Jacobs

# Memorandum

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| **Subject** | **Kaikohe WWTP Interim Options Assessment** | **Project Name** | Kaikohe WWTP Review |
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| **Date** | 11 August 2021 | | |
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## 1. Introduction

Far North District Council (FNDC) are in the process of applying for a new discharge consent to allow continued operation of their Kaikohe Wastewater Treatment Plant (WWTP). The current discharge consent allows for the discharge of treated wastewater into the Wairoro Stream and expires in November this year. In line with Northland Regional Council's (NRC) Proposed Regional Plan (PRP), it is expected that the new consent will include more stringent effluent discharge conditions.

The Kaikohe WWTP will require a significant upgrade in the future to meet the discharge conditions outlined in the PRP. A review of the options to meet the expected conditions has been undertaken by others. Implementation of an IDAL treatment process within the existing ponds and addition of UV disinfection has been identified as the preferred approach (Harrison Grierson, 2020). Detailed design, construction and commissioning of the full upgrade will take a period of time to complete. In the interim, there are several improvements that can be implemented, relatively quickly, to improve the treatment performance of the existing WWTP; many of which could be incorporated into the final upgraded WWTP. These improvements require the new consent to include interim conditions that can be met by these upgrades. Jacobs has been engaged by FNDC to support their application to this effect.

The first stage of the Kaikohe WWTP Review was a performance assessment of the WWTP. The current performance was assessed against the discharge consent conditions. The long-term performance of the WWTP and the results of two-week interstage sampling and analysis programme were then compared against the expected design performance as determined by a theoretical model of the WWTP. Details of this assessment have been included in the Kaikohe WWTP Performance Assessment Technical Memorandum.

The findings from the performance assessment guided the investigation of interim, short term, upgrade options for the Kaikohe WWTP. The intent of these upgrades is to act as a first stage to the WWTP's intended longer-term upgrade. This staged approach allows treatment performance to be improved and to meet new, interim consent conditions. Upgrade options have been subject to an initial qualitative multi-criteria analysis (MCA) to screen the options and enable the identification of a preferred option to take forward.

## 2. Interim Upgrade Options

The Kaikohe WWTP will require a significant upgrade in the future to align with NRC's PRP. Based on the options assessment conducted by Harrison Grierson in November 2020, the recommended long-term solution is an IDAL treatment process within the existing ponds and the installation of an additional disinfection (UV) unit. This is estimated to cost up to $8.9M and would take several years to implement. This recommended option requires consultation with mana whenua and other stakeholders as the consenting process progresses. In the meantime, interim options have been considered as a steppingstone toward this long-term option.

To support FNDC's imminent application to renew their discharge consent, Jacobs has been engaged to assess and recommend short-term upgrades that could be implemented to support interim consent conditions. Consideration has been given to how each option will complement the WWTPs recommended long-term option. Options that require significant capital expenditure have not been considered.

As discussed in the Kaikohe WWTP Performance Assessment Technical Memorandum, site logbook data for the Kaikohe WWTP shows frequent breaches of consent due to high flows and ammoniacal-nitrogen ($NH_4$-N) and occasional breaches in E. coli levels in the effluent over the last three years. This review identified that the WWTP is underperforming for biological oxygen demand (BOD), $NH_4$-N and bacteria (E. coli) removal, compared to the theoretical performance. Therefore, short-term upgrade solutions have focused on targeting these three contaminants. For the purpose of the MCA in Section 3, upgrades have been grouped into six separate options, though a combination of options may need to be implemented. A summary of the options considered is given in Table 1.

During the desktop performance assessment and data analysis, as well as through observations made at the site visit, several improvement opportunities were identified regarding the maintenance of the Kaikohe WWTP processes . Observed issues included;

- A significant build-up of sludge within the anaerobic and oxidation ponds resulting in a reduction of the available treatment volume
- The inlet screen being out of service for repair/replacement meaning unscreened wastewater entering the pond
- Significant vegetation growth on the oxidation pond, reducing the penetration of light and the available treatment volume and encouraging vermin and birds, a source of coliform bacteria.

It is recommended that periodic desludging of the ponds, as well as removal of vegetation should be undertaken as part of regular maintenance activities to ensure sufficient active volume within the pond is maintained, to provide the level of treatment required within the pond.

**Table 1: Summary of maintenance and short-term upgrade options for the Kaikohe WWTP, targeting BOD, TN, and E. coli removal.**

| | Maintenance | In Pond Passive | In Pond Mechanical | Additional Process |
|---|---|---|---|---|
| **BOD** | ▪ Desludge the anaerobic and oxidation ponds<br>▪ Reinstall Screen<br>▪ Maintain wetland planting | ▪ Install Baffles/Curtains in oxidation pond | ▪ Install Mixers/Aerators in the oxidation pond | ▪ Effluent Filtration |
| **$NH_4$-N** | ▪ Desludge the anaerobic and oxidation ponds<br>▪ Maintain wetland planting | ▪ Aquamat<br>▪ Enhancing BOD removal will assist ammonia removal | ▪ Install Mixers/Aerators in the oxidation pond | ▪ Advanced wetland system<br>▪ Nitrifying Filter |
| **E. Coli** | ▪ Desludge the anaerobic and oxidation ponds<br>▪ Surface growth removal on oxidation pond<br>▪ Maintain wetland planting | ▪ Install Baffles/Curtains in oxidation pond | | |

The options in Table 1 that are able to target effluent quality improvements for multiple key parameters have been carried forward for review and are summarized as:

- Operation and maintenance activities
- Option 1 mechanical aeration and mixing of the oxidation pond
- Option 2 installation of baffle curtain in the oxidation pond
- Option 3 installation of growth media in the oxidation pond
- Option 4 addition of nitrifying filter
- Option 5 addition of advanced wetland system.

### 2.1 Operation and Maintenance Activities

Operation and maintenance activities described within this section include the necessary maintenance activities that should be completed immediately, and regularly repeated, at the WWTP. These activities are therefore not 'options' but in fact the baseline requirements to keep the WWTP operating as designed. All other options presented in this document build on from this “base line” option and assume that these maintenance activities are completed.

Key maintenance activities are:

1) **Desludging both the anaerobic and oxidation ponds -** This will increase the effective volume of the ponds which will increase the hydraulic retention time (HRT). This is key to improving WWTP performance as it allows more time for digestion, oxidation, and disinfection reactions to occur. This targets all three contaminants in focus, as well as supporting the removal of total suspended solids (TSS) via sedimentation.

   An increased HRT gives more time for the solids to settle and for the bacteria to digest the organic content of the influent. In the oxidation pond, an increased HRT gives nitrifying bacteria the time to grow and oxidise the $NH_4$-N once the heterotrophic dissolved oxygen (DO) demand has been satisfied. More disinfection will also occur, provided the pond surface has sufficient exposure to UV light. Desludging also helps to reduce short circuiting, where solids build up results in the formation of channels which exacerbates poor treatment.

2) **Reinstating the inlet screen –** This will reduce the total solids content of the influent wastewater and therefore the solids entering the ponds, allowing it to operate as designed. Removal of large solids and non-digestible content also reduces build-up at the bottom of the pond. This allows the effective volume and HRT to be maintained and treatment to occur as detailed above. Screening also supports the option for beneficial reuse of the digested solids, as plastics and other inert material do not contaminate the sludge. Screening can also reduce the risk of low-density solids (plastics) floating on the surface causing a nuisance. Should mixing or aeration of the ponds be included then screening will be essential to avoid rag and other material wrapping around the shafts, reducing performance, and causing damage.

3) **Removing the surface plant growth from the oxidation and maturation ponds –** A significant buildup of floating plant growth around the oxidation pond perimeter has occurred in the last few years particularly in the northern part of the pond. This impacts on the surface area available for exposure to sunlight and therefore the amount of UV disinfection occurring. It also impacts the amount of photosynthetic activity by algae, which in turn affects the DO in the pond. Weeds can form quiescent patches in the pond, causing anoxic zones, uneven sludge accumulation and short circuiting. They can also encourage birds and vermin to the pond, which can result in higher pathogen levels.

4) **Maintaining wetland planting –** Planting in the constructed wetland has become sporadic and maintenance is required. It was noted by the operator that the plants in the wetland had been difficult to get established during the last replanting programme. Well maintained wetland planting can improve retention time and settling of solids, provide surface area for biofilm growth, enhance aeration, assimilate nutrients, and shade the water to reduce algal growth. Overall improved performance and effluent quality of the targeted measures can be achieved.

Changes may also be considered to the operation of the WWTP. The key change which could impact on the performance of the plant, especially if seasonal variations in the Wairoro Stream remain part of the compliance requirements, is limiting the discharge of septage during the summer. This will reduce the load to the plant and improve the effluent quality. This will be subject to the ability for septage discharge to be delayed by haulers or diverted to Kaitaia WWTP. Consideration of these factors may limit the applicability of this as an option, it has not been carried forward into the option evaluation.

### 2.2 Option 1 – Aeration/Mixing of the Oxidation Pond

Pond aeration has a two-fold effect of supplying oxygen for the microbial degradation of organic matter, as well as providing mixing so that microorganisms come into contact with dissolved and suspended organic matter (EPA, 1999). Therefore, installing a mechanical aeration system on the oxidation pond would help to satisfy the DO demand for both BOD and $NH_4$-N removal, lowering the concentration of these contaminants in the effluent.

This solution has been recommended to FNDC in the past (VK Consulting Environmental Engineers, 2000). It is easy to implement, aerators can simply be installed to sit within the existing oxidation pond. There is capital cost for the equipment, however the WWTP is likely to incur this cost in the future preferred long-term upgrade. There may be a requirement to upgrade the power supply to the site transformer), but again, this is likely to be required for the future preferred long-term upgrade. The IDAL solution is an activated sludge process involving time-phased aeration and settling. As such, a mechanical aeration system will be required in the future and investment in this system now will support the long-term option implementation.

The main disadvantage of this option is the ongoing operating cost associated with the continuous power draw. The addition of an aerator also introduces the need for additional maintenance and general cleaning. Power costs can be reduced by switching the aerators off at night when there is no algal activity. Proper equipment selection, positioning and application will be necessary to minimize the operating cost and optimise serviceability of the equipment.

### 2.3 Option 2 – Baffle Curtains

Baffle curtains installed in the oxidation pond will improve the WWTP performance by controlling the flow path through the pond to prevent short circuiting. “Short circuiting” refers to when wastewater flows along a direct path to the outlet, resulting in the HRT and contact with microbes being minimal. Baffle curtains may also be employed to sectionalize the pond into different treatment zones.

For the Kaikohe WWTP, baffle curtains could be installed in the oxidation pond to maximize the effective treatment volume and therefore the HRT. The oxidation pond has a large surface area and therefore a high HRT which could make it prone to short circuiting. Dye testing or other measurement of mixing in the pond can be undertaken to confirm whether short circuiting is an issue and quantify the potential benefits of curtain installation. The use of the full pond area can provide improvement in BOD removal (and an associated improvement in ammonia removal) as well as improved disinfection. The baffle curtains may be re-used and/or repurposed as part of the long-term process upgrade as the IDAL process identified includes a partitioning of the oxidation pond. Whilst there is an initial capital cost outlay, once installed there is no significant operating or maintenance cost.

## 2.4 Option 3 – Growth Media

Growth media in ponds uses plastic or organic support media to provide a surface for bacterial growth which improves the treatment capacity, particularly for nitrogen as it enables nitrifying bacteria to grow and oxidise $NH_4$-N. Three types of growth media systems have been reviewed, as detailed in this section. AquaMats were carried forward in the option comparison as an example high surface area growth media solution that is currently available on the market, If growth media is considered an appropriate interim option the specific market solution will be determined at a later date.

### 2.4.1 AquaMats

AquaMats are high-surface area growth media designed to support beneficial bacteria and agal communities. Extra treatment is achieved so long as sufficient oxygen is provided, which is why this solution typically comes with its own dedicated aeration system. AquaMats come with bottom laid, pressure differential piping (PDP) to provide oxygen and adequate mixing to carry nutrients across the media surface.

Growth media systems are successfully employed in facultative ponds world-wide. However, there have been situations in New Zealand whereby locally made solutions have been installed using trickling filter media or geotextiles, and these have had dire consequences. Water New Zealand Good Practice Guide for Waste Stabilisation Ponds recommends ensuring that growth media suppliers can provide successfully operating reference WWTPs as proof for the quality and reliability of their product (Cameron & Clark, 2017). AquaMat technology originated in the United States and have reference plants in the USA, Asia and NZ in the treatment of municipal and industrial wastewater (BrickHouse Technologies Ltd).

FNDC considered a floating growth media similar to this in 2010 based on proposals from Kauri Park Ltd and Infracon Ltd. The proposal was approved at the time based on a 700 m3 floating wetland and 1,600 m3 biofilm attachment surface proposed by Kauri Park Ltd (Fog, 2010). This was not progressed to implementation.

The main disadvantage is that these will not be retained when the WWTP undergoes the long-term IDAL upgrade. While the media is designed to be self-cleaning and requires minimal maintenance there will be ongoing operating costs associated with aeration equipment operation and maintenance.

### 2.4.2 Floating Wetlands

Floating wetlands are another form of growth media, consisting of a base matrix made from synthetic webbing into which selected plants are grown. Over time, the plants develop a root system which hangs into the water column below. The roots provide oxygen and act as a growth media for biofilm, they also have the added benefit of acting as a natural filter. Above, the plants grow naturally and can provide shade to the water, reducing the ponds algal growth.

FNDC considered similar solutions to this in 2010 based on proposals from Kauri Park Ltd and Infracon Ltd. Approval and signed authorization was received by the CEO at the time to proceed with a 700 m3 floating wetland and 1,600 m3 biofilm attachment surface proposed by Kauri Park Ltd (Fog, 2010). This upgrade pathway was not progressed.

Floating wetlands have been installed in WWTPs around New Zealand with variable results. Some ponds have achieved higher nutrient removal, whereas with others these systems have led to substandard results and non-compliance (Cameron & Clark, 2017). These systems require high levels of maintenance, and if not properly maintained can lead to reduced effluent quality. This can be seen at the Kaitaia WWTP, where plant overgrowth and sludge build up at the roots has led to the formation of anoxic zones underneath the wetland. Operators report increased algae collection around the wetland which impact on effluent quality and create a significant odour nuisance. Due to the variability of performance and poor results at the Kaitaia WWTP, this is considered a high-risk option for the Kaikohe WWTP and was not progressed to MCA.

#### 2.4.3 BioShells

Bioshells are another growth media option that can be implemented at the Kaikohe WWTP to target ammonia removal. The technology consists of concentrically nested shells packed with high surface area media that are infused with air from the bottom. They sit on the bottom of a wastewater treatment pond and are completely submerged. When the water flows through them from bottom-to-top, the attached growth within the shell digests the organic content in the liquid. Unlike other systems mentioned in this section, media growth is maximized by the way in which air is optimally guided through the shell (Marshall Projects, 2019). Bioshells require blowers air distribution pipework and therefore will require ongoing maintenance and operating costs.

Bioshells are an appealing option due to their air distribution efficiency, which results in a relatively low power draw. Due to their modular design, installation is easily scalable to reach desired effluent limits. FNDC have installed Bioshells at the Paihia WWTP and have reported a significant improvement in performance. The Paihia WWTP upgrade, although it treats a larger population, was a significant cost which likely makes this option unaffordable as an interim solution especially as the process would not be retained in the future long-term upgrade.

### 2.5 Option 4 – Nitrifying Filter

Nitrifying filters are a non-submerged fixed-film biological reactor consisting of a fixed bed of packing material (rocks, gravel slag, plastic, etc.) over which wastewater is continuously distributed. Similar to Option 3, this option uses the attached growth concept to target $NH_4$-N removal. As the wastewater passes through the media, microorganisms gradually attach themselves to the surface to form a biofilm. These microorganisms then work to decompose the organic material and oxidise ammonia in the passing wastewater.

Low rate filters are relatively simple and highly dependable systems. In most low rate filters, only the top portion of the packing will have appreciable biological slime. As such, autotrophic nitrifying bacteria can populate the lower regions and oxidize $NH_4$-N. Provided that the nitrifying population is well established, climactic and wastewater conditions are favourable, a well-operated filter can achieve good BOD removal and a highly nitrified effluent (Metcalfe & Eddy, 2003).

Key issues with nitrifying filters are odour, sloughing and clogging of the filter by algae growth. Odours occur when the wastewater is stale or septic, or the weather is warm. Sloughing refers to the process whereby, due to the growth of the biofilm layer, microorganisms near the surface lose their ability to cling to the medium and a portion of the slime falls off. These solids are then entrained within the wastewater stream but, for a low-rate filter, are generally well-digested (EPA, 2000). Algae can only grow in the upper reaches of the filter where sunlight is available and, during the day, can add oxygen to the wastewater. However, they tend to clog the media surface and cause odours.

At Kaikohe, both odour and biofilm sloughing issues can be targeted by locating the filter at the outlet of the oxidation pond, prior to the CWLs. Potential for odour is reduced by ensuring the wastewater is partially treated prior to entering the filter. The CWLs and NWL offer an opportunity for removal of slough solids. To avoid excessive algae growth on the filter surface, the filter could be shaded. The system can be designed for appropriate loading rate that considers both nitrifying performance and algae solids loading.

This filter would be a temporary measure to improve nitrification at the WWTP and would not be integrated with the long-term IDAL process upgrade. Therefore, to keep costs low, a rudimentary system is envisaged for Kaikohe consisting of an open structure of temporary tanks, filled with rock media of an appropriate size. Local iwi would be able to provide advice on suitable locally sourced rock for this treatment device. This arrangement will also keep maintenance requirements, and therefore cost, to a minimum. There is a significant difference in water level between the oxidation pond and the constructed wetlands which may be able to provide sufficient head for the nitrifying filter to operate without the need for pumping.

### 2.6 Option 5 – Advanced Wetland System

Pond-based systems make up the majority of NZ wastewater treatment infrastructure. Degrading infrastructure and increasingly stringent discharge requirements have driven a large focus for emerging technologies that are suitable for retrofit to these systems. One such technology is the use of an advanced wetland system (AWS) to modify the operation of existing wetlands to control nitrification and denitrification processes.

Jacobs has significant expertise in this area and were involved in the pilot trial of an AWS at Watercare's Wellsford WWTP. The AWS pilot at Wellsford involved a nitrification bed (fill-and-drain wetland using zeolite media for nitrification) followed by a horizontal subsurface flow wetland with carbon dosing for denitrification. The wetlands were planted with native species selected for their large root masses that grow easily in NZ and provide dense cover. The wetland media was selected based on its capacity for ammonium exchange and was sourced locally from a quarry in Whangarei. The pilot plant was constructed and commissioned in 2018 and collected data to date shows an AWS can reduce nutrient levels below consent requirements at the Wellsford WWTP.

To implement this option at full scale will require the existing constructed wetlands to be decommissioned and replaced by the AWS system. The primary and secondary treatment at the plant will be retained. The AWS system performed exceptionally well for TN removal and it was concluded that AWS could provide solutions for small pond and wetland based WWTPs in NZ (Tan, Bickers, Simmonds, & Vazquez-Burney, 2020).

There is an opportunity to implement an AWS at the Kaikohe CWLs to intensify the process and target nutrient removal. A full AWS is a longer-term solution that requires significantly more investment compared to those previously discussed in this document. If the long-term process for the WWTP is reviewed a full AWS could be an option. Alternatively, the fill and drain nitrifying wetland concept could be applied to the oxidation pond in a similar way that the nitrifying filter would be used. This part of the AWS targets ammonia oxidation which is the first priority for performance improvement at the Kaikohe WWTP.

Local iwi would be able to provide advice on native plant species from the local environment that would be expected to perform well in a wetland environment.

### 2.7 Predicted Treatment Performance

The maintenance activities represent the first steps to regaining the full design capacity of the WWTP. This can be further improved by the installation of baffle curtains (option 2) to reduce short-circuiting in the pond, improving utilization of the ponds large volume and allowing more organic digestion and $NH_4$-N oxidation to occur. It is believed that implementing these changes will drive performance closer to that predicted by the model results originally presented in the Kaikohe WWTP Performance Assessment Technical Memorandum, repeated below in Table 2.

The addition of an aeration system (option1) in the oxidation pond will further enhance the WWTP performance beyond its current design capacity. To gauge the extent of this improvement, the Kaikohe WWTP model was altered to include aeration within the oxidation pond. The result was an increased in BOD removal from 79% to 84% within the pond and an overall increase from 95% to 99% removal for the entire WWTP (Table 2).

**Table 2: Kaikohe WWTP performance summary for current conditions and modelled performance considering WWTP design and aeration.**

| Parameter | Current Performance | Design Capacity (from Model) | Improved Capacity (Model with Aeration) |
|---|---|---|---|
| **$BOD_5$** | 93% | 95% | 99% |
| **$NH_4$-N** | 33% | 52% | 62% |
| **E. coli** | < 1 log[1] | > 4 log | > 4 log |

1. Removal between the CWL and NWL only.

The addition of aeration to the model also results in an improved reduction in ammonia. However, as discussed in the Kaikohe WWTP Performance Assessment Technical Memorandum, literature models are more reliable when predicting BOD and pathogen removal. There is less confidence around nitrogen due to the unreliability of data available and the difficulty in comparing data from different trials. Test methods for ammonia are sensitive to a range of factors, meaning it is very difficult to compare data sets between sources and therefore determine a numerical prediction method. For pond systems, ammonia performance depends on pH, temperature, HRT and BOD.

Growth media have had mixed performance results in FNDC for example the floating wetlands at Kaitaia WWTP have not performed as hoped and caused algal issues, however the bioshells at Paihia WWTP have reportedly provided good performance. This mixed experience is shared across New Zealand and so the performance of this option is less certain. It also does not align with the future upgrade pathway so costs will be lost when the upgrade goes ahead.

For the Kaikohe WWTP, it is believed that the nitrifying filter (option 4) could offer significant benefits and alleviate some of the issues around ammonia treatment. This could be done in a low-cost manner (such as a plastic tank and rock media) and is an option that should be considered moving forward if lower effluent ammonia concentrations are required. Further investigation is required to determine what exactly this solution may look like, and a good indication will be provided by the interstage testing. However, it is important to note, that this would become redundant if an IDAL process was constructed in the future.

The AWS concept (option 5) is another option that could be successfully applied to the Kaikohe WWTP. Jacobs could assist FNDC to design a suitable system to meet future consent requirements aligned with the PRP. However, this is a potentially a long-term solution that could be implemented either alongside or as an alternative to the proposed IDAL system. Direction is required from FNDC as to whether this is an option they want to explore as a long-term option.

## 3. Technical Multi-Criteria Analysis (MCA)

Options for interim upgrades to the Kaikohe WWTP were subject to a comparative technical assessment considering the following criteria for performance, noting that no designs have been developed within this scope of work:

- Cost (considering whole of life cost, CAPEX + OPEX)
- Constructability / Implementation
- Operability / Maintenance
- Performance Improvement
- Compatibility with Long Term Plan (IDAL Solution) / Opportunity for Staging.

The MCA involved rating upgrade options for each category using a traffic light system. A high (green), medium (orange), or low (red) score was given for each option based on a qualitative assessment. The results are provided in Table 3. No assessment has been made on cultural consideration, as this is best led by mana whanau and social and environmental assessment have also not been completed as it is important that mana whenua and other relevant stakeholders have input into this assessment.

**Table 3: MCA results for Kaikohe WWTP interim upgrade options.**

| | Maintenance | Option 1 Aeration | Option 2 Baffle Curtains | Option 3 AquaMats | Option 4 Nitrifying Filter | Option 5 AWS |
|---|---|---|---|---|---|---|
| **Cost** | ▪ Base case cost including pond desludging. Expensive but required as part of regular maintenance. | ▪ Relatively small equipment cost.<br>▪ High operating cost due to power draw from aerator. | ▪ High equipment cost.<br>▪ Minimal operating cost. | ▪ High equipment cost.<br>▪ High operating cost to maintain and provide aeration. | ▪ Potentially high equipment cost – dependent on final design.<br>▪ Minimal operating cost. | ▪ High capital cost.<br>▪ Potentially moderate operating cost, depending on final design. |
| **Constructability / Implementation** | ▪ Can be carried out as per O&M instructions. | ▪ Simple installation on existing oxidation pond. | ▪ More challenging installation within oxidation pond. | ▪ More challenging installation within oxidation pond. | ▪ Standalone unit.<br>▪ Requires alignment with hydraulic profile of WWTP. | ▪ Either a retrofit of existing wetland or potentially significant civil works.<br>▪ Requires alignment with hydraulic profile of WWTP. |
| **Operability / Maintenance** | ▪ Base case maintenance. | ▪ Mechanical maintenance required. | ▪ Minimal maintenance required. | ▪ Maintenance of plants critical to performance. | ▪ Minimal maintenance required. | ▪ Some maintenance required. |
| **Performance Improvement** | ▪ Base case improvement. | ▪ Some improvement by increased DO. | ▪ Improvement by reduced short-circuiting in oxidation pond. | ▪ Performance improvement uncertain. | ▪ Potential for high $NH_4$-N removal. | ▪ Potential for high $NH_4$-N removal. |
| **Compatibility with Preferred Solution** | ▪ Does not affect final solution. | ▪ Aligns with IDAL solution. | ▪ Potentially aligns with IDAL solution. | ▪ Does not align with IDAL solution. | ▪ Does not align with IDAL solution. | ▪ Does not align with IDAL solution.<br>▪ Offers alternative long-term solution. |

# 4. Preferred Upgrades

Based on the comparative technical assessment of the short-term upgrades considered in this document, it is recommended that

- FNDC proceed with the required maintenance and operation activities.
- FNDC install baffle curtains and aeration units on the oxidation pond to provide improvement in treatment performance.

It is believed that these options combined offer a low-cost, simple to implement solution to enhance the aerobic treatment process which also aligns with the WWTPs long-term plan.

# 5. Interim Conditions

The review of the options available for interim upgrades and the likely performance of the preferred upgrade approach has been undertaken to inform the development of interim conditions for the effluent from the WWTP. The interim conditions will form part of the broader consenting strategy to provide a pathway to the ultimate long-term consent conditions and associated upgrade pathway (preferred solution is an IDAL process). As such, the interim conditions must align with the progression from the current operation of the WWTP to the final consented condition, considerations for this progression include:

- The current plant is receiving more flow and likely higher load than was anticipated under the current consent.
- Septage makes up a significant proportion of the influent loading which means a high BOD, NH4-N, and solids load to the WWTP which appears to be impacting on the treatment performance.
- The current consent includes in stream sampling which introduces factors which are outside of the control of the treatment process.

These factors mean that the interim consent conditions will be a departure from the current consent conditions and will not be directly comparable, especially as end-of-pipe conditions are being pursued. The conditions show an improvement in performance from what is currently being achieved by the plant. The proposed interim conditions are described in the following sections.

## 5.1 Condition 1 – End-of-Pipe Measurement

A key recommendation is that FNDC pursue WWTP effluent conditions measured at the end of the treatment process (end-of-pipe) rather than continuing with the in-stream conditions which are in the current consent. This will remove the impact of upstream issues and river water quality impacting on the consent compliance and will give FNDC a clearer understanding of the treatment performance required.

## 5.2 Condition 2 – Discharge Flow Limit

When applying for interim consent conditions we recommend pursuing average and 95th percentile dry weather flow conditions, rather than a maximum limit per the current consent. This allows for variation in flow from the catchment and for lingering impacts from wet weather outside the definition of “dry weather”. In the two-year period we reviewed the average of the 30-day rolling average of the dry weather flow (as defined in the current consent) was 1,871 m3/d and the 95th percentile flow was 2,388 m3/d.

## 5.3 Condition 3 – BOD, $NH_4N$, E. coli Limits

Table 4 summarises the current performance and the modelled performance of the WWTP with the proposed upgrades:

**Table 4: Kaikohe WWTP average effluent concentrations achieved currently and estimated by model performance considering WWTP design and aeration.**

| Parameter | Current Performance | Design Capacity (from Model of desludged ponds) | Proposed Interim Upgrades (Model of desludged ponds with Aeration) |
|---|---|---|---|
| **$BOD_5$ (mg/L)** | 19 | 14 | 1 |
| **$NH_4$-N (mg/L)** | 36 | 27 | 22 |
| **E. coli (MPN/L)** | 2,077 (median) | 65 | 65 |

As described above, modelled performance of the WWTP is the "ideal" in terms of removal rates and we have confidence in the modelled performance regarding $BOD_5$ removal and disinfection performance. Nitrogen removal performance is less certain. As such, the interim conditions which we expect to achieve should also consider typical treatment performance expected of a pond system with similar levels of treatment as that for Kaikohe WWTP.

The proposed interim conditions for the Kaikohe WTP effluent in terms of end-of-pipe effluent concentrations (based on desludged ponds with the addition of a baffle curtain and aeration in the oxidation pond) are:

- $BOD_5$: 95 percentile concentration of below 30 mg $BOD_5$/l
- $NH_4$-N: 95 percentile concentration of below 30 mg $NH_4$-N/l
- E. Coli: Disinfection performance of 4 log removal, achieving a geometric mean of effluent sampling results below 1000 MPN/100mL.

These conditions are higher than the final effluent concentrations predicted by the model. Again, it should be noted that the model shows an idealized removal of $BOD_5$ and E. coli, and that the ammonia removal modelling is uncertain. The model results presented at this stage are also dependent on assumptions around influent data and pond conditions, which require validation by interstage test results. However, the modelling does provide a level of certainty around the expected WWTP capability to achieve the proposed interim conditions. As the proposed interim conditions must be able to be met at all times, they need to account for spikes in loading (such as those experienced when receiving septage), maintenance activities, climactic changes, and other non-ideal conditions at the WWTP.

### 5.4 Condition 4 – Monitoring Frequency

We propose that the end-of-pipe effluent parameters be monitored on a monthly basis and aligned with similar consents held by FNDC, to reduce the compliance complexity which is brought about by the current consent conditions.

## 6. Recommendations & Next Steps

Based on the technical evaluation of the interim upgrade options available we recommend that FNDC proceed with the necessary maintenance activities and install baffle curtains and aeration within the oxidation pond. The proposed interim conditions described in Table 4 are based on an assumed influent composition and further work is required to finalize the expected performance resulting from these upgrades. The next steps required as part of Jacobs scope are:

- Receive and review interstage sampling results and update the model as necessary
- Review interim treatment upgrades with FNDC and their consenting consultant to discuss the upgrade approach and interim consent condition expectations
- Finalize this review and the recommendations based upon receiving feedback on these deliverables from FNDC.

The maintenance activities discussed in this document (desludging the pond, reinstating and maintaining the screen, removing surface plant growth, and maintaining wetland planting) will be ongoing and are also required at other FNDC sites. It is recommended that FNDC develop a maintenance program for all their WWTPs to ensure these activities are carried out as required. Jacobs can support the development of this program.

We have recommended that end-of-pipe effluent conditions are specified in the new consent. An assessment of environmental effects (AEE) will be required to support this. It is recommended that FNDC collaborate with mana whenua and other stakeholders as part of the consenting process.

In parallel with the consenting process the selected interim upgrades will need to be developed further to concept design stage to enable accurate cost estimation for FNDC financial planning. Jacobs can support the delivery of the interim upgrades through to completion in partnership with FNDC.

## 7. References

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