Far North District Council

ATTACHMENTS / NGĀ ĀPITIHANGA

UNDER SEPARATE COVER

Infrastructure Committee Meeting

24 March 2021

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Far North District Council
Te Kaunihera o Tai Tokerau ki te Raki

Hihi Wastewater Treatment Plant

CAPITAL WORKS BUSINESS CASE

HE WHENUA RANGATIRA
A DISTRICT OF SUSTAINABLE PROSPERITY & WELL-BEING

Project Code:	WWP0655	**Project ID (Finance):**	551302
Objective ref:	A3068094	**Objective version #:**	1

1 Purpose

This Business Case details the investment need and provides the high-level approach for capital investment that will be further specified and developed during the Detailed Design stage.

Recommendation: *Hihi Wastewater Treatment Plant* – Replacement of plant with a Membrane Bio Reactor.

It should be noted that the construction costs are similar for both Membrane Bioreactor (MBR) and Activated Sludge Plants (ASP) and both systems have advantages, disadvantages and risks. With the accuracy of cost estimation at this stage in the process, it is not possible to select between these options on price alone. The recommended option has resulted from an overall analysis of Quality, Time and Cost:

- Quality – MBR produce a very high quality of effluent, even with changes in load and are not susceptible to poor settlement due to Nocardia. While ASP can produce high quality effluent, performance may dip during changing load conditions (which Hihi does experience), particularly on ammonia and suspended solids.
- Time – An MBR plant can be constructed in approximately 3 months less than the activated sludge solution.
- Cost – Both options show similar capital cost and, while operating and Whole of Life Costs are greater for MBR, over the term of the life, this should be weighed against the benefits noted above.

As noted in WSP's Hihi Options Review from 2020, the membrane bioreactor (MBR) option is the most robust and adaptable solution for future performance needs and resource consent demands, as well as offering the most operationally consistent performance. It is this option that appears to best satisfy the project objectives and level of service expectations.

However, there are also risks associated with MBR plants and it is worth noting the following:

- MBR is a new system for FNDC, which introduces a level of risk with regards to ongoing operational costs. Hihi is a relatively small community to be able to withstand uncertain costs. Detailed design should better inform the whole of life cost expectations.
- MBR technology is still relatively new, compared to ASP, and much is still being learned about how best to operate them.
- Whole of life costs are greater due to the requirement for skilled operators and replacement of membranes. Costs also differ significantly depending on the adopted technology and the site conditions.
- MBR plants are susceptible to membrane fouling, which significantly reduces membrane performance and lifespan. Fouling control strategies are still being researched.

In contrast to MBR, activated sludge plants are a familiar system to FNDC, local operators know how to run them and the whole of life costs are lower than for an MBR. But while ASP can produce high quality effluent for the majority of the time, performance and level of service may dip during changing load conditions, which are experienced at Hihi.

2 Problem / Opportunity

Problem:

- The existing plant infrastructure has been assessed as structurally unsound and unsafe, capacity is insufficient for both peak flow and peak load and the plant footprint is not within the designated boundary.
- The constructed wetlands are in poor condition and cannot perform adequately due to blocked pipes and overflowing basins.
- Stormwater infiltration needs to be addressed.
- The plant's poor condition and insufficient capacity is now impacting operation and the environment is at high risk from contamination.

Opportunity:

- Upgrade of existing plant infrastructure to comply across all current and expected consent conditions. The existing Resource Consent is due for renewal in Nov-22 which will include new conditions for compliance.

- Improve quality and performance - upgrade system process to align with the capacity requirements for area of benefit.
- Provide community with safe, reliable wastewater treatment while achieving value for money.
- Upgrade the wetlands poor condition due to lack of maintenance.

Figure 1) Hihi, Te Hiku Ward, Far North District

3 Background

History on site location and community consultation:
Hihi is a small community on the east coast in the Far North ward of Te Hiku, off SH10, see Figure 1. Hihi's population varies throughout the seasons; the approximate population over the winter months is 200 residents, then during the summer months the population increases to around 400. Hihi beach is also a very popular destination for tourists and during the Christmas holiday period (24 Dec to 7 Jan), the peak season of summer, population increases to over 600.

The Hihi Wastewater treatment plant (WWTP), built around 1975, is located alongside the Hihi Marchant Road Reserve which sits within the boundary of residential properties. The wetland marshes are located off Hihi Road, approximately 800m away from the plant. The plant undertakes both primary and secondary treatment processes, then effluent is pumped from the plant to wetland marshes for tertiary treatment. It is then discharged by gravity to Hihi stream, a minor watercourse that runs through the settlement of Hihi before reaching the coast at Hihi beach. This WWTP employs an extended aeration, activated sludge process. The plant consists of two aerations

Figure 2) WWTP shown inside recreational reserve

tanks that operate in series, followed by a sedimentation tank, which collects the clarified wastewater in an effluent storage tank and from here it is pumped through a rising main to a series of wetland cells.

Reports ranging from 2001 through to 2019 provide evidential data that Hihi treatment plant is structurally at the end of its life and has been patched up over the years to keep it operational. More equipment has been added to keep the plant functioning, but this has resulted in a non-functional operating workspace and has not resolved all the underlying issues, which now cannot be resolved unless the plant is replaced. Current consent conditions allow for the condition of the plant, however, when the resource consent is renewed in 2022, the condition of the treatment plant and the wetlands will no longer be acceptable.

During 2006-2011, relocation of the plant was investigated after 79% of the community favoured moving the treatment plant from its existing location due to the environmental impacts the residents were subjected to e.g. odour, noise, general health and well-being. The most favoured option was relocating the plant to the wetlands, with only the adjacent landowner (to the wetland lots) opposing, therefore investigations were initiated. Based on the conclusion of these studies, relocation to construct the new plant (using the MBR system) at the wetlands was unable to be justified on a cost/benefit basis. It was therefore removed as an option and further remedial options required investigation. The community were consulted, and reference was made stating they understood the implications of relocation and endorsed retaining the plant within the existing site.

Feasibility continued by proposing to stage the project, prioritising remediation of the aeration tank. Stage one would be for the aeration tank to undergo further investigations and Stage two would be to upgrade the plant as the final stage of works. Proposals were requested for stage one, but the remedial work estimates received came in well over budget and, due to the unknown outcome of the consent process and a reluctance to fund this, no upgrade to the tank was initiated. The plant has been operated following a reactive maintenance approach only; planned or proactive maintenance and renewals appear to have been deferred due to potential replacement of the plant.

3.1 Key Issues:

The following are key observations made from prior assessments on the Hihi WWTP, listed in Section 18.1 Appendix A - Hihi WWTP Referenced Material. It is important to highlight that these conditions are a direct result of sweating the asset past its use-by date and lack of investment towards operational maintenance:

- The original WWTP at Hihi was constructed over 40 years ago for a lower population approximately 200 people. It has insufficient flow and load treatment capacity for current demand with peak population of 400-600 people.
- The plant is not robust against seasonal variation and suffers poor solids settlement (Nocardia filaments) and insufficient nitrification as a result.
- Peak flows to the site were designed at 2.5 l/s but current treatment pumps deliver approximately 4 l/s. Additionally storm pump will operate in high wet well conditions. Flooding occurs in very high flows as all pump capacity is exceeded. Peak flow to works of 8 l/s is estimated.
- The plant is compromised by the absence of effective screening of influent.
- The consent conditions for ammonia and dissolved oxygen are exceeded periodically in the stream.
- To deal with high flow deficiency, flow bypasses secondary treatment and sand filtration against the consent conditions.
- High sludge levels were identified within the wetland cells indicating substantial loss of biomass from the treatment plant. Poorly disinfected effluent will pass through the stream to a popular bathing beach.
- Five stormwater storage tanks installed at the rear of the plant extends outside of the lawful designated area, which does not meet planning requirements.
- The assets constructed over 40 years ago were a “low budget solution” and have reached the end of their asset life. This includes primary, secondary tanks and a mechanical scraper mechanism of the clarifier.
- Structural failure has resulted in the collapse of an internal baffle in the aeration tank. The concrete tanks are leaking in several places. Significant Leaks will require at least a 2-week shut down of the whole plant to “patch repair”. Catastrophic failure would take the whole plant out of service until a new plant can be built (estimated minimum of 6 months) and would require removal of wastewater to another treatment plant during this time.

- Many assets have poor accessibility that limits maintenance.
- There is insufficient standby equipment to provide continuous high-quality treatment. For example; to change the blower, the roof of the blower building must be removed, and no secondary treatment is possible in this time.
- The plant and wetlands cannot cope with storm events and there are regular reports of overflows and flooding; the potential risk impact is **very high** against financial, compliance and reputation risk categories.
- There have been instances where excessive inflow and infiltration of stormwater have caused the aeration tank to overflow and spill raw sewage and biosolids into the environment.
- The wetland cells have not been maintained and now require remediation; pipe blockages continue to restrict effluent from reaching all cells, resulting in overflows from the first basin directly into open drains adjacent to the basins. The wetland marshes are also overgrown with weeds and unable to perform.
- Land slips are known at the wetland site and there is evidence of further recent movement in the bank. This will impact on treatment and cause loss of wetlands with consequential impact on stream, stream ecology and bathing beach.
- The site is known to cause nuisance odours and noise to the community. The plant has an issue with the bacteria Nocardia, which causes persistent and excessive foaming in activated sludge plants and can lead to effluent quality deterioration, malodour, increased plant maintenance and hazardous working conditions resulting from foam spilling out of the aeration basin. There are also houses in close proximity to this plant.

The Hihi WWTP has received some upgraded features, such as installation of filtration and ultraviolet disinfection processes, as well as an upgrade to the on-site pump station in 2013. However, these upgrades have only masked the larger issues that will eventually result in health, safety, quality and environmental implications.

In conclusion, the existing Hihi treatment plant is at the point of failure; it is structurally at the end of its life and can no longer meet acceptable performance criteria for the community of Hihi Beach.

3.2 Highest Risks arising from the issues

To assist Far North District Council with the business case for the upgrade of the Hihi Wastewater Treatment Plant a Business Risk workshop was held on 4th December 2019, attended by representatives from FNDC, Broadspectrum, Hoskin Civil and WSP. The issues and risks in the workshop focussed on business risk. The workshops aim was to capture all the issues of the Hihi WWTP, and by use of a risk rating (probability and impact) understand the effect of the issues. The highest rated business risks are:

- Site boundary/designation
- Elevated ammonia (NH3), E-coli and high total suspended solids after treatment. Reduced dissolved oxygen (DO) in wetlands discharge
- Bypass sand filters and secondary treatment during heavy rain events
- Unable to control Nocardia presence
- Clarifier and WAS tank capacity insufficient and pump station floods due to insufficient capacity
- Mixed liquor suspended solids (MLSS) uncontrollable
- Unscreened wastewater
- Insufficient flow buffering
- Inadequate aeration (too little and too much)
- Sludge accumulation in effluent tank
- Sludge build-up in wetlands
- Hill stability with history of slips impacting on wetland
- Single UV reactor
- Leaking main reactor
- Clarifier scraper unreliable and poor condition and has worn the base of the clarifier
- All tanks at end of life; Clarifier tank structure poor and Secondary reactor structure poor condition
- No redundancy on blowers (single unit) or sand filters and limited critical spares for blower
- Limited Maintenance access to sand filters

- SCADA (Red Lion) no longer supported
- Building housing sand filter and UV has no air conditioning or venting
- Insufficient water for washdown
- Manual handling of screenings
- Proximity of pumps to electrics

Note; related risks have been combined above to create a clearer picture. For the full risk report refer to Appendix F - Business Risk Assessment of WSP's Hihi Options Report.

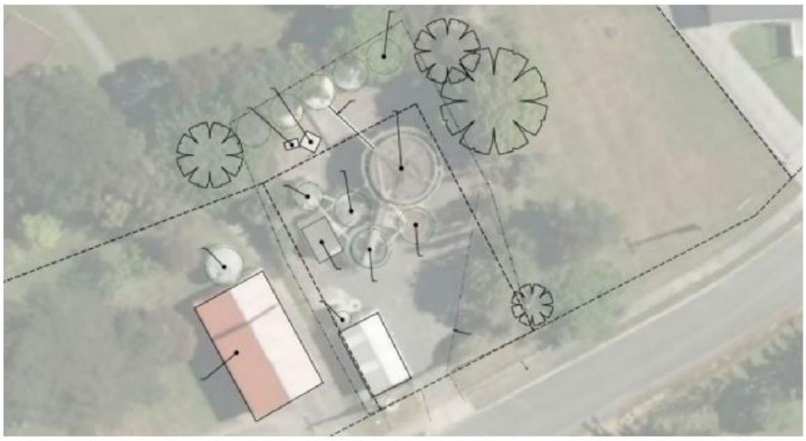


Figure 3) Hihi WWTP, Marchant Road – Site boundary and existing asset layout.

4 Objectives

The objectives for this project are:

- Meet Council's Strategic Priority of affordable core infrastructure by providing the agreed level of service to the Hihi community.
- Achieve Council's Community Outcome of communities that are healthy, safe, connected and sustainable by investing in proven technologies that are safe, have optimal whole of life costs and meet compliance conditions.
- Ensure that the treatment plant complies with the requirements of the Resource Consent to discharge treated effluent and aligns with conditions set under the District Plan.
- Balance the impact on rates with the objectives above to ensure a fair approach to the ratepayers.

5 Benefits

This project will provide:

- A healthy, safe and sustainable community at Hihi through:
  - Avoiding a loss of service through failure
  - Achieving required flow rates, loading and volume capacity
- A wisely managed and treasured environment through:
  - Eliminating overflows and flooding with a system designed to cope with current flows and storm events, as well as expected future growth
  - Construction of a legally compliant plant
- Affordable infrastructure
  - An economic solution which provides the agreed level of service

6 Options

6.1 Options identified

The following long-list options were identified at an Options Engineering Workshop in January 2020;

- Do minimum – refurbishment of aeration tank
- Activated Sludge Plant (ASP)
- Pump to Mangonui
- Moving Bed Bioreactor
- Membrane Bio Reactor (MBR)

The workshop included internal team members from planning, operations, asset management and project delivery, and external representatives from WSP (technical advice), Far North Waters and Broadspectrum (operational team) and Hoskin Civil (Project Managers). These five options were evaluated over a two-day workshop, where project constraints were risk-assessed against the following aspects;

- Affordability
- Land
- Neighbours
- Climate Change
- Consent Conditions
- Amenity
- Land Use
- Nuisance
- Time/Programme
- Maintenance/Operations
- Asset Life
- Wetland Construction
- Quality
- Safety
- Whole of Life Costs

The Do Minimum option was a refurbishment of the existing aeration tank. As this tank is at the end of its life, refurbishment does not mitigate any of these aspects and is not considered a viable option.

The Pump to Mangonui option would meet a number of aspects but was eventually discounted due to (i) whole of life costs far exceeding benefits, and (ii) expected time to obtain a resource consent for a harbour crossing, including objections, exceeding project timeframe of 2 years.

The Moving Bed Bioreactor option was also discounted due to (i) cost, (ii) operational impact of new technology, and (iii) no additional identifiable benefits over the activated sludge process.

The workshop confirmed two replacement options for this final detailed business case. Along with a default, Do Nothing, option these are:

- Option 1 – Do Nothing
- Option 2 – Install new Activated Sludge Treatment System, demolish and remove old system. Scope also includes earthworks within the wetlands and necessary repairs to the network.
- Option 3 – Install new MBR system, demolish and remove old system.

6.2 Options analysis

Category	Option 1 Do Nothing	Option 2 New Activated Sludge Plant (ASP)	Option 3 New MBR System
Capital Expense	Total cost would mirror Option 2 or 3, depending on the option chosen, as the plant would have to be replaced in a few years due to the imminent structural failure of the aeration tank. Structural failure of the	Total Capex cost estimated at $6,215,951. This cost includes initial deliverables, temporary repairs to current tank, design and construction	Total cost estimated at $6,370,973. This cost includes initial deliverables, temporary repairs to current tank and design and construction.

Far North District Council

Capital Works Business Case
Hihi Wastewater Treatment Plant

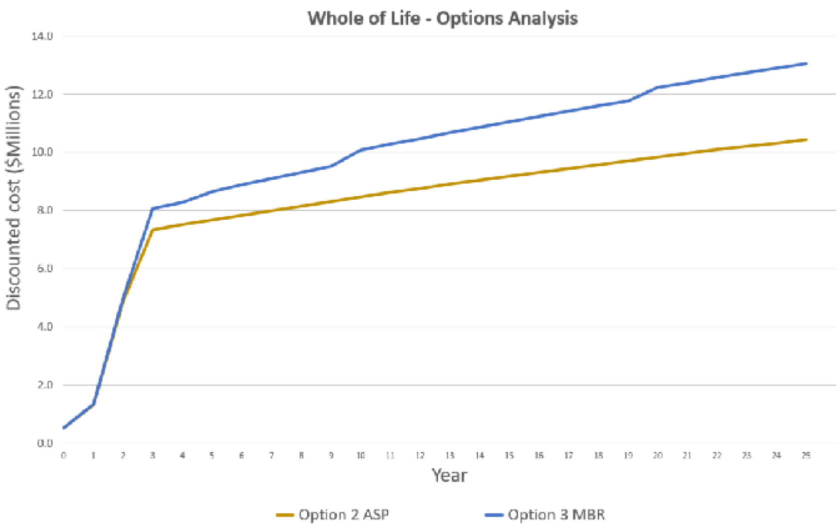
Category	Option 1 Do Nothing	Option 2 New Activated Sludge Plant (ASP)	Option 3 New MBR System
	aeration tank would have catastrophic effects on the environment, local community and reputation. It would also incur significant extra costs of daily wastewater removal, likely for an extensive time, while emergency measures or a replacement plant was procured, designed and built. Consequences would include infringement notices, fines and likely prosecution. The RMA specifies the maximum fine is $300,000 for a natural person and $600,000 of any other person.	and necessary repairs to the network. In addition, Opex costs for wetland works are estimated to be around $700,000. This will be funded separately to the project from the sludge management fund. Further details of these costs are included in the Project Cost section.	Repairs to the network are also estimated as $600,000. In addition, Opex costs for wetland decommissioning are estimated to be around $700,000. This will be funded separately to the project from the sludge management fund. Further details of these costs are included in the Project Cost section.
Rating Implications	Same as Option 2 or 3 as the plant will need replacing once structural failure occurs.	• $1,458.49 replacing existing capital rate of $435.28	• $1,851.01 replacing existing capital rate of $435.28 This figure includes repair to the network which may not be required. Removal of this aspect reduces the rate by approximately $200.
Advantages	None	Complies with current consent conditions. Can be designed to account for future growth and peak loads and expected consent conditions. Improved quality of effluent compared to current system. Little to no increase in operational expenditure. This is a conventional solution, known to operators. Assets Maintainable.	The MBR will produce a very high quality of effluent. High Biomass adapts rapidly to change in load – provides a consistent level of service. Could remove the need for the wetlands. Can be designed to account for future growth and peak loads and expected consent conditions. Complies with current consent conditions. Is unlikely to have any additional capital changes required from the renewal of the resource consent. Could remove the need for wetlands altogether.

Capital Works Business Case
Hihi Wastewater Treatment Plant

Category	Option 1 Do Nothing	Option 2 New Activated Sludge Plant (ASP)	Option 3 New MBR System
			Can be built in limited footprint of designation; inclusion of membranes in the system eliminates the need for secondary clarifiers (which ASP need), results in significantly reduced footprint. Staged construction and decommissioning could minimise plant downtime during construction. Could be largely modular for removal from site to new location if sea level rises. Assets maintainable.
Disadvantages	The existing Resource Consent is due for renewal in Nov-22, which will include new conditions for compliance. This plant will not meet new conditions. This would result in infringement notices, fines and potential prosecution. The existing plant is not performing as it should and is structurally unsound; it must be replaced as soon as possible. Failure to replace the plant exposes the council to the following major risks: • Environmental – Contamination is already occurring; high sludge levels and low dissolved oxygen were identified within the wetland cells indicating poorly disinfected effluent passes through the stream to a popular swimming beach. • Safety for operators, locals and tourists. • Continual breaches of consent conditions. • Reputation - National exposure is likely if there is a catastrophic	The site footprint is still likely to pose challenges for the layout of an Activated Sludge Plant. This site has minimal buffer zone between it and the next property. Sand filter access not addressed. Activated Sludge Plants often have issues with Nocardia which require managing to control it. These plants often produce excess sludge that would require monitoring and management. Activated sludge plants have limitations with removal of recalcitrant (compounds that remain in the treated effluent and then persist in the environment), potentially causing environmental and health problems. The activated sludge plant could require additional capital spend to comply with new resource consent conditions.	It is a more technical plant to manage and will require a full-time employee on site and highly trained personnel. MBR plants are susceptible to membrane fouling, which significantly reduces membrane performance and lifespan, resulting in a significant increase in maintenance and operating costs. Failure to control membrane fouling may lead to failure to treat the required design flows. Fouling control strategies are still being researched. It requires regular chemical cleaning, and chemical storage and disposal. Higher energy costs. Membrane cost, availability and lead time. This has been accounted for in whole of life costs. Potential transport issues for larger vehicles that require a turnaround bay. Emergency power supply required. This has been

Capital Works Business Case
Hihi Wastewater Treatment Plant

<table>
<tr><th>Category</th><th>Option 1
Do Nothing</th><th>Option 2
New Activated Sludge Plant (ASP)</th><th>Option 3
New MBR System</th></tr>
<tr><td></td><td>failure as the deteriorating condition of the plant is well documented.</td><td>Due to the size of the new plant (similar to existing), installation and decommissioning of the old plant may require an extended period of plant downtime.

Requires continued use of the wetlands.</td><td>allowed for in the project costs.</td></tr>
<tr><td>Whole of Life</td><td colspan="3">

Note: MBR plants have two membranes that each require replacement every 5-10 years, they cost between $180k – $250k each. These have been included in the whole of life calculations at 10 years with a value of $200k, but they may occur more regularly or be a higher value membrane. Whole of life cost will be more accurately determined through the design stage.</td></tr>
<tr><td>Operational costs</td><td>Current operational costs (operations and power) have been as follows:
• 16/17 FY $116,977
• 17/18 FY $112,822
• 18/19 FY$163,877
• 19/20 FY $183,419
• Projected 20/21 costs $220,000</td><td>Expected yearly operating costs:
• Approximately $181,000. Includes operator cost at 10 hrs per week $60/hr.
These costs would be more accurately estimated during detailed design.</td><td>Expected yearly operating costs:
• Approximately $250,000. Includes expected operator cost.
These costs vary greatly between MBR technology selected and would be more accurately estimated during detailed design.</td></tr>
<tr><td>Operating Impact</td><td>Contamination would continue to occur and worsen; poorly disinfected effluent would continue to pass through the stream to a popular bathing beach in the tourist-oriented town.</td><td>Temporary repairs should be undertaken to the existing plant whilst the new plant is designed for construction installation.

During the implementation of the treatment plant</td><td>Temporary repairs should be undertaken to the existing plant whilst the new plant is designed and constructed.

This is a new system for the operational team to</td></tr>
</table>

Category	Option 1 Do Nothing	Option 2 New Activated Sludge Plant (ASP)	Option 3 New MBR System
	Continual breaches of consent conditions would result in infringement notices, fines and potential prosecution. The current plant presents a number of safety issues for the operators; • Manual handling of screenings • Proximity of pumps to electrics • Limited maintenance access to sand filters • Building housing sand filter and UV has no air conditioning or venting • Insufficient water for washdown Nocardia issues would persist which affects the efficacy of the plant.	upgrade, the existing plant needs to remain operational. Due to the size of the new plant (similar to existing), installation and decommissioning of the old plant will require careful planning and staging. This may be achieved through item-by-item replacement.	learn and manage. Highly skilled training is required, and FNDC would need to allow for operational assistance during the Defects Liability Period. It is likely that an operator is required onsite for the majority of the time and allowance has been made for this in the whole of life and operating cost estimates.
Risks	Failure to replace exposes the council to the following major risks: • Environmental – due to the plant's poor condition and insufficient capacity for both peak flow and peak load. Contamination is already regularly occurring; High sludge levels were identified within the wetland cells indicating poorly disinfected effluent will pass through the stream to a popular bathing beach in the tourist-oriented town. • Safety for operators, locals and tourists. • Continual breaches of consent conditions, infringement notices and fines. • Reputation - National exposure is likely if there is a catastrophic failure as the deteriorating condition	The site footprint is still likely to pose challenges for the layout of an Activated Sludge Plant – design will be required to determine if this system will fit within the designation. The activated sludge plant could require additional capital spend to comply with new resource consent conditions. This is unlikely as the new plant would be designed to meet modern standards. This process will require use of the wetlands. The price will allow for basic earthworks to address the worst issues at the wetlands. However, there is still a risk of landslides at this site. The condition of the rising main is as yet unknown. This should be investigated	MBR is a new system for FNDC, which introduces a level of risk with regards to ongoing operational costs. It is important to note that MBR plants are still relatively new technology. The efficiency of the filtration process in an MBR is governed by the activated sludge filterability, which is still not well understood and is determined by the interactions between the biomass, the wastewater and the applied process conditions. The costs for MBR differ significantly depending upon the adopted technology and the site conditions. MBR plants are susceptible to membrane fouling, which significantly reduces membrane performance

Category	Option 1 Do Nothing	Option 2 New Activated Sludge Plant (ASP)	Option 3 New MBR System
Risks, continued	of the plant is well documented.	as upgrading or repair may be required. The current plant poses a significant environmental risk and designing and building a replacement will extend the time the current aeration tank remains in operation. Temporary repairs to the existing plant will be required to minimise risk. There is a large impact on ratepayers; Consultation will be required.	and lifespan. Fouling control strategies are still being researched. Proposed lifespan of the membranes is between 5-10 years. The whole of life cost has been calculated as replacing both membranes every 10 years, but this could be required almost twice as often; membranes cost between $180k – $250k each. Hihi is a relatively isolated community and this will make it more expensive to get resources delivered and additional professional support. The wetlands may not be required but may need to be decommissioned to eliminate environmental risks. The current plant poses a significant environmental risk and designing and building a replacement will extend the time the current aeration tank remains in operation. Temporary repairs to the existing plant will be required to minimise risk. There is a large impact on ratepayers; Consultation will be required.
Interdependencies	N/A	Site survey required to confirm boundary and establish if existing storage tanks are outside designation. All critical success factors to be completed prior to implementation.	All critical success factors to be completed prior to implementation.
Stakeholders	Hihi Community, Iwi Operational team, Public Visitors / Tourists	Hihi Community, Iwi Operational team Public Visitors / Tourists, Far North Waters	Hihi Community, Iwi Operational team Public Visitors / Tourists, Far North Waters

Category	Option 1 Do Nothing	Option 2 New Activated Sludge Plant (ASP)	Option 3 New MBR System
Programme	Continued reactive approach (with escalating costs) until plant fails. Emergency response post failure until plant is replaced.	Programme will require staging e.g.; 1. Temporary repairs (may not be required as other systems could be implemented such as mobile septic system) 2. Design 3. Enabling works for new plant 4. Demolish, remove and install new	Programme will require staging e.g; 1. Temporary repairs (may not be required as other systems could be implemented such as mobile septic system) 2. Design 3. Enabling works for new plant 4. Demolish, remove and install new

Table 1) Options analysis

6.3 Ability of the options to address the major risks

The table below summarises the risks and issues that each option addresses, with emphasis on the most serious risks identified in WSP's Business Risk Assessment.

Risk	Option 1 Do Nothing	Option 2 New ASP	Option 3 New MBR
Site boundary/designation	No	Yes	Yes
Elevated ammonia (NH3), E-coli and high total suspended solids after treatment. Reduced dissolved oxygen (DO) in wetlands discharge.	No	Yes	Yes
Bypass sand filters and secondary treatment during heavy rain events	No	Yes	Yes
Nocardia presence (Note: Conventional ASP plants are always susceptible to Nocardia.)	No	No	Yes
Clarifier and WAS tank capacity insufficient and pump station floods due to insufficient capacity Mixed liquor suspended solids (MLSS) uncontrollable	No	Yes	Yes
Unscreened wastewater	No	Yes	Yes
Insufficient flow buffering	No	Yes	Yes
Inadequate aeration (too little and too much)	No	Yes	Yes
Sludge accumulation in effluent tank	No	Yes	Yes
Sludge build-up in wetlands	No	Yes	Yes
Hill stability with history of slips impacting on wetland	No	No	No but wetlands decommissioned
Single UV reactor	No	Yes *	Yes
Leaking main reactor	No	Yes	Yes
Clarifier scraper unreliable and poor condition and has worn the base of the clarifier	No	Yes	Yes
All tanks at end of life; Clarifier tank structure poor and Secondary reactor structure poor condition	No	Yes	Yes
No redundancy on blowers (single unit) or sand filters and limited critical spares for blower	No	Yes *	Yes
Limited Maintenance access to sand filters	No	Yes *	Yes
SCADA (Red Lion) no longer supported	No	Yes	Yes
Building housing sand filter and UV has no air conditioning or venting	No	Yes *	Yes

Insufficient water for washdown	No	Yes *	Yes *
Manual handling of screenings	No	Yes *	Yes *
Proximity of pumps to electrics	No	Yes *	Yes *

** Depending on outcomes specified for detailed design.*

7 Recommendation

An analysis of the three options has been completed based on the WSP Options Report and a QS Peer Review Report. The detailed information from both reports has been collated, along with an analysis of the rate impacts and whole of life costings against each option.

As noted in WSP's Hihi Options Review from 2020, the membrane bioreactor (MBR) option is the most robust and adaptable solution for future performance needs and resource consent demands, as well as offering the most operationally consistent performance. It is this option that appears to best satisfy the project objectives, while balancing the cost implications.

8 Project Deliverables

8.1 Items Completed to date

The following have been completed:

- Indicative business case that identified what further investigation and actions were required to enable completion of the business case.
- Structural assessment of aeration tank.
- Options Review by WSP.
- Business Risk Assessment Workshop.
- QS Report

8.2 Next Steps

This Business Case will need to be presented to Council to confirm the preferred option. Regardless of the replacement Option chosen, the deliverables are:

Initial Deliverable	Recommendation
Implement temporary measures on aeration tank	Temporary measures to stabilise aeration tank (interim mitigation) should be undertaken until new plant is implemented. The WSP Structural Condition Assessment in 2019 proposed the following actions on the critical structural elements; • The tank should be cleared of sediment and the base examined • All cracks on the perimeter should be sealed appropriately • Regular maintenance and structural inspections of the existing tank should occur to monitor the deterioration of the reservoir. • Estimated minimum cost is $80,000 and it is expected to take 2 weeks. Additional budget has been allowed for in project costs due to expected continued deterioration of the tank. Alternative options to temporary repairs may exist (such as mobile septic system) and will need to be further explored. NOTE: No temporary measures have yet been implemented.
Site Survey	Recommend engaging a surveyor to complete.

Prepare an Engagement Plan	Proposed solution, programme and rates impact to be presented to community. Consultation required with NRC regarding upcoming resource consent renewal and conditions.
Cultural Impact Assessment	May be best completed with consultation with NRC regarding resource consent.
Conservation and Ecology Report - Wetlands	May be best completed with consultation with NRC regarding resource consent.
Planning Assessment	Engage Planner to advise what items are required as part of the resource consent process.
Physical Works Deliverable	
Procurement	Open tender for Design and Build Contract
Construction	Proposed staged construction methodology: Stage 1: Enabling works Stage 2: Demolition, Construction, Installation, commissioning Stage 3: Wetlands upgrade, (priced in Option 2, but not in Option 3). Requirement to be confirmed during design phase.

9 Critical Success Factors

The following items are critical to the success of the project.

Critical Success Factor	Justification
Decision from Council regarding preferred option	This Business Case covers the benefits, issues and risks of the two replacement options. A recommendation has been made based on the current understanding of the risks and benefits of each option. However, the preferred option may change if the Council perceives that the risks or costs of that option outweigh the benefits.
Timing	The chosen option must be implemented as quickly as possible; the current plant poses a significant environmental risk.
Risk reduction	Whichever option is preferred, a risk management plan will need to be developed for the project. The role of risk management should be sited with one person and be reported on monthly in a documented format to be utilised as a monitoring tool.
Affordability	The following will be critical to the success of the project: • Funding – Ensure sufficient funding is available in the LTP. • Rates - Either the Hihi community accept the impact on their rates, or the impact on ratepayers is reduced.
Community engagement / iwi consultation	Ensure community know the reasons behind Council's decision and the impact of that decision.
Definition of Scope	A formal Scope of Work for the preferred option will be developed to be used for procurement.
Health and Safety	Site specific safety plans, site access plans, health and safety and hazard reporting plans will also require approval as part of the procurement process. These will be approved by Council, or suitably qualified personnel, prior to commencing any works.
Quality Assurance	It is important to plan for and effect an audit process for supplier performance to ensure quality assurance of service delivery, standards of excellence, agreed levels of service are met and asset life cycle competency.

Continued level of service throughout construction	Temporary repairs, or an alternative, need to be considered as the current plant poses a significant environmental risk. In addition, the small footprint of the site will present challenges for maintaining wastewater treatment during construction and commissioning. A detailed methodology will be required as part of the procurement process detailing the contractor's approach to demolition, construction and commissioning.

10 Procurement

10.1 Procurement Approach for Initial Reports and Consultation

The recommended consultant assessments and reports highlighted under scope deliverables and critical success factors should be commissioned and have been allowed for in project costs. These items are required to provide certainty in the proposed solution and alleviate the community's concerns by providing clarification around any environmental and community impacts. All reports can be direct sourced as they will be under the FNDC procurement threshold value.

Deliverables include:

- Certificate of Titles – boundary properties of plant, wetlands and stream.
- Site Survey – confirmation of plant boundary required; existing storage tanks currently sit outside boundary on desktop assessment.
- Concept design
- Cultural Impact Assessment.
- Conservation and Ecology Report.
- Planning Assessment – FNDC or external planner (pending on internal capacity).
- Consultation – undertake community engagement with the ratepayers.

10.2 Procurement Approach for Option 2 or 3

It is recommended that Option 2 or 3 be procured by Open Tender for a Design and Build contract with weighted attributes. It is recommended that the RFT non-price attributes weightings reflect the project deliverable requirements. Therefore, increasing standard weightings for critical attributes such as proposed solution, construction methodology and programme. Tenderers should be encouraged to:

- Collaboratively design alongside the plant supplier to problem-solve out or mitigate high risk items and recognise any 'out of scope' anomalies.
- Be forthcoming with innovative and sustainable solutions.

It will be a requirement for tenderers to:

- Design solution
- Manage supply, delivery and installation of package plant directly with supplier.
- Separable portions could include:
    - Enabling works (pending scope but may include; land extension, wetland remediation)
    - Plant Supply and Installation
    - Demolition, Decommissioning
    - Remediation, reserve works (scope depends on option chosen)

11 Project Timeline

The indicative timeline is aligned to the delivery approach of either option. They reflect that the business case is to be delivered to the Council meeting on 25 February 2021.

11.1 Timeline for Options 2 and 3

Task	Apr 21	May 21	Jun 21	Jul 21	Aug 21	Sep 21	Oct 21	Nov 21	Dec 21	Jan 22	Feb 22	Mar 22	Apr 22	May 22	Jun 22	Jul 22	Aug 22	Sep 22	Oct 22	Nov 22	Dec 22	Jan 23	Feb 23	Mar 23	Apr 23	May 23	Jun 23	July 23	Aug 23	Sept 23	Oct 23	Nov 23
Temporary Remediation	X	X	X																													
Initial Deliverables	X	X	X	X	X	X	X	X	X																							
Procurement									X	X	X	X	X																			
Design														X	X	X	X	X	X	X	X	X										
Construction																							X	X	X	X	X	X	X	X	X	X

12 Project Cost

12.1 Funding

The figures below were obtained in December 2020 from the Budget included in 2021/31 LTP.

Funding ($)	2020/21 Forecast	2021/22 LTP	2022/23 LTP	2023/24 LTP	All years
Opex					
Sludge – external services – GL 1.5514.01.2407	*522,750*	*1,070,592*	*1,089,327*		*2,682,669*
Capex					
New (PR 551302.1.1.4917)	*0*	*2,500,000*	*3,400,000*	*0*	*5,900,000*
Renewal (PR 551302.1.1.4922)	*100,000*	*0*	*0*	*0*	*100,000*
Total Capex Available	*100,000*	*2,500,000*	*3,400,000*	*0*	***6,000,000***

12.2 Cost Estimation

Option 2 - ASP

Cost Estimation ($)	2020/21	2021/22	2022/23	2023/24	All years
Opex – incl Professional Services					
Wetlands work (Sludge management)			*700,000*		***700,000***
Capex					
Temporary measures to stabilise current aeration tank	*300,000*				***300,000***
Initial deliverables	*40,000*	*60,000*			***100,000***
Design and Construction Costs, includes repair to the network *		*500,000*	*3,439,706*	*1,876,245*	***5,815,951***
				Total Project Capex Cost	***6,215,951***

** Repair to the network is included in the construction cost as ASP plants are more susceptible to variable flows and removing irregular influx from stormwater is desirable.*

Option 3 – MBR

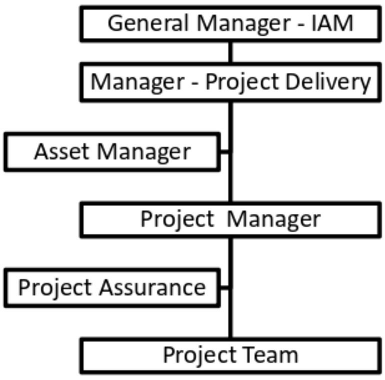
Cost Estimation ($)	2020/21	2021/22	2022/23	2023/24	All years
Opex – incl Professional Services					
Wetlands Decommissioning* (Sludge management)				*700,000*	***700,000***
Capex					
Temporary measures to stabilise current aeration tank	*300,000*				***300,000***
Initial deliverables	*40,000*	*60,000*			***100,000***
Design and Construction Costs		*500,000*	*3,439,706*	*1,876,245*	***5,970,973***
				Total Project Capex Cost	***6,370,973***
Repair to the network**				*600,000*	***600,000***
				Total Cost, including network repairs	***6,970,973***

** The wetlands may need to be decommissioned to avoid non-compliance. This would be an Opex cost from a different budget and potential costs have been included in this table to give a full picture of possible costs.*

*** Repair to the network is included as a separate item as it would be ideal to undertake, but is not assumed to be imperative to the MBR option. This would need to be confirmed during design. These costs have been included in the rate calculation.*

13 Project Approach

13.1 Project Governance



Name & Position	Project Roles *
Andy Finch General Manager – IAM	Executive Sponsor
Tanya Proctor Manager – Project Delivery	Senior Responsible Owner
Mark Keehn Asset Manager	Business Representative
Glenn Rainham Operations Manager	Business Representative
Corey Hutchinson Maintenance Manager	Business Representative

* Responsibilities for project roles are detailed in the Capital Works Project Management Framework.

13.2 Project Management

Management of the project will be undertaken following the requirements and procedures detailed in Far North District Council's Capital Works Project Management Framework, and consistent with expectations for a **Complex** project.

13.3 Project Constraints, Assumptions & Dependencies

The following items can be resolved, refer to Recommendations and Timeline sections for further details.

Type	Description	Action required
Constraint	Budget and rate impact	FNDC
Dependency	Final decision on preferred option from Council	FNDC
Constraint	Site Survey and certificate of titles will confirm the designation that the solution must fit within	FNDC
Dependency	Cultural Impact Assessment	FNDC
Dependency	Planning Assessment	FNDC
Dependency	Consultation Report / Public Meeting	FNDC
Dependency	Design of solution and installation methodology must be confirmed	FNDC

14 Quality considerations

14.1 Quality requirements:

The Hihi WWTP has an existing resource consent due to expire in Nov-2022, the sites listed are also designated and have conditions set under the District Plan.

Resource Consent:

- Northland Regional Council (NRC) have four monitoring sites, three are located at the constructed wetlands and one is at the WWTP site.
- Resource Management Act and the Regional Water and Soil Plan apply to this site/activity.

- Hihi WWTP existing resource consent: RC – CON19940739901

  Endorsed: 14-05-2008

  Expiry: 30/11/2022

  Conditions:

  1) The discharge of treated wastewater into an unnamed tributary of Hihi Beach (Hihi Stream).
  2) To discharge contaminants to ground via seepage from the base of an artificial wetland.
  3) To discharge contaminants (primarily odour) to air from wastewater treatment facilities.

- Resource Consent conditions renew 2022, new conditions are unknown; consultation is required to determine if the preferred solution will meet consent conditions.

<u>Far North District Council Plans:</u>

1. Existing Site (Lot 78 DP 73991)
   - District Plan – Underlying zone Coastal Residential with a Designation (FN164) for the purpose of Hihi Sewage Treatment and Disposal – applying to Lot 78 DP 73991 and SO 69378 Blk IV Mangonui SD.
2. Neighbouring Site (Part Lot 71 DP73991)
   - District Plan – Recreation reserve land zoned recreational activities subject to the Reserves Act.
3. Wetland Site (Part Lot 1 37697 and Part Lot 2 DP 88975)
   - District Plan – Rural Production Zone with designation FN164A. The designation was approved on 1 May 2008 – Consent number RC 2061079. This decision was issued by the Environment Court, it has specific conditions that apply to the site.
4. Far North District Council's Engineering standards and Guidelines 2004 (3rd revision July 2007).

Note: Figure 4 shows the Far North District Zoning (referred to in the previous numbered points) for Hihi WWTP designations.

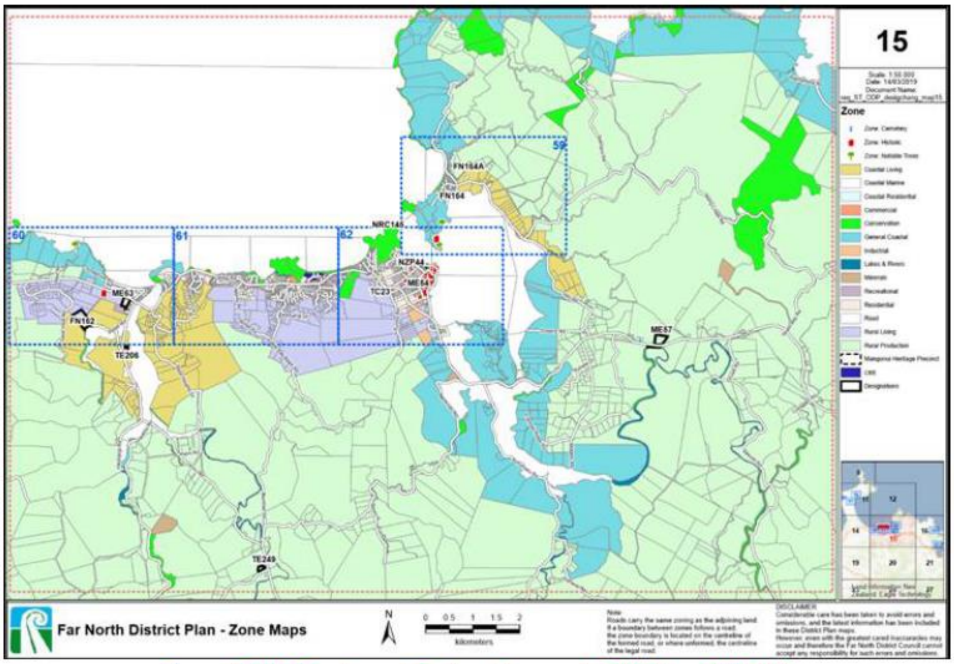


Figure 4) FNDC Zoning and Designations – refer FN164 and FN164A

Noise
All noise associated with the site and access construction shall comply with the permitted activity standard of the Rural Production Zone of the Proposed Far North District Plan. Construction noise shall be within levels required by NZS 6803:1999 'Acoustics – Construction Noise'.

Odour
Odour concerns are minimal; the grit and screenings facility that is proposed is the most likely source of offensive odours. Options would be investigated; however, a biofilter is the preferred option if the odours are to be managed aggressively.

14.2 Quality tolerances:

Lower standards have been adopted over the past few years during feasibility investigations to identify the best outcome for Hihi. Quality has been compromised this has been managed extremely well by the operational team and the community as the circumstances have been less than desirable and continue to decline. The current circumstances are tolerated for now. However, when the resource consent is renewed in 2022, the condition of the treatment plant and the wetlands will no longer be acceptable, therefore the following points should be addressed.

WWTP, Marchant Road:
Most recently, adverse conditions for the activated sludge process have resulted in the accumulation of foaming from the filamented bacteria, Nocardia. Nocardia is difficult to eliminate due to its growth cycle; the bacterium branches out and cells break off and dissipate, the gram-positive genus continues to branch out, break off and spread. While it is difficult to eliminate Nocardia, a better functioning plant should substantially reduce the issues caused by it.

Constructed Wetlands:
The constructed wetlands have also been neglected due to insufficient funding and maintenance. Observations made from a recent site visit confirmed that the wetland basins were performing poorly. Several prior reports indicate the wetlands poor condition is nothing new, stating the basins regularly overflow due to blocked pipes. At the site visit the first cell was clearly struggling to perform and the basin was overflowing into an open drain caused by blocked pipes. The marshes are covered in weeds, there is minimal visibility of scheduled plant life, vegetation or aquatic planting and no sign of animal life – these natural elements are key to a wetlands function and success.

A conservation report should be commissioned, reporting on the ecology and flows in the receiving stream, local species, monitoring and effects of current systems in place, water features and flora and fauna. An assessment of the current design/cell layout requires options for remediation to bring the wetlands back to the distinct ecosystem they should be and serve as home to a wide range of plant and animal life.

15 Risks and Issues

15.1 Risks with Option 1 – Do Nothing

RAG	Risk / Issue description	Risk owner
A	Upgrades have been made which extend the plant outside the existing site boundary/designation.	FNDC Planning/Asset Management
R	Resource consent expiry 2022 – new conditions currently unknown.	FNDC Finance/ Asset Management/Delivery
R	HSQE Issues exist with the current plant; Limited Maintenance access to sand filters; Building housing sand filter and UV has no air conditioning or venting; Insufficient water for washdown; Manual handling of screenings; Proximity of	FNDC Health & Safety/Asset Management

	pumps to electric; Issues with Nocardia; No redundancy on blowers (single unit) or sand filters and limited critical spares for blower; SCADA (Red Lion) no longer supported. These pose health and safety, compliance and environmental risks.	
R	Poorly treated effluent is achieved which will not be acceptable in renewed consent conditions; high total suspended solids, elevated E-coli, elevated ammonia and reduced dissolved oxygen.	FNDC Asset Management
R	Clarifier capacity designed for 2.5 l/s flow but flow has increased with the population increase to be 4 l/s. There is insufficient treatment capacity for peak flow and parts of the system have to be bypassed in heavy rain.	Project Delivery
R	All tanks are at the end of their design life (30 years); Some are structurally unsound and leaking. All tanks are critical to the process, so failure in one is catastrophic as there is no backup.	FNDC Asset Management/Delivery
R	Sludge reaches and builds up in the wetlands. This exceeds the maximum condition in consent and impacts on the local stream which leads to a popular swimming beach.	FNDC Asset Management/Delivery

15.2 Risks with Option 2 - ASP

RAG	Risk / Issue description	Risk owner
R	Site footprint - existing site location is very small and should be extended. Extension further back requires a planning assessment, site survey (boundary confirmation).	FNDC Planning/Asset Management
A	Buffer zones around the current footprint are minimal – there is a house in close proximity.	FNDC Asset Management
A	Community – odour and noise of new plant (there have been previous concerns with existing plant). This should be substantially improved.	FNDC Planning/Asset Management
R	Rate impacts – explore options to decrease impact on residents.	FNDC Finance/ Asset Management/Delivery
R	Resource consent expiry 2022 – new conditions currently unknown. The activated sludge plant could require additional capital spend to comply with new resource consent conditions.	FNDC Finance/ Asset Management/Delivery
R	Aeration tank structural integrity fails, resulting in spillage into the environment and harbour. Temporary measures to stabilise aeration tank or other interim measures should be undertaken to mitigate this risk until new plant is implemented. This is included in the project estimate.	FNDC Health & Safety/Asset Management
A	Construction and Decommissioning: existing plant to remain operational until new plant is commissioned. Ability to do this will need to be confirmed.	Project Delivery / coordination with community
R	The plant and wetlands cannot cope with storm events, which results in overflows and flooding; the potential risk impact is very high, due to risk of an environmental spill into the harbour. This risk will not be mitigated until the new plant is operational which will realistically be the 22/23 financial year.	FNDC Asset Management
R	Climate change: If sea-level-rise predictions and/or a 1-in-50-year storm event occurs, an environmental spill/harbour contamination could occur. An Activated Sludge Plant is not designed to be relocated; however, it should be able to be designed to mitigate the effect of large storm events.	FNDC Asset Management/Delivery
A	Nocardia is often an issue with ASP, even if it is eliminated in the short term, it will likely reappear.	FNDC Asset Management
R	Supply chain stability will need to be explored due to the impacts of the current and ongoing pandemic.	Project Delivery

R	The condition of the rising main between the ASP and the wetlands is as yet unknown. This should be investigated and there is a risk that it may require upgrading or repair. Cost is unknown as yet.	Project Delivery

15.3 Risks with Option 3 - MBR

RAG	Risk / Issue description	Risk owner
R	Post construction/implementation operational management – need contractual assurance that the operational team are skilled to do all maintenance duties required with new plant. The MBR process requires the plant operators to have a high level of skill to ensure optimal operation and early detection of degradation in membrane performance; This means having an office with a staff member onsite (this has been accounted for in whole of life and operational cost calculations). Failure to manage the plant well could result in more frequent membrane replacement, at significant cost.	FNDC Asset Management/Delivery
R	MBR is a new system to FNDC; There is a lack of published operational advice and experiences available on flat sheet and hollow fibre membranes in New Zealand. Current proposals are not based on actual flow and load data.	FNDC Asset Management/Delivery
A	Community – odour and noise of new plant unknown. Biofilters could be required to reduce odour, this cost is not included in estimate.	FNDC Planning/Asset Management
R	Rate impacts – explore options to decrease impact on residents.	FNDC Finance/ Asset Management/Delivery
A	Resource consent expiry 2022 – new conditions currently unknown. The membrane plant will produce a very high quality of effluent and is unlikely to have any additional capital changes required from the renewal of the resource consent.	FNDC Finance/ Asset Management/Delivery
R	Aeration tank structural integrity fails while the old plant remains in operation until the new plant is built, resulting in spillage into the environment and harbour. Temporary measures to stabilise aeration tank or other interim measures should be undertaken to mitigate this risk until new plant is implemented. This cost is included in the estimate.	FNDC Health & Safety/Asset Management
A	Construction and Decommissioning: existing plant to remain operational until new plant is commissioned. Ability to do this will need to be confirmed.	Project Delivery / coordination with community
R	The plant and wetlands cannot cope with storm events, which results in overflows and flooding; the potential risk impact is very high, due to risk of an environmental spill into the harbour. This risk will not be mitigated until the new plant is operational which will realistically be the 22/23 financial year.	FNDC Asset Management
A	The wetlands are not required for this option. Leaving them in place could result in non-compliance but this is yet to be confirmed. Decommissioning has been included in the project cost section.	FNDC Asset Management
A	If the repairs to the network are not undertaken to address stormwater ingress, the plant should be designed to cope with this issue if this is possible.	FNDC Asset Management/Delivery
A	Climate change: If sea-level-rise predictions and/or a 1-in-50-year storm event occurs, an environmental spill/harbour contamination could occur. This can be accounted for in design of the new plant.	FNDC Asset Management/Delivery
R	Supply chain stability will need to be explored due to the impacts of the current and ongoing pandemic.	Project Delivery

16 Key Stakeholders

Stakeholder	Interest level	Influence level	Recommended approach	Dependency
FNDC Asset Management	High	Empower	Detailed BC	N/A
FNDC Project Delivery	Medium	Inform	Detailed BC	N/A
FNDC Planning	High	Collaborate	Detailed BC	N/A
FNDC Finance	High	Involve	Detailed BC	N/A
NRC	High	Involve	Planning assessment	Critical Success Factor
Community	High	Inform	Consultation Report - Public Meeting	Critical Success Factor
Iwi	High	Inform	Consultation Report - Public Meeting	Critical Success Factor
Plant Supplier	High	Involve	Proposal request	Site Survey
Far North Waters	High	Inform	Consultation during design	Critical Success Factor

17 Document sign off

Role	Name, title	Signature	Date
Prepared by:	Jody Kelly Project Manager, Hoskin Civil Ltd		26/01/21
Reviewed by:	Mark Keehn Asset Manager, FNDC		
Reviewed by:			
Approved by:			

18 Appendices

18.1 Appendix A - Hihi WWTP Referenced Material

Date issued	File name	Description of detail	Author/Company
30-Oct-2019	Indicative Business Case	Stage 1 BC – Next Steps	Hoskin Civil Ltd
25-Nov-2019	Hihi WWTP Activated Sludge Reactor	Structural Condition Assessment	WSP
11-Mar-2020	Hihi Options Review and Appendices	Options Workshop Findings. Appendices include the Business Risk Workshop which is an important document to read.	WSP
August 2020	Hoskin Civil QS Report August 2020	Peer Review	Hoskin Civil Ltd

Far North District Council
Te Kaunihera o Tai Tokerau ki te Raki

Hihi Wastewater Treatment Plant

CAPITAL WORKS BUSINESS CASE

HE WHENUA RANGATIRA
A DISTRICT OF SUSTAINABLE PROSPERITY & WELL-BEING

Project Code:	AAPXXXX	**Project ID (Finance):**	551302
Objective ref:	A1833495	**Objective version #:**	22

Capital Works Business Case
Hihi Wastewater Treatment Plant

1 Purpose

This Project Brief details the investment need and provides the high-level approach for capital investment that will be further specified and developed during the Detailed Design stage.

Recommendation: *Hihi Wastewater Treatment Plant - Major plant upgrade with a membrane bioreactor package. This is an indicative business case with recommendations to complete preliminary works prior to confirming costs. These will confirm the suitability of the preferred solution and allow the final business case to be prepared.*

2 Problem / Opportunity

Problem:

- The existing plant infrastructure has been assessed as structurally unsound and unsafe, capacity is insufficient for both peak flow and peak load and the plant footprint is not within the designated boundary,
- Stormwater infiltration needs to be addressed,
- The plant's poor condition and insufficient capacity is now impacting operation and the environment is at high risk from contamination,
- The constructed wetlands are in poor condition and cannot perform adequately due to blocked pipes and overflowing basins,
- The existing Resource Consent is due for renewal in Nov-22 which will include new conditions for compliance,
- Operational maintenance of FNDC assets requires programming, this should include allowances for funding plant upgrades in accordance to their lifespans/spec requirements,
- FNDC records show evidential assessments and reports ranging from 2001 to 2019 confirming Hihi WWTP has unsafe and poor performing plant/assets still in use,
- Further investigations are required before the final business case can be submitted.

Opportunity:

- Upgrade of existing plant infrastructure to comply across all consent conditions,
- Improve quality and performance - upgrade system process to align with the capacity requirements for area of benefit,
- Value for money - providing a solution that will last 40 years,
- Membrane Bioreactor (MBR) – the proposed system has been selected based on modular buildability, these are purpose built, they can also be easily transported/relocated if required – this aligns with climate change predictions,
- Improve the Marchant Road Reserve's function and accessibility by moving the plant further back and relocating and upgrading the playground to the sea front and installing a public toilet, (the funding for this reserve has been moved out to prevent unnecessary renewal work),
- Upgrade the wetlands poor condition due to lack of maintenance – this will ensure compliance; for the resource consent renewal process due to commence in 2020.

Figure 1) Hihi, Te Hiku Ward, Far North District

3 Background

History on site location and community consultation:
Hihi is a small community on the east coast, off SH10 in the Far North ward of Te Hiku, see Figure 1. Hihi's population varies throughout the seasons; the approximate population over the winter months is 200 residents, then during the summer months the population increases to around 400. Hihi beach is also a very popular destination for tourists and during the Christmas holiday period (24 Dec to 7 Jan), the peak season of summer increases to over 600 in population.

The Hihi Wastewater treatment plant (WWTP) was built around 1975, it is located alongside the Hihi Marchant Road Reserve which sits within the boundary of residential properties, and the wetland marshes are located off Hihi Road, approximately 800m away from the plant. The plant undertakes both primary and secondary treatment processes, effluent is then pumped from the plant to wetland marshes for tertiary treatment before it is discharged by gravity to Hihi stream, a minor watercourse that runs through the settlement of Hihi before reaching the coast at Hihi beach. This WWTP employs an extended aeration, activated sludge process. The plant consists of two aerations tanks that operate in series followed by a sedimentation tank, which collects the clarified wastewater in an effluent storage tank, from here it is pumped through a rising main to a series of wetland cells.

Figure 2) WWTP shown inside recreational reserve

Reports ranging from 2001 through to 2019 provide evidential data that Hihi treatment plant is structurally at the end of its life and has been patched up over the years to keep it operational whilst pending the outcome of the resource consent process due to expire 2022. This has resulted in adding more equipment to keep the plant functioning but not resolving all the underlying issues, which now cannot be resolved unless the plant is replaced.

During 2006-2011, relocation of the plant was investigated after 79% of the community favoured moving the treatment plant from its existing location due to the environmental impacts the residents were subjected to e.g. odour, noise and general health and well-being. The most favoured location was shifting the plant to the wetlands with only the adjacent landowner (to the wetland lots) opposing, therefore investigations were initiated. Based on the conclusion of these studies; relocation to construct the new plant (using the MBR system) at the wetlands was unable to be justified on a cost/benefit basis. It was therefore removed as an option and further remedial options required investigation. The community were consulted, and reference was made stating they understood the implications of relocation and endorsed retaining the plant within the existing site.

Feasibility continued by proposing to stage the project, prioritising remediation of the aeration tank. Stage one would be for the aeration tank to undergo further investigations and Stage two would be to upgrade the plant as the final stage of works. Proposals were requested for stage one, but the remedial work estimates received came in well over budget and due to the unknown outcome of the consent process and a reluctance to fund this, no upgrade to the tank was initiated.

The following are key observations made from prior assessments reviewed on the Hihi WWTP, references to these are appended; 19.1) Appendice A - Hihi WWTP Referenced Material. It is important to highlight that these conditions are a direct result of sweating the asset past its use-by date and no investment towards the operational maintenance:

- The plant has been operated following a routine maintenance approach only; planned or proactive maintenance and renewals appear to have been deferred due to potential replacement of the plant,
- The plant is compromised by the absence of effective screening of influent,
- Hydraulic overloading adversely effects the performance of the clarifier,

- Overflow evidence results in serious loss of biomass, which adversely affects biological performance of the treatment plant, such overflows also create an unhygienic unacceptable mess,
- Residual life for each asset was given between 4-12 years, this indicated the plant would require replacement by 2013,
- The wetland cells have not been maintained and now require remediation and possible redesign, pipe blockages continue to restrict effluent from reaching all cells resulting in overflows from the first basin directly into open drains immediately adjacent to the basins,
- High sludge levels were identified within the wetland cells indicating substantial loss of biomass from the treatment plant,
- Monitoring results show high-quality effluent generally still obtained after wetland treatment,
- The wetland marshes are overgrown with weeds and unable to perform within the natural environment,
- There have been instances where excessive inflow and infiltration have caused the aeration tank to overflow and spill raw sewage and biosolids into the environment,
- The large aeration tank's central dividing wall has collapsed, and the aeration pipe work has rotted away, resulting in almost no air diffusion through the tank,
- Both aeration tanks are deemed structurally unsound and unsafe,
- The overall capacity of the treatment plant is no longer sufficient enough to manage peak flow and peak load, this causes intermittent very poor effluent passing to the tertiary wetlands,
- Five stormwater storage tanks installed at the rear of the plant currently sit outside the designation boundary,
- The plant and wetlands cannot cope with storm events, there are regular reports of overflows and flooding, the potential risk impact is **very high** against risk categories: financial, compliance and reputation.

The Hihi WWTP has received some upgraded features, such as installation of filtration and ultraviolet disinfection processes, as well as an upgrade to the on-site pump station in 2013. However, these upgrades have only masked the larger issues that could eventually result in health, safety, quality and environmental implications.

In conclusion the existing Hihi treatment plant is at the point of failure; it is structurally at the end of its life and can no longer meet the performance criteria for the community of Hihi Beach.

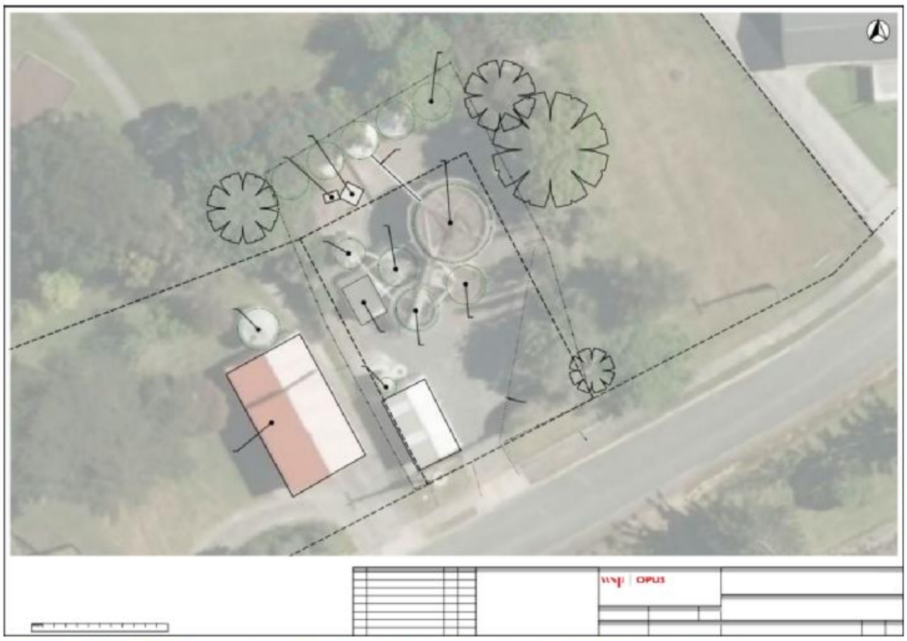


Figure 3) Hihi WWTP, Marchant Road – Site boundary and existing asset layout.

4 Objectives

The objectives for this project are:

- Undertaking works to meet compliance obligations - ensure that the treatment plant complies with the requirements of the Resource Consent to discharge treated effluent and aligns with conditions set under the District Plan.
- Investment to achieve a desirable community strategic outcome - replace assets at the end of their useful life thereby reducing operational expenditure.
- Maintaining an agreed level of service through upgrade of an asset - reduce operational expenditure by addressing and minimising risks associated with the current plant.

5 Benefits

The benefits of this project are:

- Meeting the requirements for the area to align with flow rates, loading and volume capacity,
- Health, safety and quality compliance for the community, operational team and the environment,
- Value for money – existing asset has been sweated beyond its design life and is now at the point of failure, the proposed solution has a 40-year life span and modular buildability which can be relocated it required.

6 Project Deliverables

A strategic analysis of prior condition assessments and options analysis has been performed; from this we identified some areas that have not been fully investigated or completed. Based on these findings the project deliverables have been staged.
It is important to note that some deliverables are dependent on another. In this case the recommendation is to initiate the deliverables under each stage and complete in parallel. Refer to **Error! Reference source not found.** showing high level timelines.

Initiation Phase	
Stage 1 – Feasibility (In Scope)	**Specific exclusions (out of Scope)**
Prepare indicative business case that identifies what further investigation and actions are required to enable completion of the business case.	
Structural assessment required for aeration tank.	
Temporary measures to stabilise aeration tank (interim mitigation is required until new plant is implemented). Pending an up to date structural report of the tank, possible solutions could include; • Temporary bund around plant, • Tank repairs – install new central dividing wall, concrete and steel options, waterproofing options include coating or a liner, • Secondary tank option (temporary) - onsite options, modular unit, smaller unit just for overflow, • Investigation into reducing stormwater infiltration and a consultation strategy to implement this.	
Stage 2 – Master planning (In Scope)	**Specific exclusions (out of Scope)**
Site Survey	
Certificate of Titles for directly affected properties	
Cultural Impact Assessment	
Arborist Report – Reserve/Plant	
Conservation & Ecology Report - Wetlands	

Planning Assessment	
Consultation Report	
Landscape Plan - Wetlands	
Wetland Remediation Assessment/Redesign Options	
Condition assessment of Whatuwhiwhi Screen – several reports, including the Opus Feasibility have suggested that this screen could be refurbished and used at Hihi.	
Consultation - Public Meeting	
Conceptual Drawings - package plant sizing needs to be obtained and reviewed to ensure sizing suitability of the system. Investigations covering; connecting existing plant/services to new plant; reviewing installation of package plant details; working with supplier to recognise site constraints; infrastructure anomalies, etc, whatuwhiwhi screen refurbishment (tbc); investigation into remediation / upgrade work to reserve and neighbouring property consultation if required.	
Final Business Case	
Preliminary Design Phase	
(In Scope)	**Specific exclusions (out of Scope)**
Early contractor involvement and Supplier to complete preliminary design, specifications, phasing of construction/implementation, proposed methodology, site constraints, operational methodology for changeover and decommissioning.	
Implementation Phase	
Design / Build Contract (In Scope)	**Specific exclusions (out of Scope)**
Staged construction methodology (proposed) Stage 1: Enabling works: Stage 2: Construction, Installation, commissioning: Stage 3: Demolition / Decommissioning/ Reinstatement/Reserve Upgrade Stage 4: Wetlands upgrade Stage 5: SW infiltration – Note: The issue of stormwater infiltration could be investigated/addressed now as a mitigation measure for the current plant loading, as well as a benefit for the new plant	To be confirmed: • Package Plant – MBR system supplied, • Reserve upgrade, relocate playground, accessway, (not fully scoped yet), • Possible Whatuwhiwhi screen refurbishment.
Whatuwhiwhi screen refurbishment and installation (tbc)	

7 Critical Success Factors

The purpose of this Indicative Business Case is to highlight what actions are still required to put together a robust and well-informed business case. The below factors should be understood as critical to successful project delivery, they should inform the selection of options for the business case and have not yet been implemented.

Critical Success Factors	**Justification**
Site Survey	Existing storage tanks at plant (Lot 78 DP 73991) are sitting outside the designated boundary.
Cultural Impact Assessment	Cultural assessment confirming if the locations have any archaeological sites significant to maori, are heritage or/and have cultural historical data

	associated. (Iwi and community previously requested confirmation of this).
Planning Assessment	Required to determine whether or not to 'notify', e.g. limited or public notification. (Iwi and community previously requested confirmation of this).
Landscape Plan – Wetlands	Required under the conditions applying to designation FN164A. (Iwi and community also previously requested confirmation of this).
Wetland Remediation Assessment	Required under the conditions applying to designation FN164A.
Arborist Report/Other/Reserve Options - Plant	Planner to provide advice of benefits.
Early contractor involvement; • confirm installation and construction methodology (connecting existing plant/services to new plant), • review the design of the package plant, confirming new layout within site boundary, minimising unknown site anomalies, • concept drawings of package plant showing new plant layout fits within site footprint. • landscape plan/remediation proposal for reserve (scope to be defined).	ECI is a collaborative process and with clear objectives and 'best for project' behaviours it will add value to procurement and project delivery. Involving contractors in the preliminary design process is an efficient means of designing and planning site specific infrastructure. Minimising risk, recognising innovative opportunities and providing rationale solutions are just a few of the benefits having a contractor's specialist knowledge early during planning and design.

8 Options

8.1 Options identified

There are three (3) options available at this stage:

- Option 1 – Do minimum
- Option 2 – Relocation of WWTP to wetlands
- Option 3 – Upgrade existing plant and install new MBR system – refer to Figure 4) Option 3 - Site layout proposed solution

8.2 Options analysis

The Opus (2006) Consultation Plan identified the following items as key factors from the community's perspective;

- Main concern – the environment
- Elimination/reduction in odour from existing WWTP
- Provision of emergency WW storage
- Gain more reserve area for community
- Landscape improvements

The options analysis has currently been completed on three options for consideration. These are high level observations, which have highlighted several areas that require additional investigations to complete the feasibility and master planning for Hihi WWTP. We recommend investigation a fourth option as an alternative to an MBR plant on the current site or Marchant Reserve.

Far North District Council

Capital Works Business Case
Hihi Wastewater Treatment Plant

Category	Option 1 – Do minimum	Option 2 – Relocation of WWTP to wetlands	Option 3 – Major upgrade – MBR packaged plant and reserve land swap
Benefits	Funding available, Shortest programme.	Removal of treatment plant from residential area and beachfront will have >50% of community in favour. Existing plant can continue to function whilst new plant is built (existing plant will require do minimum remediation as an interim measure).	New asset can manage peak flows and loads, odour and noise levels can be managed properly. It can be shifted further back into reserve, extending and upgrading the community reserve towards the beachfront. A new system will be compliant with RC conditions and has a 40yr lifespan. Modular system can be relocated if required (50yr sea-level-rise predictions).
Capital Expense	Cheapest option. Funds available to complete delivery 20/21.	Most expensive option. Funds available to do minimum 20/21 as interim measure. More funding will be required to relocate.	Second most expensive. Best value for money. Best long-term operational system for Whole Of Life.
Operating Impact	High risk of operational issues including overflows. Operational team and community exposed to non-compliant standards for health, safety and quality.	Top Energy confirm FNDC will need to make provision for electrical capacity at the new plants point of supply, new pump station and main transfer will need more investigations. Longest programme which may require remediation of existing as an interim measure.	New system for operational team to learn and manage. Training required, provision for operational assistance during DLP.
Rating Implications	Lowest impact on rates	Highest impact on rates	Second highest impact on rates, which could be the highest risk.
Risks	RC conditions renew 2022. High likelihood the plant and wetlands will not meet all conditions set. Plant location at risk of sea-level-rise-prediction within 50yrs. The plants poor function and flow issues won't be resolved through the do minimum so there is a high risk of community and operational team exposure to health issues.	More land may be required and relocation of the plant will be subject to consenting. Longest programme. Landowners bordering the wetland property may oppose. Rate impacts will be substantial.	Rate impacts; community oppose option to shift plant further back into reserve (even with the reserve upgrade provision), noise and odour should be eliminated through the new MBR.

Interdependencies	Site survey required to confirm boundary and establish if existing storage tanks are outside designation.	New designation/consent, public notification, cultural impact assessment, conservation report, community consultation and new site location investigations for relocation will be required including servicing e.g. power capability, rising main capacity etc.	This solution requires all critical success factors to be completed prior to implementation e.g. site survey, planning assessment, cultural impact assessment, conservation report, community consultation. Public notification may be required – this will be determined during the planning assessment.
Stakeholders	Neighbouring properties to reserve and plant on Marchant Rd, Community, Iwi Operational team Public Visitors / Tourists	Neighbouring properties to reserve and plant on Marchant Rd and landowners for wetland site for new plant. Community, Iwi Operational team	Community, Iwi Operational team Public Visitors / Tourists

Table 1) Options analysis

Figure 4) Option 3 - Site layout proposed solution

THE FOLLOWING SECTIONS EXPLAIN DELIVERY OF THE RECOMMENDED OPTION.

9 Recommendation

Preferred Option - Major Upgrade - Membrane Bioreactor (MBR) Packaged Plant and Reserve Land Swap

1) Membrane Bioreactors (MBRs) offer treatment of wastewater from communities to an extremely high level. A membrane bioreactor is a biological wastewater treatment system that incorporates a microfiltration membrane on the discharge to remove virtually all suspended solids, bacteria, and protozoa from wastewater.
2) The land swap proposal shown in Figure 4) Option 3 - Site layout proposed solution, has been identified as a key element for providing the best value and long-term solution for Hihi and FNDC;
   - Opportunity to upgrade the reserve for the community and provide an improved accessible recreational reserve footprint,
   - Moving the plant further back behind the fire station is a better use of space and footprint,
   - The rear corner is slightly elevated; this removes the risk of predicted sea-level-rise, shown below in Figure 5.
3) Temporary stabilisation and/or mitigating measures on the existing aeration tank and plant capability to continue operating during design and construction (approx. 2 years).

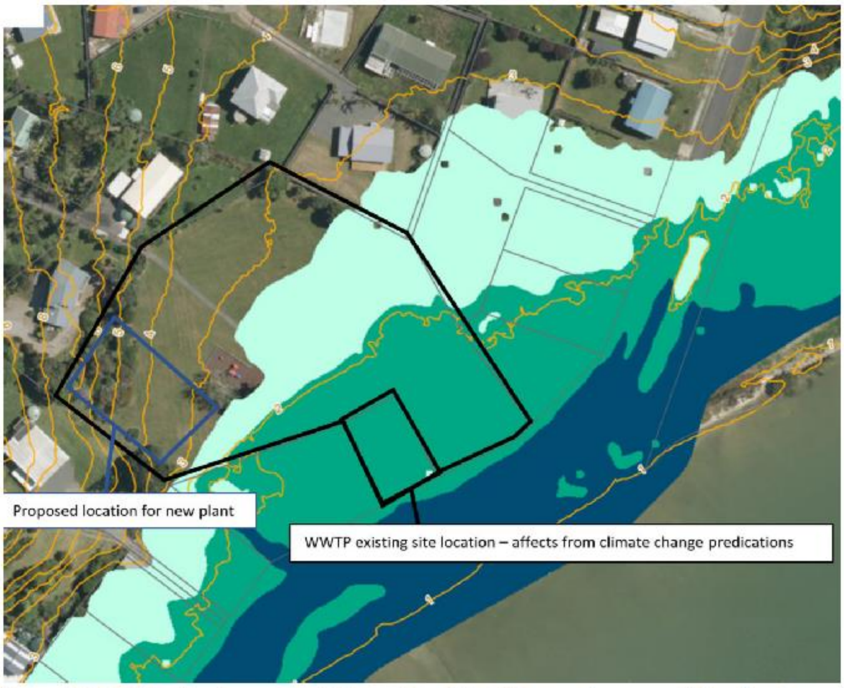


Figure 5) NRC climate change predictions. Blue: 1-in-100-year storm event (flooding by sea), Green: 1-in-50-year storm event from sea-level-rise, Pastel Green: 1-in-100 storm event from sea-level-rise.

To ensure the preferred option is the best solution for FNDC and Hihi community the following items should be completed;

<u>Hoskin Civil to engage and complete alongside FNDC team:</u>

- Site survey
- Planning Assessment
- Cultural Impact Assessment
- Landscape Plan for Plant
- Conservation and Ecology Report for Wetlands

- Wetlands Remediation Assessment
- Consultation Report
- Public Meeting
- ECI and supplier engagement – conceptual drawings of package plant, existing and proposed site layout plans, site constraints, delivery and installation phasing.
- Hoskin Civil will provide a recommendation report outlining a complete scope of work for project delivery under an open tender, including a programme timeline, phasing requirements and critical path items.

These report findings will mitigate the high-risk items associated with the recommended option, which will then define the remaining evidence to submit Hihi WWTP final business case.

10 Procurement

10.1 Procurement Approach

1. Hoskin Civil Ltd can commence engagement for the recommended consultant assessments and reports highlighted under scope deliverables and critical success factors. These items are required to provide certainty in the proposed solution and alleviate the community's concerns by providing clarification around any environmental impacts. All reports can be direct sourced as they will be under the FNDC procurement threshold value.

   Deliverables include:

   - Certificate of Titles – boundary properties of plant, wetlands, stream,
   - Site Survey – confirmation of plant boundary required, existing storage tanks currently sit outside boundary on desktop assessment,
   - Cultural Impact Assessment
   - Conservation and Ecology Report
   - Planning Assessment – FNDC or external planner (pending on internal capacity),
   - Consultation Report – prepare three option analysis for public meeting,
   - Wetland Remediation Assessment – proposal for redesign and remediation options with estimates.

2. Early Contractor Involvement (ECI) – Engage three proposals/quotations through a Closed tender, this removes complacent expectations and provides more competitive pricing.

   Deliverables include:

   - Collaboratively scope the construction methodology alongside the plant supplier to problem solve out or mitigate high risk items and recognise any 'out of scope' anomalies.
   - Assess existing infrastructure with plant supplier confirming the main works required for the package plant to be installed within footprint availability.
   - Work with consultants delivering the above assessments (working with Hoskin Civil and the consultant) to cover off any additional items that will provide additional benefits to project delivery.
   - Programme timeline for detailed design completion and construction for community consultation.
   - Work with key stakeholders (if required) including neighbouring properties to resolve individual property concerns.
   - Be forthcoming with innovative and sustainable solutions.
   - Remain committed to the ECI delivery model, providing the community with a value for money service.
   - Provide preliminary drawings showing layout of proposed package plant within the designated boundary. Include concepts of existing infrastructure remaining, and phasing required to keep plant operational during construction, including demolition and decommissioning,
     - Contact supplier/s to confirm if this is part of their delivery if not include in ECI contract.

3. Design and Build – Two-staged open tender under a major works contract recommended including, but not limited to;

   - Manage supply, delivery and installation of package plant directly with supplier,
   - Separable portions:

- Enabling works (pending scope but may include; land extension, temporary playground relocation, reserve upgrade, reserve remediation)
- Plant Supply and Installation
- Demolition, Decommissioning
- Remediation, reserve works (tbc)

11 Project Timeline

The indicative timeline below is aligned to the delivery approach and staging, major milestones include:

- April-20 - Master planning complete
- May-20 – Final Business Case submission
- Dec-20 – Preliminary Design complete
- Apr-21 – D&B contract start

12 Project Cost

12.1 Funding

Funding to be provided, requested 25/10/2019

Funding ($)	2019/20	2020/21	2021/22	All years
Opex				
Professional Services -	*0*	*0*	*0*	*0*
Capex				
New (XXNNNN-49XX)	*0*	*0*	*0*	*0*
Renewal (XXNNNN-49XX)	*0*	*0*	*0*	*0*
Total	*0*	*0*	*0*	*0*

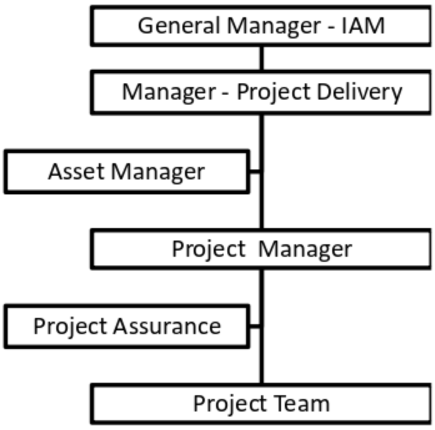
12.2 Cost Estimation

Master planning (Professional Services – external consulting)				
OPEX	**2019/20**	**2020/21**	**2021/22**	**All years**
Option 1	*32,000*	*TBC*	*TBC*	*TBC*
Option 2	*250,.000*	*TBC*	*TBC*	*TBC*
Option 3	*200,000*	*TBC*	*TBC*	*TBC*
Option 4	*TBC*	*TBC*	*TBC*	*TBC*

High-level estimates based on QS review Oct-19

13 Project Approach

13.1 Project Governance



Name & Position	Project Roles *
Andy Finch General Manager – IAM	Executive Sponsor
David Clamp Manager – Project Delivery	Senior Responsible Owner
Name Asset Manager	Business Representative
Name Operations Manager	Business Representative
Name Maintenance Manager	Business Representative

* Responsibilities for project roles are detailed in the Capital Works Project Management Framework.

13.2 Project Management

Management of the project will be undertaken following requirements and procedures detailed in Far North District Council's Capital Works Project Management Framework, and consistent with expectations for a **Complex** project.

13.3 Project Constraints, Assumptions & Dependencies

The following items can be resolved, Hoskin Civil can deliver these items alongside FNDC – refer to Recommendations and Timeline sections.

Type	Description	Action required
Dependency	Site Survey	Hoskin Civil/FNDC
Dependency	Cultural Impact Assessment	Hoskin Civil/FNDC
Dependency	Planning Assessment	Hoskin Civil/FNDC
Dependency	Design of Package Plant – site footprint and installation methodology must be confirmed	Hoskin Civil/FNDC
Dependency	Landscape Plan	Hoskin Civil/FNDC
Dependency	Arborist Plan	Hoskin Civil/FNDC
Assumption	Wetland Remediation Assessment – include under Landscape Plan	Hoskin Civil/FNDC
Constraint	Consultation Report / Public Meeting	Hoskin Civil/FNDC

14 Quality considerations

Quality requirements:

The Hihi WWTP has an existing resource consent due to expire in Nov-2022, the sites listed are also designated and have conditions set under the district plan.

Resource Consent:

- Northland Regional Council (NRC) have four monitoring sites, three are located at the constructed wetlands and one is at the WWTP site,
- Resource Management Act and the Regional Water and Soil Plan apply to this site/activity,
- Hihi WWTP existing resource consent: RC – CON19940739901

Endorsed: 14-05-2008
Expiry: 30/11/2022
Conditions:

1) the discharge of treated wastewater into an unnamed tributary of Hihi Beach (Hihi Stream).
2) To discharge contaminants to ground via seepage from the base of an artificial wetland.
3) To discharge contaminants (primarily odour) to air from wastewater treatment facilities.

Far North District Council Plans:

1. Existing Site (Lot 78 DP 73991)
   - District Plan – Underlying zone Coastal Residential with a Designation (FN164) for the purpose of Hihi Sewage Treatment and Disposal – applying to Lot 78 DP 73991 and SO 69378 Blk IV Mangonui SD.
2. Neighbouring Site (Part Lot 71 DP73991)
   - District Plan – Recreation reserve land zoned recreational activities subject to the Reserves Act.
3. Wetland Site (Part Lot 1 37697 and Part Lot 2 DP 88975)
   - District Plan – Rural Production Zone with designation FN164A. The designation was approved on 1 May 2008 – Consent number RC 2061079. This decision was issued by the Environment Court, it has specific conditions that apply to the site.

Far North District Zoning for Hihi WWTP designations are shown in Figure 8) FNDC Zoning and Designations – refer FN164 and FN164A. These site locations are referenced as per above for 1), 2) and 3), these are shown in **Error! Reference source not found.**.

Noise
Noise is relatively minor with an MBR system, the blowers will be housed as they are the largest noise source on the plant. Screening and planting will be initiated through a landscape plan to provide a sufficient barrier to noise.

Odour
Odour concerns are minimal; the grit and screenings facility that is proposed is the most likely source of offensive odours. Options would be investigated; however, a biofilter is the preferred option if the odours are to be managed aggressively.

Quality tolerances:
Lower standards have been adopted over the past few years during feasibility investigations to source the best outcome for Hihi. Quality has been compromised due to costs and timing around the consenting process, this has been managed extremely well by the operational team and the community as the circumstances have been less than desirable and continue to decline.

WWTP, Marchant Road:
Most recently, adverse conditions for the activated sludge process have resulted in the accumulation of foaming from filamented bacteria, this bacterium is difficult to eliminate due to its unique characteristic of nocardia; a part of nocardia's natural growth cycle is spread through the bacterium branching out and breaking, these cells then begin to dissipate, the gram-positive genus continues to branch out, break off and spread.

Constructed Wetlands:
The constructed wetlands have also been neglected due to insufficient funding and maintenance. Observations made from a recent site visit confirmed a lack of operational maintenance resulted in wetland basins that were performing poorly. Several prior reports indicate the wetlands poor condition is nothing new, stating the basins overflow due to blocked pipes regularly. At the site visit the first cell was clearly struggling to perform showing the basin overflowing into an open drain caused from blocked pipes. The marshes are covered in weeds, there is minimal visibility of scheduled plant life, vegetation or aquatic planting and no sign of animal life – these natural elements are key to a wetlands function and success.

A conservation report should be acquired, reporting on the ecology and flows in the receiving stream, local species, monitoring and effects of current systems in place, water features and flora and fauna. An assessment of the current design/cell layout requires options for remediation to bring the wetlands back to the distinct ecosystem they should be and serve as home to a wide range of plant and animal life.

Figure 6) Constructed wetlands, the first cell overflowing into the open drain which goes directly into cell 2.

Figure 7) Overgrown marshes and high sludge levels within the wetland cells indicating substantial loss of biomass from the treatment plant.

Far North District Council

Capital Works Business Case
Hihi Wastewater Treatment Plant

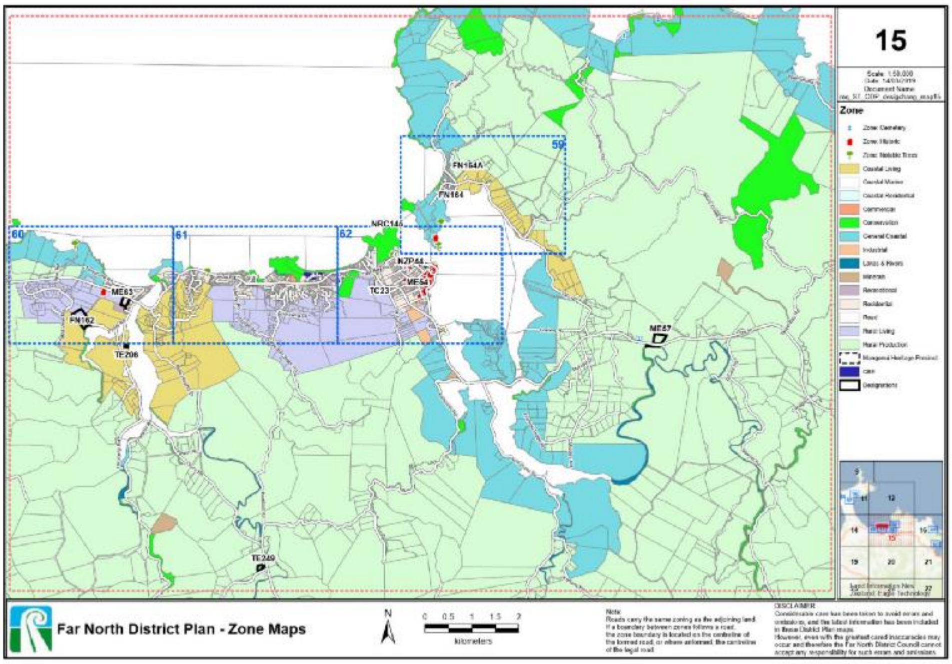


Figure 9) FNDC Zoning and Designations – refer FN164 and FN164A

Figure 8) Treatment Plant - Consented Site Locations

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15 Risks & Issues

RAG	Risk / Issue description	Risk owner
A	Site footprint - existing site location is very small and should be extended. Extension further back requires a planning assessment, site survey (boundary confirmation). Preferred solution should be extended further back into reserve. Reserve can then be relocated at the coastal sea front (as preferred by community).	FNDC Planning/Asset Management
A	Community – odour & noise of new plant (previous concerns and this will be highlighted when the reserve neighbouring properties are advised the plant may be relocated closer to their properties)	FNDC Planning/Asset Management
R	Rate impacts – funding options to decrease impact on residents	FNDC Finance/ Asset Management/Delivery
A	Resource consent expiry 2022 – new conditions to be met	FNDC Finance/ Asset Management/Delivery
R	Plant not upgraded – HSQE impacts: operational team H&S onsite and community health and environment is compromised. e.g. activated sludge has the bacterium nocardia growing within it, quality control is poor, overflows are imminent.	FNDC Health & Safety/Asset Management
R	Aeration tank structural integrity fails, resulting in spillage into the environment and harbour.	FNDC Health & Safety/Asset Management
A	Construction and Decommissioning: existing plant to remain operational until new plant is commissioned and existing houses to be connected to the new system as the existing treatment plant will be decommissioned.	Project Delivery / coordination with community
R	The plant and wetlands cannot cope with storm events, which results in overflows and flooding, the potential risk impact is very high, due to risk of an environmental spill into the harbour.	FNDC Asset Management
R	Wetlands excluded from renewal scope for remediation – non-compliance.	FNDC Asset Management
A	Post construction/implementation operational management – contractual assurance that the operational team are skilled to do all maintenance duties required with new plant. MBRs require advanced specialist maintenance which must be programmed, failure to do so can result in major failures.	FNDC Asset Management/Delivery
R	Climate change - sea-level-rise predictions and/or 1 in 50 storm event occurs = Environmental spill/harbour contamination	FNDC Asset Management/Delivery

16 Key Stakeholders

Stakeholder	Interest level	Influence level	Recommended approach	Dependency
FNDC Asset Management	High	Empower	Indicative BC	N/A
FNDC Project Delivery	Medium	Inform	Indicative BC	N/A
FNDC Planning	High	Collaborate	Indicative BC	N/A
FNDC Finance	High	Involve	Indicative BC	N/A
NRC	High	Involve	Planning assessment	Critical success factors
Community	High	Inform	Consultation Report - Public Meeting	Critical success factors
Iwi	High	Inform	Consultation Report - Public Meeting	Critical success factors
QEII Trust	Medium	Inform	Consultation Report	Critical success factors
MBR Supplier	High	Involve	Proposal request	Site survey, ECI involvement

ECI - Contractor	High	Collaborate	Contract - Medium Works	Critical success factors can progress alongside ECI investigations.

17 Document sign off

Role	Name, title	Signature	Date
Prepared by:	Jody Kelly Project Manager, Hoskin Civil Ltd	V01 - drafted for Asset Management review	25-Oct-19
Reviewed by:	Bill Down Asset Manager, FNDC		
Reviewed by:			
Approved by:			

18 Appendices

18.1 Appendice A - Hihi WWTP Referenced Material

Date issued	*File name*	*Description of detail*	*Author/Company*
Dec-2001	*200112 Conditional Assessment of WT Assets at Kaikohe & Kaitaia and WWT Assets at Hihi & Kerikeri copy*	*Condition Assessment*	*Harrison Grierson Consultants Limited*
Jul-2005	*Preliminary Options Evaluation - Hihi WWTP New Site Investigations*	*Relocating Plant Options*	*MWH*
Apr-2006	*Proposed Hihi WWTP Relocation Hihi Road, Hihi- Consultation Report#2*	*Relocation Consultation Report*	*Opus*
Jun-2006	*2006 Hihi*	*Preliminary Design Report*	*Opus*
Aug-2006	*200608 - Hihi Wastewater Treatment Plant O & M Manual*	*Plant Operations Manual*	*FNDC*
May-2008	*Resource Consent - CON 19940739901*	*RC Confirmation*	*NRC*
Dec-2012	*NRC Issue Abatement Notice - Condition 6 of RC non-compliant*	*Monitoring results - e-coli quality upgrade required*	*NRC*
Dec-2012	*Outline Plan Waiver RC2130159*	*Pump shed*	*FNDC*
Mar-2013	*20130320 Hihi WWTP NRC monitoring report 20 March 2013*	*Monitoring Report for RC*	*NRC*
May-2014	*2014-05 FT report*	*Aeration tanks - condition assessments*	*Fraser Thomas*
Sep-2014	*201409 FT report 2014-09-09 Fraser Thomas*	*Options Analysis*	*Fraser Thomas*
Apr-2015	*2015-04-23 TSL proposal*	*Aeration Tank renewal*	*TSL*
Dec-2015	*2015-12-23 Hihi WWTP Options Analysis Report - Final signed*	*Options Analysis*	*Opus*
Mar-2019	*20190326 Hihi WWTP Conceptual design Options Signed (002)*	*Conceptual design options*	*Opus*

Hihi Wastewater Treatment Plant

Conceptual Design Options

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Document History and Status

Revision	Date	Author	Reviewed by	Approved by	Status
A	11/3/19	B Reig Carriedo	A Springer		DRAFT
1	20/3/19	B Reig Carriedo	A Springer	E Foschieri	Issue 1

Revision Details

Revision	Details
1	Update following internal QA.

1 Background

Hihi is a small community in Far North District of New Zealand. Approximate population is 200 people in winter, rising to approximately 400 in summer, and for 2 weeks of the year, peak holiday period, population is considered to be as high as 600 people.

The existing works was constructed using precast concrete tanks, but it has now been identified that these are structurally unsound and unsafe, so must be replaced.

It is also recognised that there is a compliance issue in the overall capacity of the treatment plant is insufficient for both peak flow and peak load. This causes intermittently very poor effluent passing to the tertiary wetland and into the stream.

The scope of this project is to replace the tanks with a new treatment plant that will be compliant across all consent conditions and provide a safe system for over 40 years.

It is recognised that the treatment works will be reconsented in 2022, and tighter standards for effluent may be required. Selection of option reflect how tighter standards may be managed if required.

2 Design Conditions

2.1 Influent wastewater

According to the report *"Hihi Wastewater Treatment Plant. Design Basis"* attached in Appendix A (Design Basis Report Rev.1, Feb.2019, WSP-Opus,) the wastewater to be treated will have the following characteristics:

Table 1 – Influent Wastewater

Parameter	Units	Off Peak	Peak DWF	Peak WWF
Flow	m^3/d	35	85	750
Biological Oxygen Demand (BOD)	kg/d	17.5	42.5	42.5
Total Suspended Solids (TSS)	kg/d	17.5	42.5	42.5
Carbonaceous Oxygen Demand (COD)	kg/d	35	85.5	85.5
Total Kejldahl Nitrogen (TKN)	kg/d	4.9	11.9	11.9
Total Phosphorus (TP)	kg/d	0.60	1.45	1.45

Where Peak Dry Weather Flow (DWF) corresponds to the period months of December, January and February, including the period of maximum occupancy (*24 of December to 7 of January) while the Off Peak corresponds to the rest of the year.*

Peak Wet Weather Flow (WWF) will include the days with significant rain during any time of the year.

2.2 Discharge conditions

To comply with the different conditions set in the current discharge consent the following limits have been set for the Wastewater Treatment Plant (WWTP):

Table 2 - Limits at the WWTP outlet

Parameter	Unit	WWTP Outlet	Limit
Escherichia Coli	UNF/100 ml	130	95 %
	UNF/100 ml	50	Median
N-NH3	g N/m^3	5.00	Max
pH	Units	6-8	Within
DO	g O/m^3	6.00	Median
TSS	g /m^3	10	Median

These limits for the WWTP are set based on achieving compliance from the discharge from the tertiary wetland with compliance in the receiving stream.

3 Existing Plant

A layout of the existing plant is provided in App.B. Wastewater enters the WWTP into a wet well from where two pumps convey the water either to the treatment line or to wet weather storage, controlled on wet well water level.

One pump conveys wastewater into the existing secondary treatment that includes the following main elements:

- First Biological Reactor, 6 m diameter with 4.50m total height
- Second Biological Reactor, 3.42 m diameter with 3.35m total height
- Circular clarifier, 3.42 m diameter with 2.80 m total height
- Final Effluent Tank, 2.70 m diameter.
- Waste Sludge Tank

The second pump conveys wastewater (above the capacity of the treatment plant) into five 25 m^3 storage tanks, from where it can be returned to the wet well by a manual valve. Once the storage capacity of the tanks is reached an actuated valve opens to pass the flow into the Final Effluent Tank, effectively bypassing treatment. In this mode, the solids loading is too great for the sandfilters so this is bypassed directly to the UV unit. This results in very poor disinfection. There is no consent condition that permits this discharge of partially treated wastewater.

The air required for the support of the biological process is produced by one 15 kW blower.

Sludge produced in the biological process is removed from the clarifier tank and conveyed into a Waste Activated Sludge (WAS), 3.36 m diameter and 1.9 m height, from where it is removed from the WWTP for final disposal.

Wastewater, after secondary treatment or overflow effluent from the storage tanks, is pumped into the tertiary treatment comprising three pressure sand filters (1.20 m diameter), with a bypass line, that feed into a UV disinfection system (Wedeco UV System Type LBX 200e). Before being transferred to the existing wetland and prior to the final discharge the wastewater is disinfected via an UV system ,with a capacity to treat more than 30 m^3/h,

Neither the design or the capacity of the existing plant is enough to reach the required treatment to meet the limits of the consent, therefore a major upgrade and modification of the existing elements is required.

Some of the major issues that have been identified include::

- Some of the elements of the existing WWTP (overflow storage tanks) are not within the designated site boundary (refer to layout plan in App.B)
- Structures of the existing concrete tanks are failing and need replacement
- Insufficient Biological Reactor volume to reach the required degree of nitrification for peak load
- Insufficient clarifier area to handle the peak WWF
- Insufficient tertiary filtration capacity for the peak WWF
- Insufficient wastewater storage with an improper hydraulic connection that allows untreated wastewater flows to go straight to the tertiary treatment with no secondary treatment
- Insufficient aeration capacity to ensure a full treatment at peak load.
- Plastic pipes between assets are cracked and deteriorating.

A significant project constraint is the need to keep the existing WWTP in compliant operation during the necessary works

4 Proposed Options

In order to solve the identified issues, we believe that any design option should consider:

- Inlet Screen
- New biological reactor and clarifier
- Control and Blower building
- Sludge System
- Additional Sand Filter
- Demolition of redundant assets

Treatment options considered:

1 Conventional Activated Sludge, similar to existing process, including a screen, biological reactors, new clarifier tanks, sludge system and a sand filter upgrade
2 Moving Bed Bioreactors (MBBR), including screen, reactors, new clarifier, sludge system and a sand filter upgrade
3 Membrane Bioreactor (MBR) including 1mm fine screen, reactor and membrane system and a sludge system.

All options require pre-screening and grit and sand removal is recommended.

All options require additional building for controls and blowers, and for the MBR, to house chemical cleaning systems.

Due to the requirement of maintaining the WWTP in operation, the construction process must be developed in stages with provision for different temporary connections for each of the proposed solutions. Staging plans are provided in Appendix D

All redundant assets should be removed from site.

4.1 Option 1 – Conventional Activated Sludge

4.1.1 Process description

This solution provides a like for like replacement of the existing activated sludge treatment and upgrade of the tertiary filter capacity.

From the existing wet well, using the existing pumps, wastewater will the pumped through a 100 mm PVC pipe into a new inlet screen from where it will flow into the first of two identical biological reactors.

The new inlet screen will be mounted so that its discharge enters the activated sludge plant, and screens can drop to a low-level bin. Thus avoiding significant below ground structures or double pumping.

Due to the high variation on loads between the peak and off-peak seasons, two identical biological reactors have been proposed so either of them can operate as standalone units (off-peak), feed directly from the screen outlet, or as two units in series by the operation of connecting valves (on-peak).

Each biological reactor includes an anoxic chamber (1.25 x 4.1 and 4 m of water depth) followed by an aerated chamber (3 x 4.1 and 4 m of water depth). Each anoxic chamber has a submersible mixer to keep the mixed liquor from settling and each aerobic chamber is equipped with a lift out grid of air diffusers. Air to be provided by two blowers (one duty and one standby) located inside a new building for acoustic reduction.

Aeration equipment will be placed in a new aeration building (approx. 3 x 5 m) to be constructed adjacent to the new biological reactors.

Discharge from the reactors passes to two new rectangular clarifiers, required to deal with the wet weather flows, rectangular clarifiers are necessary as a circular clarifier is unable to fit on the site.

Each clarifier has a side water depth of 3m, with a 2m width and 6. m length.

A scraper system will transfer sludge across the floor of the reactor to the sludge outlet pumps returning to the anoxic zone. WAS can be diverted from this line on timer to the sludge holding tank.

Effluent from both clarifiers will pass to the existing final effluent tank and then pumped to the tertiary treatment.

In the tertiary treatment a new filter, identical to the three existing ones, will be provided to expand the treatment capacity. The filter will be connected to the existing pumps, cleaning system and the existing UV reactor.

In order to be able to include this new filter, the existing building must be extended, and the external services relocated.

4.1.2 Staging of proposed works

In order to maintain the compliance of the existing plant the required works should be undertaken in different stages:

(i) *Preparation Works: remove second biological reactor from service, with temporary connection from first reactor to clarifier. Demolish second reactor. Undertake groundworks on site for new process.*

(ii) *New Biological Treatment: in this stage the new biological reactor, screen system and associated building (aeration system) will be constructed, installed and tested. Once satisfactory a temporary connection between the new biological reactors and the existing clarifier will be made.*
A temporary connection for sludge recirculation will be built connecting the existing recirculation pumps to the new biological reactor.
At the end of this stage, the first biological reactor can be disconnected, emptied and demolished to provide space for the new clarifiers.
Site services, intermediate tanks and transfer pumps to be relocated.

(iii) *New Clarifiers: in this stage the new clarifiers will be constructed, including the sludge management systems. Once the units are complete the permanent connections can be made with the effluent, sludge and reactors.*
At the end of this stage the plant will provide complete secondary treatment and tertiary treatment for all flows, except for peak WWF.
Remaining clarifier and pipe services can be demolished

(iv) *Expansion of Tertiary Filters: in this stage the construction and connection to the water line and to the backwash line of a new filter unit will be required. In order to do that the existing building will have to be expanded and the backwash tank will have to be relocated.*

(v) *Final Reinstatement. – reinstate all accesses and level ground.*

4.1.3 Main works

The new units to be built are:

- *Placement of a new screen*
- *Two new biological reactors*
- *One aeration building*
- *Two clarifiers*
- *Two sludge pumps (recycle and waste)*
- *A new sludge retention tank replacing the existing one that will be demolished due to its maintenance state.*
- *A new final effluent tank prior to tertiary treatment to replace the existing one that will be demolished due to its maintenance state.*
- *One new tertiary filter that will require the extension of the existing tertiary treatment building and displacement of the water tank (backwash water)*

The following existing units will be incorporated into the new WWTP:

- *Pump shed, that houses the pumps to tertiary treatment that will be maintained and the blower to the existing biological treatment that will be decommissioned*
- *Tertiary treatment where the three filters will be complemented by a fourth filter and the UV reactor maintained.*

The following existing units will have to be demolished:

- *Aeration tank (6.m diameter and 4.5 m height)*
- *Aeration tank (3.42 m diameter and 3.35 m height)*
- *Sedimentation tank (3.42 m diameter and 2.80 m height)*
- *Existing blower at the pump shed*
- *Existing Final Effluent Tank and Sludge Retention tank that will be replaced as stated*

4.1.4 Risks and Benefits

- *This is a conventional treatment process that is familiar to the site operations team.*
- *Option can fit within the site, however requires rectangular clarifiers.*
- *The clarifier sizing to meet the peak flow condition means that a long retention time will occur. This increases the risk that suspended solids will float and increase the solids loading to the sand filter. The sand filter will operate more when this is occurring, particularly in warm weather. To reduce this, it will be normal practice to run only 1 clarifier and automatically turn on the second in high flow conditions.*

- *By designing a fully nitrifying plant, it will remain biologically stable under all loading conditions, and should have well settling sludge all year.*
- *No change to sludge disposal route.*
- *Process can be supplied as build off site modules for more rapid installation, but due to phasing, has a long time on site.*

4.2 Option 2 – Fixed Film Treatment

4.2.1 *Process description*

This solution can be provided either as a Moving Bed BioReactor (MBBR) which utilises floating plastic media within the biological reactor stage or a Submerged Aerated Filter (SAF) which has a fixed media for bacterial growth. Either option have the same configuration and very similar footprint. The description below is based on an MBBR.

The main difference from the Conventional Activated Sludge (Option 1) comes from the requirement of the process to have a primary treatment, prior to the biological reactor, that will be provided by a primary settlement tank, a lamella settler.

As in the previous option water will the pumped from the existing wet well, using the existing pumps, by a 100 mm PVC pipe into a new inlet screen from where it will flow into the primary treatment.

Primary treatment will be provided by a lamella sedimentation unit (4.10 x 1.40 m of plant surface) equipped with a 1 m inclined lamella pack to improve the sedimentation rate while maintaining a small footprint.

Water treated in the lamella settler will flow into the first of the two biological reactors that will operate either as a standalone process or in series, while settled sludge will be pumped into the sludge retention tank.

Although there is not a total nitrogen standard it is necessary to denitrify the wastewater to ensure sufficient alkalinity (which if limiting inhibits ammonia removal) and to reduce the risk of rising sludge in the clarifier.

Each biological reactor includes an anoxic chamber (1.25 x 1.90 and 4.00 m of water height) followed by an aerated chamber (3.00 x 1.90 and 4.00 water height). Each anoxic chamber has a submersible mixer to keep biomass in suspension. Each aerobic chamber is equipped with a grid of air diffusers to provide the oxygen required for the biological process that will be produced by two (one duty and one standby) blowers located inside a new building for acoustic management.

Both chambers will be filled (up to 50% of the total volume) with a plastic media to support the growth of the biological biomass in the reactor and a retention screen will be provided at the end of each chamber. [SAF does not require this screen.]

Aeration equipment will be placed in a new aeration building (4.20 x 3.10 m) identical to that required in the Conventional Activated Sludge option, to be constructed close to the new biological reactors.

As with the Conventional Activated Sludge option, at the end of each aerobic chamber an outlet has been provided to transfer the mixed liquor to two new rectangular settlers, also either a drain outlet to inlet pump station or a small sump will be provided in each reactor for emptying by means of a drainage pump.

Each clarifier has a side water depth of 3.00 m, with a 2.00 m width and 6.00 m length.

A scraper system will transfer sludge across the floor of the reactor to the sludge outlet pumps returning to the primary treatment. Biomass is cosettled in the primary treatment and waste sludge transferred on timer to the sludge holding tank.

Effluent from both clarifiers will pass to the existing final effluent tank and then pumped to the tertiary treatment.

In the tertiary treatment a new filter, identical to the three existing ones, will be provided to expand the treatment capacity. The filter will be connected to the existing pumps, cleaning system and the existing UV reactor.

In order to be able to include this new filter the existing building must be extended, and the external services relocated.

4.2.2 Staging of proposed works

In order to maintain the compliance of the existing plant the required works should be undertaken in different stages:

(i) *Preparation Works: remove second biological reactor from service, with temporary connection from first reactor to clarifier. Demolish second reactor. Undertake groundworks on site for new process.*

(ii) *New Biological Treatment: in this stage the new biological reactor, screen system, primary settling unit and associated building (aeration system) will be constructed, installed and tested.*
A temporary connection between the new biological reactors and the existing settler will be made to hydraulically connect both units.
Once these works have been completed the plant will operate with the new biological reactor and the existing settler providing better treatment than that currently provided.
At the end of this stage the first biological reactor can be disconnected, emptied and demolished to provide space for the new settling units.
At this point, the existing blower can also be dismantled and some relocation of the tertiary pumps for easiest maintenance can be considered.

(iii) *New Clarifiers: in this stage the new clarifier units will be constructed, including the sludge management systems.*
Once the units are constructed and equipped the water line will connect these with the new reactors and with the effluent tank to supply the tertiary treatment.
The sludge line will be connected so that sludge can be recirculated to the new biological reactor and can be purge from the system into the existing sludge tank.
At the end of this stage the plant will provide complete secondary treatment and tertiary treatment for all flows, except for peak WWF.
Remaining clarifier and pipe services can be demolished.

(iv) *Expansion of Tertiary Filters: in this stage the construction and connection to the water line and to the backwash line of a new filter unit will be required. In order to do this, the existing building will have to be expanded and the backwash tank will have to be relocated.*

(v) *Final Refurbishment of Plant: as a final stage the affected areas will be refurbished to provide a better aspect and improved maintenance.*

4.2.3 Main works

The new units to be built are:

- *Primary treatment, lamella clarifier*
- *Two new biological reactors*
- *One aeration building*
- *Two clarifiers*
- *Two sludge pumps (recycle and waste)*
- *A new sludge retention tank replacing the existing one that will be demolished due to its maintenance state.*
- *A new final effluent tank prior to tertiary treatment to replace the existing one that will be demolished due to its maintenance state.*
- *One new tertiary filter that will require the extension of the existing tertiary treatment building and displacement of the water tank (backwash water)*

The following existing units will be incorporated into the new WWTP:

- *Pump shed, that houses the pumps to tertiary treatment that will be maintained and the blower to the existing biological treatment that will be decommissioned*
- *Tertiary treatment maintaining only the pumping system to the wetland and the UV reactor.*

The following existing units will have to be demolished

- *Aeration tank (6.00 m diameter and 4.50 m height)*
- *Aeration tank (3.42 m diameter and 3.35 m height)*
- *Sedimentation tank (3.42 m diameter and 2.80 m height)*
- *Existing blower at the pump shed*
- *Tertiary filters and support elements (backwash system)*
- *Existing Final Effluent Tank and Sludge Retention tank that will be replaced as stated*

4.2.4 Risks and Benefits

- *MBBR is a conventional process, but will be unfamiliar to the site operations team., however, it is simple to operate with low operator interaction required.*
- *Option can fit the site, however it does require rectangular clarifiers.*
- *The clarifier sizing to meet the peak flow condition means that a long retention time will occur. This increases the risk that suspended solids will float and increase the solids loading to the sand filter. The sand filter will operate more when this is occurring, particularly in warm weather.*
- *By designing a fully nitrifying plant, it will remain biologically stable under all loading conditions, and should have well settling sludge all year.*
- *Primary treatment is required before the reactor to remove gross solids and fibres which will clog the media. This will result in a change of sludge type being removed from site. It is assumed that this can be disposed of in the same way as the current sludge.*
- *Can be constructed in modular tanks*
- *Needs to be constructed in phases, so longer period on site.*

4.3 Option 3 – Membrane Bioreactor (MBR)

4.3.1 *Process Description*

This solution considers the construction of a biological process based on using low pressure membranes for the solids separation stage. The description below is based on a specific supplier's system. Alternative membrane suppliers will have differing configuration that also provide a similar footprint and process performance. E.g. Xflow membranes are located after the reactor, as a clarifier would be, and held within a building.

The use of a membrane separation stage provides some advantages from the use of conventional sedimentation units:

- *Smallest Process Footprint*
- *Highest Quality Effluent*
- *Smaller footprint for the separation process due to the compact nature of the membranes*
- *Stability against sludge settlement problems.*
- *Smaller footprint for the biological reactor due to the ability of the membranes to operate at a higher concentration of suspended solids*
- *Very high degree of solids retention that make the use of conventional sand filters as tertiary treatment unnecessary*
- *Enhanced disinfection*
- *Shortest construction time, as can be built in one phase.*
- *Modular systems enable rapid installation.*

Disadvantages

- *Higher pre-treatment standards that would require the installation of additional pre-treatments steps (varying from one membrane manufacturer to another) but may include a Fats Oils and Grease (FOG) and sand removal step and a 1 mm screen for additional screening*
- *A higher technical complexity to properly operate the membrane system including the use of cleaning in place (CIP) systems on a time basis*
- *A higher energy consumption as additional air is required to maintain the membranes*
- *More building area to include some of the additional equipment required by the process*

For this option, wastewater will be pumped from the existing wet well, using the existing pumps, by a 100 mm PVC pipe into a new inlet screen from where it will flow into the biological treatment.

The new inlet screen will be the Whatuwhiwhi screen that should be refurbished in accordance with the Options Analysis Report of 23rd December 2015, and it will be placed in a platform at the inlet of the biologic process so the pre-treated water discharges into the biological reactors.

Screened effluent will go to a secondary screen, 1 mm, to provide the additional pre-treatment required to safely operate the membranes.

Two identical biological reactors have been designed so they can operate as standalone units, feed directly from the screen outlet, or as two units in parallel by the operation of a mural gate that connect both.

Each biological reactor includes a reaction chamber and a membrane chamber.

Each aerobic chamber, 2.50 x 2.80 m with a water height of 3.50 m, is equipped with a grid of air diffusers to provide the oxygen required for the biological process that will be produced by two blowers (one duty and one standby) located inside a new building.

Each membrane chamber, 2.50 x 2.70 m with a 3.50 m water height, will be equipped with the necessary membrane cassettes to provide the required solid separation by suction of the water through the membranes.

Each membrane chamber will be equipped with an air diffuser system to provide the air necessary to maintain the membranes without fouling. One additional blower shall be provided and installed on the aeration building.

Also, to ensure the absence of operational problems a Cleaning in Place (CIP) system using sodium hypochlorite will be provided for routine membrane cleaning.

Aeration equipment, suction pumps and CIP equipment will be placed in a new aeration building (7.30 x 5.10 m) to be constructed close to the new biological reactors.

To provide operation flexibility, each membrane chamber is connected to a recirculation pump that sends the concentrated sludge into the inlet of the biological process to provide the required concentration in the aerobic chamber with a certain independence from the operating concentration in the membrane chamber.

Two suction pumps (one duty and one standby) will be installed in the aeration building to send the membrane filtered water to the existing effluent tank from where it will be pumped to the UV system and into the wetlands.

Excess sludge produced in the biological system will be purged by two sludge pumps and sent to the existing sludge storage tank for disposal.

4.3.2 *Staging of proposed works*

In order to maintain the existing plant in operation with, at least, a level of treatment similar to the existing, the required works should be made in different stages:

(vi) *Preparation Works: Remove second biological reactor from service, with temporary connection from first reactor to clarifier.*

(vii) *Undertake groundworks on Site for New Process.*

(viii) *New Biological Treatment: in this stage the new biological reactor, membrane tanks, screen system and associated building (aeration system) will be constructed, installed and tested.*

(ix) *Final Refurbishment of Plant: as a final stage the affected areas will be refurbished to provide a better aspect and improved maintenance.*

4.3.3 *Main works*

The new units to be built are:

- *Two new biological reactors*
- *One aeration building*
- *Two sludge pumps (recycle and waste)*
- *A new sludge retention tank replacing the existing one that will be demolished due to its maintenance state.*
- *A new final effluent tank prior to tertiary treatment to replace the existing one that will be demolished due to its maintenance state.*

The following existing units will be incorporated into the new WWTP:

- *Pump shed, that houses the pumps to tertiary treatment that will be maintained and the blower to the existing biological treatment that will be decommissioned*

The following existing units will have to be demolished and/or retired:

- *Aeration tank (6.00 m diameter and 4.50 m height)*
- *Aeration tank (3.42 m diameter and 3.35 m height)*
- *Sedimentation tank (3.42 m diameter and 2.80 m height)*
- *Existing blower at the pump shed*
- *Existing Final Effluent Tank and Sludge Retention tank that will be replaced*
- *Sand filters can be decommissioned*

4.3.4 Risks and Benefits

- *MBR is a variant on the conventional activated sludge process, so many aspects will be familiar with current operations team. However, a good technical knowledge is required to operate the membrane process. It is recommended that operator training and ongoing technical support for the first year be provided as part of the project delivery.*
- *Operational time on site should reduce as a fully automated process, requiring low routine intervention, compared to existing plant.*
- *Option can fit within the site and does not require phasing.*
- *Effluent quality will be < 5, < 5, < 5, < 5 (BOD, TSS, NH3, E Coli) guaranteed*
- *Membranes will be sized for peak flow. As this is occasional, no standby is required should membranes be required to be taken out of service.*
- *All influent must be screened to 1 mm to prevent clogging of the membrane cassettes (some suppliers are less sensitive to fibrous material and may only require 3 mm). Screen failure is critical and will require immediate operator attendance.*
- *The fully nitrifying activated sludge process will remain stable all year.*
- *The sludge will be similar to the current activated sludge but may be more viscous. Checks will be required on the sludge handling system at the receiving site.*
- *MBR systems can periodically generate a stable foam. For this reason, it is recommended that there is 1 m of freeboard on the tanks for containment.*
- *The use of membranes removes the need for clarifier, sand filter and UV systems.*
- *Chemical cleaning is periodically required for membrane systems. Careful selection of membrane system will reduce chemicals required and the operator intervention required. For example, some systems are pipe-based membrane modules so can be cleaned in a minimum volume of chemical, whereas other modules require lifting from the reactor and putting into a soak tank for the clean and will require larger volumes of chemical.*

4.4 Other Options Considered

4.4.1 *Low Energy Treatment*

A number of technologies offer low energy and low operator intervention. These include trickling filters and wetlands. These options will not fit on the existing site, so have not been considered further.

4.4.2 *Storm Storage*

As part of the option development consideration was given to a variant of the above Option 1 - Activated Sludge and Option 2 - Fixed Film (MBBR).

In the above options, the flow through the plant is based on 750 m^3/d, so having no bypass of treatment. In the variants, a lower flow, of 255 m^3/d (3 x peak average daily flow) is considered, with the excess being stored on site. As a minimum, this option requires 500 m^3 of storage.

It is not possible to construct a tank of this size on site, even after demolition of the existing assets, unless the tank is constructed substantially into the ground. This may impact on other assets and the existing sewer services.

For this reason, this option has not been investigated further.

4.4.3 *Other Location Treatment Plant*

If the treatment option could not be built on site, it would be necessary to build a new treatment works. For a small extension, it may be possible to expand the site boundary, but this may encounter local resistance as the site moves closer to occupied domestic property.

Alternatively, a new location could be obtained outside of the village. This would require a new pump station and a transfer main to the new site and a return main to the discharge point. If the new location is more than 2 km from the current site, the expected capital cost for the transfer main will be greater than the construction of the treatment plant, effectively doubling the cost of any new solution.

A new location would be subject to planning and consenting, which could, if suitable land was found take a period of 3 years. This programme may not meet the need to replace the existing process before the tanks fail.

As options have been developed that do not require a new location or expansion beyond the site boundary, this option has not been progressed.

4.4.4 *Other Discharge Location*

The use of alternative discharge locations has been considered. This includes discharge to Doubtless Bay, or Mangonui Harbour.

Coastal discharges will not be as constrained by ammonia conditions as the toxicity of ammonia in seawater is substantially less than in freshwater. This enables a smaller fixed film process such as a trickling filter or SAF to be used with elevated ammonia expected at peak times. Recent best practice in New Zealand has set precedent to get local agreement to new coastal discharges, as seen by Watercare at Clarks Beach and Snells Beach. This has required a membrane treatment system followed by UV to protect shellfish quality and recreational waters.

If this best practice were followed, a new MBR process would be built with the additional capital cost for coastal outfall.

A new discharge could take 5 years + to get approval, which may not meet the need to replace the existing process before the tanks fail.

This option offers no cost or programme benefits so has not been considered further.

5 Estimated Budgets

5.1 Estimated Construction Budget

The estimated construction costs of the different options studied are presented on the following table (additional detail can be found in Appendix B):

Table 3 -Capex Costs

	Option 1 Conventional Activated Sludge [$]	Option 2 Fixed Film Treatment [$]	Option 3 Membrane Bioreactor [$]
Preliminary and General	85,200	90,197	137,780
Design	55,892	58,588	90,225
Connection to Pre-treatment	9,080	15,430	16,280
Pre-treatment	29,960	29,960	80,010
Biological reactor	131,240	156,910	476,370
Aeration	40,430	40,430	51,600
Services Building	24,740	24,740	70,740
Pipework to Clarifier	20,830	23,450	-
Secondary Clarifier	67,910	67,910	-
Pipework from Clarifier to Effluent tank	4,940	4,940	15,150
Sludge RAS + WAS	56,460	54,950	66,060
Tertiary Treatment	48,080	48,080	-
Electrical Installation Works	35,340	35,520	34,200
Control	15,480	15,480	23,220
Commissioning and Testing	12,600	12,600	15,300
Temporary Connections	5,310	5,310	-
Demolitions and Site Reinstatements	65,600	65,600	69,600
SUB TOTAL PROJECT COST	**709,092**	**750,095**	**1,146,535**
Installation and Commissioning (20% On Project Cost)	141,818	150,019	229,307
Design (8% On Project Cost)	56,727	60,008	91,723
Management Supervision Quality Assurance (5% On Project Cost)	35,455	37,505	57,327
TOTAL PROJECT COST (Excluding GST)	**943,092**	**997,626**	**1,524,892**
FNDC Cost	85,000	85,000	85,000
Consultant	85,000	85,000	85,000
GRAND TOTAL	**1,113,092**	**1,167,626**	**1,694,892**
Project Uncertainty (30% On Grand total)	333,928	350,288	508,467
TOTAL FOR BUDGET (Rounded)	**$1,450,000**	**$1,520,000**	**$2,200,000**

5.2 Estimated Operation Budget

5.2.1 Labour

Proposed Option 1 (Conventional Activated Sludge) and 2 (Fixed Film Treatment) will have similar labour requirements to the operation of the existing wastewater treatment plant, so no additional labour budget will be necessary to operate these options.

For Option 3 (Membrane Bioreactor) while there will be an increase in the working hours dedicated to the operation of the membrane system, mostly for membrane cleaning, we can consider that these hours will be compensated for by the reduction on hours devoted to the operation of the sand filters and the UV system, so no additional labour budget will be necessary for operation of this option.

5.2.2 Chemicals

Option 3 (Membrane Bioreactor) will require the use of hypochlorite to clean the membranes. We have estimated, based on other projects, a requirement of 5 litres per day of sodium hypochlorite for cleaning the membranes, so the additional operational budget, at $2 per litre of hypochlorite, add up to $10 per day, and a total of $3,650 per year.

5.2.3 Power

For the evaluation of power cost the estimated unit power of the main equipment has been considered and the normal operation hours at average flow (see Appendix 2).

A power cost of $0.45 per kWh has been assumed resulting in the following additional power operation costs:

Table 4 -Additional Electricity Costs

	Option 1 Conventional Activated Sludge	Option 2 Fixed Film Treatment	Option 3 Membrane Bioreactor
Daily Power Consumption, kWh	59.60	96.10	69.00
Daily Cost at $0.45/kwh	$ 26.82	$ 43.25	$ 31.05
Annual Cost (Rounded)	$ 10,000	$ 16,000	$ 11,000

5.2.4 *Total Additional Operational Costs*

The total additional operation cost of the different options can be summarized as

Table 5 -Additional Annual Operational Costs

	Option 1 Conventional Activated Sludge	Option 2 Fixed Film Treatment	Option 3 Membrane Bioreactor
Labour	$ -	$ -	$ -
Chemicals	$ -	$ -	$ 10.00
Power	$ 26.82	$ 43.25	$ 31.05
Daily Total	$ 26.82	$ 43.25	$ 41.05
Additional Annual Opex (Rounded)	**$ 10,000**	**$ 16,000**	**$ 15,000**

For the purpose of estimation no costs have been assessed for sludge disposal. There will be differences in sludge disposal associated with each option.

- *Option 1 As current, 0.5 % DS No change to budget*
- *Option 2 Approx 1.5 % DS, 67 % reduction in tankering will occur*
- *Option 3 Approx 1% DS 50% reduction in tankering will occur.*

6 Discussion

A comparison between options is provided in the following table:

Table 6 -Comparison of Options

	Option 1 Conventional Activated Sludge	Option 2 Fixed Film Treatment	Option 3 Membrane Bioreactor
Fit Site Footprint	Phasing required	Phasing required	Good
Ammonia	Good	Good	Good
TSS	Add sand filter	Add sand filter	Excellent
E Coli	Good	Good	Excellent
Power	< $30/d	< $45/d	<$35/d
Chemicals	None	None	Sodium Hypochlorite
Capital Cost	Moderate	Moderate	High
Operational Costs	Moderate	Moderate	Moderate

Three options have been developed in sufficient detail for costing. All are capable of achieving the required performance for Hihi WWTP and can be constructed on the existing site while maintaining the existing process.

Using build off site techniques, the time on site can be minimised, with complete fitted out tanks being delivered to site and assembled onto base slabs. The membrane plant has the shortest delivery programme as no phased demolition is required before completion. The duration of project has not been included in the cost estimate (site establishment, site supervision etc) that will potentially increase the costs associated with the ASP and Fixed Film Option.

MBR are very robust under widely varying and rapidly varying conditions, and should poor settlement occur as a result, the membranes prevent any solids carry through. There is an increase in complexity in ASP and MBBR options necessary to manage the clarifier retention time, which will be excessive at low flows. This condition increases risk of solids loss from the clarifier and increased operational demand of the sand filters. This robustness also offers the ability to reduce operational visits to the site, provide all critical equipment is linked to telemetry to notify of failure. It is known that for small membrane systems, site visits are reduced to as little as 2 hours per 2 weeks.

From our experience of the NZ market, to meet the requirements of the effluent described, we consider that if this was put to market, most competitive bids will offer packaged membrane systems. This is an established technology in NZ and has good technical support.

Future Standards

It is uncertain on what future standards may be required on the Hihi WWTP. This will be dependent on water quality and ecology in the receiving watercourse and recreational usage.

Phosphorous Removal may be required.

- Option 1 : Dosing of chemical to reactor, increases MLSS, and may impact on clarifier sizing.
- Option 2 : Dosing of chemical to lamella, no impact on process
- Option 3: Dosing of chemical to reactor, increases MLSS, no impact.

Total Nitrogen may be required.

- Each option has included for an anoxic zone that will provide denitrification. If this is insufficient, the process can be modified in two ways. Increase in recycle to remove more nitrate,

Tighter Ammonia Standard

- Option 1 Additional Reactor volume added as modular tank,
- Option 2 Additional Reactor volume added as modular tank
- Option 3 Increase MLSS in existing reactor. No change.

Tighter Microbial standards

- Option 1: Upgrade of UV.
- Option 2: Upgrade of UV
- Option 3: No change.

Tight viral standards as discharging indirectly to a bathing water or shellfish area

- Option 1: Membrane required and UV or chlorination
- Option 2: Membrane required and UV or chlorination
- Option3: Pass MBR effluent through the existing UV.

With consideration to layout, all future options can be accommodated within the footprint of the existing Hihi WWTP

7 Recommendation.

For the purpose of setting a project budget it is recommended that the MBR option is taken forwards. This option is the most process robust for current requirements and offers the most future proofed solution for potential future consent requirements.

APPENDIX A Basis of Design

Hihi Wastewater Treatment Plant

Design basis

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Document History and Status

Revision	Date	Author	Reviewed by	Approved by	Status
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Revision Details

Revision	Details
Final	Design Basis Report
Rev_01	Changes to include Barry Somers comments (11/02/19)

1 Executive Summary

This document has been produced to define the flows loads and required plant performance for the Hihi WWTP plant replacement.

Hihi has a significant peak holiday season particularly the two weeks of Christmas Holidays (24th of December - 7th of January) the daily flow to the WWTP almost triples I this period from 35 to 85 m^3/d. Future plant design must therefore consider performance at Peak and off peak periods.

Based on the available data the following **characteristics for the influent wastewater** can be used. This will overestimate off peak loading, but is representative of peak demand.

Table 1 -Influent characteristics for the Hihi wastewater

Parameter	Units	Recommended for Design	Off Peak	Peak DWF
BOD	g/m^3	500	499	400
TSS	g/m^3	500*	802	312
COD	g/m^3	1,000	997	800
TKN	g N/m^3	140	140	
T Phosphorus	g P/ m^3	17	17	
Alkalinity	g CO_3Ca/m^3	480	480	

* TSS at most WWTPs is normally is seen as 1:1 with BOD, so for specification this is assumed similar.

Recent Data has been analysed for flow discharged from works and the following flows are recommended. The peak flow is selected to enable all flows under all conditions to be treated.

Table 2 - Design loads for the influent wastewater

Parameter	Value
Off-peak Average Dry Weather Flow (Off-Peak ADWF)	35 m^3/d
Peak Average Dry Weather Flow (Peak ADWF)	85 m^3/d
Peak Wet Weather Flow (PWWF)	750 m^3/d *

* Flow previously estimated. Max flow recorded at 411 m^3/d, but it is understood that the inlet pump system is unable to pump a higher flow rate and localised flooding has been reported.

Design Loads:

Table 3 - Design loads for the influent wastewater

Parameter	Units	Off Peak	Peak DWF	Peak WWF
BOD	kg/d	17.5	42.5	42.5
TSS	kg/d	17.5	42.5	42.5
COD	kg/d	35	85.5	85.5
TKN	kg/d	4.9	11.9	11.9
T Phosphorus	kg/d	0.60	1.45	1.45

To enable compliance at the discharge from the Wetlands under all loading conditions the plant must be designed to achieve the following standard.

Table 3 - Future WWTP Effluent Parameters

Parameter	Units	Median	Maximum	
BOD	g/m^3	10	20	
TSS	kg/d	15	30	
NH_3	kg/d	1.5	5	
E Coli	kg/d	50	130	

These values assume that the wetland will provide some additional treatment, particularly of ammonia in peak summer conditions.

2 Wastewater Flows

2.1 Previously stated

As included in the document *Hihi WWTP Options Analysis Report* during January 2014 Council's Maintenance Contractor Transfield Services Ltd (TSL) and Far North District council (FNDC) agreed on a design basis for Hihi WWTP process capacity.

Flow data for the design horizon (2032) were set as:

Table 5: Design Flow - Hihi WWTP Options Analysis Report (dated 23 Dec. 2015, Opus)

Parameter	Value
Design horizon	Up to 2032
Off-peak Average Dry Weather Flow (Off-Peak ADWF)	50 m³/d
Peak Average Dry Weather Flow (Peak ADWF)	150 m³/d
Peak Wet Weather Flow (PWWF)	750 m³/d

At high flows there is a current practice of bypassing secondary treatment and the teritary sand filters. This bypass at high flows results in poorly treated effluent passing through the UV and to the wetlands. This practice may exceed consented standard for several parameters, which is not considered a responsible practice. The basis for future plant design is to provide secondary and tertiary treatment to all flows.

2.2 Review of existing data

2.2.1 Data to be used

While incoming flow data since January of 2010 is available, data before 2015 are considered as inaccurate as those data include a double counting of the recirculated flows and flows from filter backwashing operations. So, to determine the actual and expected flows only the incoming flow data since 2015 has been used.

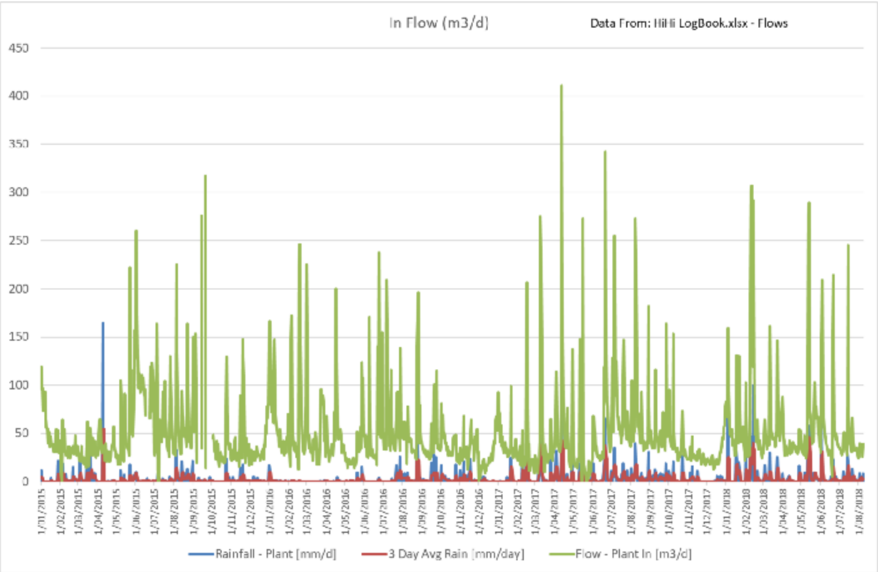

Figure 2-1 : Hihi WWTP In Flow (m^3/d) since 2015

A basic statistical analysis of the flow data – since 2015 as stated – provides the following values:

Table 3: Flow Statistics (2015-2018)

	Flow - Plant In [m^3/d]	Flow Plant Out [m^3/d]
50 % Percentile	37	36
95 % Percentile	142.	134.
100 % Percentile	411	315

It should be noted that this data, which includes the use of the storm storage tanks, may be an underestimate of the flow arriving at the works by up to 125 m^3/d (stored capacity).

Additionally, there was noted evidence of flooding on site from the inlet pump station that could not be quantified.

2.2.2 *Peak Wet Weather Flow*

The maximum recorded in flow to the WWTP, during the 2015-2018 period, has been 411 m^3/d, lower than the 750 m^3/d previously established as the design value, and the maximum discharge value established in the Resource Consent.

We propose that as not all flow is currently measured, and flow data may not incorporate all storm scenarios, that 750 m^3/d for the PWWF be used. This will only affect the hydraulic capacity of the plant, with a peak flow of 8.7 l/s, but not sufficient to change pipework across the process.

2.2.3 *Operational conditions*

Wastewater flow entering the WWTP varies during the year due to the different population in the area, and to the environmental conditions (i.e. rainfall).

We can consider three different operational periods on the area that will define different flows to the WWTP:

- *__Peak Holiday Operation__: corresponding to the period between the 24 of December and the 7 of January were occupancy is at a maximum*
- *__Holiday Operation__, corresponding to the months of December, January and February, except for the Peak Holiday Operation, were occupancy is above the normal levels but below the maximum levels*
- *__Off Peak Operation__, the months between March and November were occupancy is variable but below*

While Holiday and Off-Peak operation can be considered as to different periods, in terms of occupancy, the flow data available indicate that they are relatively similar in terms of flow distribution. This can be seen analysing the daily flows for Dry Days in those periods:

Table 4 - Flows (m³/d) Dry Days Holidays Vs Off-Peak

	Dry Days - Holidays	Dry Days – Off-Peak
50 % Percentile	31	31
75 % Percentile	41	38
95 % Percentile	69	107
100 % Percentile	246	225

That can be considered normal as similar levels of occupancy to the Christmas occupancy can be seen in different periods through the year providing similar flows into the WWTP, so both periods (Holidays and Off-Peak) can be considered as only one period the Off Peak Dry Weather.

WSP Opus experience of other holiday intensive catchments in New Zealand, shows that the strength of wastewater varies substantially over the year. This indicates that for Hihi, although the number of connections is fixed, there is a difference in occupancy that with increased summer occupancy offsets the reduction in summer infiltration.

On the other hand, the following figure shows the evolution of the wastewater flow incoming to the WWTP for the last two Christmas periods where it can be seen the increase and decrease on the flows during the period, and specifically around the two weeks of Christmas

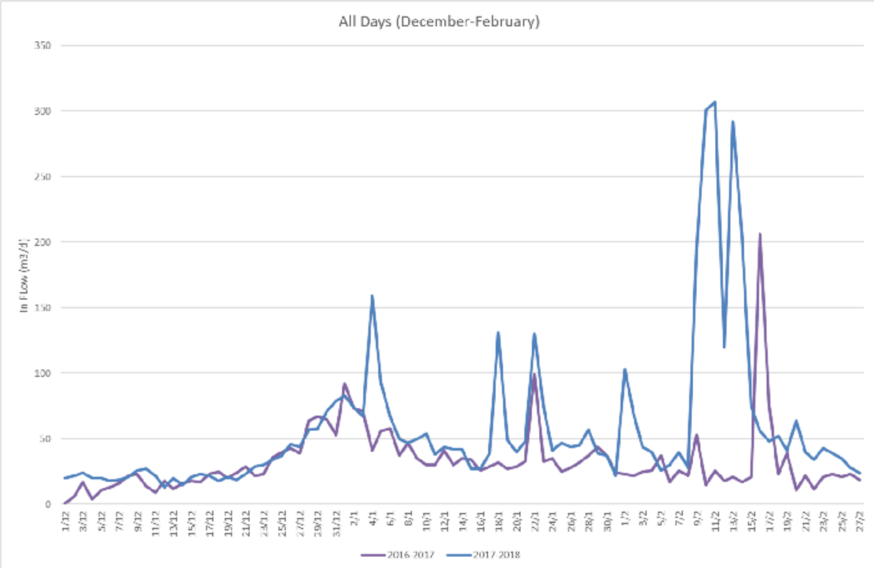

Figure 2-2 : Flows December February – All days

Incoming flows depends not only of the population but also on the meteorological conditions (i.e. rainfall). Taken into consideration the definition of dry day included in the actual consent:

"...a dry weather discharge day is any day on which there is less than a 1 millimetre of rainfall, and that day occurs after three consecutive days either without rainfall or with rainfall of less than 1 millimetre on each day."

We can see the evolution of flows on dry days for the holiday period with flows rising from 25 m³/d mid December to 80-90 m³/d at New Year, and then decreasing through the school holiday.

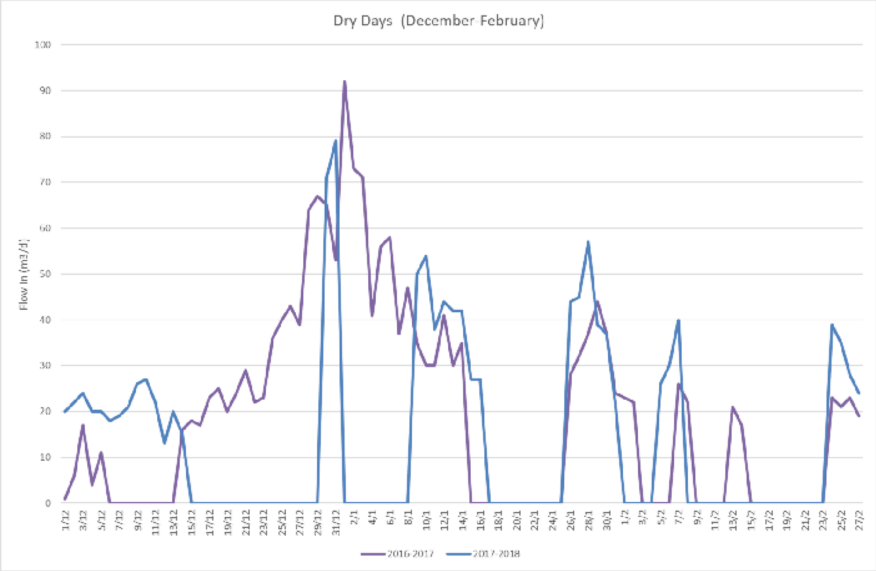

Figure 2-3 : Flows December February – Dry Days

2.2.4 Peak Average Dry Weather Flow

Considering the flow data available since 2015 during the Peak Holiday period (24/12 to 7/1) we have calculated the following basic statistics parameters:

Table 5 - Peak Holiday Flows (m³/d)

	All Days	Dry Days
50 % Percentile	67	64
75 % Percentile	81	75
95 % Percentile	143	82
100 % Percentile	166	92

While the ADWF can be identified close to the 50% percentile of dry days (64 m³/d), due to the limitation on the data and their quality, we believe that a more conservative value, close to the 90% percentile of the dry days, should be set. Therefore, we propose a revised value of 85 m³/d.

2.2.5 Off Peak Average Dry Weather Flow

Considering the flow data available since 2015 during the off-season period (March to November) we have determined the following basic statistics parameters:

Table 6 – Off-Season Flows (m³/d)

	All Days	Dry Days
50 % Percentile	38	31
75 % Percentile	55	38
95 % Percentile	144	107
100 % Percentile	411	225

In accordance with the above table, the ADWF for the off-season period has been set close to the 50% percentile as 35 m³/d.

2.3 Reviewed Values

According to the above analysis we propose the following design flows to substitute the values proposed in the Hihi WWTP Options Analysis Report (dated 23 Dec. 2015, Opus) as shown below:

Table 7: Design Flows – Revised Values

Parameter	Units	Off peak ADWF	Peak ADWF	PWWF
Design Report	m^3/d	50	150	750
Revised value	m^3/d	35	85	750

3 Wastewater Characterization

3.1 Previously stated

The document *Hihi WWTP Options Analysis Report (dated 23 Dec. 2015, Opus)* considers, for the design of the WWTP, the following constant concentrations:

Table 8: Design Concentrations (Design Report)

Parameter	Concentration (g/m^3)	Average Dry Weather Daily Load (kg/d)
COD	1000	150
BOD	500	75
TKN	100	15

No additional characterization (e.g. TSS) was included in the Design Report.

3.2 Review of existing data

The WWTP influent is sampled only during peak loading conditions and provide the basis for the influent characterisation.

Most samples are only analysed for BOD and TSS, but the results below are the most comprehensive individual characterisation available.

Table 9: Sample results influent WWTP

Date	28/12/2016	03/01/2018
Type	Not Indicated	Composite
TSS	660	350
VSS	610	
CBOD5	580	280
TBOD		340
COD	1,200	
COD dissolved	330	
COD Floc	330	
COD on TSS	210	
Total Nitrogen		140
N Dissolved	110	
TKN	140	
Nitrate	-	
Nitrite		
Ammonia	100	
Total Phosphorus	16	17
DR Phosphorus	12	
pH	8	
Alkalinity	480	

It is understood that these samples are taken at periods of high load when works performance is poor only. These data can be considered representative of peak loading conditions.

While no other parameters, apart from BOD and TSS, are routinely measured at the inlet, some of them can be estimated based on other samples provided:

- COD, the results of the existing samples provide a ratio COD/BOD in the normal range of 2 so COD will be estimated as two times the BOD.
- TKN, one of the existing samples provide a result of 140 g/m^3 of TKN and the other indicates a result of Total Nitrogen of 140 g/m^3 so a total value of 140 g/m^3 has been assumed for the design.
- Total Phosphorus, both existing samples provide a value in the order of 17 g/m^3 of total phosphorus so that value will be considered for design.
- Alkalinity, only one of the samples indicate a value for Alkalinity, 480 g CO_3Ca / m^3, that will be considered sufficient for nitrification (based on an activated sludge with denitrification).

A comparison of data for the same period with monitoring at Mangawhai, a catchment with significant Christmas Period population increase, also sees BOD of 500 mg/l, NH3 of 100 mg/l. The results are therefore considered representative of the likely wastewater in the catchment.

3.3 Proposed Influent Characteristics

The following basic values for wastewater concentration at the influent of the WWTP are proposed for the design review:

Table 10 - Review Design Concentrations (g/m^3)

Parameter	Units	Design Report	Off Peak	Peak DWF
BOD	g/m^3	500	499	400
TSS	g/m^3	N/D	802	312
COD	g/m^3	1,000	997	800
TKN	g N/m^3	N/D	140	
T Phosphorus	g P/ m^3	N/D	17	
Alkalinity	g CO_3Ca/m^3	N/D	480	

It's normal to assume that the total load to the Wastewater Treatment Plant is not affected by rainfall events, that do not provide additional contaminant load so contaminant loads on Wet Weather will have a similar value to contaminant loads on Dry Weather Days, so the the following daily loads should be used for the design of the WWTP:

Table 11 - Design Loads (kg/d)

Parameter	Units	Off Peak	Peak DWF	Peak WWF
BOD	kg/d	17.5	42.5	42.5
TSS	kg/d	17.5	42.5	42.5
COD	kg/d	35	85.5	85.5
TKN	kg/d	4.9	11.9	11.9
T Phosphorus	kg/d	0.60	1.45	1.45

It can be seen that the daily load of organic contaminants and nutrients on the peak period is more than doubled during the off-peak season.

It's our understanding that there is not going to be a significant increase on the possible occupancy during the peak season in the area, as it has almost reach its full capacity, and designing the wastewater treatment plant to cope with the peak season will provide a significant safety margin for any potential urban growth in the area.

4 Discharge Consent

4.1 General aspects of existing consent

Hihi Beach Wastewater Treatment System has a Resource Consent (RC 7399) valid until 30/11/2022 that includes conditions for:

- The effluent from the WWTP (NRC Sampling site 100165);
- The effluent from the Wetland into the unnamed tributary (NRC sampling site 101874);
- The affection on the water receiving body, unnamed tributary, based upon upstream and downstream sampling sites (NRC Samplings Sites 101130 and 108481 respectively)

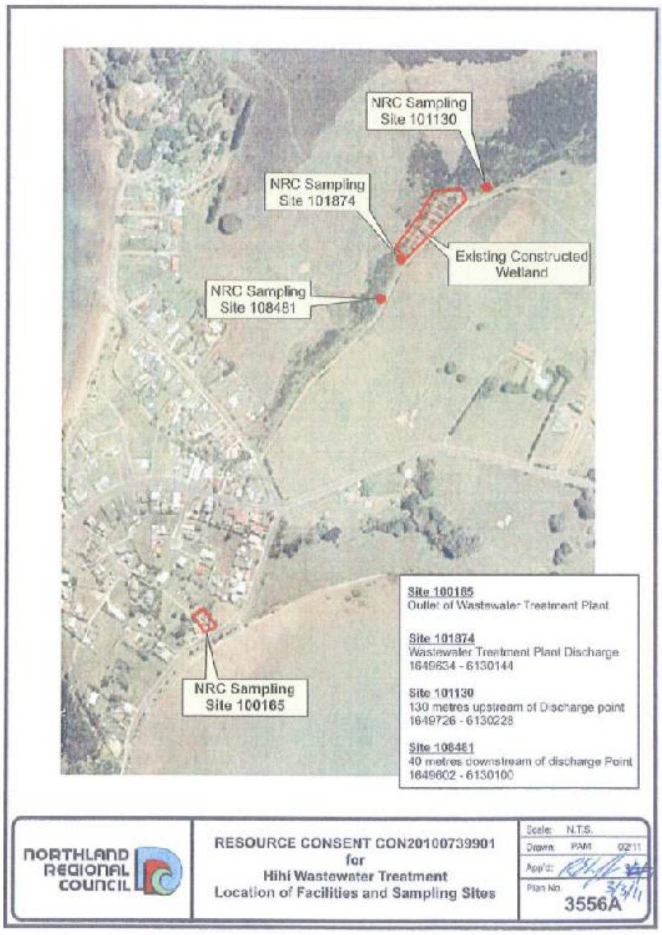

Figure 4-1 : Sampling Sites

Impact to the water body is measures in two different ways: as absolute values, downstream and as the difference (increase or decrease) of certain parameters between upstream and downstream, of the discharge (clause 8).

Regarding flows the consent (Clause 1) should not exceed 250 m^3/d, measured as a 30-day rolling average of dry weather discharges[1].

The expected Dry Weather Flows have been established as 50 m^3/d during off-peak and 150 m^3/d during peaks, well below the consented limit.

4.2 WWTP Limits on Consent

Regarding the water quality on the outlet of the WWTP the only limit fixed by the consent (Clause 6) relates to **Escherichia coli, that should be below 130 Col/100 ml** in at least 95% of the samples of treated water.

> 6 Prior to 1 May 2012, the wastewater treatment system shall be upgraded so that it treats the wastewater to a level whereby at least 95 percent of all samples of treated wastewater collected from Northland Regional Council Sampling Site Number 100165 have an *Escherichia coli* concentration of 130 per 100 millilitres or less. Compliance with the required *Escherichia coli* standard shall be determined by the results of monitoring undertaken in accordance with Section 4.2.1 of the Monitoring Programme in Schedule 1 (**attached**).

Regarding disinfection an additional condition is set regarding variation of the median E. Coli Value that can be set as a target for discharge:

> (h) The increase in the median *Escherichia coli* concentration shall not exceed 50 per 100 millilitres, for downstream samples when compared to upstream samples, taken in accordance with Section 4.2.2 of the Monitoring Programme in Schedule 1 (**attached**). This Condition 8(h) shall cease to have effect once the upgraded treatment system required by Condition 6 has been commissioned.

4.3 Downstream limits on Consent

As the receiving water body is a temporary water body – without flow in certain periods of the year – absolute conditions for downstream can be considered similar to conditions for the discharge (after the Constructed wetland). Those parameters (Clause 8) are:

- pH between 6,50 and 9 pH units

> (b) The natural pH of the downstream sample of water shall be within the range 6.5 to 9.0, unless the upstream sample of water also falls outside of this range;

- Total Ammoniacal nitrogen (NH-N) limit is pH dependant between a limit of 2,57 g/m^3 at pH 6 and a limit of 0,18 g/m^3 at pH 9,0

> (i) The concentration of total ammoniacal nitrogen in the downstream sample shall not exceed the following:

[1] A dry weather day is any day on which there is less than 1 millimetres of rainfall, and that occurs after three consecutive days either without rainfall or with rainfall of less than 1 millimetre on each day.

pH of water at the time of sampling	Total Ammoniacal Nitrogen ([NH_3 + NH_4]-N) (grams per cubic metre)
6.0	2.57
6.1	2.56
6.2	2.54
6.3	2.52
6.4	2.49
6.5	2.46
6.6	2.43
6.7	2.38
6.8	2.33
6.9	2.26
7.0	2.18
7.1	2.09
7.2	1.99
7.3	1.88
7.4	1.75
7.5	1.61
7.6	1.47
7.7	1.32
7.8	1.18
7.9	1.03
8.0	0.90
8.1	0.78
8.2	0.66
8.3	0.56
8.4	0.48
8.5	0.40
8.6	0.34
8.7	0.29
8.8	0.24
8.9	0.21
9.0	0.18

In the event that the upstream sample concentration of total ammoniacal nitrogen exceeds the above concentrations for a given value of pH, then the treated wastewater discharge shall not result in an increase in concentration of total ammoniacal nitrogen in the downstream sample of more than 0.10 grams per cubic metre when compared to the upstream sample concentration.

It is assumed that the wetland, particularly in summer, will remove some ammonia. The pH is not monitored, but domestic wastewater is usually around pH 7-7.2 unless very septic or from an algal rich pond. Neither of these occur so the discharge limit can be read as setting a value of 2 m g/m^3 of total Ammoniacal Nitrogen on the discharge

To achieve this discharge, it can be assumed either;

- The WWTP effluent shall be capable of meeting the final effluent without the wetland, 2 g/m^3 NH_3
- Or The Wetland shall provide some treatment to meet the consent, so the WWTP shall meet 5 g/m^3.

Both of these are considered maximum values to ensure compliance.

4.4 Changes on water body

The consent (Clause 8) establish the maximum change in certain parameters between the upstream and downstream sampling sites that may have some incidence on the requirement at the WWTP, even in the absence of data on the upstream flow, including:

- Temperature: a maximum change of 3 degrees Celsius is allowed on the consent. As the discharge comes from the wetland it is expected to be always in a similar range of temperature as the natural water.

(a) The natural temperature of the downstream sample of water shall not change by more than 3 degrees Celsius when compared to the upstream sample of water;

- Dissolved Oxygen (daily minimum) shall not decreased by more than 20%. It's hard to evaluate the implications of this condition, as flows and conditions upstream can be really varied but we can assume that probably some kind of aeration will be needed to obtain a dissolved oxygen level around 6 g/m3. It is considered that this parameter is not relevant to the WWTP discharge, which should always be oxic.

(c) The concentration of dissolved oxygen (daily minimum) in the downstream sample of water shall not be decreased by more than 20% when compared to the upstream sample of water;

- HUE shall not change in more than 10 Munsell units and visual clarity should not change in more than 35%. Both conditions are mostly related to the level of suspended solids in the water. Even when the wetland will act as a filter, reducing the Suspended Solids Concentration providing a certain degree of treatment, a **suspended solids** concentration can be set up for the design of the WWTP. As the actual WWTP has a UV disinfection unit, the required suspended solid concentration for operation, **below 10 mg/l**, can be set as a target on the outlet for design purposes.

(f) The hue of the downstream sample of water shall not be changed by more than 10 Munsell units when compared to the upstream sample of water. The visual clarity of the downstream sample of water shall not be changed by more than 35% when compared to the upstream sample of water.

5 WWTP Design Parameters

Considering the requirements of the actual consent and the expected characteristics of the water body were the discharge takes place we can set the following design as average value for the secondary and tertiary treatment:

Table 12: WWTP Effluent Characteristics Proposed

Parameter	Unit	WWTP	Wetland	Limit	Type
Escherichia Coli	UNF/100 ml	130	130	95 %	Consent
	UNF/100 ml	50	50	Median	Estimated (Consent Stream Variation)
N-NH3	g N/m^3	5	2	Max	Estimated (Consent Downstream Value)
pH	Units	6-8	6-8	Within	Estimated (Consent Downstream Value)
TSS	g /m^3	15	10	Median	Estimated

Parameter	Unit	WWTP	Wetland	Limit	Type
					(Consent Stream Variation Hue/Visual Clarity)
Total Nitrogen	g N/m³	N/D	N/D		Not Required
Total Phosphorus	g P/m³	N/D	N/D		Not Required

The most limiting factor for the operation and design of the WWTP is the requirement for full nitrification of the effluent – especially during the Dry Peak period where daily loads of organics and nutrients to the plant double the value of the off-peak daily load - as the limit is actual limit on the consent is set as a *"shall not exceed"* condition with a maximum value of around 2.00 g N/m^3 (pH dependent)

In the above table it is assumed that the wetland will continue to remove some ammonia, so to achieve < 2 mg/l NH3 in the discharge to stream, it is assumed that the WWTP achieve < 5 mg/l. It is proposed that this is adopted as the design target for the WWTP package.

6 Consent Review Proposal

Several consent condition changes should be considered for the future consent.

Consider changing the ammonia from a maximum to 95%ile value to permit some variation.

An assessment of the ecology and flows in the receiving stream should be undertaken. This will enable appropriate nutrient standards to be set based on the ecology of the water course. Also to identify whether there is a natural stream which otherwise would be an empty channel, so not a viable ecological community. These may enable a relaxation of ammonia consent.

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APPENDIX B Capex Summary and Opex Estimate

Capex - Option 1 – Conventional Activated Sludge

		Quantity	Rate	($) Amount
G-01	**Preliminary and General**			**85,200**
G-02	**Design**			**55,892**
C-01	**Connection to Pre-treatment**			**9,080**
	Pipe 100 mm HDPE buried	20.00	423	8,460
	Pipe 100 mm HDPE unburied	5.00	123	620
C-02	**Pre-treatment**			**29,960**
	Allowance to complete rebuild of Inlet Screen	1.00	12,500	12,500
	Supply and Install SS Screen Box	1.00	12,774	12,780
	Relocate and install inlet screen onto Platform	1.00	1,277	1,280
	Install control panel on handrailing	1.00	1,500	1,500
	DN100 Gate valve	2.00	950	1,900
C-03-C	**Biological reactor - Civil Works**			**108,250**
	Biological Reactor	1.00	86,250	86,250
	Local Sump - emptying	2.00	1,500	3,000
	Platform	16.95	250	4,240
	Handrail (m)	31.20	300	9,360
	Stair (1 m width) Unit Height	4.50	1,200	5,400
C-03-E	**Biological reactor - Equipment**			**22,990**
	Mural connecting gates (0,80 x 0,80)	1.00	2,000	2,000
	Pipe 100 mm HDPE unburied	12.00	123	1,480
	Pipe 100 mm HDPE buried	12.00	423	5,080
	Submerged mixer 0,3-0,5 Kw	2.00	4,850	9,700
	Pump Drainage/solids transfer	2.00	2,365	4,730
C-04	**Aeration**			**40,430**
	Blower 250 Nm3/h 4,5 m - P = 10 Kw	2.00	5,440	10,880
	Noise control chamber for blower	2.00	2,100	4,200
	Diffuser system (18 units PK300)	2.00	1,755	3,510
	Pipe Stainless Steel DN 80 buried	20.00	300	6,000
	Pipe Stainless Steel DN 80 Unburied	5.00	400	2,000
	DN80 Butterfly valve	4.00	40	160
	DN80 Air Flowmeter	2.00	300	600
	DO probe with holder	2.00	6,540	13,080
C-05	**Services Building**			**24,740**
	Aeration Building (4,20 x 3,10)	1.00	24,738	24,740
C-06	**Pipework to Clarifier**			**20,830**
	Pipe 150 mm HDPE buried	30.00	524	15,710

		Quantity	Rate	($) Amount
	Pipe 150 mm HDPE unburied	4.00	174	700
	DN150 Gate valve	4.00	1,104	4,420
C-07-C	**Secondary Clarifier - Civil Works**			**34,010**
	Settlers (2 x 2 x 5,90 x 3,5 m)	1.00	24,500	24,500
	Platforms (m2 Tramex)	8.85	250	2,220
	Handrail (m)	12.30	300	3,690
	Stair (1 m width) Unit Height	3.00	1,200	3,600
C-07-E	**Secondary Clarifier - Equipment**			**33,900**
	Sludge Scrapper Mechanism (w = 2, l = 5,90)	2.00	12,850	25,700
	Mural Gates (0,60x0,60) h + 1 m	2.00	2,000	4,000
	Floatables tramp	2.00	2,100	4,200
C-08	**Pipework from Clarifier to Final tank**			**4,940**
	Pipe 100 mm HDPE buried	6.00	423	2,540
	Pipe 100 mm HDPE unburied	4.00	123	500
	DN100 Gate valve	2.00	950	1,900
C-09-C	**Sludge RAS + WAS - Civil works**			**8,830**
	Pumps chamber 1 (2,50 x 1,50 x 1.8)	1.00	8,822	8,830
C-09-E	**Sludge RAS + WAS - Equipment**			**47,630**
	Pumps RAS (50 m3/h - 3 m - 1,50 Kw)	2.00	5,000	10,000
	DN100 Retention valve	2.00	2,560	5,120
	DN100 Gate valve	6.00	950	5,700
	Pipe 100 mm HDPE unburied	5.00	123	620
	Pipe 100 mm HDPE buried	15.00	423	6,350
	DN100 Flowmeter	1.00	2,300	2,300
	Pumps WAS (5 m3/h - 10 m - 1,5 Kw)	2.00	2,400	4,800
	DN80 Retention valve	2.00	2,300	4,600
	DN80 Gate valve	2.00	1,020	2,040
	Pipe 80 mm HDPE unburied	4.00	118	480
	Pipe 80 mm HDPE buried	9.00	368	3,320
	DN80 Flowmeter	1.00	2,300	2,300
C-10-C	**Tertiary Treatment - Civil Works**			**37,200**
	Reubication of Water tank	1.00	3,000	3,000
	Extension of filter building (6 x 4 m)	1.00	34,200	34,200
C-10-E	**Tertiary Treatment - Equipment**			**10,880**
	Sand Filter, 1.2 m diameter	1.00	4,700	4,700
	DN80 Gate valve	2.00	1,020	2,040
	DN80 Butterfly valve	2.00	262	530

		Quantity	Rate	($) Amount
	Pipe 80 mm HDPE unburied	6.00	118	720
	DN100 Gate valve	2.00	950	1,900
	Pipe 100 mm HDPE unburied	8.00	123	990
C-11	**Electrical Installation Works**			**35,340**
	Power Supply to service building	1.00	6,000	6,000
	Power supply to Screen	1.00	2,160	2,160
	Power supply to biological Reactors	1.00	12,000	12,000
	Power Supply to Settling	1.00	3,000	3,000
	Local Supply to each motor	11.00	180	1,980
	Control Board	1.00	10,200	10,200
C-12	**Control**			**15,480**
	PLC Hardware and SCADA modification Simple	1.00	9,360	9,360
	Software and programming	1.00	6,120	6,120
C-13	**Commissioning and Testing**			**12,600**
	Commissioning and Testing	1.00	4,200	4,200
	Training	1.00	8,400	8,400
C-14	**Temporary Connection Biologic-Existing Settling**			**5,310**
	Pipe 100 mm HDPE unburied	20.00	123	2,460
	DN100 Gate valve	3.00	950	2,850
C-15	**Demolitions and Site Reinstatements**			**65,600**
	Dem. Aeration tank (3.42 m diameter and 3.35 m height)	1.00	3,500	3,500
	Dem. Aeration Tank (6 m diameter and 4.5 m height)	1.00	5,000	5,000
	Dem. Sedimentation tank (3.42 m diameter and 2.8 m height)	1.00	3,000	3,000
	Dem. Various Elements (stairs, landing, footings, etc.)	1.00	19,400	19,400
	Final Effluent Tank Replacement (15 m3)	1.00	5,460	5,460
	Sludge Retention Tank Replacement (10 m3)	1.00	5,040	5,040
	Site reinstatement	1.00	24,200	24,200
	SUB TOTAL PROJECT COST			**709,092**
	Installation and Commissioning (20% On Project Cost)			141,818
	Design (8% On Project Cost)			56,727
	Management Supervision Quality Assurance (5% On Project Cost)			35,455
	TOTAL PROJECT COST (Excluding GST)			**943,092**
	FNDC Cost			85,000
	Consultant			85,000
	GRAND TOTAL			**1,113,092**
	Project Uncertainty (30% On Grand total)			333,928
	TOTAL FOR BUDGET (Rounded)			**1,450,000**

Capex - Option 2 – Fixed Film Treatment

		Quantity	Rate	($) Amount
G-01	**Preliminary and General**			**90,197**
G-02	**Design**			**58,588**
C-01	**Connection to Pre-treatment**			**15,430**
	Pipe 100 mm HDPE buried	35.00	423	14,810
	Pipe 100 mm HDPE unburied	5.00	123	620
C-02	**Pre-treatment**			**29,960**
	Allowance to complete rebuild of Inlet Screen	1.00	12,500	12,500
	Supply and Install SS Screen Box	1.00	12,774	12,780
	Relocate and install inlet screen onto Platform	1.00	1,277	1,280
	Install control panel on handrailing	1.00	1,500	1,500
	DN100 Gate valve	2.00	950	1,900
C-03-C	**Biological reactor - Civil Works**			**93,180**
	Biological Reactor	1.00	53,940	53,940
	Local Sump - emptying (0,8 x 0,80 x 0,40)	2.00	1,500	3,000
	Primary Settler (1,40 x 4,40 x 3,50)	1.00	17,850	17,850
	Primary Settler Cover	6.16	210	1,300
	Platform	15.05	250	3,770
	Handrail (m)	26.40	300	7,920
	Stair (1 m width) Unit Height	4.50	1,200	5,400
C-03-E	**Biological reactor - Equipment**			**63,730**
	Mural connecting gates (0,80 x 0,80)	1.00	2,000	2,000
	Pipe 100 mm HDPE unburied	12.00	123	1,480
	Pipe 100 mm HDPE buried	12.00	423	5,080
	Submerged mixer 0,3-0,5 Kw	2.00	4,850	9,700
	Pump Drainage/solids transfer	2.00	2,365	4,730
	Package media random 500 m2/m3	24.00	560	13,440
	Lamella Packages (1 m H - m2)	5.60	4,875	27,300
C-04	**Aeration**			**40,430**
	Blower 250 Nm3/h 4,5 m - P = 10 Kw	2.00	5,440	10,880
	Noise control chamber for blower	2.00	2,100	4,200
	Diffuser system (18 units PK300)	2.00	1,755	3,510
	Pipe Stainless Steel DN 80 buried	20.00	300	6,000
	Pipe Stainless Steel DN 80 Unburied	5.00	400	2,000
	DN80 Butterfly valve	4.00	40	160
	DN80 Air Flowmeter	2.00	300	600
	DO probe with holder	2.00	6,540	13,080
C-05	**Services Building**			**24,740**
	Aeration Building (4,20 x 3,10)	1.00	24,738	24,740

		Quantity	Rate	($) Amount
C-06	**Pipework to Clarifier**			**23,450**
	Pipe 150 mm HDPE buried	35.00	524	18,330
	Pipe 150 mm HDPE unburied	4.00	174	700
	DN150 Gate valve	4.00	1,104	4,420
C-07-C	**Secondary Clarifier - Civil Works**			**34,010**
	Settlers (2 x 2 x 5,90 x 3,5 m)	1.00	24,500	24,500
	Platforms (m2 Tramex)	8.85	250	2,220
	Handrail (m)	12.30	300	3,690
	Stair (1 m width) Unit Height	3.00	1,200	3,600
C-07-E	**Secondary Clarifier - Equipment**			**33,900**
	Sludge Scrapper Mechanism (w = 2, l = 5,90)	2.00	12,850	25,700
	Mural Gates (0,60x0,60) h + 1 m	2.00	2,000	4,000
	Floatables tramp	2.00	2,100	4,200
C-08	**Pipework from Clarifier to Final tank**			**4,940**
	Pipe 100 mm HDPE buried	6.00	423	2,540
	Pipe 100 mm HDPE unburied	4.00	123	500
	DN100 Gate valve	2.00	950	1,900
C-09-C	**Sludge RAS + WAS - Civil works**			**8,830**
	Pumps chamber 1 (2,50 x 1,50 x 1.8)	1.00	8,822	8,830
C-09-E	**Sludge RAS + WAS - Equipment**			**46,120**
	Pumps RAS (50 m3/h - 3 m - 1,50 Kw)	2.00	5,000	10,000
	DN100 Retention valve	2.00	2,560	5,120
	DN100 Gate valve	6.00	950	5,700
	Pipe 100 mm HDPE unburied	10.00	123	1,230
	Pipe 100 mm HDPE buried	10.00	423	4,230
	DN100 Flowmeter	1.00	2,300	2,300
	Pumps WAS (5 m3/h - 10 m - 1,5 Kw)	2.00	2,400	4,800
	DN80 Retention valve	2.00	2,300	4,600
	DN80 Gate valve	2.00	1,020	2,040
	Pipe 80 mm HDPE unburied	4.00	118	480
	Pipe 80 mm HDPE buried	9.00	368	3,320
	DN80 Flowmeter	1.00	2,300	2,300
C-10-C	**Tertiary Treatment - Civil Works**			**37,200**
	Reubication of Water tank	1.00	3,000	3,000
	Extension of filter building (6 x 4 m)	1.00	34,200	34,200

		Quantity	Rate	($) Amount
C-10-E	**Tertiary Treatment - Equipment**			**10,880**
	Sand Filter, 1.2 m diameter	1.00	4,700	4,700
	DN80 Gate valve	2.00	1,020	2,040
	DN80 Butterfly valve	2.00	262	530
	Pipe 80 mm HDPE unburied	6.00	118	720
	DN100 Gate valve	2.00	950	1,900
	Pipe 100 mm HDPE unburied	8.00	123	990
C-11	**Electrical Installation Works**			**35,520**
	Power Supply to service building	1.00	6,000	6,000
	Power supply to Screen	1.00	2,160	2,160
	Power supply to biological Reactors	1.00	12,000	12,000
	Power Supply to Settling	1.00	3,000	3,000
	Local Supply to each motor	12.00	180	2,160
	Control Board	1.00	10,200	10,200
C-12	**Control**			**15,480**
	PLC Hardware and SCADA modification Simple	1.00	9,360	9,360
	Software and programming Simple	1.00	6,120	6,120
C-13	**Commissioning and Testing**			**12,600**
	Commissioning and Testing	1.00	4,200	4,200
	Training	1.00	8,400	8,400
C-14	**Temporary Connection Biologic-Existing Settling**			**5,310**
	Pipe 100 mm HDPE unburied	20.00	123	2,460
	DN100 Gate valve	3.00	950	2,850
C-15	**Demolitions and Site Reinstatements**			**65,600**
	Dem. Aeration tank (3.42 m diameter and 3.35 m height)	1.00	3,500	3,500
	Dem. Aeration Tank (6 m diameter and 4.5 m height)	1.00	5,000	5,000
	Dem. Sedimentation tank (3.42 m diameter and 2.8 m height)	1.00	3,000	3,000
	Dem. Various Elements (stairs, landing, footings, etc.)	1.00	19,400	19,400
	Final Effluent Tank Replacement (15 m3)	1.00	5,460	5,460
	Sludge Retention tank Replacement (10 m3)	1.00	5,040	5,040
	Site reinstatement	1.00	24,200	24,200
	SUB TOTAL PROJECT COST			**750,095**
	Installation and Commissioning (20% On Project Cost)			150,019
	Design (8% On Project Cost)			60,008
	Management Supervision Quality Assurance (5% On Project Cost)			37,505
	TOTAL PROJECT COST (Excluding GST)			**997,626**
	FNDC Cost			85,000

		Quantity	Rate	($) Amount
	Consultant			85,000
	GRAND TOTAL			**1,167,626**
	Project Uncertainty (30% On Grand total)			350,288
	TOTAL FOR BUDGET (Rounded)			**1,520,000**

Capex - Option 3 – Membrane Bioreactor

		Quantity	Rate	($) Amount
G-01	**Preliminary and General**			**137,780**
G-02	**Design**			**90,225**
C-01	**Connection to Pre-treatment**			**16,280**
	Pipe 100 mm HDPE buried	37.00	423	15,660
	Pipe 100 mm HDPE unburied	5.00	123	620
C-02	**Pre-treatment**			**80,010**
	Allowance to complete rebuild of Inlet Screen	1.00	12,500	12,500
	Supply and Install SS Screen Box	1.00	12,774	12,780
	Relocate and install inlet screen onto Platform	1.00	1,277	1,280
	Install control panel on handrailing	1.00	1,500	1,500
	DN100 Gate valve	1.00	950	950
	1 mm screen max flow 35 m3/h	1.00	51,000	51,000
C-03-C	**Biological reactor - Civil Works**			**92,460**
	Biological Reactor	1.00	74,930	74,930
	Platform	16.70	250	4,180
	Handrail (m)	26.50	300	7,950
	Stair (1 m width) Unit Height	4.50	1,200	5,400
C-03-E	**Biological reactor - Equipment**			**383,910**
	Mural connecting gates (0,80 x 0,80)	2.00	2,000	4,000
	Pipe 100 mm HDPE unburied	8.00	123	990
	Pipe 100 mm HDPE buried	8.00	423	3,390
	Submerged mixer 0,3-0,5 Kw	2.00	4,850	9,700
	Pump Drainage/solids transfer	2.00	2,365	4,730
	Membrane Package Zenon Total flow 35 m3/h	1.00	337,500	337,500
	Pumps Suction 35 m3/h	2.00	9,450	18,900
	Cleaning in Place system (membranes)	1.00	4,700	4,700
C-04	**Aeration**			**51,600**
	Blower 250 Nm3/h 4,5 m - P = 10 Kw	3.00	5,440	16,320
	Noise control chamber for blower	3.00	2,100	6,300
	Diffuser system (18 units PK300)	4.00	1,755	7,020
	Pipe Stainless Steel DN 80 buried	20.00	300	6,000
	Pipe Stainless Steel DN 80 Unburied	5.00	400	2,000
	DN80 Butterfly valve	7.00	40	280
	DN80 Air Flowmeter	2.00	300	600
	DO probe with holder	2.00	6,540	13,080
C-05	**Services Building**			**70,740**

		Quantity	Rate	($) Amount
	Aeration Building (7,3 x 5,1)	1.00	70,737	70,740
C-08	**Pipework from Clarifier to Final tank**			**15,150**
	Pipe 100 mm HDPE buried	20.00	423	8,460
	Pipe 100 mm HDPE unburied	8.00	123	990
	DN100 Gate valve	6.00	950	5,700
C-09-C	**Sludge RAS + WAS - Civil works**			**12,080**
	Pumps chamber 2 (1,50 x 1,00 x 1,80)	2.00	6,038	12,080
C-09-E	**Sludge RAS + WAS - Equipment**			**53,980**
	Pumps RAS (50 m3/h - 3 m - 1,50 Kw)	2.00	5,000	10,000
	DN100 Retention valve	2.00	2,560	5,120
	DN100 Gate valve	6.00	950	5,700
	Pipe 100 mm HDPE unburied	5.00	123	620
	Pipe 100 mm HDPE buried	12.00	423	5,080
	DN100 Flowmeter	1.00	2,300	2,300
	Pumps WAS (5 m3/h - 10 m - 1,5 Kw)	2.00	2,400	4,800
	DN80 Retention valve	2.00	2,300	4,600
	DN80 Gate valve	3.00	1,020	3,060
	Pipe 80 mm HDPE unburied	10.00	118	1,190
	Pipe 80 mm HDPE buried	25.00	368	9,210
	DN80 Flowmeter	1.00	2,300	2,300
C-11	**Electrical Installation Works**			**34,200**
	Power Supply to service building	1.00	6,000	6,000
	Power supply to Screen	1.00	2,160	2,160
	Power supply to biological Reactors	1.00	12,000	12,000
	Local Supply to each motor	13.00	180	2,340
	Control Board	1.00	11,700	11,700
C-12	**Control**			**23,220**
	PLC Hardware and SCADA modification MBR	1.00	14,040	14,040
	Software and programming MBR	1.00	9,180	9,180
C-13	**Commissioning and Testing**			**15,300**
	Commissioning and Testing MBR	1.00	5,100	5,100
	Training MBR	1.00	10,200	10,200
C-15	**Demolitions and Site Reinstatements**			**69,600**
	Dem. Aeration tank (3.42 m diameter and 3.35 m height)	1.00	3,500	3,500
	Dem. Aeration Tank (6 m diameter and 4.5 m height)	1.00	5,000	5,000
	Dem. Sedimentation tank (3.42 m diameter and 2.8 m height)	1.00	3,000	3,000

		Quantity	Rate	($) Amount
	Dem. Existing Filters and Pipe Work	1.00	4,000	4,000
	Dem. Various Elements (stairs, landing, footings, etc.)	1.00	19,400	19,400
	Final Effluent Tank Replacement (15 m3)	1.00	5,460	5,460
	Sludge Retention Tank Replacement (10 m3)	1.00	5,040	5,040
	Site reinstatement	1.00	24,200	24,200
	SUB TOTAL PROJECT COST			**1,146,535**
	Installation and Commissioning (20% On Project Cost)			229,307
	Design (8% On Project Cost)			91,723
	Management Supervision Quality Assurance (5% On Project Cost)			57,327
	TOTAL PROJECT COST (Excluding GST)			**1,524,892**
	FNDC Cost			85,000
	Consultant			85,000
	GRAND TOTAL			**1,694,892**
	Project Uncertainty (30% On Grand total)			508,467
	TOTAL FOR BUDGET			**2,205,000**

Opex – Power – Option 1 – Conventional Activated Sludge

Equipment	kw	hrs	kwh/d
Feed Pump	3.00	2.00	6.00
Screen	0.50	2.00	1.00
Anoxic Mixer 10W/m3	0.20	24.00	4.80
RAS/WAS	0.20	24.00	4.80
Aeration	1.50	24.00	36.00
Sand Filter	1.50	2.00	3.00
UV	2.00	2.00	4.00
Total Power			**59.60**
Power at $0.45/kwh			**$ 26.82**

Opex – Power – Option 2 – Fixed Film Treatment

Equipment	kw	hrs	kwh/d
Feed Pump	3.00	2.00	6.00
Screen	0.50	2.00	1.00
Primary Treatment	1.00	0.50	0.50
Anoxic Mixer 10W/m3	0.20	24.00	4.80
RAS/WAS	0.20	24.00	4.80
Aeration	3.00	24.00	72.00
Sand Filter	1.50	2.00	3.00
UV	2.00	2.00	4.00
Total Power			**96.10**
Power at $0.45/kwh			**$ 43.25**

Opex – Power – Option 3 – Membrane Bioreactor

	kw	hrs	kwh/d
Feed Pump	3.00	2.00	6.00
Screen	0.50	2.00	1.00
Primary Treatment	-	-	-
Anoxic Mixer 10W/m3	0.20	24.00	4.80
RAS/WAS	0.40	24.00	9.60
Filtrate Pump	0.10	2.00	0.20
Aeration	2.00	24.00	48.00
Reduciton in transfer Pump Head	- 0.30	2.00	- 0.60
Total Power			**69.00**
Power at $0.45/kwh			**$ 31.05**

APPENDIX C Layout Plan

PLAN
SCALE: 1:100

DRAWING IN PROGRESS
PLOTTED ON 2019-3-18 AT 2:35 PM
DRAFT - NOT FOR CONSTRUCTION

Revision	Amendment	Approved	Revision Date
A	ISSUED FOR INFORMATION		

wsp | OPUS
Whangarei Office
+64 9430 1700
125A Bank Street
PO Box 553
Whangarei 0110

Designed: E. FOSCHIERI	Approved:	Approved Date:
Drawn: R. CRAWFORD	Scales: 1:100 AT A1	

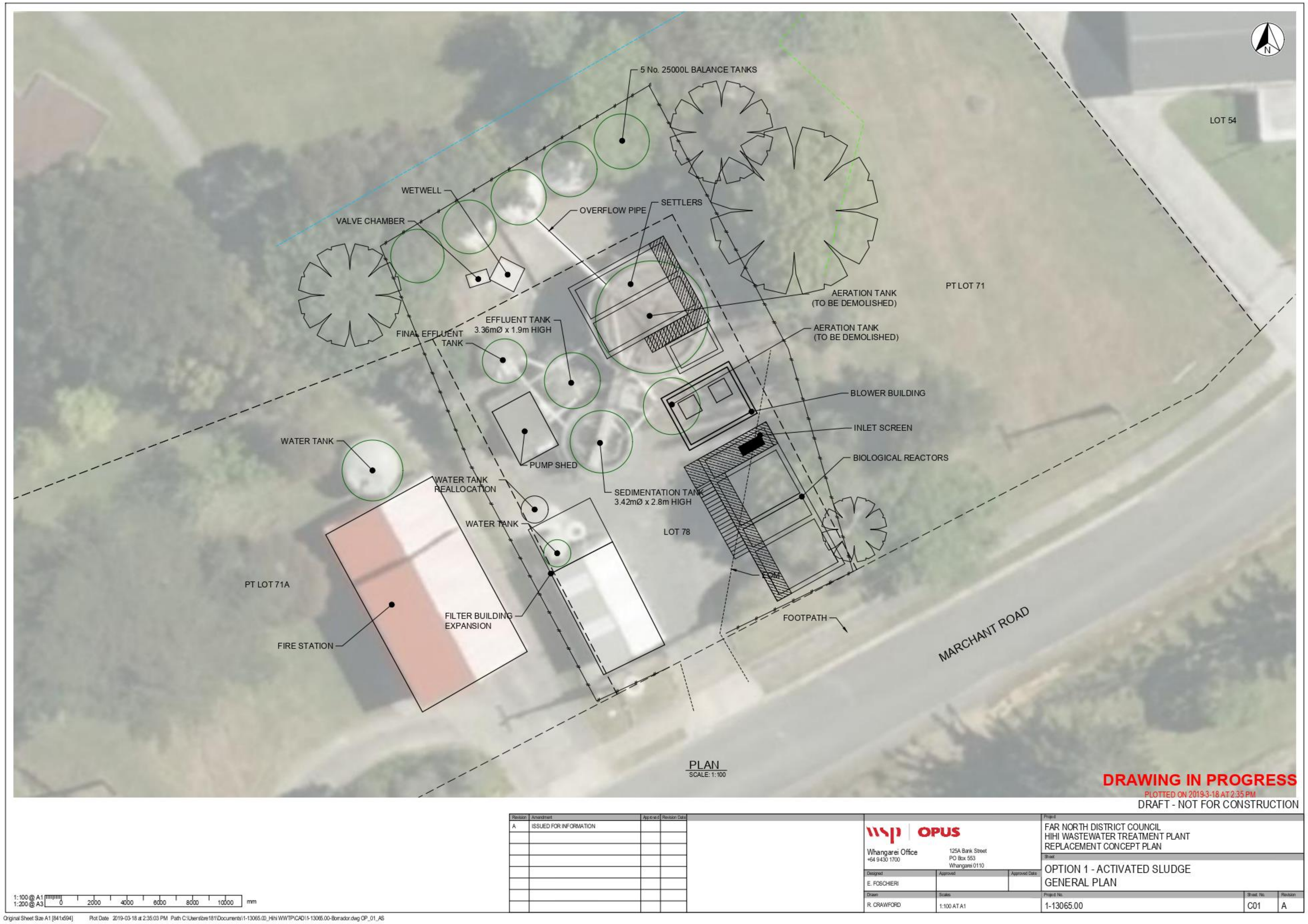
Project: FAR NORTH DISTRICT COUNCIL
HIHI WASTEWATER TREATMENT PLANT
REPLACEMENT CONCEPT PLAN

Sheet: EXISTING PLANT
GENERAL PLANT

Project No.	Sheet No.	Revision
1-13065.00	C01	A

1:100 @ A1 / 1:200 @ A3 — 0 2000 4000 6000 8000 10000 mm

Original Sheet Size A1 [841x594] Plot Date 2019-03-18 at 2:35:00 PM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LOT 54
WETWELL
VALVE CHAMBER
OVERFLOW PIPE
SETTLERS
AERATION TANK
(TO BE DEMOLISHED)
PT LOT 71
EFFLUENT TANK
3.36mØ x 1.9m HIGH
FINAL EFFLUENT
TANK
AERATION TANK
(TO BE DEMOLISHED)
BLOWER BUILDING
INLET SCREEN
WATER TANK
BIOLOGICAL REACTORS
PUMP SHED
WATER TANK
REALLOCATION
SEDIMENTATION TANK
3.42mØ x 2.8m HIGH
WATER TANK
LOT 78
PT LOT 71A
EOM
FILTER BUILDING
EXPANSION
FOOTPATH
FIRE STATION
MARCHANT ROAD
PLAN
SCALE: 1:100
DRAWING IN PROGRESS
PLOTTED ON 2019-3-18 AT 2:35 PM
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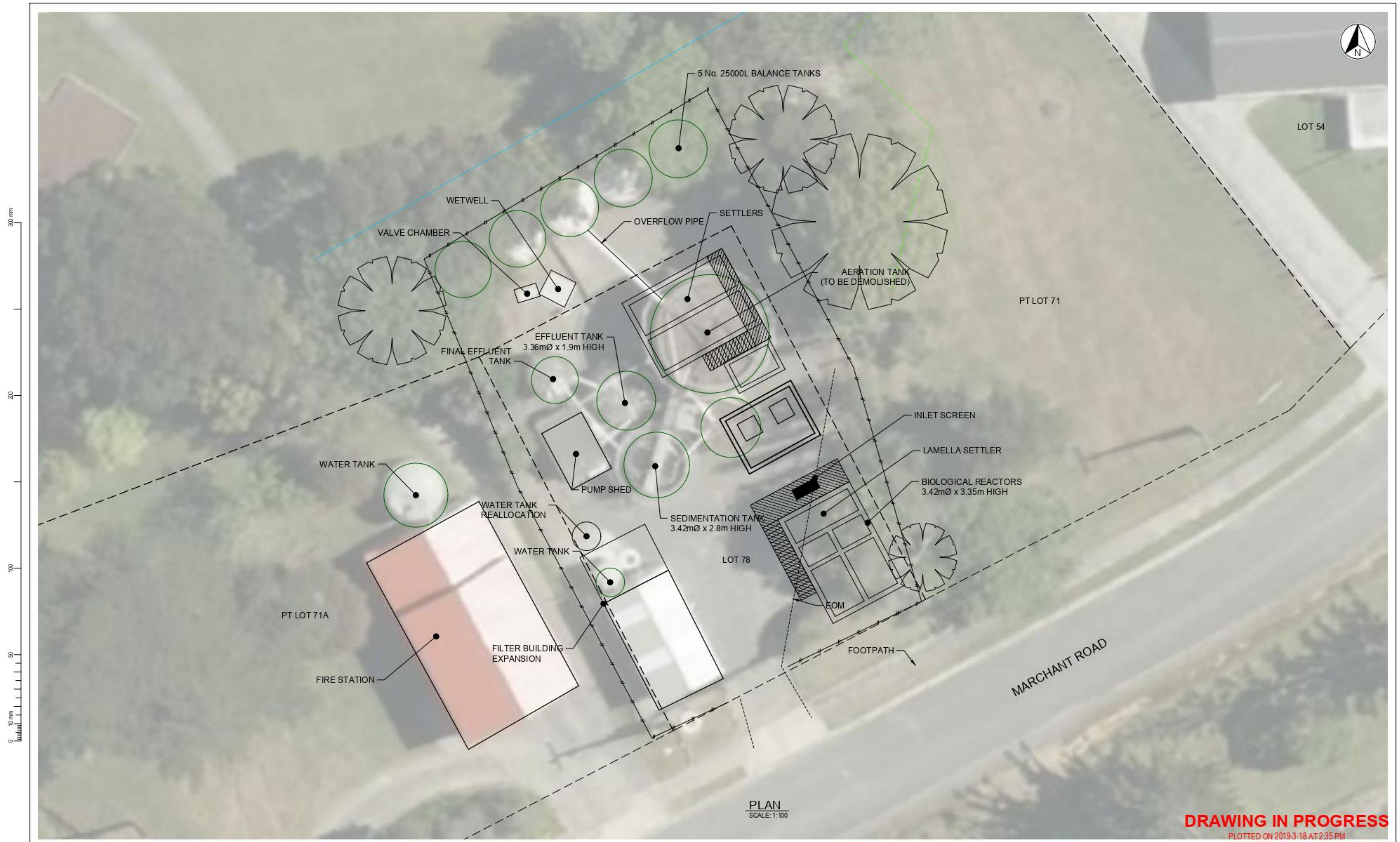
Revision | Amendment | Approved | Revision Date
A | ISSUED FOR INFORMATION
wsp OPUS
Whangarei Office
+64 9430 1700
125A Bank Street
PO Box 553
Whangarei 0110
Designed: E. FOSCHIERI
Approved
Approved Date
Drawn: R. CRAWFORD
Scales: 1:100 AT A1
Project
FAR NORTH DISTRICT COUNCIL
HIHI WASTEWATER TREATMENT PLANT
REPLACEMENT CONCEPT PLAN
Sheet
OPTION 1 - ACTIVATED SLUDGE
GENERAL PLAN
Project No. 1-13065.00
Sheet No. C01
Revision A



DRAFT - NOT FOR CONSTRUCTION

Revision	Amendment	Approved	Revision Date
A	ISSUED FOR INFORMATION		

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Whangarei Office
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Designed	Approved	Approved Date
B. REIG CARRIEDO		

Drawn	Scales
R. CRAWFORD	1:100 AT A1

Project
FAR NORTH DISTRICT COUNCIL
HIHI WASTEWATER TREATMENT PLANT
REPLACEMENT CONCEPT PLAN

Sheet
OPTION 2 - MBBR SOLUTION
GENERAL PLAN

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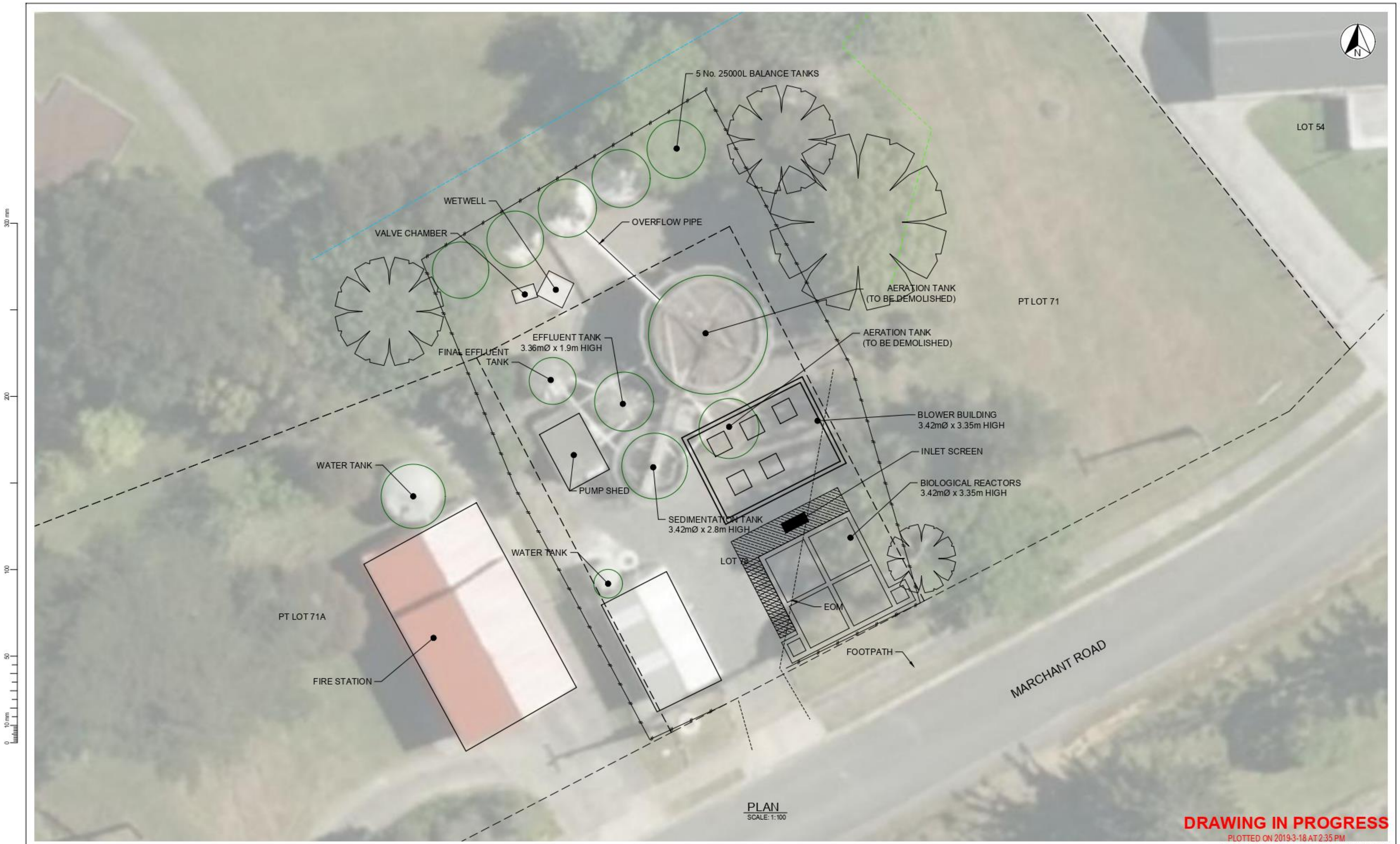

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HIHI WASTEWATER TREATMENT PLANT
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Sheet: OPTION 3 - MBR
GENERAL PLAN

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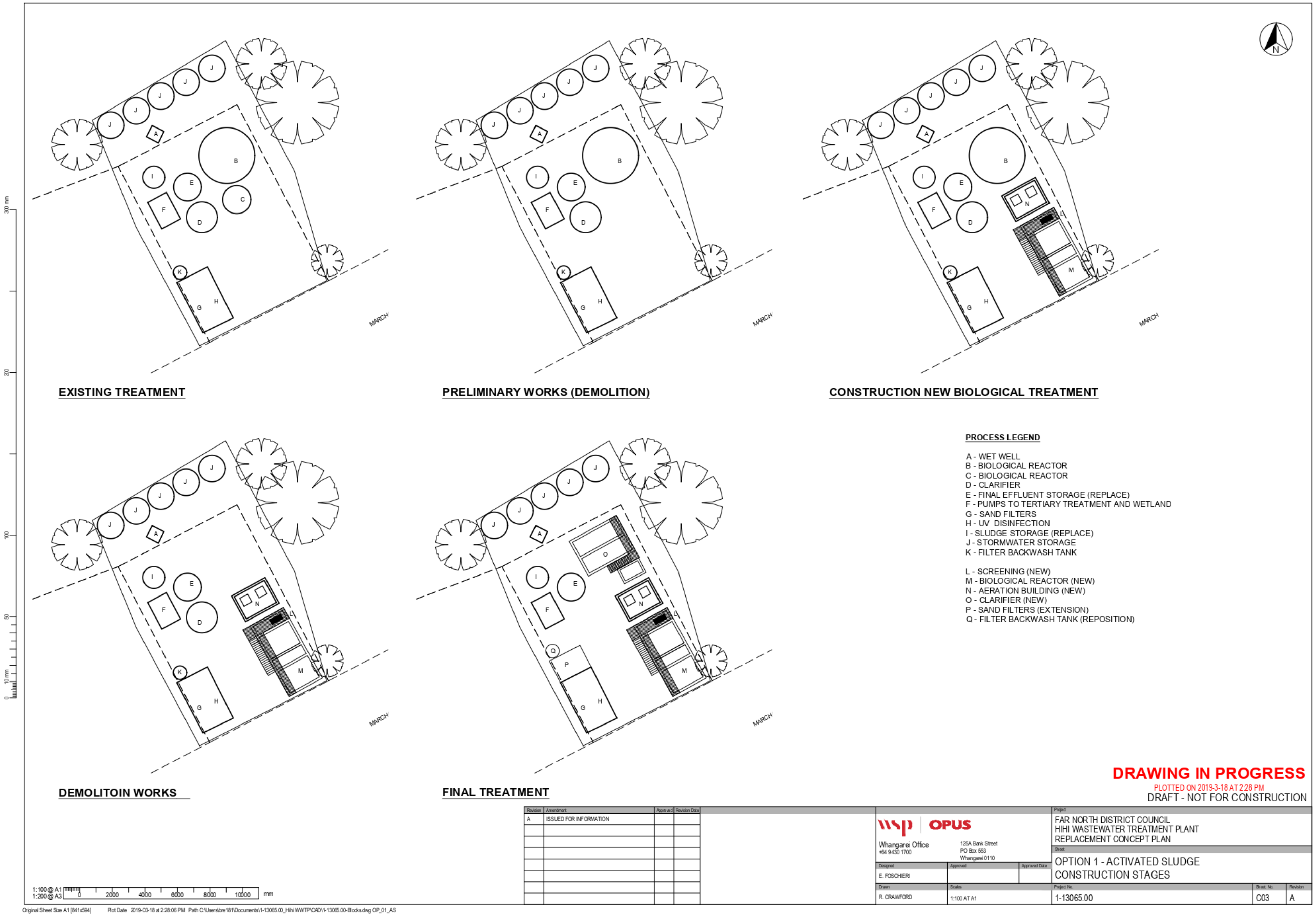
APPENDIX D Construction Sequence Drawings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F - PUMPS TO TERTIARY TREATMENT AND WETLAND
G - SAND FILTERS
H - UV DISINFECTION
I - SLUDGE STORAGE (REPLACE)
J - STORMWATER STORAGE
K - FILTER BACKWASH TANK
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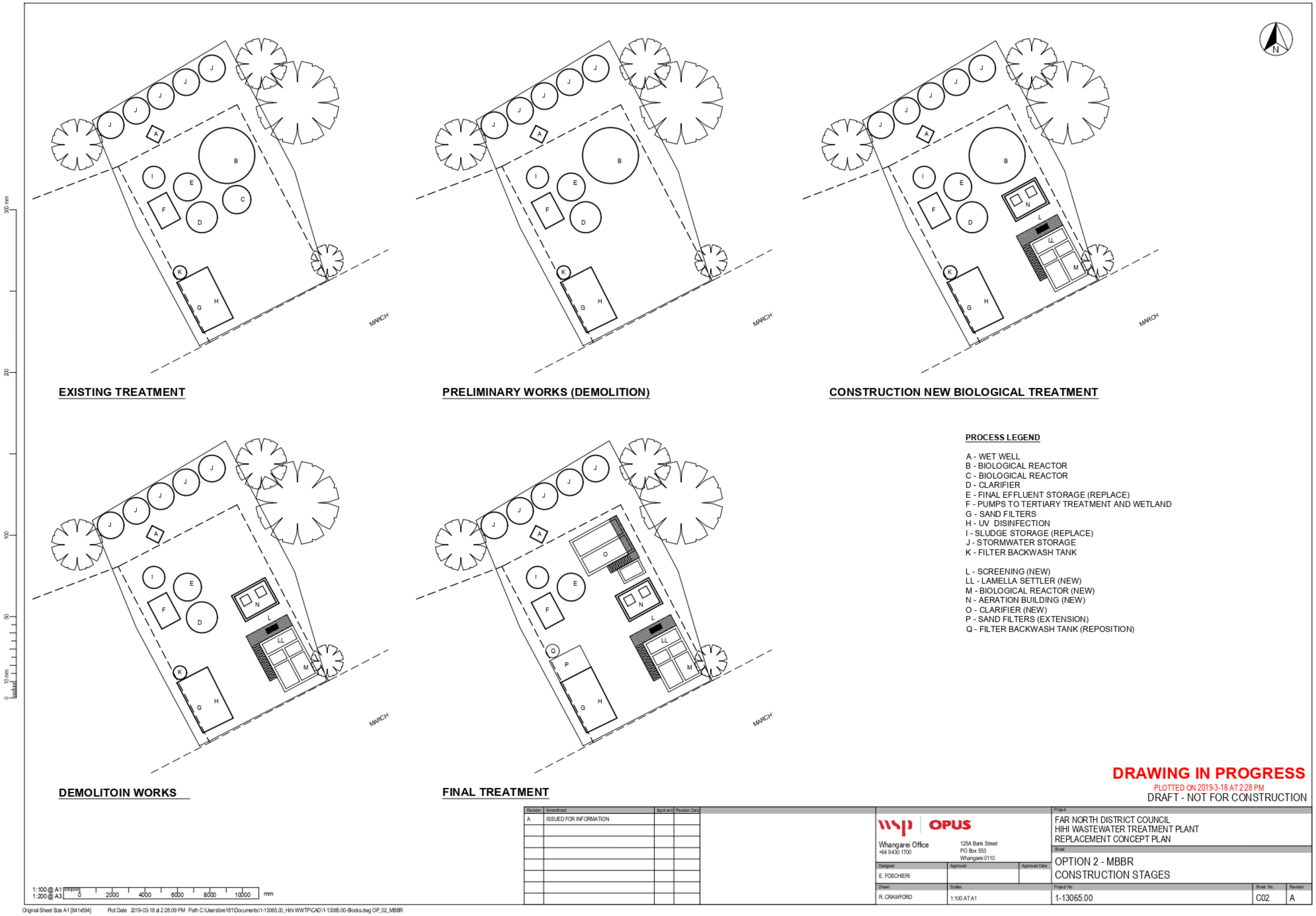
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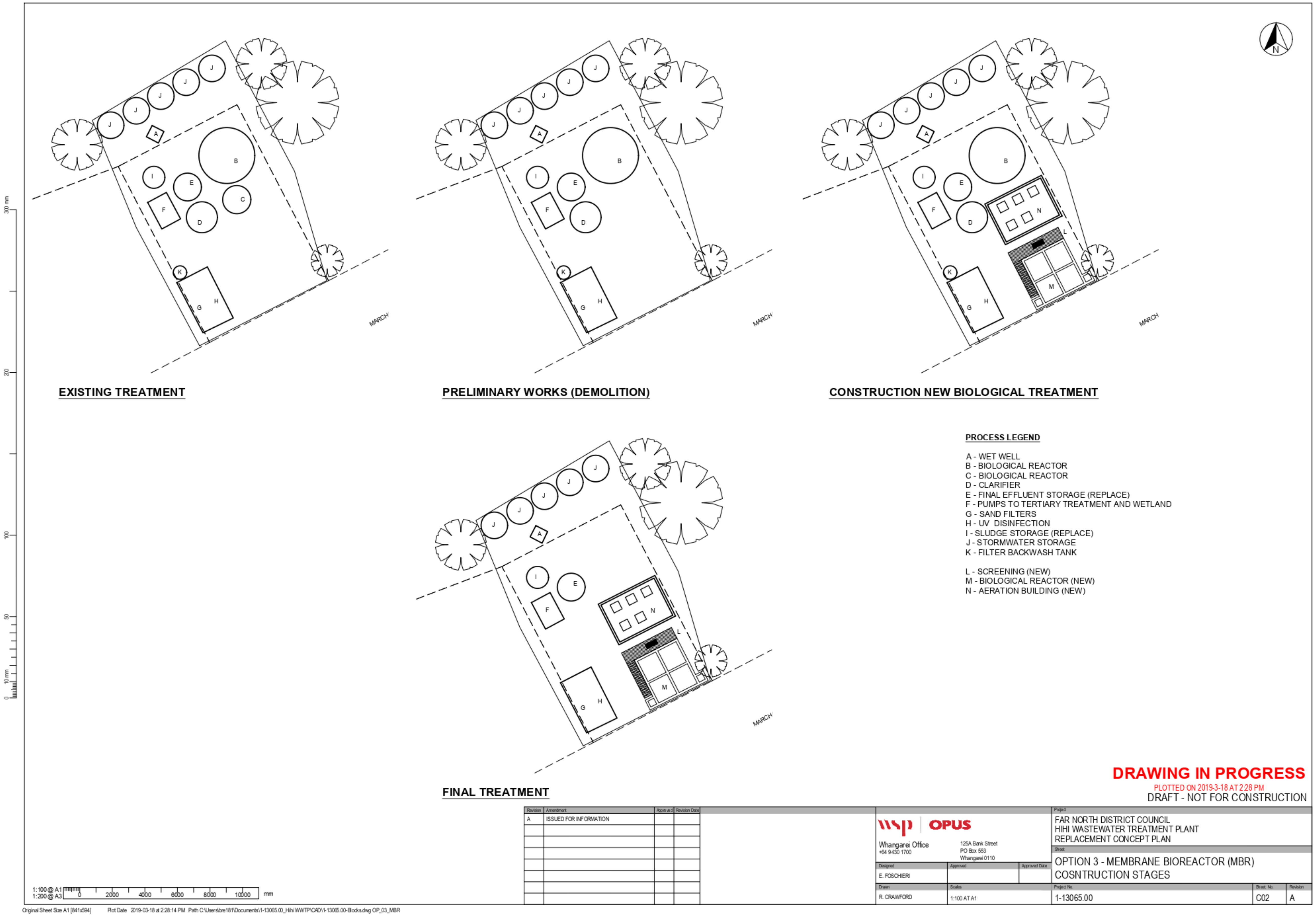
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Project Number: 1-13191.00

Hihi WWTP Activated Sludge Reactor

25 November 2019

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Structural Condition Assessment

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Revision	Details
1	Comment on report and findings
2	Comment on scope an overall intended use of the report

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Disclaimers and Limitations

This report ('**Report**') has been prepared by WSP exclusively for Far North District Council ('**Client**') in relation to structural condition assessment of the Hihi WWTP Activate Sludge Reactor ('**Purpose**') and in accordance with the offer of service dated 30 October 2019. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

This report is a high-level commentary based solely on issues observed from visual inspections of the tank and previous experience with similar structures. No detailed analysis has been completed at this stage.

1 Background

An inspection by Fraser Thomas in 2014 (attached in Appendix A) found significant damage to the large aeration tank at Hihi wastewater Hihi WWTP Activated Sludge Reactor located at Marchant Road, as shown below. This report included the following observations:

- The internal dividing wall had partially collapsed
- Flaking of the tank waterproofing and,
- Exterior cracking.

In October 2019 WSP was commissioned by Far North District Council (FNDC) to carry out an inspection to confirm the previously observed issues and assess any further damage that has arisen. This assessment was to include:

1 An external assessment looking for visible issues, including:

- Displacement of deformation of any structural elements
- Checking for cracks on the outside wall of the tank
- Staining or discolouration
- The state of ground to assess any saturation, saddened soil
- Ground settlement

2 An internal assessment of issues visible from the top of the tank, checking the inner walls of the tank, dividing wall and general condition of assets.

3 The preparation of a brief report that includes a description of the condition of each critical element, with photos and recommendations.

2 Inspection

Two inspections of the reservoir were carried out by Isabelle Mander (WSP Graduate Engineer)..

The first inspection was conducted on the internal conditions with the tank drained on the 31st of October 2019. The interior of the tank was observed from the tank's external railing. The site conditions were overcast, following rain the previous day.

The second inspection of the external condition with the tank full took place on the 5th of November 2019. The conditions on site were hot and clear, in a dry weather period.

The specific defects, recommended actions and approximate maintenance intervention timeframes are shown in the table below. In some cases, further investigations have been recommended before maintenance begins to identify damage that could not be assessed visually.

During both inspections the maintenance operator was present at all times.

3 Site observations

3.1 Access

The access from Marchant Road is by a sealed single vehicle crossing, onto a gravel pad with room for manoeuvring. Both the access and the pad were in good condition and no defects were noted.

3.2 External Structure

Several cracks along the construction joints were observed, and one section was noted as being wet. This section was approximately 50mm long and covered in mould. Some vertical cracking was also observed, in addition to calcification and mould growth around the cracks. Other than the section noted no wet patches were found. The wall should be water-blasted to clear mould so cracks can more easily be recorded.

No signs of the base failing were observed. The connection between the base and the rest of the tank is secure, with no signs of cracks, calcification or wet patches. The ground surrounding the reservoir was stable and showed no signs of settlement.

3.3 Internal Structure

3.3.1 Dividing Wall

A section of the internal dividing wall was noted to have collapsed in the Fraser Thomas report. The internal assessment revealed this to still be true, in addition to further degradation of the wall. Cracking on the western side of the wall suggests this section will fail in a similar manner if left. Scour also affects this wall and the outline of steel reinforcing can be seen. Due to this lack of support the wall is bowing and has been observed to sway while the tank is running. The wall should be removed or replaced to avoid further damage.

3.3.2 Perimeter Wall

Minor spalling of concrete. Exposed reinforcement

3.3.3 Base Slab

An internal assessment of the base could not be made as sediment within the tank covered the floor.

3.4 Fixtures

There is minor damage to the tank's fixtures. Several have begun to rust and should be replaced to prevent further damage. Three defunct clamps should be removed and the holes sealed. In addition, five of the vertical aeration pipes had fallen into the tank and should be removed.

3.5 Inspection Photos

A full set of photos from both inspections is provided in Appendix B.

Item	Defect or Issue	Recommended Action
External Structure		
1.1	Cracking around the two construction joints around 75% of tank	Sika approved contractor to seal the cracks with Sikadur 31

1.2	A 50mm moist crack covered in mould on the north side of the tank that runs along the lower construction joint	Clean out crack and repair with sika monotop

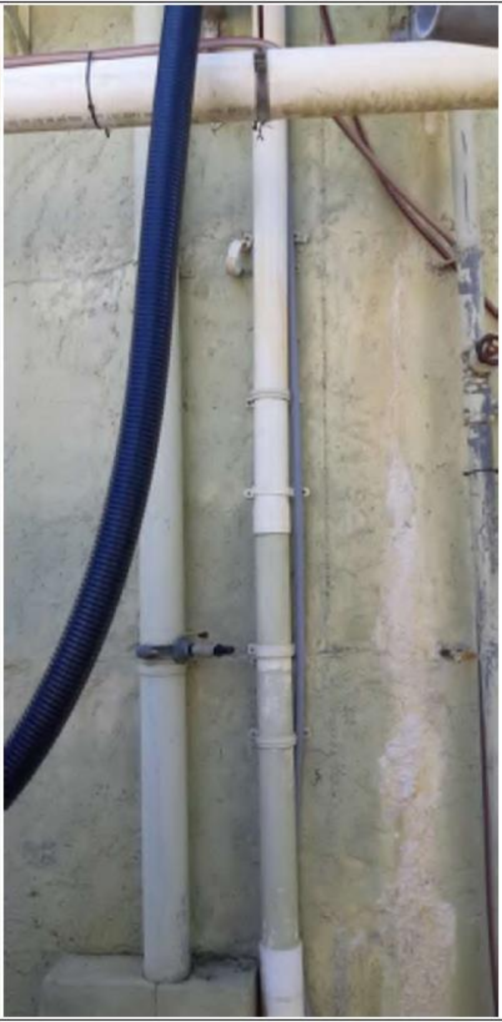
1.3	7 m of vertical cracks in various locations around the tank	Sika approved contractor to seal the cracks with Sikadur 31

 		
1.4	Exposed reinforcing is visible inside the tank	Remove laitance and repair with sika monotop
		
1.5	Scour inside the tank and wear of tank waterproofing	Re-apply waterproofing with a product from an approved supplier
		
1.6	Moss and mould may be obscuring the extent of cracks	High pressure water blast walls of the reservoir to remove all vegetation, debris and laitance

Internal Dividing Wall

2.1	The wall is showing several signs of failure: The eastern segment has collapsed The western segment is showing significant cracking The wall has been eroded and the outline of reinforcing can be seen The wall has been noted to sway when the tank is running	Repair or replace the internal dividing wall.

Fixtures		
3.1	Obsolete Brackets	Remove and seal holes with appropriate mortar

3.2	Rust on external brackets, valves and bolts	Replace with stainless steel fixtures
		
3.3	Rust and mould underneath external walkways	Clean element and record rate of corrosion

3.4	Several defunct pipes have fallen into the tank and remain there	Remove the defunct pipes and replace as needed

Other		
4.1	Sediment build-up inside the tank which limits the capacity of the tank and prevented a full inspection of the base	Remove sediment and drain tank to conduct a full inspection of the base; In the future perform regular maintenance to prevent build-up

4 Risks / Remedial Works

Based on the observations made on site, and drawing on previous experience of similar structures, we would expect failure to occur in certain elements, as described below.

4.1 Internal Dividing Wall

The internal dividing wall has already experienced partial failure. It can be expected to fail completely as further deterioration occurs over time, or during a significant seismic event.

The internal wall is not considered to be a structural element; therefore, its failure will not result in loss of contents or progressive failure of the tank.

The serviceability of the tank may however be affected, with the dividing wall no longer performing its original function.

4.1.1 Remedial Works

While not essential to the structural stability of the tank, a full replacement of the internal wall would be advisable to maintain full function. Advice from a process specialist should be sought before undertaking this.

4.2 Perimeter Wall

The perimeter wall is a critical structural element, and minor signs of cracking are already present. There is also a limited area of damp which indicates some water egress.

The cracks observed will propagate over time, resulting in minor leaking, initially noticeable as further damp present on the external surface. This may also occur suddenly if a significant seismic event occurs.

If cracking does worsen to the point of water egress, then there will be a small rate of loss of contents. This may be repaired immediately, otherwise the rate of water egress will increase exponentially until the internal water level reaches the level of the cracking.

4.2.1 Remedial Works

Further investigation would be required to confirm, but we would expect:

- *Full repair of all cracks/spalling, to prevent worsening. This can be expected to cost between $40k to $80k, taking around 2 weeks to complete.*
- *Detailed Seismic Analysis to check the structural capacity is sufficient to withstand the expected earthquake loading. A design fee for this can be provided, but we would expect it to be around $8k - $10k, taking around 2 weeks to complete.*

4.3 Base Slab

The base slab is also a critical structural element, but has not yet been observed, due to presence of debris.

It is common to see minor leakage in a base slab of this age, especially around any penetrations (inlet, outlet, scour etc). While this loss of contents is very limited and does not tend to be compounded by seismic actions, it is a very serious concern as it can lead to effectively scouring the fill from beneath the tank. If this is not prevented in time, then the structure will be undermined and become destabilised once the foundation is compromised, leading to structural failure and loss of contents.

4.3.1 *Remedial Works*

As leaks in a base slab can be very difficult to locate, even when cleaned, it is common practise to construct a new overlay slab, approx. 200mm thick to provide confidence in a watertight base element with a 50+ year design life.

This would be expected to cost approximately $100k, taking around 3 weeks to construct.

4.4 Wall – Base Connection

While not easily observable on site, a common failure experienced by tanks of this age is a lack of structural connection between the base slab and perimeter wall.

If these two are not connected then they may separate when an earthquake causes uplift of the wall, resulting in loss of contents.

4.4.1 *Remedial Works*

There are several methods of preventing this failure:

- *Construct a new reinforced concrete nib at the base of the wall, providing a connection to the wall and base, expected to cost approximately $100k, taking around 3 weeks to construct.*
- *Install a new overlay base slab which is fixed to the perimeter wall. This also provides a new base slab, preventing leaking as described above. This would be expected to cost approximately $100k, taking around 3 weeks to construct.*

4.5 Service Life

4.5.1 *Seismic*

We have not carried out a full structural assessment of the structure. However, based on previous experience of similar structures and accounting for the defects observed we would expect the following:

- *The structure would remain standing after a significant seismic event, but;*
- *The structure would experience significant additional cracking, resulting in loss of contents*

Therefore, the structure is not expected to remain functioning after a significant seismic event unless repairs are carried out.

4.5.2 *Durability*

If no repairs are carried out, then all cracking and spalling of concrete will propagate to the point where egress of stored water becomes unacceptable. This would be expected within 10 years.

If repairs are carried out and appropriate maintenance is continued, the service life may be perpetuated for 50 years or more. However, the maintenance costs of repairing an ageing structure like this will increase as time goes on, with more regular inspections and maintenance schedules required.

5 Conclusion

We recommend the following actions:

- The tank should be cleared of sediment and the base examined.
- The internal dividing wall should be removed or repaired, with advice from a process specialist.
- All cracks should be sealed appropriately.
- Regular maintenance and structural inspections of the existing tank should occur to monitor the deterioration of the reservoir.
- A Detailed Seismic Assessment of the tank should be carried out to determine the percentage compliance with the National Building Standard. This may include reinforcement scanning and more detailed investigations.

Project Number: 1-13085.03

Hihi Options Review

11 March 2020

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Disclaimers and Limitations

This report, '**Hihi Options Review**' has been prepared by WSP exclusively for Far North District Council in relation to consideration of issues and selection of preferred option for upgrade of Hihi WWTP, and in accordance with the ACENZ Short Form Agreement for Consultant Engagement, with Far North District Council, Dated 3 February 2020.

The findings in this Report are based on and are subject to the assumptions specified in the Report and discussions at stakeholder workshops. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

1 Introduction

In 2010 the Hihi wastewater treatment plant (WWTP) was identified for plant upgrade. However, this investment has been deferred until the current long-term plan. The Hihi WWTP has been identified as having deteriorating assets, with the main treatment reactor having been structurally condemned. WSP, as WSP Opus, undertook in 2018 a process review of the site and identified many issues including condition of all concrete tanks, process capacity and performance. From this several options were developed to address environmental needs and customer demands.

This report summarises the

- The evaluation processes used,
- The issues and associated risk to FNDC,
- Options considered,
- Evaluation and selection of options,
- Costs and indicative layouts for the solution(s) considered, and
- A recommendation for the preferred solution with budget costs.

1.1 Background Information

Hihi is located on the Southern Edge of Doubtless Bay in Northland. The main village sits on an Isthmus between Doubtless Bay and Mangonui Harbour and as having two beaches, is a popular retirement and holiday destination. The village consists of residential housing and a campground. All properties are served by roof tank water supply, so water usage is low for the catchment. See Figure 1 and 2 for location of Hihi and the Hihi WWTP. Figure 3 shows the existing Hihi WWTP with site designation boundaries.

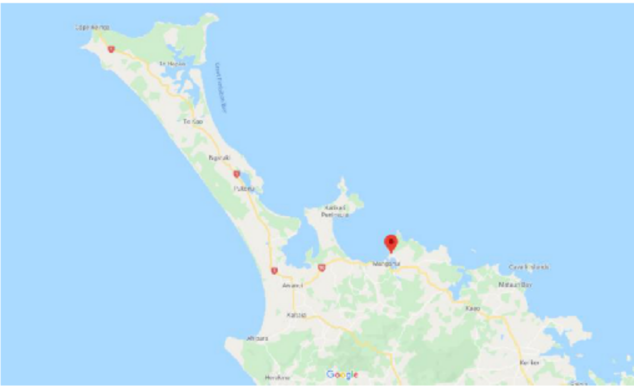

Figure 1: Location of Hihi, Northland.

Figure 2: Aerial Photograph of Hihi Community

Figure 3: Existing Hihi WWTP showing site designation boundary.

1.2 Project History

The Hihi WWTP was originally installed as a temporary installation, so was designed with the least expensive approach possible. The plant is now at 30 years old and assets are deteriorating. This deterioration has been ongoing, and several investigations have been undertaken in relation to this. Only recent studies are included in the list below.

1990	Hihi Wastewater Treatment works was constructed.
May 2014	Fraser Williams identified poor structural condition of main treatment reactor and advised that even with repair only 3 to 5 years additional life of tank would be attained.
October 2018	Site visit and observations memorandum (WSP Opus)
February 2019	Basis of Design (WSP Opus)
March 2019	Conceptual Design Options Report (WSP Opus)
November 2019	Structural Assessment (WSP)
December 2019	Business Risk Assessment Workshop with FNDC stakeholders
January 2020	Options Workshop with FNDC stakeholders
March 2020,	Options Study Report

Reports associated with the above key steps are presented in this report as Appendices.

2 Basis of Design

2.1 Flow and Load

WSP (as Opus) undertook a site assessment and flow and load review in 2018/19 for FNDC. These are presented in Appendix A. From this data a Basis of Design has been developed. This was presented to FNDC in February 2019. This is attached as Appendix B. This section is a summary of these investigations and reports.

Flow data has been analysed to assess the expected future flows. These are summarised in Table 1 below. There is a marked difference between peak flows (85 m^3/d) in December/ January and off-peak periods (35 m^3/d) due to differences in seasonal population.

Influent concentrations to the Hihi treatment works have only been measured at peak loads coinciding with plant overloading. This gives a maximum design load.

Future flow and load are not expected to change significantly as the catchment is now close to full development. Land at the edges of the community is generally too steep for housing.

Loads are estimated on average concentration times flow.

Table 1: Flow and load data for the Hihi WWTP.

Parameter	Units	Off Peak DWF	Peak DWF	Peak WWF	Load [kg/d] Off Peak	Load [kg/d] Peak
Flow	m^3/d	35	85	750	-	-
BOD	g/m^3		491		17	42
TSS	g/m^3		604			51
COD	g/m^3		983		34	84
TKN	g/m^3		140		5	12

As expected for a small wastewater treatment plant, routine sampling of influent is not undertaken. Only 2 samples have been taken since 2015 for crude sewage and these coincide with peak population and operational issues on the site.

This data is characteristic of a high holiday population and water supply from roof tank.

Historically the catchment has seen high levels of infiltration and ingress, but remedial work undertaken over years ago has reduced this to a manageable level.

2.2 Population

The resident population given in the 2013 census is 170 people. Data from flow and incoming wastewater shows that peak population is over 500 people..

The census shows that the resident population is largely middle aged to retired. Several properties are Baches and not fully occupied. Typically, off season, 2 persons will occupy a property but at peak holiday periods, population will increase to 4-8 people per property. This gives from residential dwellings an estimated doubling of population. Additionally, the campground will operate seasonally and is connected to the wastewater system. Exact population data cannot be confirmed without specific load studies, requiring continuous flow recording and 24-hour composite samples over an extended period.

Since 2013, the catchment has grown as remaining sections have been developed and it is noted that the catchment plots are fully developed.

This population presents challenges to the existing works that has insufficient process capacity for peak population.

2.3 Future Consent Requirements

A resource consent is in place for the Hihi wastewater system with conditions for the wastewater effluent and odours on the receiving environment and neighbours. This consent includes both the wastewater treatment works and the wetland sites. Water and effluent quality parameters are principally at the point of discharge to the stream, with the exception of E. coli that is measured after the UV system at the WWTP.

The current resource consent for the Hihi WWTP is largely compliant for all parameters and conditions. However, at times, the ammonia concentration entering the watercourse is non-compliant, and dissolved oxygen (DO) can also be depleted. These events coincide with peak plant loadings.

The resource consent is to be renewed in 2023. To develop and compare options on a like for like basis an estimate of expected effluent quality targets has been made. At this stage it is not known exact standards to be applied, so it is assumed that to meet the current standard all year a consent at the treatment works discharge shall be;

BOD	10 mg/l	Average	20 mg/l	90%ile
TSS	15 mg/l	Average	25 mg/l	90%ile
NH3-N	1.5 mg/l	Average	5 mg/l	90%ile
E coli	< 200 Median		< 1000 Maximum	
Total P	not determined.			

Should total phosphorous be determined as required, this may be managed by the addition of alum salts to remove phosphorous by chemical means. This approach can achieve Standards of < 1 mg/l may be achieved by this method, provided a filtration process is present.

3 Options Development

3.1 Business Risk Assessment Workshop

A Business Risk Assessment Workshop was undertaken on 4 December 2019 at Kaikohe with the stakeholders from FNDC and Broadspectrum as operators and maintainers of the Hihi WWTP. Figure 4 shows the existing Hihi WWTP configuration, this layout with the information and Section 2 was used as background for the workshop. This enabled capture of all known issues and stakeholder buy-in to the project direction and outcomes. This workshop explored all the issues at the Hihi WWTP and wetlands sites. The output of these risks is presented in Figure 5. Descriptions are only provided for the red high-risk items in Figure 5.

To prioritise these issues, a risk assessment was made using business risk. This is presented in Appendix F as part of the Business Risk Assessment Workshop, 4 December 2019, WSP.

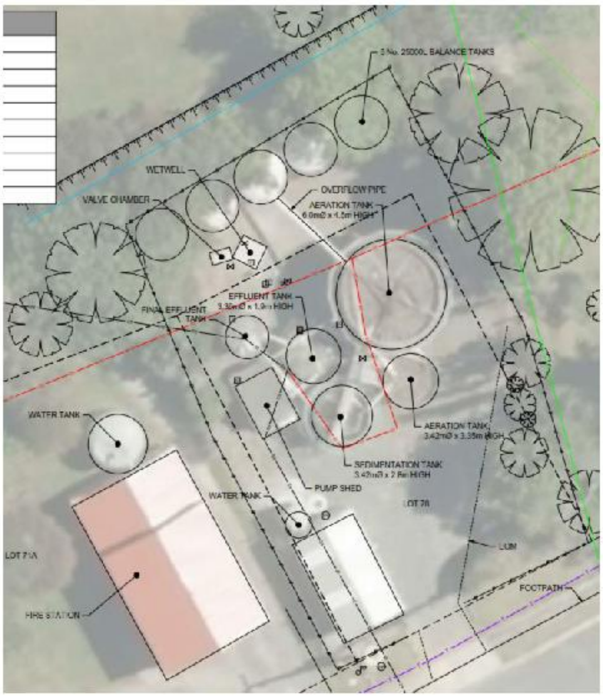

Figure 4: Existing configuration of Hihi WWTP.

Figure 5: Root Cause Business Risk Overview

Likelihood

Likelihood was scored as:

VH	Very High	almost certain, is occurring now either intermittently or continuously or will occur within 1 year.
H	High	likely, may occur now intermittently, but not continuously, or will occur within 5 years
M	Medium	probable, will occur within 5 – 10 years, occasional
L	Low	unlikely, will occur within 10-20 years, Infrequent
VL	Very Low	rare, will occur > 20 years

Impact

Risks considered included Business risk impacts of:

- Compliance,
- Safety,
- Customer Nuisance,
- Pollution,
- Prosecution, and
- Reputation.

Full scoring of all issues and Risks is presented in Appendix F

The key issues were identified as:

- The original WWTP at Hihi was constructed 30 years ago for a lower population approximately 200 people. It has insufficient flow and load treatment capacity for current demand with peak population of 400-600 people.
- The plant is not robust against seasonal variation and suffers poor solids settlement (Nocardia filaments) and insufficient nitrification as a result.
- Peak flows to the site were designed at 2.5 l/s but current treatment pumps deliver approximately 4 l/s. Additionally storm pump will operate in high wet well conditions. Flooding occurs in very high flows as all pump capacity is exceeded. Peak flow to works of 8 l/s is estimated.
- The consent conditions for ammonia and dissolved oxygen are exceeded periodically in the stream.
- To deal with high flow deficiency, flow bypasses secondary treatment and sand filtration against the consent conditions.
- Poorly disinfected effluent is discharged in bypass conditions to the wetland and will pass through the stream to a popular bathing beach.
- The WWTP extends outside of the lawful designated area, so does not meet planning requirements.
- The assets constructed 30 years ago were "low budget solution" and have reached the end of their asset life. This includes key tanks and mechanical scraper mechanism of the clarifier.
- Structural failure has occurred of an internal baffle in the main reactor. The concrete tanks are leaking in several places. Significant Leaks will require at least a 2-week shut down of the whole plant to "patch repair". Catastrophic failure will take the whole plant out of service until a new plant can be built (estimated minimum of 6 months) and will require tankering of all flows in this time.
- Many assets have poor accessibility that limits maintenance. This accessibility impedes removal of assets without major work and as no standby on critical assets will require a whole works shutdown. As example, to change the blower the roof of the blower building must be removed, and no secondary treatment is possible in this time.
- There is insufficient standby equipment to provide continuously high-quality effluent.
- The wetland requires maintenance as it has been impacted by the shortfalls of the plant and sludge carry through.
- Land slips are known at the wetland site and there is evidence of further recent movement in the bank. This will impact on treatment and cause loss of wetlands with consequential impact on stream, stream ecology and bathing beach.
- The site is known to cause nuisance odours and noise to the community.

3.2 Options Workshop

An options workshop was held on 16 January 2020 with key FNDC Stakeholders and Broadspectrum as operator and maintainer. Minutes of this meeting are attached in Appendix G.

3.3 Long List Options

A long list of options was considered at the Options Workshop.

The options considered were:

- Activated Sludge Plant (ASP),
- Moving Bed Bioreactor (MBBR),
- Membrane Bioreactor (MBR),
- Transfer to Mangonui Catchment, and
- Repair main reactor only.

3.3.1 Activated Sludge Plant

Figure 6: Activated Sludge Plant Option (Pink Structures.

This option includes;

- Replacement of inlet pumps to 8 l/s, with new rising main and flow meter
- Elevated inlet mechanical screen,

- 2 of 7m x 5 m x 4 m activated sludge reactors with anoxic zones, return activated sludge (RAS) system, access
- 1 of 6.5 m diameter flat bottom clarifier with scraper
- RAS and waste activated sludge (WAS) system
- WAS tank
- Effluent Tank
- New transfer pumps
- Additional sand filters in building
- Additional or larger UV.
- Building for Blowers and controls.

3.3.1.1 Construction

To construct this option, it is necessary to sequentially build and have temporary flow paths on the site. For short periods only, flows can be stored in the storm balance tanks enabling critical change overs to occur without removal of wastewater from site.

This plant can only be built off peak season when flows and load are lower.

Steps for construction;

- Removal secondary reactor tank. Temporary feed clarifier from main tank.
- Construct reactor slab and new blower building.
- Install all reactors and associated mechanical and electrical (M&E) equipment.
- Temporarily feed from new reactor to clarifier, with feed from existing pump station.
- Decommission existing main reactor and base slab.
- Prepare ground and install new clarifier.
- Connect clarifier to reactor and new effluent tank.
- Temporary over pump from effluent tank to existing sand filters.
- Remove old blower room, pumps WAS Tank and clarifier.
- Extend sand filter building for new pumps and sand filters.
- Connect effluent pumps to sand filter system
- Upgrade pumps at inlet to new flow rate of 8 l/s.

3.3.1.2 Advantages

- This is a conventional activated sludge solution, known to operations
- Can be built in limited footprint of designation.
- Improved aeration efficiency should lower or not increase energy costs.

- Reduced sludge from site as control available
- Achievable construction programme
- Could be largely modular for removal from site to new location if sea level rises
- Improved quality of effluent
- No bypassing of secondary treatment at high flows.
- Assets Maintainable

3.3.1.3 Disadvantages

- Changing Seasonal conditions that grow Nocardia will persist. Making plant unstable
- No resistance to Nocardia
- Requires sequential construction. (See above) with increased construction risks and duration
- Does not address wetland issues.
- Sand filter access not addressed

3.3.2 Next Steps

This option, due to similarity to existing process and proven ability to meet consent requirements is taken forward for option evaluation and costing.

3.3.3 Moving Bed Bioreactor

Moving Bed Bioreactors are used for treatment of wastewater (see option layout in Figure 7). They consist of an aerated tank with plastic floating media (see Figure 8). This media forms the support for a bacterial population and is retained in the reactor by mesh screens. Aeration is provided by coarse air, required for treatment and for media movement. This is a fixed film system so does not require a RAS to recirculate biomass.

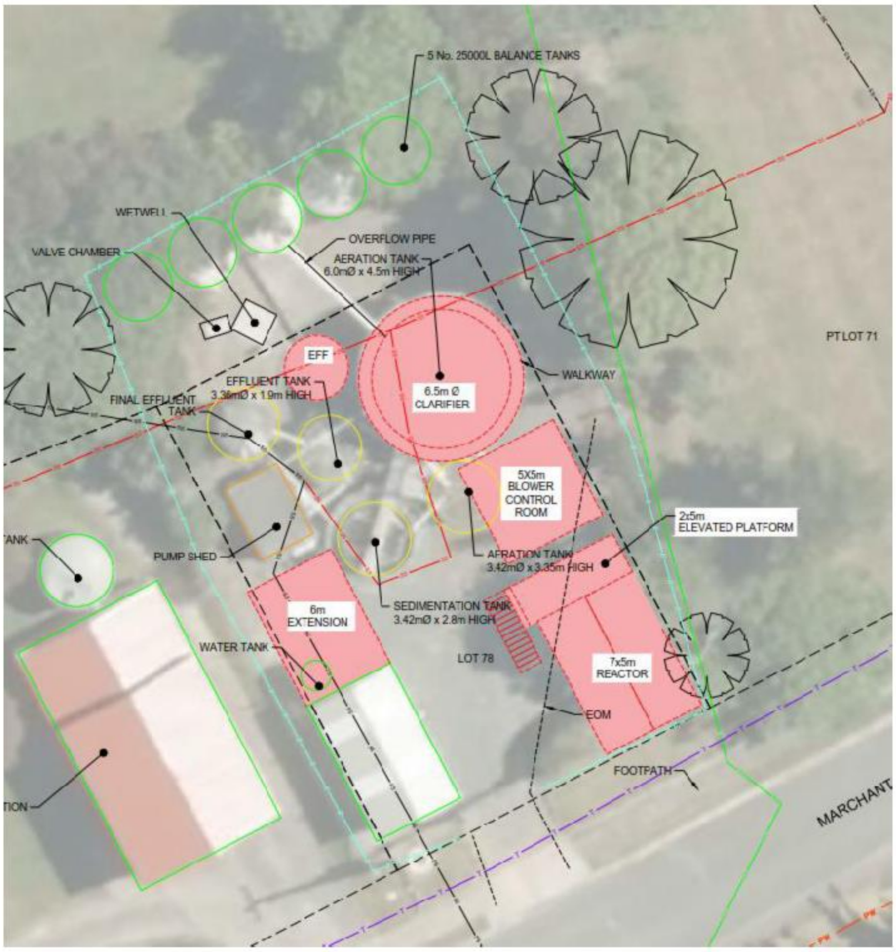

Figure 7: Moving Bed Bioreactor Option

Figure 8: Typical Moving Bed Media

This Option includes;

- Replacement of inlet pumps to 8 l/s, with new rising main and flow meter
- Elevated inlet mechanical screen,
- 2 of 7m x 5 m x 4m Moving Bed reactors with anoxic zones,
- Recycle system
- 1 of 6.5 m diameter flat bottom clarifier with scraper
- WAS system
- WAS tank
- Effluent Tank
- New transfer pumps
- Additional sand filters in extended building
- Additional or larger UV.
- Building for blowers and controls.

3.3.3.1 Construction

To construct this option, it is necessary to sequentially build and have temporary flow paths on the site. For short periods only, flows can be stored in the storm balance tanks enabling critical change overs to occur without removal of wastewater from site.

This plant can only be built off peak season when flows and load are lower.

Steps for construction;

- Removal secondary reactor tank. Temporary feed clarifier from main tank.
- Construct reactor slab and new blower building.
- Install all reactors and associated mechanical and electrical (M&E) equipment.
- Temporarily feed from new reactor to clarifier, with feed from existing pump station.

- Decommission existing main reactor and base slab.
- Prepare ground and install new clarifier.
- Connect clarifier to reactor and new effluent tank.
- Temporary over pump from effluent tank to existing sand filters.
- Remove old blower room, pumps WAS Tank and clarifier.
- Extend sand filter building for new pumps and sand filters.
- Connect effluent pumps to sand filter system
- Upgrade pumps at inlet to new flow rate of 8 l/s.

3.3.3.2 Advantages

- This is a proven technology using plastic media suspended in the tank.
- Not susceptible to poor settlement due to Nocardia.
- Biofilm adjusts rapidly to changes in loading
- Solids to clarifier are lower than mixed liquor suspended solids (MLSS), so less prone to blanket loss at high flows.
- Can be built in limited footprint of designation.
- Production of less sludge than activated sludge
- Achievable construction programme
- Could be largely modular for removal from site to new location if sea level rises
- Improved quality of effluent
- No bypassing of secondary treatment at high flows.
- Assets Maintainable

3.3.3.3 Disadvantages

- Increased aeration energy to meet demand of coarse aeration.
- Can produce very fine poor settling solids in light loading conditions.
- Requires sequential construction. (See above) with increased construction risks and duration
- Does not address wetland issues.
- Sand filter access not addressed

3.3.3.4 Next Steps

This option has been considered, but as it is new technology to the area it may create operational issues.

The costs for the plant have been estimated as higher than an activated sludge plant, as it is essentially an activated sludge plant with plastic media. Aeration is inefficient and increased aeration energy will be required.

No additional benefits were identified that differentiate this solution from an activated sludge process.

For these reasons, the option for moving bed bioreactor has not been progressed.

3.3.4 Membrane Bioreactor

The membrane bioreactor (MBR) is a version of activated sludge plant. Unlike a conventional activated sludge plant, the removal of solids is by membrane. This is usually around 0.1 µm pore size, so actively filters bacteria and some viruses and the treatment solids. This means that the plant can run at higher mixed liquor suspended solids (MLSS) concentrations, or biomass concentrations than a conventional plant and this results in a compact plant.

The MBR can be supplied as packages or a bespoke system using modules of membranes and treatment tanks.

All require fine screening to < 2 mm as blockage may occur.

The solution identified in Figure 9 is for a module membrane system external to the reactor. Flow is recycled from the membrane to the head of the plant, like a RAS from the clarifier. Effluent is guaranteed to be low in bacteria (< 1 E Coli/100ml,) and as suspended solids is < 1 mg/l, associated BOD, and nitrogen and phosphorous can be reduced.

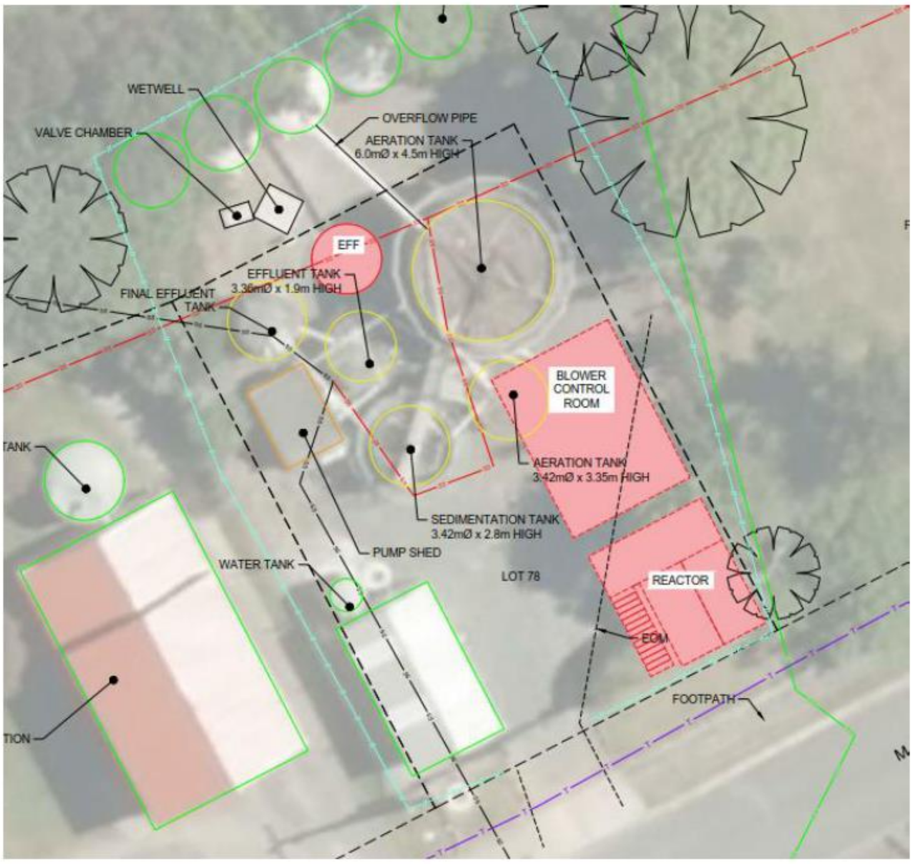

Figure 9: MBR Treatment Option

To clean the membranes a cleaning system is required. With modular membranes as shown, this will require a continuous back scour of air, and periodic back flush with hypochlorite. Volumes used are very small on this scale of plant, with chemicals being supplied in 20 litre containers. Flat sheet membranes often do not require regular cleaning and may be cleaned by back flow of hypochlorite in the membrane about twice each year. Additional building footprint is required to allow for chemical storage and dosing systems.

This Option includes;

- Replacement of inlet pumps to 8 l/s, with new rising main and flow meter
- Elevated Inlet 2mm mechanical screen,
- 1 of 6m x 4m x 5m tank with anoxic zones, RAS system, access
- 2 membrane modules and cleaning system (if required)
- WAS system
- WAS tank
- Effluent Tank
- New transfer pumps
- Building for controls, blowers and membranes.
- Removal of Sand filters, and UV

3.3.4.1 Construction

To construct this option, it is necessary to sequentially build and have temporary flow paths on the site. For short periods only, flows can be stored in the storm balance tanks enabling critical change overs to occur without removal of wastewater from site.

This plant can only be built off peak season when flows and load are lower.

Steps for construction;

- Removal secondary reactor tank. Temporary feed clarifier from main tank.
- Construct reactor slab and new blower building.
- Install all reactors and associated mechanical and electrical (M&E) equipment.
- Install new effluent tank, with transfer pumps
- Decommission existing works.
- Upgrade pumps at inlet to new flow rate of 8 l/s.

3.3.4.2 Advantages

- This is a proven technology although not familiar to FNDC
- Not susceptible to poor settlement due to Nocardia.
- High Biomass adapts rapidly to change in load
- No solids loss

- No need for sand filters and UV
- Can be built in limited footprint of designation.
- Shorter construction programme as limited decommissioning and phasing required.
- Could be largely modular for removal from site to new location if sea level rises
- Very high quality of effluent. MBR can achieve:
  - < 1 mg/lBOD
  - < 1 mg/l TSS
  - < 5 mg/l NH_3 and
  - < 1 cfu/100ml E. coli
- No bypassing of secondary treatment at high flows.
- Assets maintainable
- Lower operator attendance required as automated and robust

3.3.4.3 Disadvantages

- Similar power requirement as existing works,
- Periodic chemical cleaning,
- More technical plant to manage, and
- Does not address wetland issues, although wetland could be bypassed due to high quality.

3.3.4.4 Next Steps

This option has been taken forward for costing and consideration as it produces consistently a high quality of effluent, not impacted by fluctuation in population and not impacted by Nocardia. A reduction in operational cost is expected due to lower operator attendance.

3.3.5 Transfer to Mangonui

Consideration was given to a transfer away option. Mangonui is 1.7 km from Hihi and could receive flows by pumping under the Mangonui Harbour (see Figure 10). This distance for a 125mm pipe is achievable by directional drilling from a new pump station at the Hihi WWTP.

Concerns have been raised on the impact of the Hihi transfer on Mangonui and East Coast Bays network. Although only 30 m³/d in dry weather, an increase in peak flow of 8 l/s will probably require additional upgrades in Mangonui and through to Taipa. This network is already known to be struggling with peak flows and treatment capacity at Taipa.

The estimated costs of transfer are lower than the cost of upgrade at Hihi, but as there will also need to be a contribution to upgrade the network and Taipa WWTP soon, this is unlikely to be beneficial to the community as costs.

Mangonui residents are expected to be resistant to the transfer, particularly as increased odour may arise.

To facilitate a new harbour crossing a resource consent and AEE will be required. Other communities in New Zea;amd have objected to pipelines under harbours based on possible leaks that may impact harbour ecology and shellfish. Therefore, it is expected that for approval for a harbour crossing this application will go to environment court. To gather data and follow consenting process is anticipated that this process could to take 3 to 5 years.

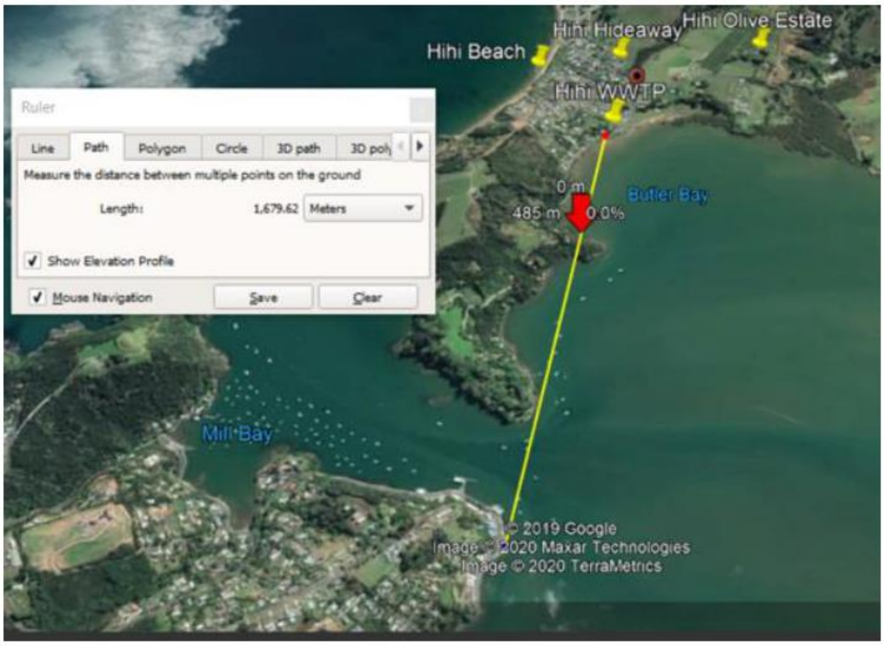

Figure 10: Option for Pipeline transfer to Mangonui

This solution will consist of:

- New transfer Pump station at Hihi WWTP.
- Gravity connection from existing sewer to new transfer pump station.
- Rising main from Hihi to Mangonui and connection chamber.

- Odour control management at Hihi (preventative) and odour treatment at point of discharge.
- Potential upgrades to Mangonui catchment including pump station upgrades and sewer upsizing.

3.3.5.1 Advantages

- Removal of Hihi WWTP, leaving only control shed (existing sand filter building) and pump station well
- Within site designation
- Return of site to reserve, recognised as favourable to neighbours.
- Removal of wetlands and associated risks
- Removal of all risks from existing plant.
- No need for Hihi WWTP consent renewal

3.3.5.2 Disadvantages

- New Resource consent required for pump station and harbour crossing
- Unable to deliver in timescale of this project (up to 5 years for consent approval)
- Upgrades in Mangonui have additional costs to community
- Increase risk of odours at Mangonui
- Removal of flow may leave no flow in receiving stream, impacting on fish and ecology

3.3.5.3 Next Steps

This option is discounted as the whole costs of transfer including Mangonui improvements are not cost beneficial to the community of Hihi. Additionally, the project timeframe of upgrade within 2 years will not be achieved with resource consent applications and expected objection to harbour crossing potentially delaying this option for 5 years or more.

3.3.6 *Main Reactor Refurbishment*

A discussion was held on the refurbishment of the existing main reactor. No other upgrades were considered.

To complete this work the main reactor will be out of service for 4 to 6 weeks resulting in all flows being removed from site by tanker. Over this period an average flow of 80 to 100 m^3/d will need to be managed and higher in wet weather with approximately 8 to 10 tankers everyday (and up to 50 in wet weather). This will not be logistically possible as there are insufficient road tankers in this region to support this activity 24/7 for the duration.

FNDC has identified in the Long Term Plan a replacement of the Hihi WWTP and this solution will not address that plan commitment that has previously been agreed by the community.

This works will require:

- Drain Tank and clean debris
- Remove baffle from reactor.
- Replace in tank aeration and move outlet pipe
- Sika product seal tank

3.3.6.1 Advantages

- Solution is cheap
- Can be built in timeframe of project

3.3.6.2 Disadvantages

- This tank is life expired and this work will increase asset life by at most 5 years before other leaks and damage appear.
- No maintenance risks are addressed
- No replacement of reactors, clarifiers, or other assets
- No additional capacity is provided
- Effluent resource consent will not be met.
- Customer nuisance will continue
- Flows will bypass treatment in high flow conditions, not as consented.
- Plant will be outside of designation
- No improvements to wetland or sand filtration
- Health and safety issues will not be addressed

3.3.6.3 Next Steps.

Although considered as low cost this solution does not address the critical business risks identified and will not meet consent, site designation and health and safety requirements. This option cannot be continued as fails to meet project needs.

4 Option Evaluation

4.1 Project Constraints

The following were considered as constraints for the Hihi WWTP upgrade and formed the basis for evaluation of options.

Affordability.	The Hihi catchment serves only 200 residents, so cost is a major concern for the community.
Land	The operational site is in a prime waterfront location in reserve. It is larger than the designated operational site, which needs to be addressed. The solution should fit within the existing designation
Neighbour	Overlooked and in close proximity to neighbours, the site is subject to noise and odour complaints. Future upgrades need to improve this for the community
Inundation/Climate Change	Being located on the foreshore, less than 1 m of sea level rise will see high tides in the site. Consideration may be given to robustness of design (e.g. electrical components above flood level) and the ability to move the plant at a later stage to an alternative location
New Consent Conditions	Currently unknown, but tighter standards are expected that will address ammonia and oxygen levels and bacterial standards. Possible total Nitrogen and Phosphorous standards are considered (at the workshop) to be unlikely, but can be accommodated in the design of the plant if needed
Amenity	The area is used for recreation, both on the foreshore and the recreational reserve around the site. Return of utilised areas (not designated) will increase the amenity for the community.
Land Use	The ideal situation for the neighbours is a new plant elsewhere, but this has been identified as very high capital cost as must include land purchase, resource consenting, transfer network and new treatment process.
Nuisance.	The proximity and history of the site in the community leads to odour and noise complaints that can be managed in the future plant
Time	The main reactor has been condemned and is not expected to last for more than 2 years without significant risk of catastrophic failure. Solutions need to be timely to address this key driver of the project
Construction Programme	The programme needs to consider duration as a key issue. Location in a holiday area will require construction off season, with limited space available on site. Sequential demolition and construction will be needed. Build off site techniques will be encouraged to meet timely delivery
Maintenance/Operations	Long term the plant must be fit for purpose, suitable for regular maintenance of all equipment. Typical asset life should be > 40

	years for the structures. This includes addressing single point of failure equipment and accessibility
Asset Life	Materials and equipment selected must be fit for purpose to meet the required Asset Life. This need to consider the impact of sea air and potentially, seawater ingress and tidal flooding (if climate change occur)>
Wetland Condition	To meet cultural needs a discharge to land, or in contact with land will be required. This need be fit for purpose and not cause nuisance, or deterioration of effluent in passing
Quality.	Effluent quality shall meet the consent, even at peak loading times
Safety	All plant shall be reasonably practicable safe for operation and maintenance of all equipment and assets. This shall include access, confined space avoidance, lifting of equipment and personnel hygiene
Whole life costs	Whole life cost is essential as the community will pay for capital expenditure and operational costs

These constraints are tabulated below in Table 2, with each option considered.

4.2 Comparison of Options

Table 2: Comparison of options with consideration to the listed contstraints.

Options	Repair	Activated Sludge Plant	Pump to Mangonui	Moving Bed Bio Reactor	Membrane Bio Reactor	Notes
Constraints						
Affordability	✔	✔ Check Cost	X	✔	X- Check Cost	Affordability limited to $4M
Land	✔	✔	✔	✔	✔ ✔	
Neighbour	✔	✔	✔ ✔	✔	✔	
Inundation/Climate change	X	X	X	X	X	Existing site conditions does not support
New Consent	X	✔	✔	✔	✔	
Amenity	✔	✔	✔	✔	✔	
Land Use	X	✔	✔ ✔	✔	✔	
Nuisance	X	✔	X	✔	✔	
Time	✔	✔	X	✔	✔	Design and construction in less than 2 years
Construction Programme	✔	✔	✔	✔	✔	
Maintenance operations	X	✔	✔	✔	✔	
Asset Life	X	✔	✔	✔	✔	
Wetland	X	X	✔	X	X	V High Quality may bypass wetland if consent permits
Quality	X	✔	✔	✔	✔	
Safety	X	✔	✔	✔	✔	
Whole Life Cost	X	✔	✔	✔	✔	

From the options considered at the options workshop, no option satisfactorily meets the demands of climate change and sea level rise inundation of the site. It was considered that a new site will be required in the future, but to meet current project needs, preference is for a modular, movable treatment solution that can be relocated.

The repair option did not meet many criteria and cannot be considered as suitable for site needs.

Almost all the option solutions for Hihi WWTP have a substantial risk from the wetland site. This requires desludging, replanting and stabilisation of the embankment. The failure of this embankment will flood the pond, bypassing the treatment, potentially washing out of sludge, and divert the stream. An allowance in solution costing has been made in the detailed cost estimate. Only pumping to Mangonui removes the risk from the wetlands as no flow will be discharged, but this option cannot be completed in the project constraint time scale of 2 years.

5 Detailed Options Evaluation

From the long list further evaluation has been done on the Activated Sludge and Membrane Bioreactor options.

5.1 Footprint

Early indications are that the options can be constructed within the site designation as above ground structures. This will enable removal of assets in the extension area. However, the inlet pump station (PS) is assumed to be retained. This is outside of the designation, and FNDC will need to consider whether its best value to construct a new PS after the works is constructed within the boundary, or modify the designation to accommodate.

Final Layout diagrams for the preferred short list options are presented in Appendix I

5.2 CAPEX Estimates

Capex estimates are budget costs estimates and reflect costs associated with similar projects and supplier budget cost estimates (see Table 3). Cost Estimate break down are provided in Appendix J.

Table 3: Indicative capital and operating cost estimates for the activaled sludge, and MBR options.

Option	CAPEX	Opex Change
Do Nothing	$20k **	$20k *
Activated Sludge	$5.21	No Change
MBR	$5.33m	No Change
Nominal Wetland Remediation and bank stabilisation	$700k	
Total Budget	$6.03 m	
* Additional costs of reactive maintenance will continue to increase. A nominal value is used.		
** Annual capitalised maintenance cost estimate to manage failing assets excluding structural failure		

Opex costs for both solutions are as for the existing works costs and have not been analysed at this stage but are discussed below.

Both options, have improved automation that will reduce operator attendance. Also, by use of more efficient aeration, aeration energy will decrease, offsetting additional power demands from sand filters (activated sludge option) or membrane cleaning (membrane bioreactor option).

Both options produce similar quantities by weight of sludge to be removed from site. This total volume is expected to be lower than current for the activated sludge plant as there will be improved control on wasting but reduced further for membrane bioreactor as the sludge is more concentrated, so having a lower volume.

Chemical usage for the membrane system is required but have not been estimated. This will vary depending on membrane system selected. However, chemical cost per year may be < $2k per year for a flat sheet membrane, or < $5k per year for a hollow fibre system. These shall be evaluated in detail during preliminary design but are dependent on the membrane system selected. Both options will have an increase in instrument maintenance requirement, with approximately 24 hours per year required, which is offset by the reduction in operator attendance for routine control checks.

Do nothing, which is not a preferred choice for this site, will see an increase in operational costs as maintenance increases with deteriorating assets and periodic capitalised reactive works required.

Overall there is no notable change to operational costs associated with this treatment plant replacement.

A comparison has been undertaken for the Membrane Bioreactor with a packagedsupply from Smith and Loveless. This was a budget quotation and not fully conforming. However, the cost comparison with correction for civils aspects, site integration, project on costs etc. is directly comparable with the WSP estimate. (S&L corrected $5.36m, WSP MBR, $5.33m).

6 Recommendations

Both options show very similar capital cost and have very little operational cost differences. Both options can be constructed within the site designation. With the accuracy of cost estimation, it is not possible to select between these options on price alone. Therefore, the following discussion considers the main risk areas for the plant.

6.1 Operability

Both options can be operated and maintained with reasonable skilled operators. Both plants will be impacted by seasonal changes in flow and load, but due to the membranes, the quality from the membrane system will not be impacted by the growth of filaments like Nocardia that are known to occur at this site. This means when filaments occur, less operator intervention is required for a membrane plant and a higher effluent quality achieved always than possible with the activated sludge plant.

6.2 Performance

The activated sludge plant can achieve very high effluent standards. However, in changing load conditions performance may dip, particularly on ammonia and suspended solids. Disinfection is dependent on the UV performance which will vary with suspended solids concentration.

The membrane system will, due to the membranes, have a higher biomass that improves robustness against load changes, and ensures that very low solids pass to the effluent with suppliers guaranteeing typically < 2 mg/l. This same mechanism ensures disinfection standards with no additional process.

A risk associated with warm conditions and full removal of ammonia to nitrate is that denitrification can occur in the clarifier. This is particularly the case when there are long retention times in the clarifier and the bacteria present deplete oxygen levels. The result is rising sludges that can challenge tertiary treatment processes. In the activated sludge solution, as the clarifier must be sized for peak wet weather flow, the low levels of flow seen at the site in dry conditions will cause excess retention time. In summer this is approximately 16 hours, and this duration increases in off peak conditions to over 24 hours. Rising sludge due to denitrification in this tank is almost certain. Excessive retention without oxygen in a clarifier can also lead to sludge floc breakdown, resulting in loss of treatment. This is likely to impact on ammonia removal for the activated sludge plant and increased sand filter washing.

6.3 Safety

Both solutions will be new build for the treatment works. These will be built to current standards of safety with safety in design processes being undertaken in conjunction with designer, FNDC and Far North Waters personnel.

During construction the phased activities in the confined space required to build increase significantly the risk of injury. The activated sludge option requires demolition of reactor and then construction of reactor and new clarifier on a live site. The membrane option will be built alongside the live site so has less risk and shorter programme.

6.4 Resilience to Future Changes of Consent

The Hihi WWTP resource consent is due for renewal in 2023, and this will not be known until after the construction of the wastewater plant. This means that should a difference in consented parameter occur, additional expenditure may be required for the activated sludge plant and less for the membrane plant.

Should there be a standard for BOD (currently only dissolved oxygen in the stream) or a standard for total suspended solids, this may be lower than the expected quality from sand filters, whereas a membrane plant will require no change. Should a change in ammonia be required, then the membrane plant can be operated with higher DO set point and increased biomass. However, the activated sludge plant is limited by solids load to the clarifier, and additional tank capacity may be required.

A total nitrogen standard will require both plants to have minor modifications to anoxic zone, which can be accommodated by internal baffle wall changes and recycle pumping. However, as some nitrogen is related to solids, the membrane plant will be less likely to require modification as this fraction is removed completely

Phosphorous will be considered if the discharge may cause eutrophication (increase in plant and algal growth due to elevated levels of nutrients). This can be accommodated for both systems by the additional of ferric salts or alum salts to the reactors and capturing the resultant metal phosphate salt in the solids fraction. To accommodate this a conservative loading to the activated sludge plant is required to enable a 20-30 % increase in treatment solids that arise from the chemical addition. The membrane system is intended to operate at 5,000-6,000 mg/l solids will also operate at much higher concentrations of 8,000-10,000 mg/l with no detriment.

Some coastal discharges are being required to consider impact on shellfisheries, or other areas for local gathering of seafood from wastewater discharges. Examples of Clarks Beach and Snells Beach have identified the need for membranes and UV disinfection to reduce bacteria and viruses. The activated sludge option would need to then consider replacing sand filters with membranes, or substantial increased power in the UV system, making the new UV system redundant.

The membrane plant will therefore produce a very high quality of effluent and unlikely to have any additional capital changes required from the renewal of the resource consent, whereas the activated sludge could require additional capital spend.

6.5 Sea-level and Alternative Future Sites

Sea-level rise is a significant risk to the plant as it is adjacent to the Mangonui Harbour. Much of the site is only 0.5 m above sea level. Both options can be designed to be resilient for occasional tidal events by raising electrical equipment above floor level and keeping critical components either as submersible in design or above water levels. This applies to both options.

Should sea-level rise cause saltwater to enter the network, occasional high levels of salt will be detrimental to the activated sludge plant as osmosis causes break down of the treatment biomass floc structure and loss to effluent of solids. However, as the membrane plant prevents any solids loss, quality is maintained, and treatment continues. Both plants may have secondary issues with foaming, which can be managed by an increase in free board on the reactors.

It is considered, depending on rate of sea level rise, that an alternative treatment site may be required in future. The activated sludge plant can be constructed as modular tanks that can be relocated. However, the size of the clarifier prevents a modular build and relocation. The membrane system is totally modular and may be relocated to alternative sites.

6.6 Programme

The complexity of installation to work around the existing plant means that the project programme for the activated sludge plant may be 3 months longer than for the membrane solution. This carries increased project costs and risks.

6.7 Recommendation.

The membrane bioreactor option is the most robust and adaptable solution for future performance needs and resource consent demands as well as the most operationally consistent performance. It can be constructed in approximately 3 months less than the activated sludge solution and so reduce site costs and safety risks associated with construction.

It is recommended that a membrane bioreactor be taken forward for the capital scheme.

A budget estimate for the Membrane Bioreactor of $5.33 m should be allowed, with a nominal additional cost of $700 for wetland remediation and bank stabilisation. Total project budget of $6.03m.

Appendix A Site Visit Findings Memorandum. October 2018

Appendix B Hihi WWTP Design Basis, February 2019

Appendix C Hihi WWTP Conceptual Design Options March 2019

Appendix D Fraser Thomas Structural Assessment, May 2014

Appendix E Hihi WWTP Main Reactor Structural Assessment December 2019

Appendix F Business Risk Assessment Workshop Report, December 2019

Appendix G Minutes of Option Workshop, January 2020

Appendix H Hihi Options Workshop Slides, January 2020

Appendix I Site Layout Drawings

Appendix J Budget Estimates for Options

wsp.com/nz

Project Number: 1-13191.02

Hihi Wastewater Treatment Plant

20 December 2019

CONFIDENTIAL

Business Risk Assessment Workshop
4 December 2019

wsp

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Disclaimers and Limitations

This report has been prepared by WSP exclusively for Far North District Council in relation to the summary report from the High WWTP Business Risk Workshop of 4 December and in accordance with the findings of the workshop. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

1 Background

Hihi is a small community in Far North District of New Zealand. The approximate population is 200 people in winter, rising to approximately 400 in summer, and for 2 weeks of the year, peak holiday period, population is as high as 600 people.

The treatment works consists of an inlet pump station lifting flows to an activated sludge plant aerated by coarse aeration. This then feeds a secondary activated sludge reactor before flowing to a clarifier. Clarified effluent is pumped through sand filters and UV before discharge to a wetland. Overflow from the wetland area passes to the local stream which after passing through the community discharges onto a bathing beach.

The existing works was constructed about 30 years ago using precast concrete tanks and PVC above ground pipework. It has been documented that the plant was only expected to be a temporary system, and as a result many of the assets have significantly deteriorated and at the end of asset life.

The Resource Consent for the current discharge is due for renewal by 2023 and new consent standards are expected for the discharge.

Linked to asset condition and process capacity for current loads, the plant has been identified by WSP 2018, to be underperforming and exceedance of consented parameters can occur.

To assist Far North District Council with the business case for the upgrade of the Hihi Wastewater Treatment Plant a Business Risk workshop was held on 4th December 2019. The root cause workshop's aim was to capture all the issues of the Hihi WWTP, and by use of a risk rating (probability and impact) understand the effect of the issues. The issues and risks in the workshop focussed on business risk only. Operational or process risk while discussed in the workshop were not captured as they will not add value to development of the business case. A separate root cause workshop can be held for operational and process risks if deemed necessary.

The workshop was attended by representatives from FNDC, Broadspectrum, Hoskins Civil and WSP.

2 Root Cause Workshop

2.1 Procedure

The workshop of 4th December, at Kaikohe, has been attended by the following personnel

Attendee	Role	Organisation
Bill Down	Project Manager	FNDC
Stephen Little	Far North Waters	FNDC
Jody Kelly	Business Case Author	JKProjects
Mark Keehn	Asset Manager	FNDC
Tommy Gordon	Ops Supervisor	Far North Waters
Greg Timplerley	Operations	Far North Waters
Kevin Hoskin	Business Case Author	Hoskin civils
Larey Marie Mulder	Facilitator	WSP
Andrew Springer	Technical Lead	WSP

This has provided a range of experiences and understanding of the plant and its issues sufficient to identify the key issues and evaluate the risk associated with each issue.

The assessment has been undertaken in a step wise approach. Information on the plant and performance are presented in the workshop slide pack in Appendix C.

Project Background.

Review of flow and loads, historic performance data, overview of plant

Plant Issues

A systematic review of the whole plant capturing issues.

Root Cause

A systematic review of the plant issues to identify the root cause of issues occurring. Information to support each cause must be demonstrated.

Business Risk

To enable prioritisation of the problems on the site, many of which have common causes, for each issue and cause, a risk review is undertaken. This considers the Risk to Far North District Council over a long term operational period and reflects the impact of do nothing. This includes the impacts and risks to Safety, Compliance, Customer Relations, Pollution, Prosecution, Nuisance, Flooding, Bathing Waters and disposal of biosolids. The Probability and Impact Tables used in the workshop are provided below.

Prioritisation

Identified risks are mapped onto a risk matrix to identify the critical risks to the business and those of lower priority. As budgetary constraints will need long term consideration, low priority risks may be deselected for resolution.

Outline Solution.

Based on the prioritisation a short review of options can be undertaken that addresses the key issues. This forms the basis of options studies.

The outcome of the workshop presented in this report is a collaboration of all stakeholders and understanding of all issues. Risk to the long-term operation of Far North District Council is understood and the need for investment can be presented in the business case.

2.2 Likelihood

Table 2-1 Wastewater business risk Likelihood matrix

	Time	Description	Frequency
Very High	<1 year	Almost certain	Nearly continuous
High	1 - 5 years	Likely	Common
Medium	5 - 10 years	Probable	Occasional
Low	10 - 20 years	Unlikely	Infrequent
Very Low	>20 years	Rare	Rare

2.3 Impact

The wastewater business risk impact matrix used to assign an impact level to the identified issues is shown in Table 2-2. For more details and guidance on the wastewater business impacts see Appendix A

Table 2-2 Wastewater business risk impact matrix

Impact	Pollution	Prosecution	Customer Relations	Health & Safety	Compliance/Consent	Solids Disposal	Nuisance	Wastewater Flooding	Bathing Water
Very High	Category 1	Repeat	Public Enquiry	Fatality	Multiple Failures>90%-tile/Upper Tier Failure	Loss of Sludge Disposal/Special Landfill Required/Loss of Treatment Facility Impact Multiple Sites	Enforcement Notice	Road Flooding	Beach Closure
High	Category 2	Standard	Sustained National Media	Severe Injury/Permanent Disability/Long Term Health Effect	Average Condition Exceeded/Failure of Reporting or Other Condition/Breach of Flow	Temporary Disposal to Landfill Due to Fail of Equipment or Service/Loss of Treatment Facility Single Site	Threat of Abatement Notice	Internal Flooding > 5 Domestic or Commercial or 1 Amenity	Beach Classified as Poor
Medium	Category 3	Mitigated	Regional Media Attention	Notifiable Incident – no injury/Short Term Health Effect/Minor Bones	Single Sample Exceedance/Not Failed Look Up	HACCUP Failure – Temporary Loss of Agricultural Disposal	Residents Group	Internal Flood of Domestic Dwelling	Drop in Beach Quality
Low	Category 4	Warning	MP/Local Action Group/Local Press	Notifiable Injury/Lost Time>2 days/Hospital Treatment Required	Exceed Operating Target	Compromise of Treatment – Loss of Efficiency/Quality	Multiple Complaints	External Commercial or Agricultural	Sample Failure
Very Low	Near miss – minor spill no impact	-	Social Media	Minor Injury/Lost Time>1 day/Local First Aid	Single Sample Over Annual Average	Unable to Remove Sludge from Site	Customer Complaint	External Flooding of Gardens	Target Failure

2.4 Risk Level

		IMPACT				
		Very Low	Low	Medium	High	Very High
LIKELIHOOD	Very High					
	High					
	Medium					
	Low					
	Very Low					

For the evaluation the prioritisation of risks was based on the above matrix.

3 Issues and Causes Identified

During the root cause workshop, 61 issues were identified by workshop attendees. Several the issues were either linked or a variation of issue already identified. For the sake of completeness all 61 issues are listed below. In Appendix B a full table is available of the issues, causes and the assigned probability and impact.

1. Site boundary/designation
2. High total suspended solids after treatment
3. Elevated E-coli after treatment
4. Elevated ammonia (NH3) after treatment
5. Unable to control Nocardia presence
6. Reduced dissolved oxygen (DO) – wetlands discharge
7. Clarifier capacity
8. Mixed liquor suspended solids (MLSS) uncontrollable
9. Unscreened wastewater
10. Pump station floods due to insufficient capacity
11. Fat, oil and grease (FOG) problems *
12. Insufficient flow buffering
13. Drainage of storm tanks
14. Bypass secondary treatment during heavy rain events
15. Bypass sand filters during heavy rain events
16. Structural failure of baffle in main reactor
17. Leaking main reactor
18. Manual handling of screenings *
19. Rag blockage of effluent pumps *
20. Inadequate aeration (too little and too much)
21. No online monitoring of process
22. Maintenance access (main reactor)
23. All tanks at end of life
24. Secondary reactor structure poor condition
25. Secondary reactor has no access
26. Secondary reactor poor aeration
27. PVC pipe failure and/or cracking

28. Base of clarifier worn by scraper
29. Clarifier scraper unreliable and poor condition
30. Clarifier tank structure poor
31. WAS tank structure poor *
32. WAS tank maintenance access
33. WAS tank capacity
34. WAS tank aeration insufficient *
35. Effluent tank at capacity (also used for sand filter back wash)
36. Sludge accumulation in effluent tank
37. Effluent tank maintenance access
38. Effluent tank structure poor *
39. Effluent pumps access poor
40. Welded plastic pipework on effluent pumps
41. Proximity of pumps to electrics
42. Maintainability of blowers (access)
43. Noise complaints
44. No redundancy on blowers (single unit)
45. Limited critical spares for blower
46. Single UV reactor
47. No redundancy on sand filters
48. Welded plastic pipework on sand filters
49. Limited Maintenance access to sand filters
50. No feedback on sand filters actuated valves
51. SCADA (Red Lion) no longer supported
52. Sand filter and UV building no air conditioning or venting
53. Sand filters and UV building too small – access issues *
54. No welfare facility on site (no potable water on site)
55. Sludge build-up in wetlands
56. Hill stability with history of slips impacting on wetland
57. Flooding of wetlands *
58. Wetland maintenance
59. Air locking of effluent pumps
60. Insufficient water for washdown
61. Use of recycled water for washdown

* Items marked are duplication of previous issues and risks and so have been removed from further evaluation. For example, 38, Effluent tank structure poor is also covered in the issue no 23, all tanks at end of asset life.

4 Risk Level of Issues

The following table presents the relative risk ratings from the workshop. Moderation of scoring has occurred and is documented separately. As example, Risk 5, Nocardia presence, a safety risk was identified as VH, H, which indicates that the event is already occurring and severe injury is resulting. Clearly no one is being permanently injured every year, so a lower risk rating is applied This has been reduced to M L. That is within 10 years, minor injury resulting in short lost time incident may occur.

Risks that duplicate as of the same cause have been omitted for clarity.

Project Number:
Hihi Wastewater Treatment Plant
Bussiness Risk Assessment

		IMPACT				
		Very Low	Low	Medium	High	Very High
LIKELIHOOD	Very High		21, 43	46	2, 5a, 5c, 7, 8, 9b, 10, 12, 20, 28, 33, 36	1, 4a, 6, 14, 15
	High		4c, 9a, 16, 22, 25, 32, 37, 39, 42, 55a, 55c, 56a, 56c, 61	50, 52a, 54	17, 26, 29, 30, 44, 45, 47, 49, 51, 52b, 60	3, 55b, 55d, 56b, 56d
	Medium		41b, 5b	27, 40, 48	18b, 18c, 18d, 18e, 35, 59	4b, 18a, 23, 24, 41a,
	Low					
	Very Low					

5 Summary of Main Issues and Risks

The following is a short summary of the main issues and their causes.

The original WWTP at Hihi was constructed 30 years ago for a lower population approx. 200 people. It has insufficient flow and load treatment capacity for current demand with peak population of 400-600 people.

The plant is not robust against seasonal variation and suffers poor solids settlement and insufficient nitrification as a result.

Peak flows to the site were designed at 2.5 l/s but current treatment pumps deliver approximately 4 l/s. Additionally storm pump will operate in high wet well conditions. Flooding occurs in very high flows as all pump capacity is exceeded.

The consent conditions for Ammonia and DO are exceeded periodically in the stream.

To deal with high flow deficiency, flow bypasses secondary treatment and sand filtration against the consent conditions.

Poorly disinfected effluent is discharged in bypass condition to the wetland and will pass through the stream to a popular bathing beach.

The WWTP extends outside of the lawful designated area, so does not meet planning requirements.

The assets constructed 30 years ago were "low budget solution" and have reached the end of their asset life. This includes key tanks and mechanical scraper mechanism of the clarifier.

Structural failure has occurred of an internal baffle in the main reactor. The concrete tanks are leaking in several places. Significant Leaks will require at least a 1 week shut down of the whole plant to "patch repair". Catastrophic failure will take the whole plant out of service until a new plant can be built (estimated minimum of 6 months) and will require tankering of all flows in this time.

Many assets have poor accessibility that limits maintenance. This accessibility impedes removal of assets without major work and as no standby on critical assets will require a whole works shutdown. As example, to change the blower the roof of the blower building must be removed and no secondary treatment is possible in this time.

There is insufficient standby equipment to provide continuously high-quality effluent.

The wetland requires maintenance as it has been impacted by the shortfalls of the plant and sludge carry through.

Land slips are known at the wetland site and there is evidence of further recent movement in the bank. This will impact on treatment and cause loss of wetlands with consequential impact on stream, stream ecology and bathing beach.

6 Outline Solution

A brief discussion was held discussing some of the options considered, but was agreed that a further workshop to discuss options and risk should be undertaken in January 2020.

Options developed previously for Hihi considered

- Moving Bed Bioreactor (MBBR)
- Conventional Activated Sludge (ASP)
- Membrane Bioreactor (MBR)

These options were identified as fitting within the current operational boundary and with phasing could be constructed while maintaining treatment quality.

Additional options were raised including;

- New Location near Hihi – although expected to be not affordable
- Pump to Mangonui catchment under harbour.

7 Actions

- WSP to circulate Draft Report before Christmas
- FNDC to discuss potential consent conditions with NRC.
- FNDC to designate land for WWTP.

Appendix A
Wastewater Business Risk

Impact Guidance Notes

Wastewater Business Risk Guidance Notes.

Pollution

	Caused by wastewater or the other Wastes from Assets
Category 1	Major Incident involves one or more of the following
	Potential or actual persistent major effect (> 7 days) on water quality or aquatic life
	Extensive fish kill (> 100 fish any size)
	Public exposure to a toxic/dangerous Substance
	Major adverse effect on amenity value, agriculture, or commerce
	Major adverse effect on site of conservation importance
	Or closure of licensed potable water, or industrial or agricultural abstraction
Category 2	Significant Incident which involves one or more of the following
	Significant effect on water quality or aquatic life
	Significant fish kill (IO- 100 fish any size)
	Significant adverse effect on amenity value, agriculture or commerce
	Contamination of watercourse bed
	Significant adverse effect on site of conservation importance
	Precautionary notice to licensed abstraction points and necessary closure of unlicensed abstraction points
Category 3	Minor incident resulting in localised environmental impact only.
	Precautionary closure of unlicensed abstraction necessary
	< 10 fish kill
	Minor impact to amenity value, agriculture or commerce
	Local contamination of watercourse bed.
Category 4	No evidence of impact to the environment or abstraction
Near Miss	Minor event, no adverse impact
	WWTP spill to ground
	Includes spill of waste to ground,

Minor spills to watercourse < 2 m3

Pollution events that if not caught early would have more severe consequence

For each pollution there is a likelihood for Prosecution. This is likely at lower Likelihood as not all incidents create prosecution.

An incident is an event even if Regional Council are not aware.

Use actual occurrences to determine frequency based on events per year

Customer Relations

Public enquiry

Official investigation into serious accident/disaster. May have resulted in multiple deaths.

Sustained National Media Interest

Sustained widespread high-level PR even for a duration of 2 weeks or more

Media Discontent

Adverse media attention (regional radio and television) at aimed at organisation

MP/Pressure Group/ Local Authority

Local papers, radio station, local MP, pressure groups such as community action group.

Complaint

Verbal, electronic or written complaint that requires response. (Comments on Facebook count as one per conversation not per comment).

Consider likelihood in rating. Example. Number of complaints per year.

Prosecution

Failure to comply with legislated agreement or other legal requirement that results in enforcement action.

Repeat Prosecution

Where we have poor historical performance, where it can be viewed we have had opportunity to correct something to prevent further pollution/compliance or adverse environmental effects.

Failure of Resource Consent based on flow or Quality leading to prosecution in last 5 years

Failure involved

- o < 60% of routine proactive maintenance activities completed.
- 0 5 monthly emergency callouts
- 0 1 unresolved issue on items of equipment or equipment off line with direct impact on compliance (e.g. duty and standby out of service)
-

Standard Prosecution

Where we have adequate historical performance including

No mitigation possible (event outside of reasonable measures e.g. Oil spill to drain from road accident)

Failure involved

- 1 sample failure in the last 5 years
- >60% of proactive maintenance activities completed
- < 4 monthly emergency callouts
- 1 unresolved issue on items of equipment or equipment off line that have direct impact (e.g. only duty working)

Mitigated Prosecution

Where we can demonstrate good historical performance to provide mitigating circumstances that should be considered.

Mitigations include

- No sample failure through operational monitoring in last 5 years
- 75% of routine maintenance activities completed (proactive)
- < 2 monthly callouts to site
- Or no unresolved issues on items of equipment or equipment off line that have a direct impact on compliance.

Likelihood should reflect number of incidents.

Warning

Regional Council or other legal enforcement organisation representative gives precautionary warning for events in breach of agreement or legislation. No fines, but action required to mitigate cause of issue.

Health and Safety

It is assumed that when considering risks that operators, visitors and unwanted guests are considered in the safety measures in place. Likelihood may vary depending on frequency of visit.

Many conditions can kill, but many only may kill. Chose most likely outcome. As Example, a trip on an uneven path may result in head injury and permanent disability. Most likely outcome is minor injury requiring local first aid. Or with lower likelihood, broken finger.

Fatality

Death direct from organisation asset or activity.

Severe Injury

Breaking major bone (e.g. leg, arm skull)

Multiple fracture of minor bones (wrist, finger, toes)

Permanent disablement

Long term health disability e.g. occupational asthma

Infection due to Work

Notifiable Incident

Major Incident but no serious injury OR

Short term health effect

Minor Bone fracture

Eye injury,

Note that Worksafe include all categories as Notifiable.

Lost Time

Lost time up to 7 days Medical treatment above first aid or hospital treatment required

Minor Injury

Lost time <1 day, local first Aid

Compliance

Historic Compliance is assessed on all routine monitoring. However, when specific events occur, then the expected impact on compliance if caught should be considered. Assume for all events that a sample will be taken, as most sampling is at random.

Multiple Failures	Failures of Look Up table 90% or 95%ile
	Exceedance of Upper Tier Standards (Maximum)
Average Exceedance	Exceedance of annual average
	Failure of Reporting
	Flow non- Compliance
	Failure of any technical condition in consent
At Risk	Multiple Sample Fails but not exceeding permitted number from look up table. One More sample fail will FAIL Works
Single Sample	Single sample failed limits (not maximum)
	Not exceeding look up table permit samples per year
Exceed Targets	Sample exceeding operational targets
	Sample exceeding annual average, but not failing average condition

Nuisance

Enforcement	Formal enforcement to resolve problem. Failure will result in prosecution.
Abatement measures	Threat or issue of abatement notice. Abatement may be by internal control measures.
Action Group	Recognition of escalation of issue when residents form group to get action.
	Escalation of written complaint to MP.

Multiple Complaints	More than 5 complaints in writing or to call Centre. Single letter to CEO.
Complaint	Written or verbal complaint from individual (not passing comment).

Wastewater Flooding

Road Flooding: Area Wide with impact on multiple people. Possible road closure and loss of access to properties.

Internal Domestic: Internal Domestic Flooding, affecting more than 5 properties (1 property 10 times per year is single flooding, but likelihood VH) Flooding of Public amenity, commercial premises or other with loss of revenue.

Internal Domestic: Single Domestic Property or flooding of commercial premise that will not cause loss of revenue.

External Flooding: Flooding of external premises either commercial or agricultural that causes loss of revenue for property owner.

External Flood: Flooding of gardens and local areas with no impact on multiple people.

Check with Reputation Risk, Nuisance, PR, Pollution and Compliance

Bathing Waters

Routine monitoring is used as measure of failure. If not routinely monitored. Consider history of events in the area. Events that will certainly impact from historical information or test of reasonableness should be rated based on experience. E.g. Historically a pump station has overflowed causing 3 bathing water failures. Despite improvements, pump station could fail. Result is repeat discharge that is known to cause failure.

Beach Closure	Beach Closure, any duration as a result of wastewater. >100 bathers impacted.
Beach Classified as Poor	Beach shown as poor due to multiple monitoring failures. Indicator > 3 bad samples in any year. OR Reported Illness directly linked to discharge. OR Potential impact on non-designated bathing water. < 20 Bathers impacted.
Drop in Classification	Deterioration in quality. Multiple bathing water failures. Damage to reputation and tourism if this beach gains poor water standards.

Sample Failure	Single bathing water exceedance of standards.
Target Failure	Exceedance of sample over recreational water standards.

Biosolids Compliance

Sludge treatment is considered to be the treatment of sludge to reduce suspended solids

And reduction of pathogens. Plants that only thicken and or dewater sludge for export are not treatment sites.

Loss of Disposal Route	Loss of treatment. Only suitable for specialist landfill disposal. (Do not use if Landfill is normal route) OR, Loss of Regional Facility impacting on multiple plants.
HACCUP Failure	Failure of control points. Sludge cannot be disposed of normal route (e.g. to land) due to temporary poor quality. OR loss of small treatment facility impacting single site.
Compromise of Treatment	Loss of efficiency or quality. Normal disposal route applicable.
Unable to move sludge from site.	Unable to move sludge from site in normal manner. Example, sludge transfer pump failure preventing loading of tanker.

Appendix B
Wastewater Business Risk

Issues & Causes with Impact & Probability

	Issues	Causes	Probability	Impact	Type of Risk
1	Site boundary/designation	Upgrades made without proper approval of designation of land.	VH	VH	Unlawful
2	High TSS from treatment	Poor settlement, SF capacity insufficient, Bypass stormwater flows, hydraulic capacity, short term elevation of sludge blanket	VH	H	Compliance
3	Elevated E-coli	Process related, poor upstream treatment and treatment bypassing - exact cause can't be identified	H	VH	Compliance
4a	Elevated NH3	Plant overloaded at peak population, insufficient aeration, alkalinity, MLSS control poor. Peak period results show high ammonia in stream > 20 mg/l (consent 2)	VH	VH	Compliance
4b	Elevated NH3	Plant overloaded at peak population, insufficient aeration, alkalinity, MLSS control poor. Prosecution due to noncompliance and pollution	M	VH	Prosecution
4c	Elevated NH3	Plant overloaded at peak population, insufficient aeration, alkalinity, MLSS control poor- Local bad publicity	H	L	Customer Relations
5a	Nocardia Presence	Poor process control (MLSS, O2) Presence of FOG leading to filament foam and odours	VH	H	Nuisance
5b	Nocardia Presence	Poor process control (MLSS, O2) Presence of FOG leading to filaments and poor sludge settlement.	M	L	Safety
5c	Nocardia Presence	Poor process control (MLSS, O2) Presence of FOG leading to filaments and poor sludge settlement.TSS loss may be managed but lower MLSS concentration may impact on other quality	VH	H	Compliance
6	Reduced DO at Wetlands- Environmental	Process over loading, poor Aeration, carry through of load to wetlands and sludge accumulation. Absolute limit in consent. Occurring now	VH	VH	Compliance
7	Clarifier Capacity	Design for lower flow 2.5 l/s (Sizing). Runs at 4 l/s On/Off Operation leading to poor settlement and flush out of TSS in light rain	VH	H	*Compliance*
8	MLSS Uncontrollable	Restrictions on sludge Tank manual controls, no routine testing undertaken. Poor MLSS control leads to TSS loss or insufficient biomass for load and poor effluent	VH	H	*Compliance*
9a	No screening	No screen installed so pump blockage occurs. Manual Clearing Required of pumps and coarse screen regularly	H	L	*Safety*
9b	No screening	No screen installed so pump blockage occurs	VH	H	*Compliance*
10	Pump Station Floods	Incoming Flow greater than treatment and storage capacity and takes return liquors. History and evidence of occurring and leaving site to reserve	VH	H	*Flooding*
12	Insufficient Flow Buffering	Storage only in wet well (< 5 m3) and 125 m3 storm tanks. Flows to works greater than storage available so requires pushing more flow than treatment can manage leading to compliance issues	VH	H	*Compliance*
13	Manual Drainage and cleaning of Storm Tanks	Flat Bottom Tanks Manual operation. No report issues			
14	Bypass biological treatment during heavy rains	Insufficient treatment capacity during peak flows Consent requires flow to be treated.	VH	VH	*Compliance*
15	Bypass Sand Filters During heavy rains	Sand Filters don't have capacity for solids. Effluent pumps can't deliver against extra head. Impacts on quality of BOD, TSS, NH3 and E coli. Consent requires flow to be treated.	VH	VH	*Compliance*

16	Structural Failure of main reactor Baffle	In tank corrosion insufficient design of baffle. Baffle partially failed already. Expect < 5 years life. May damage aeration. Baffle failure may cause short term compliance, rectified by moving inlet pipe and new aeration pipes	H	L	*Compliance*
17	Leaking Main Reactor	Age & Condition of Reactor leading to failure of tank- most likely small leakage- Reactor out for 1 week for repair	H	H	*Compliance*
18a	Failure of main Reactor	Age & Condition of Reactor leading to failure of tank- Catastrophic Failure- plant out of service for months. Known problem not addressed in timely manner will result in prosecution.	M	VH	*Prosecution*
18b	Failure of main Reactor	Age & Condition of Reactor - catastrophic failure of tank impacts on beach	M	VH	*Bathing water*
18c	Failure of main Reactor	Age & Condition of Reactor catastrophic failure leading to injury	M	H	*Safety*
18d	Failure of main Reactor	Age & Condition of Reactor - catastrophic failure of tank impacts on beach	M	H	*Pollution*
18e	Failure of main Reactor	Age & Condition of Reactor - catastrophic failure of tank impacts on beach	M	H	*Customer Relations*
20	Inadequate Aeration too much & too little	Coarse aeration with no control - occasional blockage of coarse diffusers. Leading to variable ammonia and BOD performance and Settlability of sludge.	VH	H	*Compliance*
21	No online Monitoring	Never designed for it. Have tried DO but failed as was covered with rag.	VH	L	*Compliance*
22	Maintenance access (main reactor)	No Manway - Top Access for confined space entry. Currently avoid entry and not maintain.	H	L	*Safety*
23	All Tanks at end for life	Design life reached (end of life 30 years+) All tanks critical to process so failure impacts treatment.	M	VH	*Compliance*
24	2nd Reactor Structure Poor condition	Aged Asset (Age & Condition)	M	VH	*Compliance,*
25	2nd Reactor Access	No Platform for access, no Manway. No maintenance undertaken.	H	L	*Safety*
26	2nd Reactor poor aeration	Coarse Aeration with no access for maintenance	H	H	*Compliance*
27	Pipe PVC Failure/cracking	Sunlight exposure of pipes will lead to short term loss of process.	M	M	*Compliance*
28	Base of Clarifier Worn	Long Term use of scraper. Results in rising sludge and elevates TSS in effluent	VH	H	*Compliance*
29	Scraper unreliable/ poor condition	Aged asset no redundancy /unable to access & Maintain	H	H	*Compliance*
30	Clarifier Structure poor condition	Age and Condition - top of concrete wall is delaminating. Loss of tank is catastrophic as no back up on site.	H	H	Compliance
32	WAS tank Maintenance Access	Inspection Hatch only no manway/no personnel entry	H	L	*Safety*
33	WAS tank Capacity	Insufficient for Wastage @peak loads	VH	H	*Compliance*
35	Effluent Tank @ Capacity (Also used for sand filter backwash)	Hydraulic Constraints following install of sand filters	M	H	*Compliance*
36	Sludge accumulation in effluent Tank	Solids carry-over, Difficult to clean	VH	H	*Compliance*
37	Effluent Tank maintenance access	No Manway - Top Access for confined space entry. Currently avoid entry and not maintain.	H	L	Compliance
39	Effluent Pump access	Building too Small for Equipment maintenance and access and lifting.	H	L	*Safety*
40	Welded pipe work on effluent pumps	Was Easier to construct but risk of damage in maintenance.	M	M	*Compliance*
41a	Proximity of Pump to electrics	Building too small. Water spray from leaks direct to electrical components. Will take out critical processes.	M	VH	*Compliance*

41b	Proximity of Pump to electrics	Building too small Water spray direct to electrical components. Will take out critical processes. Risk management of not working on pumps with live power in room(tbc)	M	L	*Safety*
42	Maintainability of Blowers access	Building too small see 39- requires roof removal for removal of blower.	H	L	*Safety*
43	Noise Complaints	No Cooling Fan for Blower room - If Blower room open noise issue. - Bubbling Water Currently get summer complaints	VH	L	*Nuisance*
44	No Redundancy on blowers (Single unit)	Insufficient budget and space when built with short expected Life of Plant (replacement planned!)	H	H	*Compliance*
45	Limited Critical spares for Blower	Not purchased when new as expected short life before replacement. Rely on supplier support.	H	H	*Compliance*
46	Single UV reactor	Cost Constraints noncompliance during maintenance or equipment failure- lamps have built in spare capacity. Can shut flow down in most conditions (3 days in dry off peak flows), so risk is based on failure before maintenance.	VH	M	*Compliance*
47	No Redundancy on sand filters	Cost Constraints and space limitations. Age of asset will require critical maintenance in near future requiring shutdown	H	H	*Compliance*
48	Welded pipe work on Sand filters	Easier/ to construct. Prevents some insitu maintenance and increase risk of pipe damage.	M	M	*Compliance*
49	Maintenance access to sandfilters/UV	Insufficient building Space- unable to maintain fully. Will require significant shutdown if required	H	H	*Compliance*
50	No Feedback on SF valves	M&E failures not detected or known leading to poor effluent.	H	M	*Compliance*
51	Scada no longer Supported (Red Lion)	Original Budget choice and expected life of plant (New plant was expected). Reliability will impact on control of tertiary plant and pumping with impact on compliance. Approx. 2 weeks to replace.	H	H	*Compliance*
52a	SF/ UV Building no AC/venting	Over temperature as not considered in design unsafe working environment.	H	M	*Safety*
52b	SF/ UV Building no AC/venting	Over temperature impacting on equipment, e.g. UV shuts down at 45C.	H	H	*Compliance*
54	No welfare facility on site (no potable water on site)	No provision on site. Nearest public facility in Mangonui 11km away	H	M	*Safety*
55a	Sludge build-up in wetlands	Solids carry-over (see no2)- No routine maintenance leading to odours in hot weather	H	L	*Customer Relations*
55b	Sludge build-up in wetlands	Solids carry-over (see no2)- No routine maintenance so solids carry over and low DO. Occurring Now, exceeding max condition in consent. Managed by periodic desludging around outlets	H	VH	*Compliance*
55c	Sludge build-up in wetlands	Bypass of sandfilters gives poor effluent- so occasional discharge of higher E coli. Sludge accumulation reduces retention and natural disinfection.	H	L	*Bathing water*
55d	Sludge build-up in wetlands	Solids carry-over (see no2)- No routine maintenance impact on local stream ecology and fishery	H	VH	*Pollution*
56a	Wetland Hill stability	Water Ingress in embankment leading to slip. Causes local flooding of site and unconsented wastewater discharge. High E Coli released. Currently can flood from previous slip	H	L	*Bathing water*
56b	Wetland Hill stability	Water Ingress in embankment leading to slip. Causes local flooding of site and unconsented wastewater discharge. Impact on compliance. Can flood now due to previous slip.	H	VH	*Compliance*

56c	Wetland Hill stability	Water Ingress in embankment leading to slip. Causes local flooding of site and unconsented wastewater discharge Customer complaints received	H	L	*Customer Relations*
56d	Wetland Hill stability	Water Ingress in embankment leading to slip. Causes local flooding of site and unconsented wastewater discharge. Current flooding due to previous slip.	H	VH	*Pollution*
58	Wetlands Maintenance	Wetland requires extensive desludge and maintenance. _ Deferred due to plant upgrades**. Leads to impacts from Sludge as 55**	-	-	
59	Air locking of effluent pumps	Air Entrainment into pump. Effluent Tank too small leading to overheating of water and damage to plastic pipes.	M	H	*Manifold Breaking*
60	Insufficient water for washdown	Roof tank of 1 m3 is small. Limits washdown	H	H	*Compliance*
61	Use of recycled water for washdown	Use of recycled effluent increasing risk of aerosols and health.	H	L	*Safety*

Highlighted sections are moderated scores to provide consistency in scoring.

Appendix C
Workshop Slides

Hihi WWTP

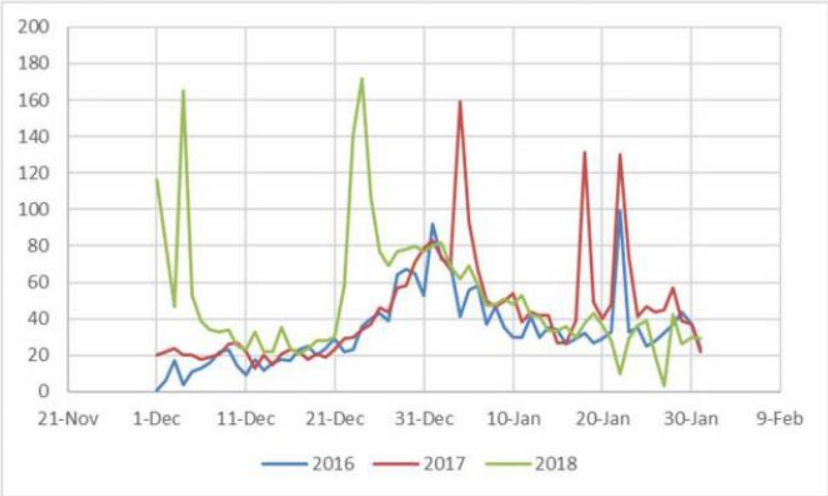
Root Cause Workshop 4 December 2019

AGENDA

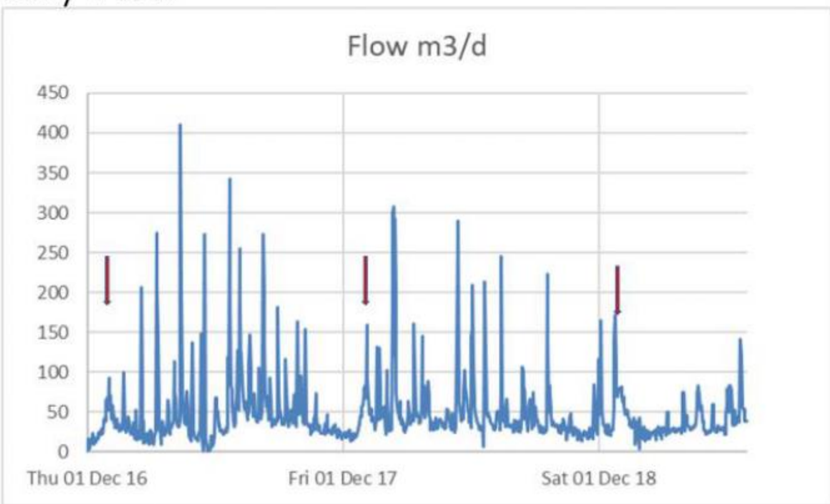
- Introductions
- The Plant – short overview
- Flow and Load
- Compliance
- Issues
- Cause of Issues
- Risk From Issues
- Prioritisation


WETLAND
Hihi Hihi
Hihi WWTP

Dec- Jan Flows



Daily Flow



Design Flows

Parameter	Value
Off-peak Average Dry Weather Flow (Off-Peak ADWF)	35 m^3/d
Peak Average Dry Weather Flow (Peak ADWF)	85 m^3/d
Peak Wet Weather Flow (PWWF)	750 m^3/d *

Christmas Holiday Influent

Date	28/12/2016	03/01/2018
Type	Not Indicated	Composite
TSS	660	350
VSS	610	
CBOD5	580	280
TBOD		340
COD	1,200	
COD dissolved	330	
COD Floc	330	
COD on TSS	210	
Total Nitrogen		140
N Dissolved	110	
TKN	140	
Nitrate	-	
Nitrite		
Ammonia	100	
Total Phosphorus	16	17
DR Phosphorus	12	
pH	8	
Alkalinity	480	

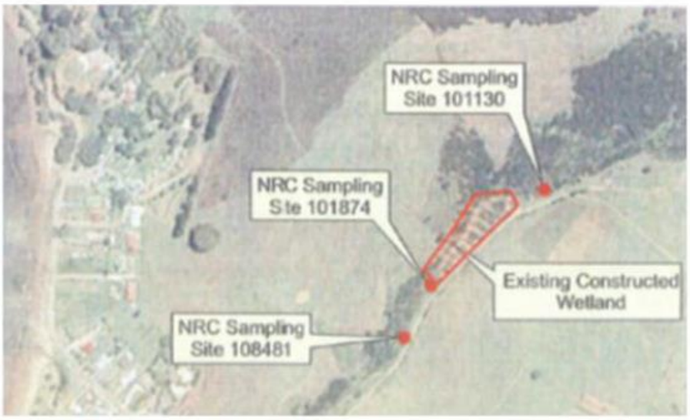
Influent Concentrations

Parameter	Units	Design Report	Off Peak	Peak DWF
BOD	g/m^3	500	499	400
TSS	g/m^3	N/D	802	312
COD	g/m^3	1,000	997	800
TKN	$g\ N/m^3$	N/D	140	
T Phosphorus	$g\ P/\ m^3$	N/D	17	
Alkalinity	$g\ CO_3Ca/m^3$	N/D	480	

Derived Load for Design

Parameter	Units	Off Peak	Peak DWF	Peak WWF
BOD	kg/d	17.5	42.5	42.5
TSS	kg/d	17.5	42.5	42.5
COD	kg/d	35	85.5	85.5
TKN	kg/d	4.9	11.9	11.9
T Phosphorus	kg/d	0.60	1.45	1.45

Current Consent

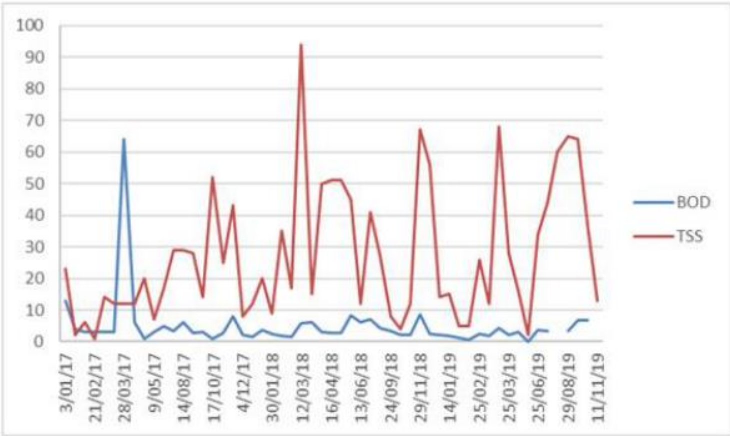


Consent

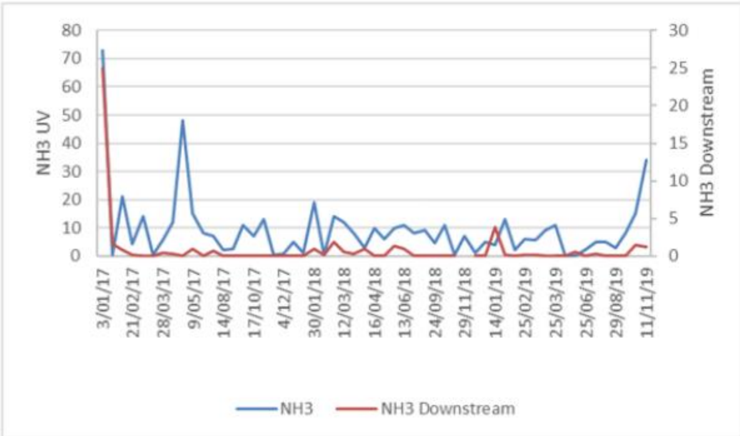
- Flow shall not exceed 250 m3/d as 30 day rolling Average

- < 130 E coli/ 100 ml – at Works effluent 95%ile
- < 50 E coli / 100 ml – at Works effluent Median
- Downstream “Shall not Exceed”
  - pH 6.5- 9.0
  - NH3 0.18 – 2.57 depending on pH
  - At pH 7.0 that’s 2 mg/l NH3.
  - DO decrease < 20%
  - Temperature no change > 3 C
  - Hue change < 10 Munsell Units/ Clarity 35%

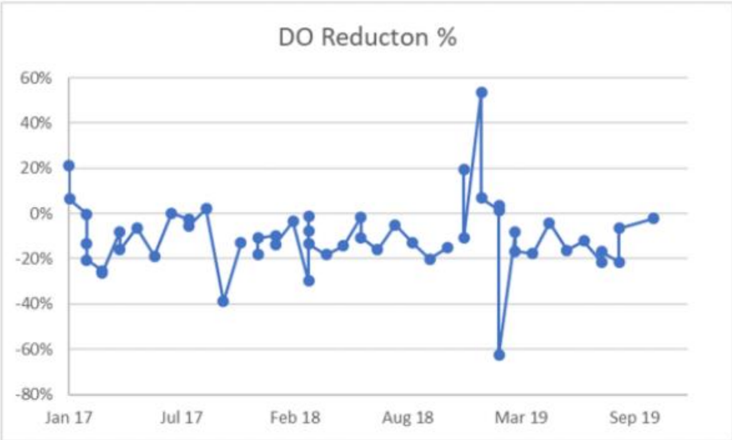
BOD and TSS – at UV



NH3 at UV and Downstream



DO impact – No more than 20% reduction



Plant Capacity

- Inlet Pump Station — About 4 l/s - tbc
- Main Reactor — 200 people
- Clarifier — 2.5 l/s upflow.

Issues

Cleaning of storm Tanks

Issues -

Inlet Pump Station

Main Reactor

Manual Screen

Cracked Intermediate Wall

Outlet Pipe

Clarifier

Sand Filter Feed Pump

Sand Filter Pipes

Wetland

Overflow Pond

Plant Issues

- Inlet Works –evidence of overfill of PS
- Capacity of storm pump unknown
- Influent diverted when storm tank full – not flow through
- Cleaning of storm tanks
- Tank Structure
- Inefficient Aeration – insufficient for peak loads ?
- Wash out of undersized clarifier
- Bypass of Treatment- storm flows bypass secondary and filtration – Poor Disinfection- Low Transmissivity
- Wetlands – condition
- Wetlands – Sludge odours?

Plant Issues

- No site welfare
- Coarse Screen Manually raked
- FE tank has small operating band causing air locking of tertiary feed pump
- Tertiary pipework is welded so unable to maintain
- Air Locking of tertiary pumps
- Unable to remove sandfilter without building change
- Insufficient water for washdown
- Aged Scada

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Minutes of Meeting

Project Name	HiHi WWTP Risk Workshop
Project Number	1-13191.02
Date	16/01/2020
Time	9 a.m. – 4 p.m.
Venue	FNDC office, Kaikohe
Subject	HiHi WWTP options review
Client	Far North District Council
Attendees	Bill Down (WD), Jody Kelly (JD), Tommy Gordon (TG), Greg Timperley (GT), Larey-Marié Mulder (LM), Andrew Springer (AS), Rueben Wylie (RW), Tanya Proctor (TP), Blair Houlihan (Northern Edge, Funding Apps) (BH)
Apologies	Mark Keehn
Distribution	Bill Down – FNDC

Overview

FMDC/WSP/Far North Waters developed a business risk assessment matrix in the workshop held for HiHi WWTP held on 4th December 2019, on the risks that are related to the performance failure and consenting issue of the WWTP. In the workshop, no options for upgrades were discussed at this stage. The risk workshop identified drivers, and key risks, and discussed and evaluated options for the replacement of the Hihi WWTP. These options and the risks relating to them were assessed and discussed with FNDC personnel to short-list the feasible options for business case and development of the discussed options

Discussion	Action	By Who/When
1 Recap of the main issues from previous workshop Major issues that impacts the performance of the WWTP during peak flows were discussed and the risks associated with them were addressed. Main issues were • Aging assets and capacity of the plant • Consent conditions for Ammonia and Dissolved Oxygen exceedance in the stream	Completed	

wsp

• Flow bypassing secondary treatment and sand filtration and UV are against consent conditions • Process capacity challenged by historic growth and holiday population • Condition of the wetland and embankments		
2. Constraints of the project Existing and future constraints of the plant and site were discussed with the attendees and constraints were recorded in a table and the options were reviewed against each of these constraints. The table is attached in this MOM for reference.	Completed	
3. Funding and budget Funding of the upgrades (or new WTTP) capex and opex were discussed for the proposed options and options were reviewed on a high level based on the budget and funding. Funding to be confirmed in March 2020 by FNDC and due to be released in December 2020, as per the discussion with FNDC finance team representative.	FNDC to confirm	March – December 2020 BH/JK/WD
4 Brain dump of developed options and their risks Ideas were captured on possible options. Options were discussed based on the feasibility, risks and constraints of each option. A table (see Table1 below) was formed to zero out any options for business case development Project Constraints identified as; • Time • Affordability • Land availability and designation • Neighbours • Climate change and innundation • Amenity • Land Use • New Consent • Nuisance • Construction (space and programme) • Operation/mainenance • Asset Life • Wetland • Safety	Completed	

• Whole Life Cost		
5 Preferred options • Previously WSP had developed options to meet future consent requirement that would fit the existing site boundary. These were presented. The constraints and the risks were identified, and the feasibility of options were discussed. The short-listed options were • Membrane Bioreactor • Activated Sludge Plant	Completed	
5a) Membrane Bio Reactor (MBR) The positives and negatives of MBR were discussed by Andrew Positives are as follows • Improves the quality of treatment • Provides stability to the treatment process • Modular in design • Meets time of delivery • Marginal increase in operational cost (due to the size of the plant) • No need for Sand Filters • UV treatment may not be needed unless if there is a need to treat viruses • No need for wetland (unless cultural) • All land options are inclusive • Low footrprint within site constraints • Improves maintenance accessibility Negatives are as follows • Higher capital cost • Need trained operators • Wetland site issue need to be addressed • Complexity of operation		
5b) Activated Sludge Plant (ASP) The positives and negatives of the Activated Sludge Plant were discussed by Andrew Positives are as follows: • ASP is a known technology • There will be little to no increase in operational expenditure	*Confirm Layout	AS

wsp

• ASP should fit within the site boundary* • Long retention time of the sludge • Improved quality of treatment • Improves site accessibility • ASP fits within the timeline • Maintenance of existing assets become feasible • Modular by design and can be linked to existing system • All Land options inclusive Negatives are as follows • Variable load and stability • Not resistant to Nocardia • Sand filter and UV is needed for tertiary treatment • Wetland must be upgraded • Very tight footprint within designation		
6) Other options **6a) Repair the existing faults** One of the options discussed were to repair the existing faults in the plant. Andrew pointed out the constraints relating this option and there were a lot of potential failing criteria. The main one being failing the new consent. It was agreed that fixing the reactor did not sufficiently address risks and operational problems to be taken forward as an option (as can be seen in Table 1). All constraints, compliance issues, space limitations, safety issues would remain, and substantial expenditure is necessary. Bill Down mentioned that FNDC has budget for re-building the plant and. suggested to go ahead with the other options.		
6b) Pump to Mangonui Andrew proposed the option to pump the sewage to Manganui by directional drilling. On assessing this option with the constraints, the main issues addressed were affordability of the option, nuisance to public and time to obtain Resource Consent. Impact on the East Coast Network and Taipa WWTP are unknown.		

wsp

Rueben from FNDC planning team suggested that the time to obtain consent is going to be long and therefore, this option is not meeting the requirements of timeframe. Other constraints that didn't meet the requirements were • Community perception at Mangonui • Impact on Taipa system • HiHi Residents paying for Taipa upgrade • Taipa has lower treatment standard • Politics with Taipa • Affordable transfer for HiHi residents This option has not been taken forward due to time and potentially higher cost for the community.		
6e) Moving Bed Bio Reactor (MBBR) MBBR option was discussed and it was decided not to go ahead with the option on common grounds, since MBR is more efficient in terms of quality, liability and land use.	Completed	
Next Actions		
7) FNDC to discuss potential consent conditions with NRC	WD	TBA
8) FNDC to confirm land availability for new-builds	WD	TBA
9) FNDC to provide more information about reserve outside the boundary of WWTP	WD	TBA
10) Design for the developed options • Confirm Footprint of ASP and MBR • Provide estimate of costs for each option	AS	TBA
11) Provide Options report that summarises issues, risks, options and costs, and the process undertaken.	AS	

Table 1 Options and constraints assessment table

Constraints	Repair	Activated Sludge Plant	Pump to Mangonui	Moving Bed Bio Reactor	Membrane Bio Reactor	Notes
Affordability	✔	✔	X	✔	X	Affordability limited to $4M
Land	✔	✔	✔	✔	✔ ✔	
Neighbour	✔	✔	✔ ✔	✔	✔	
Inundation/Climate change	X	X	X	X	X	Existing site conditions does not support
New Consent	X	✔	✔	✔	✔	
Amenity	✔	✔	✔	✔	✔	
Land Use	X	✔	✔ ✔	✔	✔	
Nuisance	X	✔	X	✔	✔	
Time	✔	✔	X	✔	✔	Design and construction in less than 2 years
Construction Programme	✔	✔	✔	✔	✔	
Maintenance operations	X	✔	✔	✔	✔	
Asset Life	X	✔	✔	✔	✔	
Wetland	X	X	✔	X	X	V High Quality may bypass wetland if consent permits
Quality	X	✔	✔	✔	✔	
Safety	X	✔	✔	✔	✔	
Whole Life Cost	X	✔	✔	✔	✔	

Hihi Cost Estimate Review, Aug 2020

Purpose

Hoskin Civil have undertaken a Cost Estimate review of Budget Cost Estimates provided by WSP as Appendix J of their Hihi Options Review dated March 2020.

Our Cost Estimate review may be considered as reasonable, based on the provided engineers costing reports and in the absence of the Design, Structural and Services drawings, the Contract Documents and other Conditions. Please note this is a review of the Budget Cost Estimates previously provided to FNDC. Minor adjustments are proposed to P&G items only.

Brief Development Description

Hihi is a small coastal community located in the Far North District of New Zealand. As a popular tourist destination, the area experiences a significant increase in population during holiday periods, particularly during the Christmas and New Year's Holidays, when the Holiday Park experiences their peak occupancy.

The Hihi community currently has an existing Continuous Stirred-tank Reactor (CSTR) wastewater treatment plant located on Marchant Rd. Due to asset condition and process capacity for current loads, the plant has been identified by the Operational Team (Far North Waters) and WSP in 2018 to be underperforming and the exceedance of consented parameters can occur.

The overall capacity of the treatment plant is insufficient for both peak flow and peak load. This causes intermittently very poor effluent passing to the tertiary wetland and into the stream.

Furthermore, the Resource Consent for the current discharge is due for renewal by 2022 and new consent standards are expected for the discharge. Hoskin Civil has reviewed the options proposed previously in various reports and outlined below:

1. Option 1 - Do minimum:

   The scope of this option is to replace an aeration tank with a new tank, constructing safe working platforms, refurbishment and installation of the inlet screen. Note; the original Do minimum solution involved refurbishment of the existing main reactor only, which was discounted as an acceptable option. Therefore, the do minimum solution reviewed is the minimum scope of work required to obtain an acceptable outcome.

2. Option 2 - Conventional Activated Sludge (ASP)

   The scope of this option is to construct a like for like replacement of the existing activated sludge treatment and upgrade of the tertiary filter capacity.

3. Option 3 – Membrane Bioreactor (MBR)

Hihi Cost Estimate Review, Aug 2020

This solution considers the construction of a biological process based on using membranes for the solid's separation stage.

Estimated Budgets:

The estimated construction costs of the different options studied, reviewed by Hoskin Civil, are presented on the following table (Option 2 and 3 proposed by WSP).

	Estimated Costs
Option 1 – Do Minimum	$ 2,424,659
Option 2 - Conventional Activated Sludge Plant (ASP)	$ 5,376,245
Option 3 - Membrane Bioreactor (MBR)	$ 5,970,973

Table 1 - Option 1: Hihi WWTP - Do minimum

Description	Unit	Qty	Rate	Estimated Price	
Preliminary and General	LS	1	$200,000	$	200,000
Aeration Tank	LS	1	$120,000	$	120,000
Access Stairs and Screen Platform incl. Handrails	LS	1	$40,000	$	40,000
Inlet Screen Installation	LS	1	$40,000	$	40,000
Electrical Installation Works	LS	1	$35,000	$	35,000
Commissioning and Testing	LS	1	$5,100	$	5,100
Aeration Tank Demolition and Site Reinstatement	LS	1	$70,000	$	70,000
Min Work on Wetland's Ponds	LS	1	$250,000	$	250,000
Repair Work to Network	LS	1	$491,244	$	491,244
Sub-total				**$**	**1,251,344**
P&G	%	15		$	187,702
Contractor Risk	%	3		$	37,540
Installation and Commissioning	%	5		$	62,567
Contractor Overheads	%	5		$	62,567
Contract Design	%	5		$	62,567
Sub-total project cost				**$**	**1,664,288**
Contractor Profit and off-site overhead	%	11		$	183,072
Sub-Total Contract Cost (Excluding GST)				**$**	**1,847,359**
FNDC Cost 10%				$	184,736
Consultant 10%				$	184,736
Engineer to Contract 5%				$	92,368
Sub-Total Contract Cost (Excluding GST)				**$**	**2,309,199**
Project Uncertainty (5% On Grand total)				$	115,460
TOTAL Estimated Cost				**$**	**2,424,659**

Hihi Cost Estimate Review, Aug 2020

Table 2 - Option 2: Hihi WWTP - ASP

Description	Unit	Qty.	Rate	Estimated Price	
Connection to Pre-treatment	LS	1	$21,460.00	$	21,460
Pre-treatment	LS	1	$91,700.00	$	91,700
Biological reactor - Civil Works	LS	1	$162,400.00	$	162,400
Biological reactor - Equipment	LS	1	$38,160.00	$	38,160
Aeration	LS	1	$100,840.00	$	100,840
Services Building	LS	1	$80,000.00	$	80,000
Pipework to Clarifier	LS	1	$17,000.00	$	17,000
Secondary Clarifier - Civil Works	LS	1	$35,000.00	$	35,000
Secondary Clarifier - Equipment	LS	1	$153,000.00	$	153,000
Pipework from Clarifier to Final tank	LS	1	$2,850.00	$	2,850
Sludge RAS + WAS - Civil works	LS	1	$2,000.00	$	2,000
Sludge RAS + WAS - Equipment	LS	1	$81,415.00	$	81,415
Tertiary Treatment - Civil Works	LS	1	$219,000.00	$	219,000
Tertiary Treatment - Equipment	LS	1	$115,316.00	$	115,316
Electrical Installation Works	LS	1	$132,760.00	$	132,760
Control	LS	1	$65,000.00	$	65,000
Commissioning and Testing	LS	1	$94,800.00	$	94,800
Temporary Connection	LS	1	$1,000.00	$	1,000
Demolitions and Site Reinstatement	LS	1	$110,000.00	$	110,000
Temporary Site Works	LS	1	$100,000.00	$	100,000
Wetland Earthworks	LS	1	$700,000.00	$	700,000
Sub-total				**$**	**2,323,701**
P&G	%	15		$	348,555
Contractor Risk	%	5		$	116,185
Installation and Commissioning	%	10		$	232,370
Contractor Overheads	%	10		$	232,370
Contract Design	%	5		$	116,185
Sub-total project cost				**$**	**3,369,366**
Contractor Profit and off-site overhead	%	11		$	370,630
Sub-Total Contract Cost (Excluding GST)				**$**	**3,739,997**
FNDC Cost 10%				$	374,000
Consultant 10%				$	374,000
Engineer to Contract 5%				$	187,000
Sub-Total Contract Cost (Excluding GST)				**$**	**4,674,996**
Project Uncertainty (15% On Grand total)				$	701,249
TOTAL Estimated Cost				**$**	**5,376,245**

Hihi Cost Estimate Review, Aug 2020

Table 3 - Option 3: Hihi WWTP - MBR

Description	Unit	Qty.	Rate	Estimated Price	
Connection to Pre-treatment	LS	1	$21,460.00	$	21,460
Pre-treatment	LS	1	$91,700.00	$	91,700
Biological reactor - Civil Works	LS	1	$150,400.00	$	150,400
Biological reactor - Equipment	LS	1	$483,660.00	$	483,660
Aeration	LS	1	$97,940.00	$	97,940
Services Building	LS	1	$138,000.00	$	138,000
Sludge RAS + WAS - Civil works	LS	1	$2,000.00	$	2,000
Sludge RAS + WAS - Equipment	LS	1	$49,165.00	$	49,165
Tertiary Treatment	LS	1	$19,000.00	$	19,000
Electrical Installation Work	LS	1	$170,600.00	$	170,600
Control	LS	1	$70,000.00	$	70,000
Commissioning and Testing	LS	1	$94,800.00	$	94,800
Temporary Connections	LS	1	$1,000.00	$	1,000
Demolitions and Site Reinstatements	LS	1	$130,000.00	$	130,000
Temporary Site Works	LS	1	$140,000.00	$	140,000
Emergency generator	LS	1	$200,000.00	$	200,000
Sub-total				**$**	**1,859,725**
P&G	%	15		$	278,959
Contractor Risk	%	8		$	148,778
Installation and Commissioning	%	30		$	557,918
Contractor Overheads	%	20		$	371,945
Contract Design	%	5		$	92,986
Sub-total project cost				**$**	**3,310,311**
Contractor Profit and off-site overhead	%	11		$	364,134
Sub-Total Contract Cost (Excluding GST)				**$**	**3,674,445**
FNDC Cost 10%				$	367,444
Consultant 10%				$	367,444
Engineer to Contract 5%				$	183,722
Sub-Total Contract Cost (Excluding GST)				**$**	**4,593,056**
Project Uncertainty (30% On Grand total)				$	1,377,917
TOTAL Estimated Cost				**$**	**5,970,973**

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Options overview:

Option 1: Do minimum

WSP was commissioned by Far North District Council (FNDC) to carry out a condition assessment of the plant to confirm the previously observed issues around flow capacity. Their Structural Report, dated 22 November 2019, concluded that the internal dividing wall of the aeration tank has already experienced partial failure. It will fail completely as further deterioration occurs over time, or during a significant seismic event. All the other elements of the tank are in poor condition; if not repaired all cracking and spalling of concrete will propagate to the point where egress of stored water becomes unacceptable.

Option 1 proposes replacement of the aeration tank including repair and modifications to the plant to accommodate a working Inlet screen (refurbished from the Whatuwhiwhi WWPT). Power supply will be required for the inlet screen, the electrically actuated sludge discharge valve and the new sludge return pump. Additionally, thorough investigation will be required for replacing or repairing other components.

The wetland requires maintenance; land slips are known at the wetland site and there is evidence of further recent movement in the bank. Hoskin Civil propose to include earthworks to reshape wetland ponds, repair faulty drainage and minor works to support an eroded bank.

Furthermore, the CCTV network report dated 2011 produced by Project Max identified the AC networks as "Leaky"; the overall condition of the network is deteriorated, attracting 46.5% Structural Grades scoring 4.1 or greater (max score is 5.6). CCTV inspections also identified several defects in the manholes, such as; leaking benching, root intrusions through the lid and around the pipe connections. Hoskin Civil propose to include the repair cost to the network to Option 1.

Option 2: Conventional Activated Sludge.

The conventional activated sludge system is a treatment process that is familiar to the site operations team.

Hoskin Civil propose to include the nominal figure of $700K for wetland remediation and bank stabilization (WSP Report 11 March 2020).

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Option 3: MBR.

Multiple reports previously provided by WSP to FNDC recommended MBR system, due to several advantages over activated sludge system.

Hoskin Civil conducted an investigation to support our business case; MBR systems are not familiar to FNDC and due to Hihi's remoteness and population size, we have outlined important aspects to consider.

It is not easy to make a general economical comparison between MBR and Activated Sludge systems. First of all, MBR is a modular system, that is easily expandable, which is often mentioned as an advantage of the system. However, this makes the system less economically competitive with conventional systems. It should be noted that the equipment and energy costs of an MBR are higher than systems used in conventional treatment. Furthermore, the efficiency of the filtration process in an MBR is governed by the activated sludge filterability, which is still not well understood and is determined by the interactions between the biomass, the wastewater and the applied process conditions.

MBR plants are operating all around the world and gaining in popularity, due to high-quality product water. It is important to note that MBR is still under development, and that the costs for MBR differ significantly depending upon the adopted technology and the site conditions.

There are two main different membrane systems; the hollow fibre membranes and plate membranes (also called "flat sheet" membranes) currently used in New Zealand.

Membrane fouling and energy consumption are important challenges that need to be managed through employing best operational practices, which could be a significant challenge for a remote WWTP plant like Hihi.

In New Zealand, a 2004 study by New Plymouth District Council found that wastewater related assets were the major consumer of energy for assets owned by the Council (Macdonald, French, & Caroline, 2008).

The aeration energy is used to both provide oxygen for biological nutrient removal, and scouring of membranes to control fouling. The total annual power costs could be substantial, adding to the operational cost and the need for an emergency generator. MBR systems often require cycling modulating valves or additional equipment to reduce the amount of bubbly flow supplied to the membrane modules, while still maintaining a certain scouring efficiency. This equipment can require increased maintenance and care over and above the accumulation device, which has no moving parts. Those systems rely on cycling air and require complex control systems to monitor plant operation to determine periods when air flow can be adjusted.

It was challenging to find accurate and relevant literature of actual operational experiences with MBR plants. Membrane fouling is the most serious problem which occurs in MBR. As an example, the first

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three flat sheet membrane MBRs were installed in New Zealand at Tirau, Turangi and Te Aroha. All three of the subject MBR plants experienced varying degrees of sludge caking between the individual membrane panels and lint build-up around the membrane module housings and associated accessories. Because of the diverse range of operating conditions and the limited information reported on the suspended biomass composition, it is difficult to establish any generic behavior affecting membrane fouling. Once membrane fouling occurs, it will reduce permeate flux, increase feed pressure, reduce productivity, increase system downtime, increase membrane maintenance and operation costs due to membrane cleaning, and decrease the lifespan of the membrane modules. Thus, the MBR process requires the plant operators (who are permanently stationed at the facility, or conduct patrols on a regular basis) to have a high level of skill to ensure optimal operation and early detection of degradation in membrane performance.

Fouling affects both capital (CAPEX) and operational (OPEX) expenditures. The CAPEX is influenced by installation of required equipment for fouling prevention or mitigation. The OPEX are influenced by energy cost due to power required for aeration, pumping and mixing, chemical cleanings of the membrane and waste sludge treatment. The energy requirements account for the majority of the operational and maintenance costs (O&M). The periodical physical cleanings are not an energy intensive processes, but they still increase the total O&M costs. The chemical cleanings carried out to recover membrane performance and utilized cleaning agents also add to the total costs and environmental impact. Also, the addition of any sort of filtration enhancing additives increases the operational costs. Finally, during membrane cleanings, filtration is not performed. Subsequently, permeate production is reduced. Thus, specific costs increase, leading to a less cost-efficient process.

The full clean and inspection for the MBR plant was estimated to take up to 6-10 weeks with cost of up to $150K. New sheets would cost between NZ180K – NZ230K each. The proposed life span of the membranes is between 5-10 years, but no real data was provided to support those claims.

As part of the business case study Hoskin Civil also obtained three different quotations for implementing different MBR membrane systems that are suitable for Hihi WWTP and have not been mentioned before.

These are as follows:

1. Guaranteed Flow Systems (GFS) propose 2 options (Formerly Canadian Pacific Ltd).

GFS Option A

Treat the 70 m^3/day of waste from the regular community using an Effbuster 70 membrane bioreactor [MBR], with the expectation that the Beach Resort will manage the treatment of the peak flows generated from that area over the 10-day holiday period.

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GFS Option B

Utilize the existing tank infrastructure, in conjunction with two new trains of membranes and controls, to treat a peak flow of 280 m3/day. Use one membrane train in low flow periods (using duty-standby to keep both trains fully functioning) and two trains during peak flow periods. During construction work the existing plant will need to be out of service. Allowance has been made in the estimate for rental of an Effbuster 70 MBR to treat the community waste for the duration of the construction period. A provisional sum has been included in the estimate for inspection and assessment of the existing tanks.

	Estimated Costs
GFS Option A – 70m^3 / day	$750,000
Effbuster 70 MBR Unit Containerised MBR 12mL x 2.4mW – installed and commissioned	
GFS Option B – 280 m^3 / day	$1,210,000
Existing tanks re-purposed as Anoxic, Aerobic and Anaerobic tanks Containerised MBR tank and control unit 6mL x 2.4mW Temporary treatment plant (Effbuster 70) in place for 5 months during construction	
Note	
Preliminary site investigation and design would be required to advance either option to confirm final price. If GFS is engaged to undertake this preliminary work, these costs would be taken from the sums allowed in the budget estimates.	

2. FILTEC proposed propose 2 options:

SUEZ's E-Series Membrane Bioreactor (MBR) ZeeWeed 500 hollow fiber membranes, 2 options:	**Estimated Costs**
2 x E-30K	$2,000,000
1 x E-75K	$1,350,000
Note	
Budget price for equipment only for the two options, including tanks and membranes, containerised process skid but excluding design/PM/civils/electrical supply. No other data was provided.	

3. Apex Environmental Ltd proposed:

SINAP flat sheet membranes. A budget price to design and construct an MBR designed to handle peak wastewater volumes of 275m^3 /day would be approximately $1.27M plus GST, ±20%. This budget includes an allowance for removal of existing equipment, turnkey supply of the process described above, design, project management, commissioning and training.

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Conclusions:

This report includes a QS review of the WSP condition assessments, feasibility and options reports, Far North Waters operational and maintenance records and the assessment of whole of life and rate impacts.

The underlying issues at Hihi around population and treatment plant capacity were provided in the WSP report dated 9 March 2020. These findings summarised the following:

- The resident population given in the 2013 census is 170 people, data from flow and incoming wastewater shows that peak population is over 500 people.
- Off season, 2 persons will occupy a property but at peak holiday periods, population will increase to 4-8 people per property. This gives an estimated doubling of population from residential dwellings.
- Additionally, the campground operates seasonally and is connected to the wastewater system, population data from the campground confirms a dramatic rise in numbers over the peak period.

Based on this information, and current budgets and rate impacts, we propose installing an independent septic system for Hihi Holiday Park, designed to deal with seasonal fluctuations. FNDC can gift this asset to Holiday Park owner(s), eliminating the need to care for an additional asset. The repair or replacement works to aeration tank (Option 1) could be conducted, as recommended by the engineers and construction of a new plant (Activated Sludge system or MBR) may not be required. The pipe network connecting the holiday park to the plant could be decommissioned and abandoned with no need to further repairs or maintenance. The quotes for this option have not been obtained, but are estimated to be as high as $350k-$400K (for independent holiday park septic system only).