendix D), with indicative contaminant removal efficiencies for BOD, TN and TP were identified to be 85%, 45% and 63%, respectively. The proposed wetlands will be located adjacent to the existing ponds within the golf course (Refer to Appendix D)

A wetland-based option has been pursued where irrigation to the golf course is proposed as it will provide aesthetic benefits and permit the storage of wastewater prior to irrigation (no effluent holding tank required).

A land disposal option is expected to be supported by regulatory authorities, the public and Iwi as it avoids any discharges into sensitive areas and can assist with providing essential water and trace nutrients to maintain vegetation and bush, particularly during extended dry periods.

The proposed land disposal system to service the LZ would meet the following requirements:

- Hydraulic loading rate of 3 mm/d, consistent with standard treated wastewater application rates (with the assumption of clay soils and suitable topography)
  - Live Zone
    - Approximately 50 ha (Primary disposal area) required
    - Separate reserve wastewater disposal areas (in the event the primary disposal area fails or does not perform as expected).
      - Standard allowances range from 33% - 50% of the primary disposal area in the Auckland region. However, this is typically applied to smaller discharges, where the irrigation area is typically under 1 ha and where localised issues in the irrigation field (e.g. localised poor infiltration) can result in a material proportion of the field being unsuitable. Larger scale discharges do not have this issue (> 1 ha) thus lower reserve area allocations (20 – 33%) are suitable.
      - Accounting for a 20 - 33% reserve area, Stage 1 could potentially require 60 - 67 ha to be nominated in total.
- Nitrogen loading
  - Standard nitrogen loading rates for the disposal of treated wastewater are <150 kg-N/ha/yr in the Auckland region.
  - Based on the identified average TN effluent concentration of 5 mg/L, the LZ flow of 1,500 m^3/d and a primary disposal area of 50 ha, the expected nitrogen loading rate is approximately 55 kg-N/ha/yr, well below the required 150 kg-N/ha/yr.
- Separation to sensitive environmental features.
- Separation to residential dwellings
- Available land within close proximity of the WWTP.

The site selection for a land disposal system would follow best practice procedures and would also take into account the following:

- The topography of the land;
- The hydrology of the area specifically relating to overland flow paths (OLFPs), flooding and groundwater;
  - The following minimum separation distances would apply to any irrigation area:

  - 10 m to any OLFP or surface water feature

    A larger setback distance to natural wetland areas can be adopted, if recommended by an ecologist.

  - 0.6 m to groundwater (including perched groundwater)
  - 10 m to any water supply bores
  - 3 m to any habitable building, embankment or retaining wall (specific design may be required)
  - 3 m to any property boundary
  - Outside of the 1 in 20-year floodplain

- The stability of the land.

The disposal area will be separated into zones and subzones to provide resting periods and to ensure an even distribution of the hydraulic load.

10.3 Option 2 – Polishing Wetland and Discharge to the Coastal Marine Area

An option utilising a series of tertiary polishing wetlands which then discharges into the permanent stream in western gully and subsequently to the coastal marine area has been investigated. The proposed location of the tertiary polishing wetlands is the head of the western gully

A vertical flow wetland (VFW) followed by a surface flow wetland (SFW) is proposed to further polish the MBR treated wastewater (as per Option 1). The sizing of the wetlands will match that of Option 1 (Refer to Appendix D). As noted in Section 10.2, indicative contaminant removal efficiencies for BOD, TN and TP are expected to be 85%, 45% and 63%, respectively.

VFWs permit nitrification (conversion of ammonia to nitrate) due to their oxygenated environment, with SFWs permitting denitrification (conversion of nitrate to nitrogen gas) due to their anoxic environment.

Following treatment within the polishing wetlands, wastewater will be discharged to a permanent stream in the western gully, which discharges into the coastal marine area.

A discharge to a permanent stream is preferred as it ensures the receiving environment maintains a degree of assimilative capacity year-round.

T+T have assessed the effects on stream ecology and marine ecology (Refer to Appendix 16 – Freshwater Ecology and Appendix 19 – Marine Ecology, respectively).

10.4 Option 3 - Connection to the Watercare Network

Wastewater from the Beachlands, Maraetai and Pine Harbour areas is currently transferred to the Beachlands WWTP through 13 pumpstations located in the wider catchment area.

As noted in Section 3.2.3, the Beachlands WWTP is operating at close to its design capacity. Watercare has not identified any plans for an upgrade to the capacity of the

Beachlands WWTP in the short term but it is expected that investigations into future capacity upgrades will occur prior to the consent renewal in 2025.

Given the expected timeline for the Beachlands South PPC area LZ development, a connection into the existing Watercare network has not been investigated further. However, there is a potential opportunity to provide a combined wastewater solution for both the PPC area development and Beachlands as a whole. This would require further discussions with Watercare to achieve this possible outcome.

10.5 Conclusions

GWE have investigated a number of options and have determined a number of feasible options exist for the disposal of wastewater from the PPC area. These options include:

1. Tertiary polishing wetlands near the existing ponds on the golf course and disposal over the 9-hole golf course land and part of the FUZ land.

   Further optioneering and investigations will be undertaken prior to the FUZ stage to ensure a suitable disposal route can be obtained and the development fully serviced.

2. Tertiary polishing wetland at the head of the western gully followed by discharge into the permanent stream in the western gully and subsequently to the coastal marine area.

3. Connection to the Watercare Network

   There is a potential opportunity to provide a combined wastewater solution for both the PPC area development and Beachlands as a whole. This would require further discussions with Watercare to achieve this possible outcome.

These options, in conjunction with best management practice procedures, provide a sustainable method of wastewater management and ensures the development can be supported.

11 TREATED WASTEWATER RE-USE OPPORTUNITIES

The re-use of highly treated wastewater for non-potable uses is becoming increasingly investigated in an urban context as part of a sustainable wastewater management strategy which promotes the beneficial re-use of resources. It can enable the recovery of the remaining trace nutrients and water resources for use in the irrigation of green amenity areas.

In a broader context, wastewater re-use can potentially reduce the overall catchment demand for water from traditional water sources (e.g. groundwater), provides a reliable source of water during drier periods and promotes the overall environmental sustainability of the development.

Subject to regulatory approval, MBR treated wastewater can potentially be utilised in the Beachlands South PPC area for the following:

- The irrigation of native plantings which provide for valuable flora and fauna habitats.

- The irrigation of open space areas, landscaped areas or golf courses which enhance the amenity value of the local area.
- The irrigation of forestry areas to assist with the wider biodiversity and ecological regeneration values of the Beachland's South development.

Overall, the re-use of wastewater within the PPC land area is feasible and represents a viable treated wastewater disposal option..

12 POTENTIAL OWNERSHIP STRUCTURES

The long-term management and funding (excluding capital costs to be funded by the developer) of the wastewater infrastructure, including the WWTP, requires consideration. The infrastructure will require on-going servicing and maintenance to ensure the system works as intended.

Following infrastructure completion and once all sections have been sold, the infrastructure can be managed through the following systems:

- Via a third-party Management/Utilities Company.
- Via a Body Corporate structure.
- Vested in Council.

Compliance with the wastewater discharge consent, including routine monitoring and reporting will also be the responsibility of the chosen entity/system. This ensures the activity is managed responsibly and ensures the protection of the environment and public health. This information will also be used to support the consent renewal process in future.

Future re-consenting will be the responsibility of the consent holder, which depending on the structure chosen, will be a Management/Utilities Company. Improvements to the system to meet future quality limits or other requirements under any new consent will also be the responsibility of the consent holder.

12.1 Third Party Management/Utility Company

The use of a utility company to manage infrastructure is increasingly becoming common within New Zealand. The utility company will often provide a series of services to homeowners, including the management of water and wastewater infrastructure, grounds maintenance and general maintenance. The utility company is often experienced with the management and maintenance of infrastructure and likely provides a similar range of services to a number of developments.

The utility company will often undertake all compliance monitoring, reporting to Council, call outs, repairs/upgrades and bill the homeowners on a monthly basis in a similar fashion to Watercare. Typically, the utility company would be contracted for periods of 3 to 5 years, with a fixed cost plus agreed annual increases contract. The utility company will often collect additional money to set aside for a 'sinking fund' for eventual asset replacement.

The use of a utility company to manage infrastructure has typically been successful within NZ as the companies are incentivised to ensure compliance to maintain their contract and through key performance indicators (KPI) which are primarily related to compliance with consent conditions.

12.2 Body Corporate Structure

Body Corporate structures are a common method of managing infrastructure within New Zealand, with a series of legal requirements for body corporates. Standard practice involves a third-party body corporate manager overseeing/leading infrastructure management.

Historically, operating a body corporate without external assistance has often created issues with long term WWTP performance and general infrastructure maintenance. Second and third generation body corporates typically prioritise saving money, reducing the cash held for asset renewal and this often manifests itself in poor operation/maintenance and then non-compliance. This can lead to fines, sharp cost increases for residents and issues with re-consenting at a later date.

12.3 Vesting with Council

Unless agreed at the outset of the project, vesting infrastructure to Council/Watercare does not typically occur. Vested infrastructure must meet Council/Watercare standards and other specific acceptance criteria, with assets requiring assessments to ensure viability to the satisfaction of Council as its asset owner. Post-construction audits are expected to confirm the design and ensure it will perform as expected. If any issues/deficiencies are noted, Council may defer ownership and request remedial works to be undertaken.

Vesting assets is expected to simplify the long-term management of wastewater infrastructure and eliminate issues associated with body-corporate management of infrastructure including short term, cost focused decision making and inadequate infrastructure strategic planning.

Vesting assets are typically associated with higher initial capital costs and potential delays due to the required application and negotiation process between the developer and Council.

12.4 Summary

Wastewater infrastructure can be managed through three different systems

- Via a third-party Management/Utilities Company.
- Via a Body Corporate structure.
- Vested to Council.

Based on historical issues and the potential for cost-focused decision making leading to non-compliance with a body corporate structure, GWE recommend that the management of infrastructure to be undertaken via a utilities company or by vesting the assets to Council.

13 CONSENTING

The discharge of treated wastewater to water bodies is common within New Zealand, especially from coastal settlements that exist adjacent to these waterbodies.

Many of these discharges are historic and have been improved over time to reduce the discharge of contaminants to the natural receiving environment through upgraded treatment plants and outfalls/diffusers to improve the dispersion of the treated effluent to the marine environment.

Auckland Council's policy is to avoid discharges to marine waters unless the following has been undertaken:

- Alternative methods of managing the wastewater have been investigated and assessed against the proposed discharge.
- Mana Whenua and other affected communities would need to be consulted and a notified consent application would be required. Affected or interested groups/parties would have an opportunity to make a submission in support or in opposition to the discharge. These submissions would go to a hearing and would be assessed by duty commissioners.
- An AEE including the effects on recreation, environment and ecology have been considered.
- Sufficient monitoring and mitigation measures have been proposed.

The level of information required to satisfy these requirements can be considerable, including detailed technical engineering reports. It is recommended that resource consent be lodged for the wastewater treatment plant and disposal as soon as the preferred option is finalised.

14 CONCLUSIONS AND RECOMMENDATIONS

GWE have undertaken a high-level options assessment of key wastewater infrastructure solutions and the concept design of a WWTP to service the proposed Beachlands South PPC area.

Based on the options analysis and wastewater infrastructure concept design outlined in this report, the PPC can be viably serviced for wastewater and no constraints have been identified that would suggest the land within the PPC area is not suitable for urbanisation.

14.1 Options Analysis Summary

Based on the identified key factors and site specific constraints, GWE have determined the following:

- The recommended reticulation solution is the LPS system. LPS systems offer numerous key benefits to the proposed development by minimising I&I flows thus reducing the demands on downstream WWTP infrastructure and will be able to fully service the catchment while minimising the requirements for additional reticulation related infrastructure (e.g. pumpstations). LPS reticulation systems are reliable and proven within an NZ context.

- A centralised WWTP is the preferred option in order to match the development intent of the wider area and reduce the potential for overall nuisance effects.
- An MBR is the recommended wastewater treatment technology for the development. An MBR WWTP is expected to be able to consistently and reliably achieve the stringent effluent quality limits imposed by the anticipated discharge routes. MBR treatment is generally considered to be the best practice treatment option and is well understood and proven within NZ.
- The proposed site of the MBR WWTP is located adjacent the southern gulley area and is bounded on three sides by areas of ecological significance. The chosen location minimises the use of any developable land and will ensure any nuisance effects are kept to a minimum.
- There are a number of feasible wastewater disposal options for the PPC area including the disposal of treated wastewater to land or disposal to a permanent stream (via polishing wetlands) in the western catchment and subsequently to the coastal marine area. As an alternative to a new independent treatment solution (MBR treatment), an expansion to the Beachlands-Maraetai WWTP to accommodate the flows from the Beachlands South PPC area is potentially feasible but would require substantial discussions and negotiations with Watercare.
- The proposed infrastructure options and solutions will be able to service the projected number of dwellings and area within the PPC area for both the Live Zone and Future Urban Zone.

14.2 Next Steps

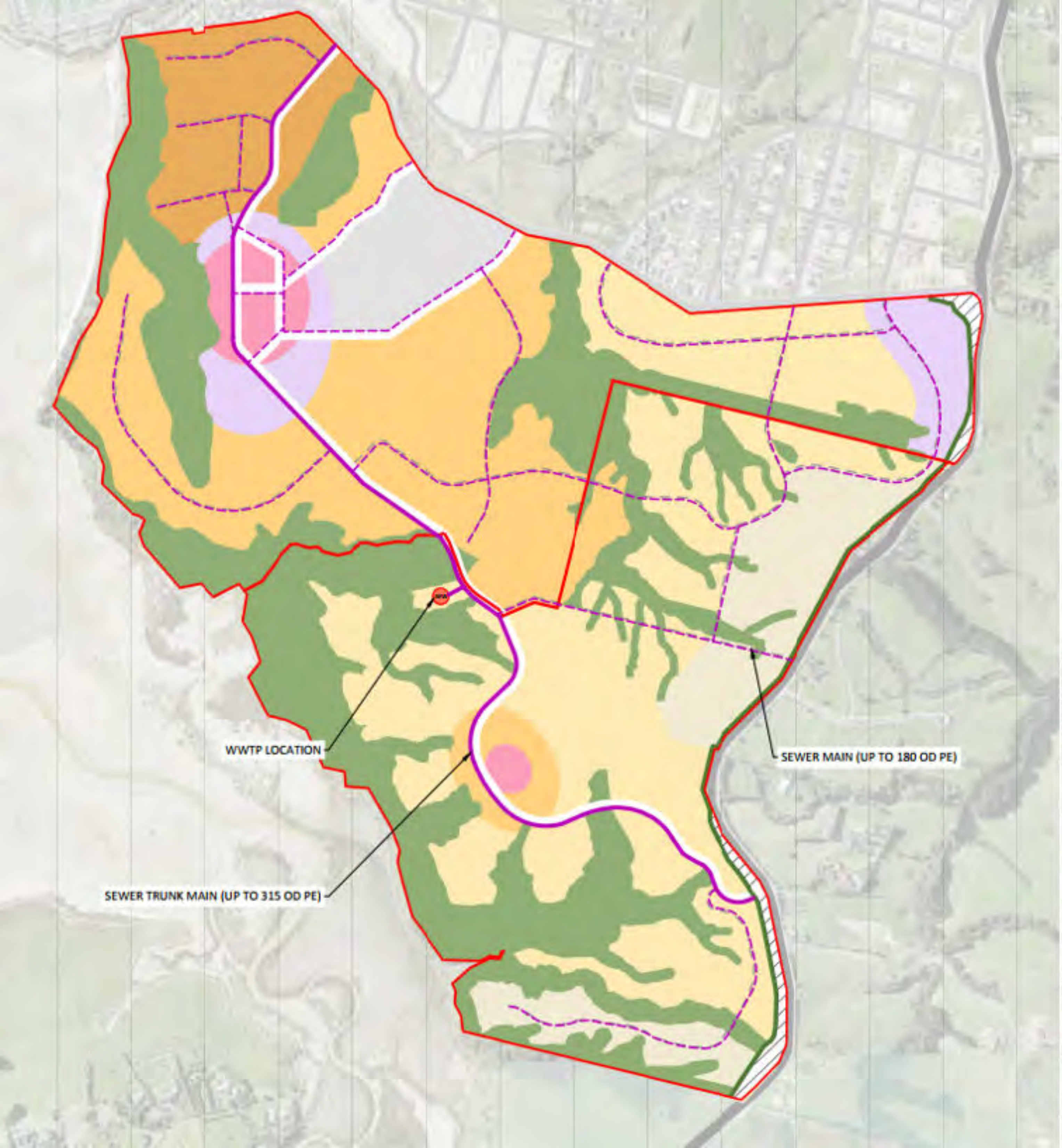
GWE will undertake specific detailed design of the preferred option when applying for a resource consent for the development. This will include:

- Undertaking further investigations and confirming the preferred wastewater disposal route. Undertake preliminary engineering design for all wastewater infrastructure elements, an assessment of environmental effects and associated stakeholder engagement.
- Preparing consent application documents and lodge for the required consents (discharge to water, land and air).
- Undertaking detailed design for all wastewater infrastructure aspects, refine CAPEX/OPEX costs and continue to undertake key stakeholder consultation.

GWE

APPENDIX A

CONCEPT RETICULATION PLAN



LEGEND

SEWER TRUNK MAIN	(solid magenta line)
SEWER MAIN	(dashed magenta line)
MINOR ROAD	(dashed grey line)

NOTES

1. RETICULATION CONCEPT ONLY
2. RETICULATION LAYOUT AND PIPE SIZES TO BE DETERMINED DURING DETAILED DESIGN
3. SEWER TRUNK MAIN AND SEWER MAINS TO FOLLOW THE ALIGNMENT OF ROADS
4. SEWER SERVICE CONNECTION/LATERAL MAINS NOT SHOWN

ISSUE STATUS: **CONCEPT**

REV	AMENDMENT	CAD	ENG	APPD	DATE
0	FIRST ISSUE	JB	DK	CC	30/11/21

GWE CONSULTING ENGINEERS
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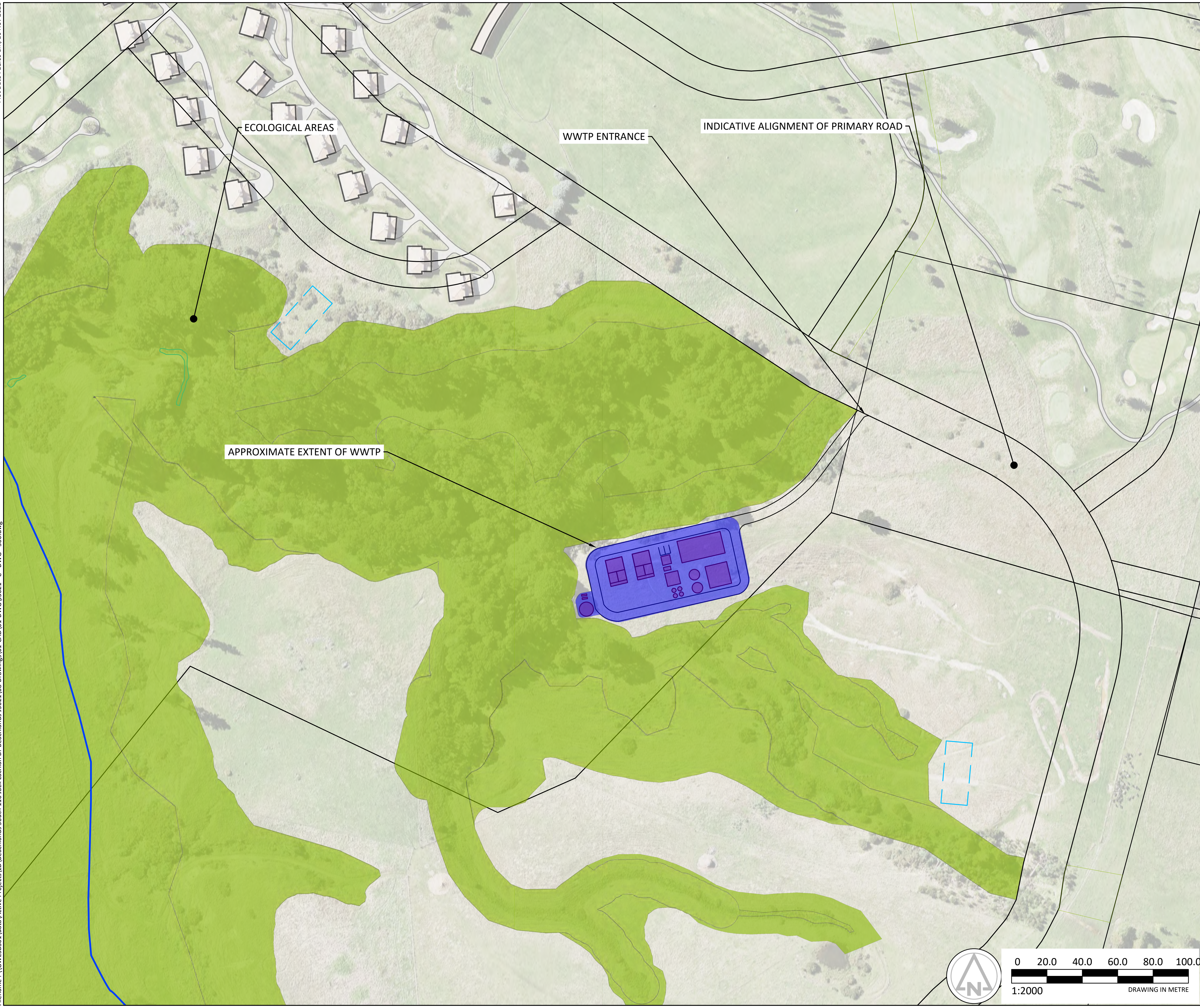
PROJECT ADDRESS:
110 JACK LACHLAN DRIVE AND 620 WHITFORD- MARAETAI ROAD, BEACHLANDS

DRAWING TITLE:
RETICULATION CONCEPT PLAN

CLIENT NAME:
BEACHLANDS SOUTH LIMITED PARTNERSHIP

SCALE: NTS		A3
PROJECT No: J3021	DRAWING No: 610	REV 0

APPENDIX B
CONCEPT DRAWINGS AND PFD



NOTES

1. DRAWING IS BASED ON JASMAX ZONING PLAN
2. LOCATIONS OF FEATURES ARE INDICATIVE ONLY.
3. CONCEPT ONLY

ISSUE STATUS:

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0	FIRST ISSUE	AY	DK	CC	8/11/21
REV	AMENDMENT	CAD	ENG	APPD	DATE

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PROJECT ADDRESS:
110 JACK LACHLAN DRIVE AND 620 WHITFORD- MARAETAI ROAD, BEACHLANDS

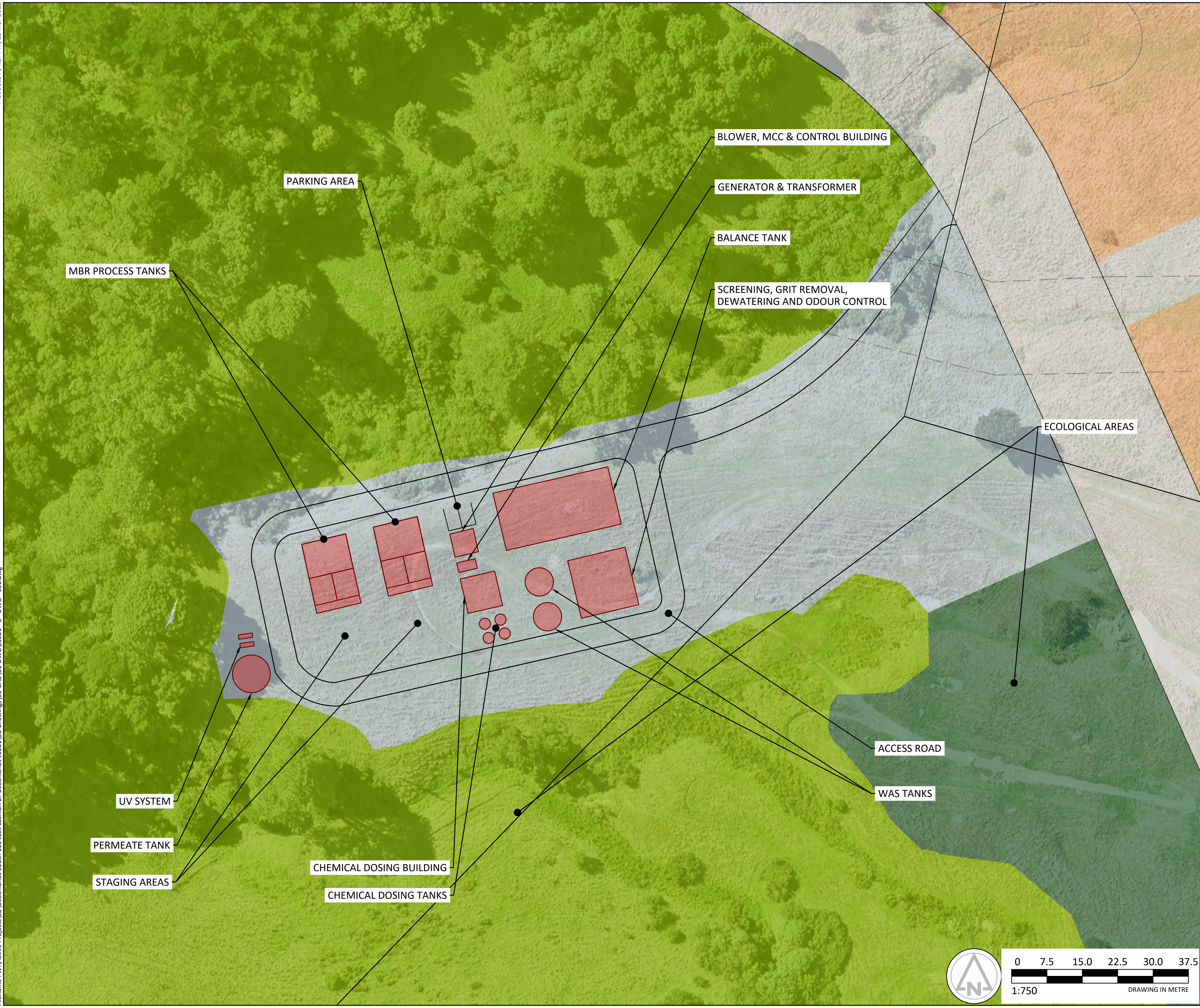
DRAWING TITLE:
WWTP LOCALITY PLAN

CLIENT NAME:
BEACHLANDS SOUTH LIMITED PARTNERSHIP

SCALE: 1:2000		A3
PROJECT No: J3021	DRAWING No: 500	REV 0

Plot Date : 04:27 PM, 23 Mar 2022

Filename : W:\Active Projects\LD\Beachlands South 110 Jack Lachlan Dr Beachlands-J3021\08-Drawings\01-CAD\01-DWG\J3021 - C - DWG - 501.dwg



LEGEND

WWTP STRUCTURES	

NOTES

1. CONCEPT DESIGN ONLY
2. DRAWING BASED ON JASMAX ZONING PLAN (PROJECT NUMBER 220103)
3. LOCATIONS OF FEATURES ARE INDICATIVE ONLY.

ISSUE STATUS: CONCEPT

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0	FIRST ISSUE	AY	DK	CC	8/11/21
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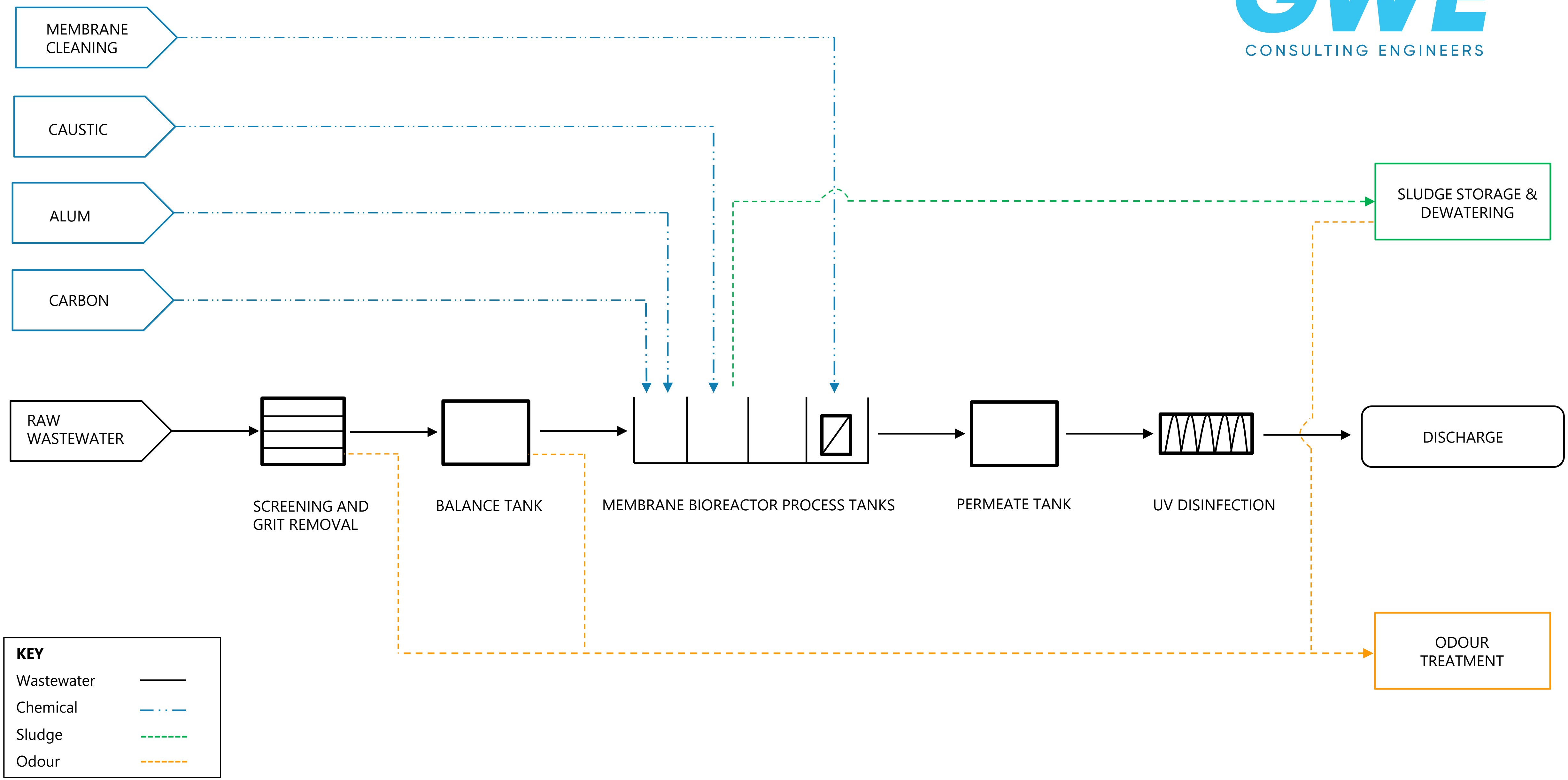
PROJECT ADDRESS:
110 JACK LACHLAN DRIVE AND 620 WHITFORD- MARAETAI ROAD, BEACHLANDS

DRAWING TITLE:
WWTP LAYOUT PLAN

CLIENT NAME:
BEACHLANDS SOUTH LIMITED PARTNERSHIP

SCALE: 1:750		A3
PROJECT No: J3021	DRAWING No: 501	REV 0

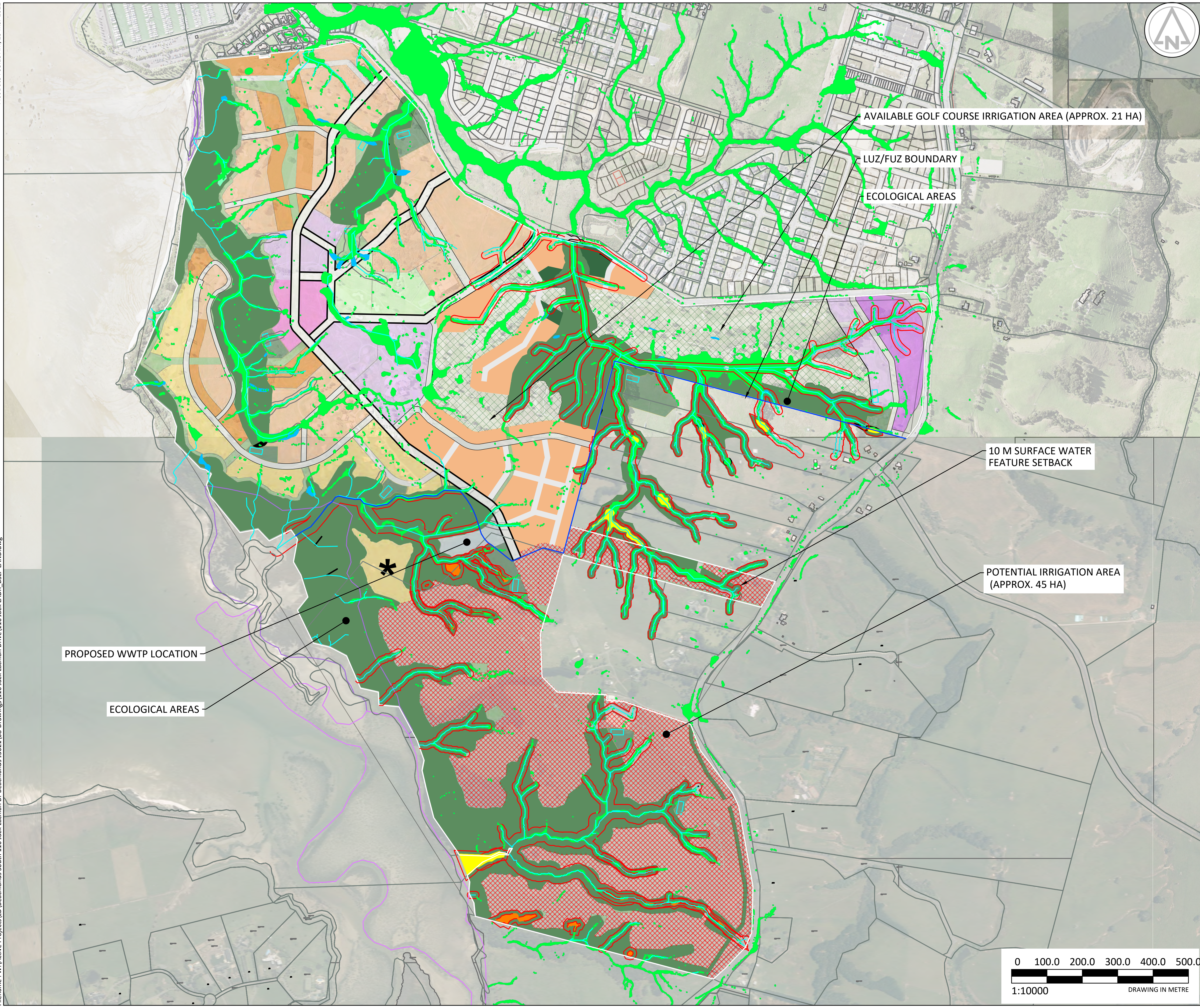
PROCESS FLOW DIAGRAM – PROPOSED BEACHLANDS SOUTH WWTP



APPENDIX C

IRRIGATION CONCEPT PLAN

Plot Date : 08:18 AM, 29 Mar 2022



NOTES

1. DRAWING IS BASED ON
   - ZONING PLAN PREPARED BY JASMAX (PROJECT 220103, SHEET UD3-03, DATED 2021) AND STREAMS, OBSERVATIONS AND SITE ZONES PLAN BY TONKIN + TAYLOR (PROJECT 1014358 4000, FIGURE 3, DATED AUGUST 2021
2. REFER TO TONKIN+TAYLOR PLAN FOR SURFACE WATER FEATURES LEGEND
3. 1% AEP FLOODPLAIN MODELLING BY HARRISON GRIERSON (100 YR INCLUDING CLIMATE CHANGE)
4. LZ DESIGN FLOW: 1,500 M^3/D
5. DESIGN DISPOSAL RATE: 3 MM/D
6. MINIMUM PRIMARY DISPOSAL AREA: 50 HA
7. RESERVE AREA: 20 - 33%
8. TOTAL AREA REQUIRED: 60 - 67 HA
9. LOCATIONS OF FEATURES ARE INDICATIVE ONLY.

LEGEND

- POTENTIAL IRRIGATION AREA
- POTENTIAL GOLF COURSE IRRIGATION AREA
- 1% AEP FLOODPLAIN
- 10 M SURFACE WATER SETBACK
- NATURAL WETLAND
- NATURAL WETLAND (EXOTIC)
- STREAM/OLFP

ISSUE STATUS: CONCEPT

	.				
#	###########	MD	DK	GW	16/03/21
REV	AMENDMENT	CAD	ENG	APPD	DATE

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PROJECT ADDRESS:
110 JACK LACHLAN DRIVE AND 620 WHITFORD-MARAETAI ROAD, BEACHLANDS

DRAWING TITLE:
IRRIGATION PLAN

CLIENT NAME:
BEACHLANDS SOUTH LIMITED PARTNERSHIP

SCALE: 1:10000		A3
PROJECT No: J3021	DRAWING No: 510	REV 0

Filename : W:\Active Projects\LD\Beachlands South 110 Jack Lachlan Dr Beachlands-J3021\08-Drawings\110 Jack Lachlan Drive\110 Jack LADR_BSLP LAND.dwg

GWE

APPENDIX D

TONKIN & TAYLOR – TERTIARY POLISHING OPTIONS LETTER

Tonkin+Taylor

Job No: 1014358.4000
22 March 2022

Beachlands South Limited Partnership
c/o Russell Property Group
PO Box 17254
Greenlane
Auckland 1540

Attention: John Dobrowolski

Dear John

Beachlands South Structure Plan Change - Tertiary polishing options for WWTP effluent

1 Introduction

An initial assessment of the potential impact of discharges from the proposed wastewater treatment plant (WWTP) to service the live zoning area of the proposed Beachlands South development has shown that the potential receiving stream adjacent to the proposed WWTP site does not have enough assimilative capacity to decrease the concentrations of the contaminants discharged from the WWTP to freshwater or marine guideline levels prior to the discharge to an area of the CMA with high ecological values.

To address the above concerns, discharge to land as well as the use of tertiary polishing wetlands were identified as options to minimise potential receiving environment effects from a joint workshop with the client and project planning and wastewater consultants.

The options are listed below:

1 Land disposal to Future Urban Zone (FUZ) land only.

2 Tertiary polishing wetland at the head of the western catchment (see Figure 2.1 below) which then discharges into the permanent stream in western catchment and subsequently to the marine environment (SEA M2).

3 A tertiary polishing wetland near existing ponds and then used to irrigate the 9-hole golf course. When the golf course is saturated the FUZ land will be used for disposal to land. We note that the wetland sizing calculations for Option 3 are the same as Option 2, but tertiary treatment is unlikely to be needed for a discharge to land.

2 Scope of Work

This report deals with the high-level polishing wetland sizing for Options 2 and 3 above with the main design objective being the decrease in concentration of ammonia and subsequent removal of the nitrate/nitrite before discharging to the receiving environment. A decrease in concentration of other water quality constituents (e.g. biological oxygen demand, total nitrogen, orthophosphate, total phosphorus and total coliforms) will be achieved concomitantly.

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We note that the same qualitative analysis for the polishing wetlands in Option 2 will be relevant to Option 3. However, as stated above, because Option 3 is a discharge to land a polishing wetland may not be needed. We also note that the surface flow wetland option discussed below is an anoxic treatment environment aimed at reducing soluble inorganic nitrogen (plant available nitrogen) but produces a low dissolved oxygen final effluent. The use of a surface flow wetland will need to consider a balance between the impact of reducing nitrogen and dissolved oxygen from a receiving environment perspective.

The approximate locations of option 2 and 3 are shown in the Figure 2.1.

Figure 2.1: Approximate locations of options 2 and 3 for tertiary polishing of WWTP effluent

3 Proposed Process Flow for Tertiary Polishing Treatment

The nitrification process will be undertaken in a vertical flow wetland (VFW) where an oxygenated environment can be maintained. VFWs treat subsurface flow introduced at the surface of the wetland, which then percolates through the filter media where treatment occurs. VFWs typically operate on a cyclical basis and are installed in parallel, with one wetland bay being flooded for a specified duration followed by resting period while the other bay is then flooded. This operating strategy allows for oxygenation of the media during the resting period. They are widely used for wastewater treatment in the northern hemisphere, but to date few VFW appear to have been built in New Zealand for this purpose.

Since VFWs convert ammonia to nitrates and nitrites, a further decrease in soluble inorganic nitrogen (SIN) (mainly nitrate/nitrite) would require the construction of a surface flow wetland where and anoxic environment can be created for denitrification, noting the dissolved oxygen issue outlined above.

The following high-level assessment of polishing wetland sizing and treatment efficiencies are based on wastewater discharge from the Live Zone of the proposed Private Plan Change. Alternative options for treated wastewater disposal will be needed for the Future Urban Zone.

3.1 Vertical flow wetland – nitrification

Sizing was based on a peak daily flow (PDF) of 2,900 m^3/day (effluent flow from the live zone), and was based on the hydraulic loading rate of 0.5 m^3/m^2/day reported in Tan et al. (2020)[1] for the tertiary polishing wetlands proposed for the Wellsford wastewater treatment plant. It is noted that the Wellsford plant design is based on the use of Zeolite media that enhances ammonia adsorption and thus nitrification. To account for the lack of this media here, the area of this wetland was increased by 10 % as a safety factor. The area for each vertical flow bay is therefore 6,400 m^2 with a depth of 1.00 m, keeping in mind that two bays would be required to allow for the alternating feeding strategy to be implemented.

3.2 Surface flow wetland – denitrification

The surface flow wetland (SFW) area is based on the system that is currently being designed for the treatment of final effluent from a WWTP in the Tararua District, where a reduction of 70 % in SIN was required. Based on the average daily flow (ADF) at Beachlands (1,950 m^3/day) and the design parameters from the Tararua wetland (2 days retention time at the ADF), an area of 7,800 m^2 would be required for the surface flow wetland with a maximum depth of 0.5 m to accommodate adequate plant growth. This would be equivalent to the SFW having a hydraulic retention time (HRT) of 2 days at the ADF and 1.35 days at the PDF.

3.3 Expected treatment efficiencies

VFW contaminant extraction performance, as monitored and reported in international science literature, varies considerably. The top performing wetlands have been reported to consistently break down 80 to 90 % of ammoniacal-N received in the discharge whereas others report no more than 35 % extraction (Alexandros *et al*., 2014). The expected treatment efficiencies of the VFWs are as tabled below based on values obtained for a variety of VFW designs reported in Alexandros *et al*. (2014). It is noted that eventual efficiency would be dependent on detailed design of the system, operating strategy and climate.

Table 3.1: Indicative average removal efficiencies in VFW (after Alexandros et al., 2014)

Water quality parameter	Average efficiency of removal
Carbonaceous Biological Oxygen Demand ($CBOD_5$)	85 %
Ammonia nitrogen (NH4-N)	75 %
Total nitrogen (TN)	45 %
Orthophosphate (OP)	58 %
Total phosphorus (TP)	63 %

To maximise nitrate removal within the SFW it is necessary to have the water disperse evenly over the whole wetland (i.e. a relatively shallow, flat bottomed design) and to prolong the retention of water within the wetland as long as possible (at least 24 hours) by creating a gentle gradient and high plant material interception. Based on the performance of other SFWs built and monitored in New Zealand, this should result in nitrate extraction rates that exceed 30 % in winter months and 70 % in summer months when comparatively lower flows are received.

[1] Tan, H.I.,Bickers, P., Simmonds, K., Vázquez-Burney. Nitrogen removal using advanced wetland technology. Paper presented at the Water New Zealand Conference and Expo. 2020.

3.4 Limitations

Performance efficiencies of the tertiary polishing VFWs will vary with season, with literature reporting NH4-N removal efficiency in a well-managed system decreasing by as much as 35 % during winter. A Similar decrease should be expected for the SFWs, and if harvesting of the plant biomass is not undertaken regularly the water column may become reseeded with organic nitrogen fractions, which can be converted to NH4-N as part of the natural nitrogen cycle.

A significant proportion of wetlands built in New Zealand to polish wastewater plant discharge have failed or their performance has diminished because no maintenance has been undertaken after construction. Maintenance plans are therefore important for ensuring acceptable performance of the tertiary polishing wetlands.

Both surface flow and vertical flow wetlands require regular, that is annual, maintenance if they are to continue to improve wastewater quality and for the plants to survive.

4 Closure

This report provides indicative sizing and treatment efficiency advice for potential wastewater polishing wetlands for the proposed Beachlands South development. The ecological effects of the disposal of treated wastewater from the proposed development, including the three polishing/ disposal options listed in Section 1, are considered in the Stream and Marine Ecological Effects Assessment reports prepared by Tonkin & Taylor Ltd[2,3].

5 Applicability

This report has been prepared for the exclusive use of our client Beachlands South Limited Partnership, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
....	....
Wageed Kamish Senior Water Resources Engineer	Peter Millar Project Director

Technical review completed by Roger MacGibbon, Principal Environmental Scientist

WKAM
t:\auckland\projects\1014358\1014358.4000\issueddocuments\wastewater discharge (vo3)\20220322.letter report - tertiary polishing options.final.docx

[2]Tonkin + Taylor, 2022a. Stream Ecological Effects Assessment for the Beachlands South Private Plan Change. Prepared for the Beachlands South Limited Partnership.
[3]Tonkin + Taylor, 2022b. Marine Ecological Effects Assessment for the Beachlands South Private Plan Change. Prepared for the Beachlands South Limited Partnership.