BALANCING A COMMUNITY'S WASTEWATER ASPIRATIONS WITH AFFORDABILITY - THE GISBORNE EXPERIENCE

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ABSTRACT

On 22 March 2011, Gisborne District Council officially opened the Banks St Wastewater Treatment Plant. The $40M project, which provided a new milliscreening facility, biological trickling filter (BTF), industrial separation and screening, prior to discharge to the existing long sea outfall, was a major step forward in addressing many of the community's long term wastewater aspirations.

However, it was not considered to be a final solution. Council was required by consent to further investigate the feasibility of alternative use and disposal (AUD) options, with the ultimate goal of removing treated domestic discharges from the outfall.

This paper is a follow on to the 2009 Water NZ paper "Gisborne Wastewater Scheme: Successfully Re-Defining a Community Project". It provides a history of the Gisborne wastewater story from the commissioning of the long-sea outfall in 1965 through to the conclusion of the 2016 Alternative Treatment and Disposal study, which sets the scene for further options assessments. It describes the issues and challenges of scaling the alternative natural treatment pilot trial undertaken by GDC and NIWA to a full scale design and development of cost estimates. It also describes the development of the consented default Stage 2 design and the value-engineering work undertaken to progress towards a solution which meets the environmental, social, cultural aspirations of the community whilst balancing the economic impacts. This project is ongoing and is expected to conclude with a refined set of five options being ready for community consultation in August 2017.

KEYWORDS

Wastewater treatment, biotransformation, affordability, alternative use and disposal, stakeholder engagement

1 INTRODUCTION

The management of Gisborne's wastewater has been a contentious issue for decades. Like many other New Zealand communities, one of the biggest challenges has been tailoring the treatment required for safeguarding public health to the disposal method, and balancing this with the community's social, and cultural aspirations whilst maintaining affordability for the community at large.

On 22 March 2011, Gisborne District Council officially opened the Banks St Wastewater Treatment Plant. The $40M project, which provided treatment via a new milliscreening facility, biological trickling filter (BTF), industrial separation and screening of large industrial flows, prior to discharge via the existing long sea outfall to Poverty Bay. This was a major step forward in addressing many of the community's long term wastewater aspirations. However, it was never considered to be a final solution. Council was required to investigate the feasibility of alternative use and disposal (AUD) options, with the ultimate goal of removing treated domestic discharges from the outfall. Furthermore, should AUD be determined to be unfeasible, Council would be required to proceed with installing a second BTF, solids separation and to provide disinfection by December 2020.

This paper is a follow on to the 2009 Water NZ paper "Gisborne Wastewater Scheme: Successfully Re-Defining a Community Project". It provides a history of the Gisborne wastewater story from the commissioning of the long-sea outfall in 1965 through to the conclusion of the 2016 Alternative Treatment and Disposal study, which sets the scene for further options assessments. It describes the issues and challenges of scaling the alternative natural treatment pilot trial undertaken by GDC and NIWA to a full scale design and development of cost estimates. It also describes the development of the consented default Stage 2 design and the value-engineering work undertaken to progress towards a solution which aims to meet the environmental, social, cultural aspirations of the community whilst balancing the economic impacts. This project is ongoing and is expected to conclude with a refined set of options being ready for community consultation in August 2017.

2 THE JOURNEY SO FAR

Gisborne's wastewater has been a contentious issue since before the current ocean outfall was installed in 1964. Prior to the outfall, wastewater was dealt with in a number of different ways. Two surf-zone outfalls were in use at Midway and Kaiti beaches. By 1964 these short outfalls were largely undersized. Other parts of the city were served by a night-cart collection system followed by landfill disposal. Neither of these disposal methods were acceptable for the Gisborne community.

In 1964, Gisborne District Council (GDC) (through its predecessor Gisborne City Council) constructed a comminutor system, outfall pump station and ocean outfall at the Stanley Road site at Midway Beach for the discharge of domestic and industrial wastewater some 1.83 kilometres offshore into Poverty Bay. The 762mm internal diameter concrete pipe stretches 1.7km out into Poverty Bay. The final 189m is fitted with 22 diffuser ports. Originally the diffusers ports were open orifices. Following identification of sediment buildup and blockages, the openings have been fitted with either duckbills or culvert socks. The Gisborne outfall was considered innovative in its time, as it was the first post-tensioned, precast concrete segmental outfall in the world.

The outfall was the only wastewater disposal infrastructure in Gisborne from 1964 to 1990. A feature of the Gisborne wastewater flows were the high proportion and high loads of trade wastes flows from primary process industries based in the city.

In 1990 a milliscreening plant was constructed at the end of Stanley Road. The 1mm aperture, rotating drum milliscreens were operated continuously from 1990 until they were decommissioned at the opening of Gisborne's new WWTP at the end of 2010.

In 1991, GDC lodged applications seeking coastal permits to continue utilising the ocean outfall. Permits were granted through to 1999 on the provision that GDC would evaluate and implement a long-term wastewater disposal scheme. Upon expiration of the consent in 1999, GDC applied for a seven year extension to the coastal permits, however an extension of only four years was granted.

This resulted in a tumultuous period for GDC. Local tangata whenua appealed to the Environment Court, on the grounds that raw wastewater discharge to the ocean broke the relationship of tangata whenua with the moana (sea) and kaimoana (seafood). GDC sought an adjournment to the Court hearing to allow time for consultation and development of a wastewater strategy acceptable to local iwi and other stakeholders.

Council applied for new consents based on construction of a primary sedimentation treatment plant by 2010, with upgrade to high rate activated sludge (HRAS) and UV disinfection by 2016. However, at the same time, pilot plant studies were being undertaken at Hastings utilising a trickling filter process with ultra-low BOD loading (per unit volume of trickling filter media), now commonly referred to as the biological or biotransformation trickling filter (BTF) process. The BTF process had the potential to recognise the concerns of tangata whenua associated with the treatment and disposal of human waste:

"A biological trickling filter (BTF) uses biological processes involving micro organisms to convert solid and fluid (dissolved) human (and other organic) wastes into carbon dioxide, water and excess cell (plant) biomass. The effluent stream from the BTF is no longer considered to be human in character and as a consequence, is inoffensive to tangata whenua and suitable for discharge through the long outfall." (Fraser & Bradley, 2007)

The Gisborne consenting process was adjourned to enable the Wastewater Adjournment Review Group (WARG) to compare the two treatment processes – HRAS and BTF – and to recommend to Council an agreed strategy that was most appropriate for Gisborne. After various investigations, costings, hui and public submissions a decision was reached to upgrade the wastewater treatment scheme in a staged project utilising the BTF process, with further upgrades to remove biological solids and install UV disinfection in the following years. The hearing for new consents and treatment plant designation was reconvened and the appropriate consents were granted to GDC in July 2007 and the associated Restricted Coastal Activity permits were approved by the Minister of Conservation in September 2007. Subsequently, design of the Gisborne Wastewater Scheme commenced in October 2007 with CH2M Beca Ltd engaged by GDC as the project consultants.

Following granting of resource consents in 2007, the costs of the originally consented scheme exceeded Council budget expectations and was deemed to be unaffordable. In 2009 a variation to the 2007 consent was sought and granted, which allowed for a single BTF with double the originally consented BOD loading to be installed during Stage 1 and for the WWTP to be moved to a new site closer to the city. The latter provided significant cost savings.

In 2015 a further consent variation was sought which allowed the deferral of the Stage 2 construction of a second BTF (to reduce BOD loading) and to provide clarification and disinfection, in order to allow Council and a Wastewater Technical Advisory Group (WTAG), a community stakeholder group, to further investigate the technical feasibility of alternative treatment and disposal options, with the ultimate goal of completely removing human-derived treated wastewater from the outfall. Clause 8 of the Decision states:

"The permit holder shall use its best endeavors to adopt those AUD options that are identified as feasible and which will enable the progressive removal of the treated human sewage from the discharge, via the marine outfall, with the objective of complete removal by 2020." (Watson, June 2009)

3 GOVERNANCE AND COMMUNITY COLLABORATION

3.1 WASTEWATER MANAGEMENT COMMITTEE

The 2007 consent stipulated the establishment of the Wastewater Management Committee (WMC). The WMC was set up to provide a governance body comprising tangata whenua and elected councilors, with the goal of reaching a just, equitable and sustainable outcome in terms of how Gisborne manages their sewage and industrial wastes.

3.2 WASTEWATER TECHNICAL ADVISORY GROUP

Following the granting of the 2015 variation, the WTAG was established with participants from multiple sectors of the community bringing varied and high levels of expertise to inform decision-making and guide the development of the AUD study. The WTAG was tasked with investigating the feasibility of Alternative (AUD). Representatives from iwi groups, the medical officer of health, local environmentalists, industry and other stakeholders who had been active in the development of the wastewater solutions over the previous decades were brought together to frame up a program of work to assess the feasibility of AUD within the Poverty Bay region.

A key objective of the group was to utilize natural treatment processes such as wetlands, as opposed to the more conventional, highly mechanical or high rate biological systems. A particular emphasis was placed by the WTAG on restoring the *mauri* or life force of the water. This was considered to go beyond the original concept of "Biotransformation" as defined in the 2007 consent, to a level of treatment which essentially removed as much human derived contaminants as possible. Human derived contaminants went beyond the conventional suite of contaminants such as BOD, TSS, Nutrients and faecal bacteria that wastewater treatment plants are designed for and was expanded to consider the level of human DNA reduction across the process, as well as an assessment of reduction of emerging organic contaminants.

The WTAG with assistance from NIWA, ESR and Northcott Research developed a program of work to investigate international developments in natural treatment methods and emerging technologies, and they developed a program of Gisborne-specific wastewater testing and a pilot trials. The focus of this paper is the latter stages of the investigation, the pilot trial study and the subsequent conceptual design phases.

3.3 SOCIAL OUTCOMES REVIEW

A Social Outcomes Evaluation Review (Palmer, 2010) was undertaken by the WTAG in 2010 and provides a baseline assessment of community values with respect to the marine environment, recreation, shell fish gathering, tourism, public health, economic impact and rating impact amongst other parameters. The report concluded that the primary concerns of those opposed to the discharge to the marine outfall related to:

- Effects on the health of water contact users
- Effects on the relationship of tangata whenua with the Moana
- Impacts on the social wellbeing of tangata whenua
- Removal of the shellfish and other kaimoana beds as a safe source of food
- Effects on the environment and marine ecology

Effects on others' perceptions of how we manage our affairs i.e. disposing untreated human waste to the ocean.

The primary concerns of those who opposed the 2010 upgrade, and hence are also unlikely to support a further upgrade, included:

- Costs to ratepayers
- Considered that the current discharge works well
- Considered that there are no effects on contact water users' health and wellbeing
- Considered that the flats around Gisborne are too valuable to be used for sewage treatment and disposal
- Considered that supporters of an improved system are a small albeit vocal minority.

3.4 EMERGING ORGANIC CONTAMINANTS

Natural treatment systems such as wetlands were also considered by the WTAG to provide greater level of emerging organic contaminant (EOC) degradation over conventional treatment systems due to the increased hydraulic retention time of the effluent and exposure of EOCs to a wider range of removal and degradation processes operating over an extended period of time, including:

- A wide range of adsorbing substrates including plant surfaces, algal biomass, and wetland sediments
- Increased exposure to sunlight (photolytic degradation),
- A combination of aerobic and anaerobic degrading micro-organisms,
- Plant derived degrading enzymes

Reduction of EOCs was considered by the group to be complementary to the principles of restoring the *mauri*. Northcott Research Consultants Ltd were engaged to investigate the effectiveness of the BTF of removing or reducing EOCs from municipal wastewater (Northcott, 2017).

The study assessed 81 different EOCs across seven broad classes and concluded that the Gisborne BTF achieves greater than 95% reduction for most of the analysed EOCs. Most of the EOCs analyzed were reduced to acceptable levels (Northcott, 2017). Twenty two demonstrated resistance to treatment and persisted in the dissolved and/or the particulate phases of the effluent or biosolids. Of particular interest was the fate of the residual EOCs, with 13 being present in both dissolved and particulate phases, 9 in just the particulate phase and one only in the dissolved phase. Removal of solids from the effluent stream would therefore have a positive impact on the overall EOC removal, however further investigation is required to assess the effectiveness of EOC destruction through different biosolids treatment methods. Options utilizing surface flow constructed wetlands and wood chip filters were recommended in order to treat the residual soluble phase EOCs.

4 ALTERNATIVE TREATMENT

4.1 PILOT TRIAL

The WTAG commissioned NIWA to develop pilot trials of an enhanced wetland and pond system (EWPS) pilot trial and of a sludge treatment reed bed. The objective of the trials were to:

- Confirm treatment removal efficiencies that could be achieved through a tertiary EWPS with respect to BOD, SS, TN, TP and E.coli.
- Confirm process design parameters for a scaled up system
- Determine operational factors which would need to be addresses in a scaled up system such as odour and insects, as well as suitability of selected plant species for the local climate.

The pilot system (Figure 1) consisted of the following unit processes in series:

- Settling tank for removal of BTF biomass.
- High Rate Algal ponds (HRAP) for sunlight disinfection and removal of organic compounds and nutrient.
- Algal Harvesters (AH) to collect the nutrient-rich algal biomass for nutrient recovery
- Surface Flow Constructed Wetlands (SFCW) for further disinfection and removal of organic compounds and nutrients
- Woodchip Denitrification Filters (WDF) for the removal of residual nitrate-N (i.e. denitrification), situated halfway along the SFCW.

The sludge reed bed pilot consisted of a series of sludge lysimeters with different growth media or plant species. The pilot was operated by GDC staff from February 2016 to August 2016.

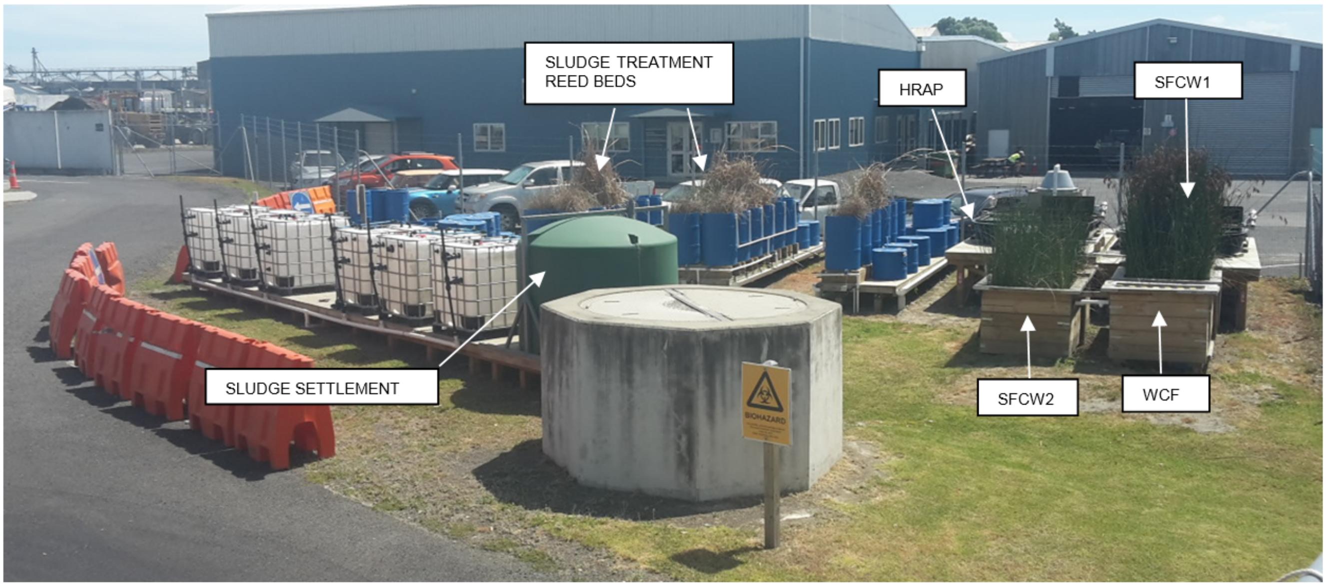

Figure 1: EWPS Pilot Trial (Nov, 2016) following completion of trial and during trial (NIWA, 2016).

Removal of total/volatile suspended solids (TSS/VSS), BOD5, nitrogen, phosphorus and E.coli was monitored throughout the trial period. Not all parameters were measured across all units, although as a minimum the settled BTF effluent and discharge from the final SFCW was monitored. The final effluent concentrations achieved across the pilot are summarized in Table 1 which show final effluent concentrations of less than 5mg/l for all parameters were achievable.

Table 1: Mean Pilot Plant Final Effluent Quality and Removal Efficiency Across EWPS (Tanner, 2016)

Parameter	TSS (mg/L)	cBOD5 (mg/L)	NH4-N (mg/L)	TN (mg/L)	TP (mg/L)	E.coli (cfu/100ml)
Raw influent to WWTP#	199	206	NM	NM	NM	NM
Post BTF (unsettled) #	71	27	NM	NM	NM	NM
Influent to HRAP Concentration (post settlement)	6.4	8.0	5.69	10.14	3.36	3.8E+0.4
Effluent Concentration	4.3	2.9	0.32	2.1	1.4	1.5E+1
Removal efficiency across EWPS	33%	64%	94%	80%	59%	3 log reduction
Removal efficiency across complete treatment system	97.7%	98.7%	NM	NM	NM	NM

NM Not Measured
\# Based on compliance monitoring data for period 23 February to 7 June 2017

The quality of the settled BTF effluent during the trial period was very good which meant the feed concentrations to the EWPS was very low. The EWPS was able to achieve very low concentrations of all the measured parameters in the final effluent and results which are comparable with more conventional advanced biological and tertiary treatment processes.

The BTF sludge settled rapidly and effectively, as shown by the low TSS in the feed to the HRAPs. Where compliance monitoring of the BTF feed and discharge to the outfall coincided with pilot sampling, the overall BOD and TSS removal efficiency was able to be evaluated and is shown in Figure 2. Prior to settlement the BTF was achieving 89% removal of BOD, which increased to 96% with settling and 98% with the tertiary EWPS. Likewise the TSS removal efficiency increased from 75% with just a single BTF, through to 96% with clarification and 97% with the EWPS.

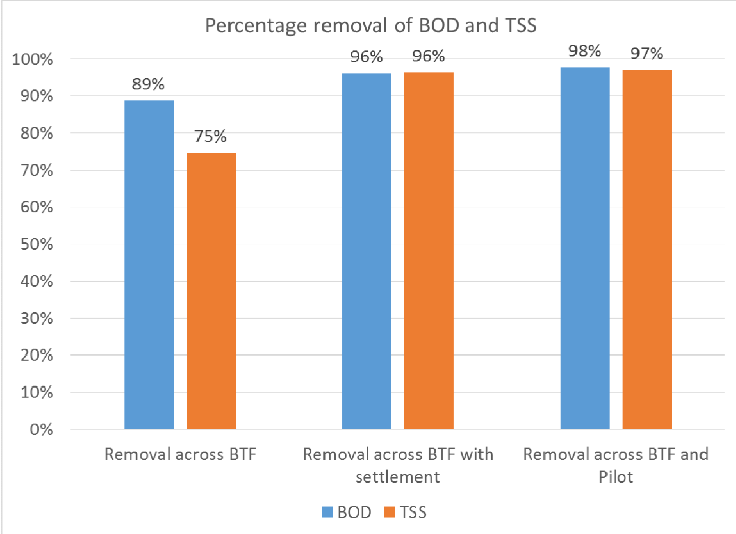

Figure 2: BOD and TSS Removal Efficiency

Of the individual unit processes, removing the biomass from the influent stream through clarification provided the single biggest net improvement in effluent quality with respect to BOD and TSS. The nitrogen and phosphorus concentrations in the raw or unsettled BTF effluent were not measured, so the removal of nutrients in the particular phase was unable to be assessed.

Of the natural treatment systems, the HRAPs provided the greatest level of treatment as the algal biomass consumed BOD and assimilated phosphorus. During the autumn period the HRAPs were able to achieve a 4 log E.coli reduction, but this dropped to 1 log during winter but was compensated for by the two surface flow wetlands and wood chip filter each achieving a 1 log reduction. The downstream SFCW and WCF provided incremental benefits, although due to the pilot units being configured in series, and hence the diminishing load to each subsequent unit, the individual performance of each unit could not be compared against the others.

Through pilot trialing the EWPS the WTAG and GDC were able to establish that a very high level of tertiary wastewater treatment could be achieved with a natural treatment system.

4.2 ENHANCED WETLAND POND SYSTEM SCALE UP CONSIDERATIONS

Following initial establishment of the pilot trial, CH2M Beca Ltd were engaged to provide a scaled up engineering concept and cost estimate of the EWPS (Option 1). In addition, a second option was developed which primarily focused on solids separation should the EWPS not proceed (Option 2). In order to meet the consent timeframe, the conceptual design was based on preliminary pilot results, and modified once the pilot was completed. The preliminary sizing was provided by NIWA to allow the conceptual design to proceed.

4.2.1 PROCESS OVERVIEW

BTF effluent would be pumped from the WWTP to the remote EWPS site. BTF solids in the effluent would be removed in four V shaped earth embankment settling ponds by gravity settling. The settled solids would be drawn off the V shaped base of the settling ponds and discharged to four sludge digesters. The clarified effluent would then gravitate to 16 high-rate algal ponds (HRAPs). The HRAPs would promote the growth of algae to remove dissolved nutrients from the wastewater and were configured in two banks of 8. During summer these banks would operate in series to maximize retention times. In winter they would operate in parallel to maintain adequate retention times under the higher winter flows. The effluent from each HRAP would be pumped to associated algal harvesters (16) with similar V shaped geometries to the sludge settlers, where the algae is separated from the effluent. Most of the algae would be pumped to algal digesters (8), with 10% by volume returned to the associated HRAP.

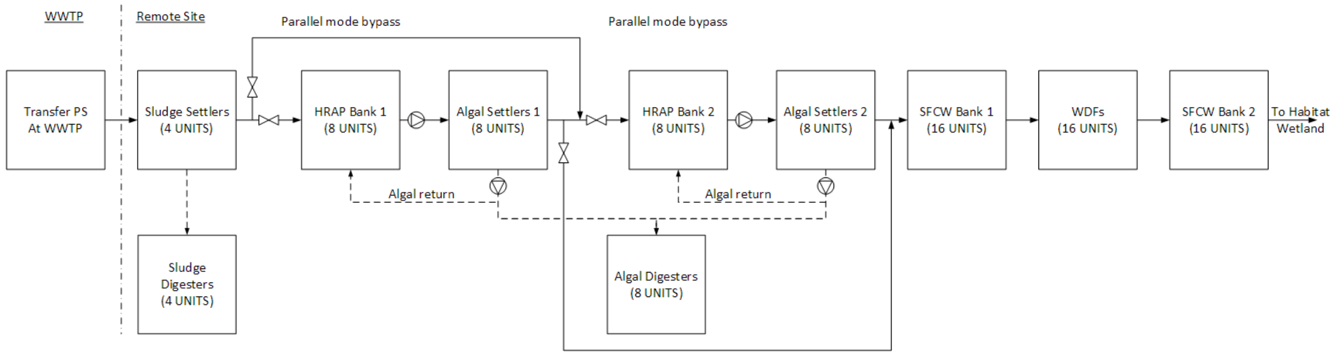

Figure 3: Gisborne WWTP Upgrade Option 1 Process Flow Diagram

The clarified wastewater from the final algal settlers would gravitate to surface flow constructed wetlands (SFCWs) configured as 16 parallel trains, which provide further treatment of dissolved organics and microbial contaminants. Woodchip denitrification filters were positioned in the middle of the SFCW and provide denitrification. The discharge from the SFCW would be discharged to a habitat wetland.

Overall the site coverage was in the order of 82 ha. Once boundary setback buffer allowances were included, typically in the order of 50 to 150m, the site required in the order of 100 - 150ha. The cost of acquiring a suitable site or the opportunity cost of converting productive land was not included in the cost estimate.

4.2.2 DESIGN FLOWS

The biological processes used in the EWPS would be subject to seasonal variation, and the treatment performance of the HRAPs in particular would be limited by lower algal growth rates in winter. As a result the scale up system was sized based on the winter flows (average 17,500m³/d, peak 39,900m³/d) and loads from the BTF. Allowances were also required for accumulated rainfall and 10% internal algal recycle streams. A summary of the design parameters for each process unit is set out in Table 2.

Table 2: *Option 1 Summary of Process Units and Design Parameters (NIWA, 2016)*

Process	No of Units	Unit Dimensions (m)	Operating Depth (m)	Unit Working Volume (m³)	System Hydraulic Residence Time
BTF Sludge Settlers	4	74x8x4.5 m	4	1125	4 hours
High Rate Algal Ponds	16	524x39x1 m	Summer: 0.3 Winter: 0.45	5469	Summer (series operation): 7.6 days Winter (parallel operation): 7.5 days
Algal Harvest Pond	16	27x9x4.5 m	4	365	Summer: 4 hours Winter: 8 hours
Surface Flow Constructed Wetlands	32	244x39x1.1 m	0.3	5469	15 days
Woodchip Denitrifying Filter	16	36x38x1.1 m	1.0	1258	1.7 days
BTF Sludge Digesters	8	77x21x4.5 m	4	3694	6-12 months
Algal Sludge Digesters	8	76x21x4.5 m	4	3889	6-12 months

The following provides a summary of some of the design considerations and challenges associated with scaling the enhanced wetland pond system.

4.2.3 HYPOTHETICAL SITE LOCATION AND GEOTECHNICAL CONSIDERATIONS

In the absence of a specific site, the option development considered a hypothetical flat site within a 2 to 8 km pumping distance of the WWTP (Figure 4). The study area was broken into five zones, each of varying geological characteristics and bound by wither the ocean to the south, Waipaoa River to the West and state highway 2 or 35. Consideration was given to the likely geological conditions prevalent within the Poverty Bay Plains study area and how they may impact on the constructability or configuration of the ponds. Assumed geotechnical conditions or risks requiring mitigation were elevated ground water, poor soil stability, seismic stability, liquefaction and/or lateral spreading and high permeability soils. These assumptions had a significant impact on the design and hence were considered to provide high cost risk uncertainty.

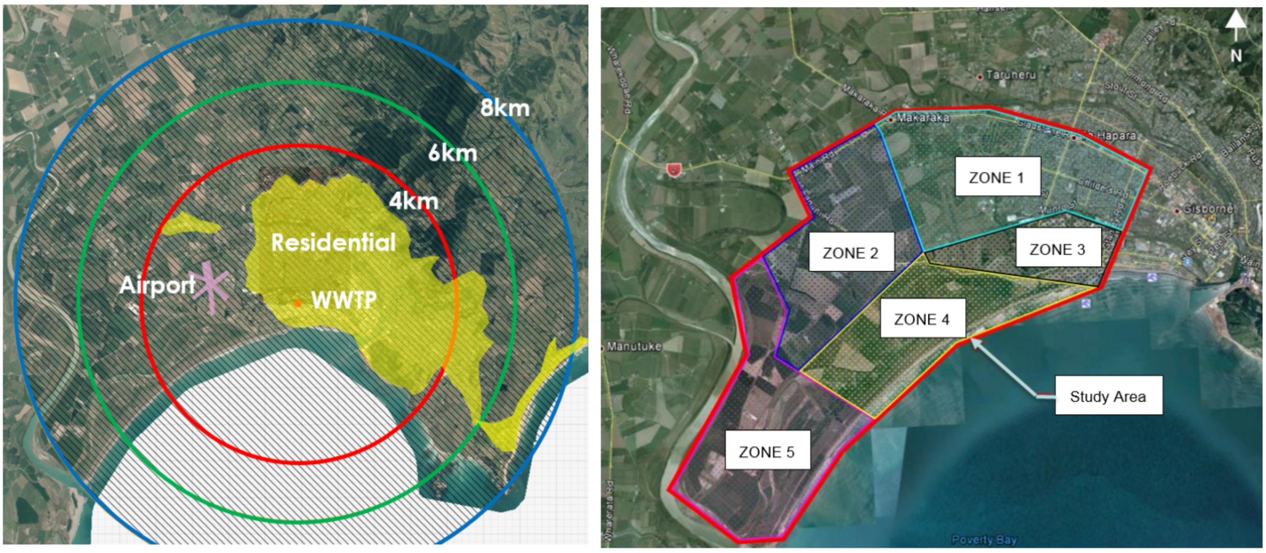

Figure 4: *EWPS Hypothetical Site Study Area*

The scale up configuration is shown in Figure 5. To provide perspective to stakeholders, commonly recognized scale items where used such as an Olympic swimming pool or a rugby field was used. Overall the site coverage for the scaled up EWPS is in the order of 82 ha. Including allowances for boundary setback buffers, typically in the order of 50 to 150m, could push the site well over 100 - 150ha. The cost of acquiring a suitable site or the opportunity cost of converting productive land was not included in the cost estimate.

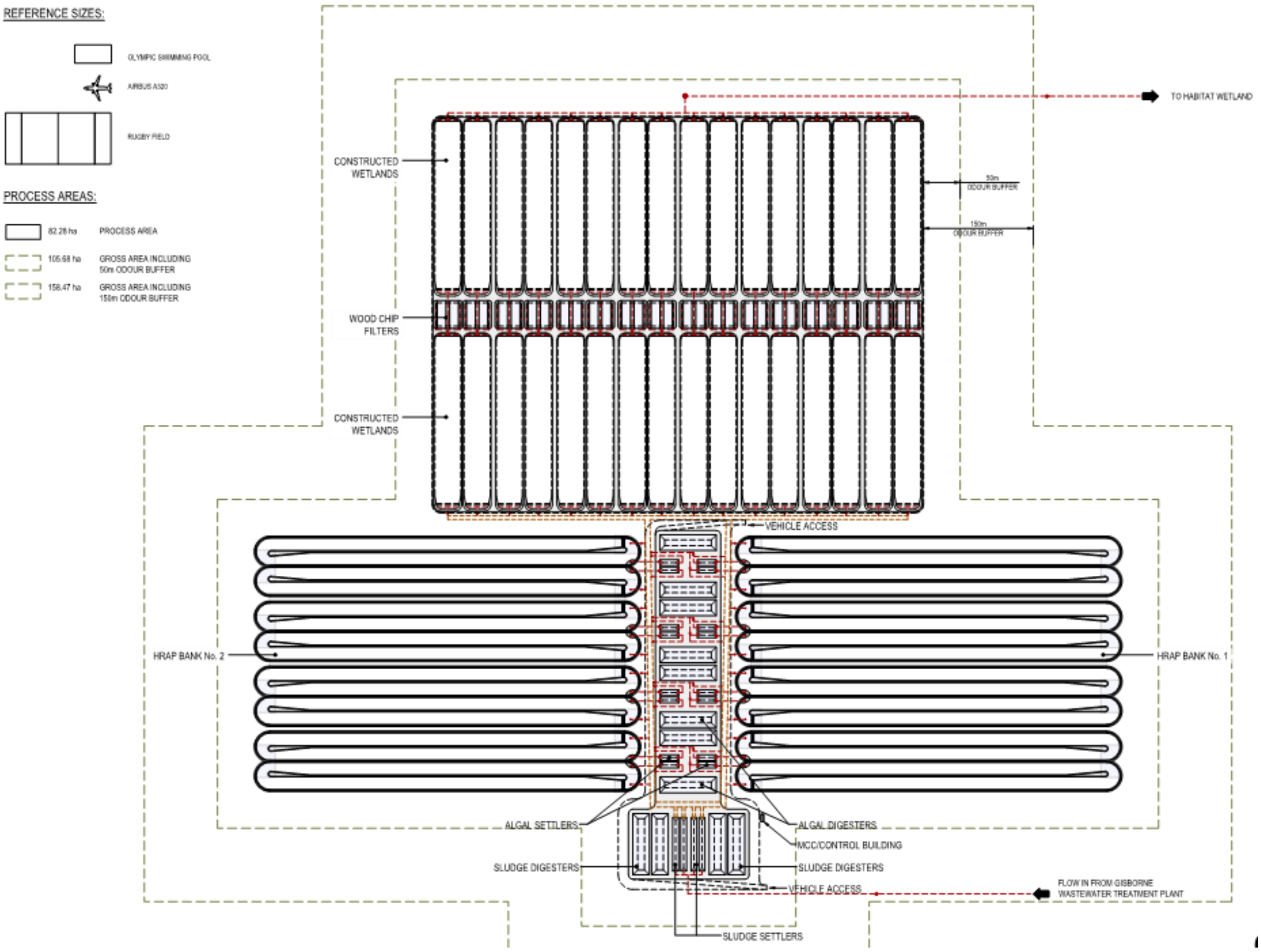

Figure 5: Enhanced Wetland Pond System Conceptual Layout (CH2M Beca Ltd, September 2016)

4.2.4 CONVEYANCE TO THE ALTERNATIVE TREATMENT SITE

Conveyance costs to the new site were considered for distances ranging from 2 – 8km from the existing Banks St WWTP, with a 6km rising main selected for the conceptual cost estimate. The assessment concluded that sizing the pipeline for the average flow (170 l/s) gives significant head losses at peak flows (460 l/s) and the pumping power required for pipelines longer than 2 km would be higher than what can be supplied by a single set of pumps. Using a larger 710mm OD pipe sized for peak flows and single stage intermittent pumping was considered preferable to a smaller diameter rising main with an intermediate booster station. If one site large enough for the system could not be found, multiple sites would be required, with additional conveyance cost to transfer wastewater between sites. Given that rising main cost estimates range from $4.7 – 12.3 million, and the pump station at the Banks St WWTP was estimated to cost $1.3 million, finding a single contiguous site was recommended.

4.2.5 V SHAPED SLUDGE SETTLING PONDS

The proposed sludge and algal settler ponds were nominally 4m deep with 0.5m freeboard and required 1:1 internal batter slopes. Due to the expected elevated water table limiting the ability to construct or maintain the deeper ponds, the settlers and digesters were set with a minimum -1.5m excavation depth and minimum invert level of -1m resulting in large above ground bund construction. In addition, due to the poor soil stability prevalent in the study area, the 1:1 batters required further geotechnical stabilisation. Both settler ponds and digesters would be HDPE lined to prevent discharges to groundwater or bund destabilisation. The costs associated with forming, stabilising and lining the steep pond bunds and providing trafficable access was significant.

The geometry of the proposed settling ponds was based on the scaled pilot installation at Cambridge but had not been tested at full scale. As such there were no off the shelf proven sludge removal technologies for the proposed design geometry and the V shaped settlers were considered to carry elevated technical and process risk. An alternative to sludge/algae settling ponds could be to utilise conventional settling tanks with lamella plates to minimise the footprint. Due to the high construction costs and the technical and process risks, it was recommended that the pond based settling processes be replaced by more conventional designs.

4.2.6 HIGH RATE ALGAL PONDS (HRAP)

The purpose of the HRAPs is to remove dissolved BOD, nutrients, and microbial contaminants from the wastewater through algal photosynthesis and sunlight UV disinfection. Pond depth ranges from 0.3m – 0.5m depending on the inlet flowrate. Algal grown in the ponds is removed in downstream algal harvesters

HRAPs are typically long and narrow, with a central baffle creating two channels and giving the ponds their characteristic 'racetrack' shape. The algae ponds are mixed using slow-speed paddlewheels, which also serve to move wastewater around the ponds. The width of the channels, and hence the overall width of the pond, is set by the need to maintain a minimum forward velocity (~0.2 m/s) to keep the algae in suspension.

Each HRAP required a dedicated submersible pump to transfer flows from the HRAP to its associated algal harvesting pond. Low shear pumps, to minimise algal floc damage, were recommended for this duty.

Due to the requirement to switch between parallel and series operation the hydraulic distribution was complex and had large pipe diameters and lengths resulting in increased cost. Optimisation of the hydraulic distribution requirements once an actual site was secured would be required.

4.2.7 ALGAE HARVESTING PONDS (AHP)

These operate on a similar basis to the sludge settling ponds. Each HRAP required a dedicated AHP, to allow isolation and control of undesirable algal species.

Algal solids are typically more difficult to remove from water than conventional wastewater biomass, and so longer retention times are required for the solids to settle out. Successful sedimentation depends on algae forming a floc, which is somewhat fragile and can be broken up by pumping between the HRAP and the AHP. Allowance for polymer addition to the wastewater to improve sedimentation during periods of sub-optimal flocculation was included in the scheme cost estimates.

Solids collected in the settling ponds is extracted and pumped to further treatment. Ten percent of the sludge collected each day in each harvester is returned to its upstream HRAP to maintain the algal population.

4.2.8 SURFACE FLOW CONSTRUCTED WETLANDS AND WOODCHIP DENITRIFYING FILTERS (SFCW & WCF)

The surface flow wetlands and wood chip filters were also configured in 16 trains. Wastewater flows through the first bank of 16 SFCWs to the WDFs, and then into the second bank of 16 SFCWs. The wetland would provide further treatment and polishing of the algal settler and wood chip filter effluents. Whereas the woodchip filter provides for denitrification.

4.2.9 TO LINE OR NOT TO LINE?

The scaled up tertiary EWPS proposed earthen ponds for all treatment processes including sludge and algal settlement. Lining the ponds minimizes discharges to land and ultimately groundwater, as well as provides a degree of protection of the civil structures. Lining the deep sludge and algal settling ponds was considered fundamental. However the need to line the HRAPs and Wetlands was less clear.

Overall the HRAP ponds covered 47 ha and the Wetlands 35 ha. A high level review of the cost differential for different liner options was undertaken. Given the large areas required, wholesale HDPE lining of the HRAPs and wetlands was considered to be cost prohibitive. Based on the experience at the Cambridge demonstration plant, it was assumed that the Gisborne HRAP and wetlands would self-seal over a period of weeks or months, avoiding the need for a fully impermeable liner system. However a woven geotextile embankment protection was considered necessary for the HRAPs and wetlands. This is a significant cost assumption, and once a preferred site is identified, allowing consideration of actual geology rather than assumed, the potential impacts of discharges to groundwater from both the HRAPs and the wetlands would need to be assessed and the consentability of discharges to groundwater reviewed. Likewise a technical assessment of the likely volume and duration of the discharge from each process would need to be made to validate this assumption.

4.2.10 BIOSOLIDS TREATMENT AND DISPOSAL

Two options for treatment of solids collected in the clarification stages, were considered depending on the type of solids. The BTF solids could be treated in either a dedicated sludge treatment wetland, or ambient-temperature digesters. Algal sludge could also be treated in separate digesters.

Sludge Treatment reed Beds (STRBs) were pilot trialed at Banks St. The scale up STRBs would have been provided as a proprietary system by a European provider. The pilot trial highlighted that growth media specification and native plant species selection was critical. Issues with odour were reported, and it was determined that the reeds required irrigation in order to maintain the plant hydration in the dry Gisborne climate. A scaled up STRB would have required between 3 -7.5ha (excluding buffers). Due to some of the technical risks and the high degree of cost uncertainty GDC decided not to develop the STRB concept further.

An alternative to the STRBs is low-rate digestion of the solids in covered anaerobic ponds. BTF and algal solids would be digested separately to allow the digested solids to be sent to different end uses. Each pond would have a flexible membrane cover, with rainwater collection on the surface, and biogas collection underneath. Liquid digestate decanted from the algal digesters would be removed from site for use as fertiliser. Digestate from the BTF digesters would be returned to the plant inlet. Digested solids would be removed annually for disposal or use off-site.

The main benefit of the sludge digesters is the conversion of volatile solids to methane gas, which reduces the mass of solids which would need to be disposed of, and production of a gas stream which can either be flared or used for energy generation.

The final choice of biosolids treatment process will ultimately depend on the chosen end use or disposal route for the biosolids. Currently Gisborne does not have a regional landfill, and so all solid wastes, including screenings from the WWTP are transported out of district. There are also no local waste facilities or commercial entities in the district which can receive the biosolids. Therefore the default disposal option was assumed to be transporting all solids out of district to landfill. Finding a long-term reuse or disposal route within the district is required, and further work, including biosolids options assessment and community engagement is considered necessary to establish the most suitable long-term method for biosolids disposal.

4.2.11 CAPITAL COST ESTIMATE

Capital cost estimates (minus 15% to plus 25% accuracy) were developed. The cost estimates included allowances for implementation and contingency, but not land purchase or Council's internal costs. Due to the large areas and earthwork volumes and the current escalation in construction rates observed in many regions around New Zealand, the construction rates were benchmarked against Council held rates for local projects and by a large national Civil Contractor and adjusted for local differences. Including 11% and 15% allowances for implementation and contingency respectively, the full EWPS scheme was estimated to cost $61.4M with an addition $8.3M for pumping and 6km of rising main. The operation cost of the EWPS was assessed at $715K per annum based on pumping and major mechanical equipment power costs, polymer, labour and biosolids disposal.

The EWPS option was developed with the goal of treating the wastewater to a standard which is suitable for disposal to land or surface water rather than the ocean, in line with the goals of the WTAG and WMC. The utilization of natural processes was considered to contribute to the cultural restoration of the water's 'mauri' or life-giving energy. While these are desirable outcomes there are a number of technical challenges which must be overcome in order to develop a system which provides these benefits at a cost which is affordable to the local community.

While it was expected that the EWPS system would be able to provide a high level of treatment for BOD, TSS nutrients, and faecal indicators, the actual expected effluent quality across the process and between process units was not available until the pilot trial was completed. This information was crucial to determine a suitable receiving environment for the treated water and determining if all the treatment stages set out in the concept design provide sufficient benefit given the significant construction cost.

In the absence of specific sites for the natural treatment options and habitat wetland / discharge location, a number of assumptions were been made which had a significant bearing on the WOL costs. Some of the major assumptions which had significant bearing on the cost estimates for natural treatment options are summarised below:

- Conveyance: Adds approximately $8.3M capital cost to all EWPS options without adding any treatment benefit. If suitable sites were able to be secured closer to Banks St, this cost could be reduced.
- Site topography: A number of assumptions have been made regarding the site topography and degree of levelling required to construct the natural processes.
- Ground Conditions: Due to the shallow groundwater likely to be encountered in the study area, all processes using deep ponds have been designed to be built out of the ground. This introduces higher capital costs associated with structural stabilisation of the earthen bunds and the required quantity of imported materials to construct the walls.

- Liners: the options assume that the HRAPs and wetlands will be largely unlined, with sufficient lining only to protect and stabilise the earthen bunds. The deep ponds, digesters and woodchip filters are all assumed to be HDPE lined. This assumption carries a high cost risk as it assumes that the unlined HRAPs and wetlands will self-seal over time and any discharge to ground will be consentable. It may also be a condition in any new consents that lining of these facilities is required to minimise seepage to sensitive ground-waters (depending on the sites finally selected).

Operational costs for both natural and conventional treatment are heavily influenced by the power cost for pumping both to and from the sites, or inter-process pumping. In addition, there is a significant capital and operating cost associated with biosolids thickening, dewatering and disposal for both natural and conventional treatment options. This could be reduced through development of a local reuse market or local disposal site for the dewatered biosolids, however in the absence of a viable existing local disposal option, out of district trucking and landfilling has been assumed as the worst case.

5 CONVENTIONAL TREATMENT

Option 2 focused on providing clarification of the BTF effluent prior to discharge to the existing ocean outfall. BTF effluent would be pumped from a new pump station to lamella clarifiers, then gravitate to the existing outfall pump station. Solids collected in the clarifiers would be pumped to the solids handling system, which was based on gravity belt thickening and either centrifuge or screw press dewatering stages to increase the solids content of the sludge to the levels required for off-site disposal. A new building with MCC room would be required to house the thickening and dewatering equipment Provision was made to install a second BTF and UV disinfection in the future in order to meet the default outfall consent requirements for TSS and enterococci. A process flow diagram of this process is shown in Figure 6.

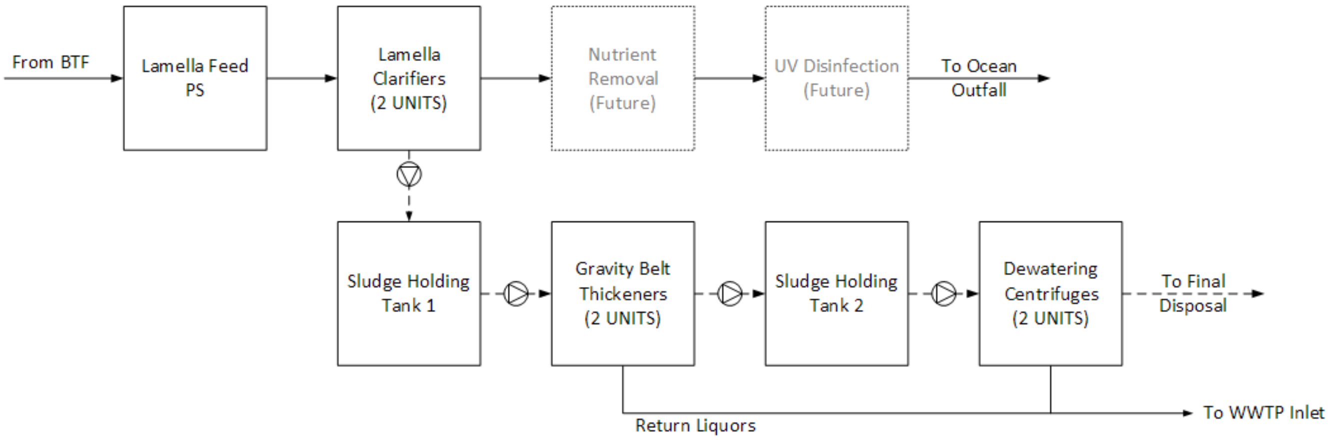

Figure 6: Gisborne WWTP Upgrade Option 2 Process Flow Diagram (CH2M Beca Ltd, September 2016)

The capital cost, including implementation and contingency was estimated at $17.7M.

Option 2 was developed to meet the standards required by the WWTP's ocean discharge consent if removing the domestic wastewater discharge from the ocean was not considered to be technically feasible or economically viable. As these standards only cover TSS, FOG and faecal indicators (Enterococci when discharging to ocean), a less extensive level of treatment is required. This option was primarily developed as a fallback treatment system if Option 1 is not considered feasible, as it uses conventional physical and mechanical processes to treat the wastewater, and so may not offer any restoration of the water's 'mauri'.

As the system employs well-understood systems and is located at the existing WWTP site where the ground conditions are well understood, the main technical challenges of this option related to the optimization of the system to suit the known ground conditions and sizing treatment units appropriately.

During the design of the original Banks Street Gisborne WWTP, high groundwater levels, liquefaction and lateral spreading where identified as key design considerations. As a result significant ground improvements are required to improve founding conditions and seismic performance of any structures built on the site. The most suitable type of ground improvements are costly, and so the treatment processes used were chosen based on both suitability and footprint. The configuration of the system was also developed with the goal of reducing the footprint of the system. This resulted in lamella clarifiers being chosen over other sedimentation systems, and a two-story biosolids building rather than spreading out the treatment equipment on one level. The site designation allowed for future expansion but would require demolition of some adjacent buildings to accommodate the upgrade. Minimising the footprint so as to limit the impact on the adjacent businesses was preferable (Figure 7).

Solids from the effluent of BTF systems is commonly co-settled with other solids in a primary sedimentation step, producing a combined solids stream for further treatment. The Banks St system does not include primary sedimentation, and so co-settling is not feasible. The solids stream produced from the proposed clarifier would be solely BTF solids, and the settling and dewatering behavior of this system is less well-understood than for the combined solids stream, or for other types of wastewater sludge. For the concept design a number of conservative assumptions were made in order to size the clarifiers and the sludge handling equipment, but further investigation would be required for final sizing if the option proceeds to final design. In particular the hindered settling rate of the solids and the sludge’s ability to separate when spun or drained will need to be evaluated.

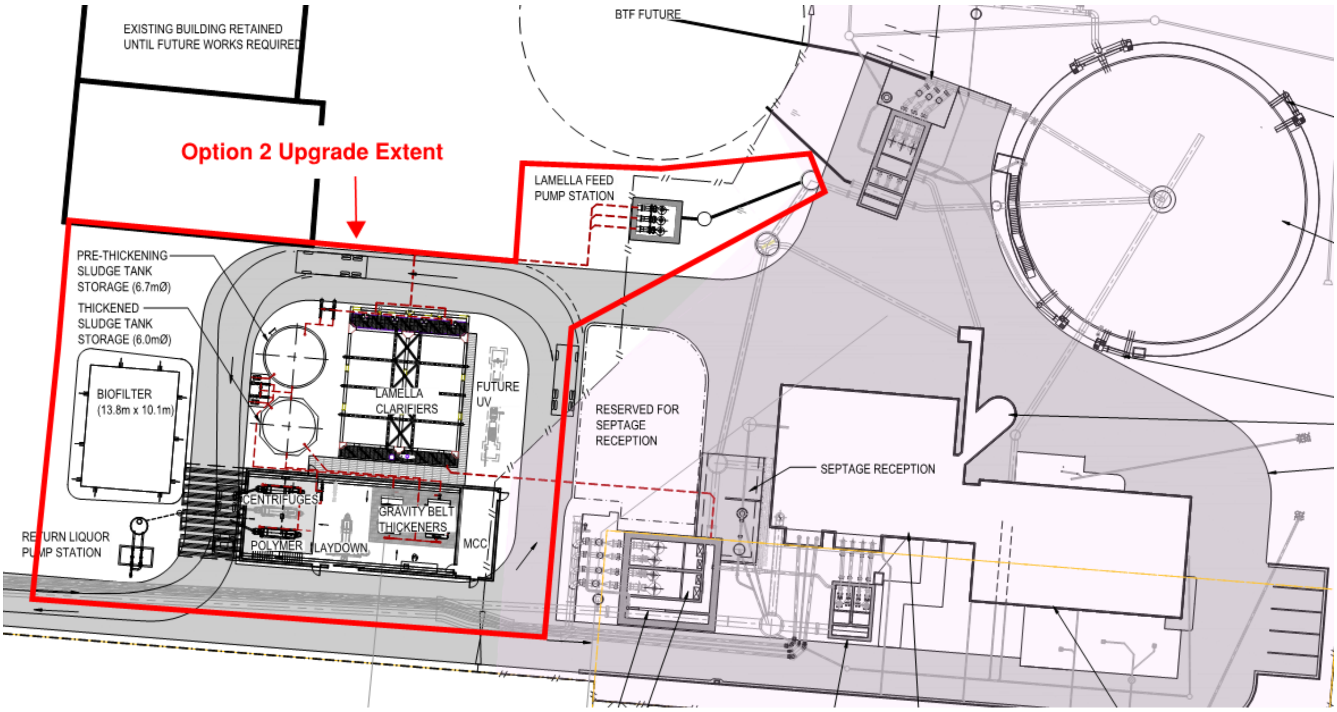

Figure 7 Option 2 Conventional Treatment Upgrade (CH2M Beca Ltd, September 2016)

6 PROCESS, TECHNICAL AND COST RISKS

The general risks associated with the options are summarised in Table 3. Overall the EWPS was considered to carry medium to high risks.

Table 3: High level risk assessment of natural and conventional treatment options

Risk	Natural Treatment:	Conventional Treatment:	Comment
Design Basis	Low	Low	Flows limited to 460l/s. Existing BTF performance well understood.
Process Performance	Medium-high	Low - Medium	Performance of scale up EWPS may differ. V shape settlers prototype design. Reliability of sludge removal from ponds.
Noise	Low	Low	
Odour	Medium	Low	Large surface area of EWPS. Difficult to mitigate odours.
Site Selection/Availability of suitable land	High	Medium	Availability of large land parcel suitable for EWPS. Conventional requires expansion into adjacent site and relocation of other council services and third party businesses.
Site Geotechnical Characteristics impacting on cost estimates	Medium-high	Low	Banks St well understood. EWPS based on hypothetical site.
Biosolids Disposal	Medium	Medium	No established regional biosolids disposal options or market.
Discharges to Land	Medium-high	Low	HRAPs and wetlands assumed to be unlined. Level of infiltration and impact on groundwater requires assessments.

7 AFFORDABILITY AND VALUE ENGINEERING

The two concept designs were presented to the WTAG in October 2016. The scaled up EWPS carried a number of process, technical and cost risks that were beyond Councils risk appetite and the capital cost estimate was significantly higher than Council or the WTAG had anticipated. A number of objectives against which a long term scheme would be tested were identified. The objectives are broadly summarized as:

- Robust asset with up to 50 year design life & long-term resource consent.
- Limit nuisance effects such as odour and midges.
- Recognition that the treatment quality needs to be aligned with the ultimate receiving environment.
- A need to determine which outcomes the community valued most such as biotransformation, restoration of the *mauri* of the wastewater, beneficial reuse of the liquid or solid streams, reducing EOCs, providing amenity or educational features
- Determination of what the community could afford.

The cost estimates for both the EWPS and conventional treatment options had been structured as "building blocks" to allow the costs to be evaluated against the treatment benefits. By assessing which processes best aligned with the overarching objectives and manipulating the size, number and configuration of both conventional treatment and natural treatment building blocks, eleven value engineering options, described as Options A through K, were identified for further refinement.

The value engineering options can be broadly categorized as conventional, natural or hybrid as summarized in Table 4. The WOL estimates considered both the capital and the operational costs over a 20y period. Each option was assessed for potential suitability for discharge to a habitat wetland, ground water via land, surface water or the ocean based on a prediction of expected effluent quality.

All value engineering options were considered suitable for discharge to ocean, although Option A and B would require a variation to the consent due to either the BOD loading or the disinfection requirement. Option C would be fully compliant with the default consent conditions. Based on assumptions regarding receiving environment nutrient assimilation capacities and human health risks, only options J and K, which utilized all elements of the EWPS, were considered suitable for discharge to all receiving environments. The remaining hybrid options used conventional clarification with or without chemical phosphorus removal and disinfection combined with varying combinations of natural processes to address residual nitrogen and phosphorus in the effluent.

Table 4: Alternative Treatment Options Categorization (CH2M Beca Ltd, , November 2016)

Option	General Overview	Type of Treatment	WOL ranges ($M)
Option A	Option 2 from the concept design. Improve the Banks St WWTP site by installing conventional solids removal, thickening and dewatering processes.	Conventional	$35
Option B	Install a second BTF to increase biotransformation and provide redundancy	Conventional	$12M
Option C	Improve the Banks St WWTP site by installing a second BTF to improve BOD_5 reduction, solids removal and disinfection, improving the "transformational"/cultural objectives of the Scheme, and limiting the process risk through the use of conventional treatment processes.	Conventional	$48
Options D, E, F & G:	Combine conventional treatment processes for solids removal and disinfection with elements of the EWPS to provide BOD and nutrient removal, spread across both the Banks St site and a remote site yet to be identified, with or without a second BTF. This allows for more fulfilment of the cultural objectives of the system through the use of additional natural treatment processes	Hybrid	$61 – $94
Options H, I, J & K:	Provide all further wastewater treatment at a remote site using either the full EWPS system (as described in Option 1) or significant elements of it combined with conventional UV disinfection. This provides the most fulfilment of the cultural objectives of the system.	Natural	$56 - 89

Following presentation of the value engineering options to the WMC and full Council in December 2016, council opted to further refine a selection of the conventional and hybrid options. The subsequent refined option development would focus on eliminating several of the risk factors, reducing the scale of the wetland treatment system such that it could be located within a 2.5km distance, and undertaking an assessment of the local surface waters to confirm the limiting assimilative capacity and hence the viability of partial or complete discharge to land or surface water.

8 CONCLUSIONS

The objective of the pilot trial was to demonstrate the level of treatment that could be achieved by a lowly loaded biological trickling filter followed by clarification and a tertiary Enhanced Wetland Pond System. The BTF was already achieving 89% and 75% removal of BOD and TSS. The pilot demonstrated through addition of clarification the BOD and TSS removal clarification was increased to 96%. The EWPS was able to further increase the BOD and TSS removal to 98% and 97% respectively. Nutrient removal across the complete BTF and EWPS was not assessed. However, the EWPS pilot demonstrated that mean TN and TP concentrations 2.1 and 1.4mg/l respectively and 3 log reduction of E.coli in the final effluent was achievable.

However, once site specific factors such as ground conditions, depth to ground water, access for vehicles and maintenance, allowances for redundancy and changes in seasonal operation were considered, the overall area of a full scale EWPS scheme exceeded 82ha, excluding buffers. The availability of suitable land parcels of this size within reasonable proximity of the WWTP was limited and would increase conveyance costs significantly. For Gisborne these factors were not favourable, and resulted in higher than expected costs for a full scale EWPS.

The challenges associated with the predominantly above ground construction and geotechnical stabilization of the V shaped sludge and algal settler ponds was not considered economic at scale. In addition, the method to reliably remove settled sludge was considered too high risk. Notwithstanding these factors, EWPS treatment may well be suited to other communities, particularly smaller towns or rural communities, where the number of natural treatment units can be reduced and suitable land in close proximity to the treatment plant is available.

In the absence of an identified ultimate discharge receiving environment or an effluent reuse market, the Gisborne option development was unable to be matched to the assimilative capacity of a specific receiving environment. This limited the ability to optimize the natural treatment configuration to balance the social, cultural, environmental benefits with the cost to the community.

By structuring the initial option development in a way that allowed the individual unit processes to be costed as “building blocks”, CH2M Beca were able to work with Council to rapidly and efficiently develop value engineering options which could be assessed against the overarching project objectives.

Gisborne District Council are currently refining the value engineering options, with a focus on aligning the individual natural process benefits to the ultimate receiving environment options whilst maintaining affordability, as well as establishing the viability of different reuse markets. Whilst a full scale EWPS configured as per the pilot trial is unlikely to proceed in the future, reducing the discharge of domestic wastewater to the ocean outfall and promoting alternative use and disposal is still very much a goal for Council and the Gisborne Community at large.

9 ACKNOWLEDGEMENTS

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