MEMORANDUM

To:	Bill Sloan
cc:	Kerry Geange
From:	Sarah Sunich
Date:	Friday, 7 March 2014
Subject:	**Martinborough Wastewater Treatment Plant – Alternatives Considered**

The following presents a description of the alternative options considered for MWWTP. The alternatives have been evaluated through a multi-criteria analysis (attached) that supports the adopted best practicable option over all three urban WWTP's which SWDC propose for MWWTP within this current resource consent process, being a focus on staged affordable land treatment supported by minor pond improvements in the short to medium term.

STATUS QUO / 'DO NOTHING'

A review of the existing MWWTP performance has identified treatment deficiencies in terms of contaminant removal, in particular nutrient removal, and highlighted potential risks for long-term effects on the Ruamahanga River. Retaining the current pond system and full disposal to water would be unable to achieve satisfactory treatment to comply with likely long-term effluent quality limits prescribed in any future consent and/or meet the overriding requirements of the RMA. Maintaining the existing discharge, would also be inconsistent with stated cultural objectives for freshwater, the policy framework within the relevant Regional Plans to '*maintain and enhance water quality*' and the adopted SWDC long-term wastewater strategy which focuses on the removal of discharges to water and promotes land treatment.

The "do nothing" option has therefore been discounted by SWDC.

INFLOW AND INFILTRATION (I/I) REHABILITATION

Typical domestic per capita wastewater flows in NZ range between 210 – 475L/per/d, and many councils use an average per capita flow of 250L/per/d for design purposes. A review of historical influent data to the MWWTP shows that the average per capita flows in Martinborough are within but at the higher end of this range (AWT, 2013[1]).

In the same review, a high level concept analysis of costs for high rate treatment and land treatment upgrade options at Martinborough was undertaken and concluded that, Martinborough's network is less 'leaky' than Featherston's and although I/I rehabilitation is important for the ongoing operability of Martinborough's wastewater infrastructure in the long term, unlike Featherston, I/I not significant enough to require deferring treatment upgrades in accordance with the long term strategy.

[1] AWT Water Ltd, South Wairarapa Integrated Wastewater Scheme - Technical Review, report prepared for SWDC, Final, August 2013.

ALTERNATIVE TREATMENT PROCESS OPTIONS

SWDC has sought advice from a number of technical experts on a variety of alternatives to improve treatment performance at the MWWTP. Option evaluations were carried out by NZET (2012)[2], and *g2e* (2013)[3,4] and included a mixture of pond enhancement, end of pond treatment and pond replacement solutions.

A summary of the alternative treatment processes considered for improving effluent quality is provided in the following section. In most cases the treatment options below would become redundant if land treatment was considered (LEI (2013)[5] in their land treatment options review have advised that land treatment would be hydraulically limited not nutrient limited). Therefore the following options were considered and evaluated in the context of a continued discharge to water, land disposal via rapid infiltration, or combined water and land discharge regime where advanced treatment in terms of nutrient and pathogen removal would more than likely be required.

Pond Enhancement

A number of simple pond modification and optimisation options were considered for enhancement of the existing pond treatment processes. It is acknowledged that many of these pond solutions would not be acceptable as standalone solutions in the event a continued water discharge were pursued as the necessary level of contaminant removal is unlikely to be achievable. The pond enhancement solutions have therefore been described for information purposes only and have been discounted as a means of achieving a long-term sustainable solution for a continued discharge to water or land disposal via rapid infiltration.

Desludging

In November 2012 SWDC commissioned Conhur Ltd[6] to undertake a sludge survey of the Martinborough pond. In April 2013 Opus Ltd[7] analysed the information collected by Conhur to assess the requirement for pond desludging. This report concluded that the treatment volume of the ponds is still sufficient to receive the current load and desludging of the ponds would not be required for a number of years. The sludge survey information was also further analysed by *g2e* (2013)[8] whom confirmed the conclusions regarding desludging by Opus. Therefore, desluding has not been included in the programme of works although a sludge survey will be carried out in several years' time in accordance with ongoing maintenance procedures for the ponds.

Flow Directing Curtains

Flow directional curtains or floating baffles are used as vertical walls which redirect flowing water within a pond through determined paths to increase the hydraulic retention time (HRT) and to prevent short-circuiting. There are a variety of curtains or baffles available, and in general consist of a flexible geomembrane that is suspended within the water column at specifically selected locations across a pond.

The installation of floating curtains was considered for MWWTP, however, the level of improved treatment from this option is difficult to quantify. Some improvement in BOD_5 and TSS removal would be expected, although whether this would be sufficient at all times to meet future consent limits is questionable. Furthermore, there is little technical evidence to suggest increased HRT will result in a significant improvement in ammonia or total nitrogen removal within the ponds. Therefore this option would need to be considered in conjunction with other pond upgrade options targeted at nutrient removal. For these reasons, this option has not been considered further.

Overflow and/or Flow Control Weirs

Pond outlet overflow weirs function in two ways: i) to allow the buffering of peak flows in each pond thus increasing HRT and providing hydraulic separation of ponds, and ii) minimising solids carry-over between ponds.

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[2] NZET, Martinborough Wastewater Treatment Plant: Review of Potential Upgrade Technologies, 10 January 2012.
[3] *g2e*, Martinborough WWTP – 2nd Assessment, prepared for SWDC, Draft, July 2013.
[4] *g2e*, Summary Martinborough Upgrade, prepared for SWDC, October 2013.
[5] LEI, Martinborough WWTP Land Discharge Scenarios and Assessment of Environmental Effects, prepared for SWDC, Final, March 2014.
[6] Conhur Ltd, Martinborough Oxidation Pond Sludge Survey Report, November 2012
[7] Opus International Consultants Ltd, Sludge Survey Report-Martinborough and Featherston WWTP's, 8 April 2013.
[8] *g2e*, Martinborough WWTP – 2nd Assessment, prepared for SWDC, Draft, July 2013.

Specifically designed overflow weirs retrofitted to the Martinborough ponds were considered, however, the overall benefit of weirs on each of the ponds would be negligible in terms of improved treatment performance in comparison to other treatment or land disposal options and would need to be considered in conjunction with other upgrade options to provide nutrient removal. An allowance has been made in the SWDC future work plan to investigate hydraulic improvements to the ponds to improve flow balancing. This may include pond overflow and/or flow control weirs or control changes to the UV pump station or a combination of both.

Enzyme and Microbial Cultures

By dosing appropriate microbes and/or enzymes into a treatment pond, a preferred culture of specific species can develop whose characteristics are more attuned to attacking a specific problem such as managing solids build up through organics reduction, and/or odour management by oxidising sulphide.

Trial doses of microbial cultures have been applied to the Martinborough ponds, however, in the absence of any conclusive performance data for this type of technology (including from other schemes), the benefits of overall treatment improvement for MWWTP are considered to be limited. The main difficulty of applying this type of technology to pond systems is the large volumes and potential for washout of the selected microbes. This is partly addressed by continual dosing, however the quantity and cost of the material being dosed typically becomes a significant operating cost. Therefore because of the uncertainty regarding effluent improvements and the relative cost of this process, this option has been discounted.

Coagulant Dosing

Addition of a coagulant is used to coagulate contaminants, such as suspended solids or total phosphorous from wastewater. The coagulated solids settle to the bottom of the pond and accumulate as sludge. Depending on the coagulant used, some of the dissolved organics and dissolved reactive phosphorus (DRP) levels can also be reduced via chemical precipitation and settling. Coagulant dosing can either occur into the influent stream, followed by flocculation, and sedimentation within the normal hydraulic regime of a pond system. Alternatively, coagulant can be added prior to a filter or within a standalone separate settling tank/clarifier to remove the finer floc particles.

Bench scale tests were undertaken on typical samples from the MWWTP. On review of these results, uncertainties regarding the efficiency of the treatment process were raised, including, uncertainties around which coagulant would be most adequate, and dosing rates. Further jar testing would be essential to address these uncertainties and more accurately assess costs.

Coagulation would result in increased volumes of settled solids leading to increased sludge management costs (increased volumes) and potential aluminium residual toxicity issues for the pond and/or receiving water biota depending on the type of coagulant used. If an aluminium based coagulant was used it could also affect sludge disposal costs due to increased aluminium levels in the sludge. Furthermore the option of coagulation would not address likely ammonia and total nitrogen removal requirements and would need to be considered in conjunction with other pond upgrade options. Operating costs could be moderate with the risk of inconsistent performance. Furthermore, if land application is pursued, additional fertiliser inputs of nutrients such as phosphorus will be required, and removing these up front would in the long term be counter-productive.

Dosing in the short-term, until the implementation of Stage 1B Land Treatment was also considered. The procurement and establishment times and costs in that two year period would however render that option ineffective at reducing any significant effects in an affordable manner.

Therefore as a result of these uncertainties, implementation times, and costs this option has been discounted.

Raising of the pond embankments

This was considered as a potential option for creating additional buffer storage volume. This option is still worth considering in respect to the pond's long-term operation and storage requirements when considering a proposed deficit irrigation regime, especially if the pond experiences frequent high water levels reaching close to or above the waveband. If there exists a potential of damaging the waveband due to high water levels an increase of the embankment and extension of the waveband could provide up to 8,500m^3 further working buffer storage. This option will be considered further at Stage 2 as part of the deferred storage item of works.

Inlet Screen

Inlet screening provides the removal of gross solids, rubbish, stringy and fibrous material and debris from entering the ponds. Removal of this material reduces its accumulation in pond sludge and therefore reduces the overall sludge volume and prevents this material from causing future pond desludging difficulties (desludging equipment blockage and non-acceptance of sludge as a potential soil conditioner due to litter content).

An inlet screen was considered for the MWWTP, and would provide long-term benefits to the plant by reducing the maintenance requirement on the surface aerators (especially failures due to the seizing up of the impellers due to floating matter), enhanced management of pond sludge, and in the case of land treatment, protection of irrigation pumps (reducing the risk of blockage). Therefore, an inlet screen at Martinborough is considered very important for the long-term efficient operation of the scheme and has been included in Stage 1 of the works programme.

Floating Treatment Wetlands

Floating Treatment Wetlands (FTW) are a variant on traditional constructed treatment wetlands that use either free-floating aquatic plants or sediment-rooted emergent wetland plants with water flowing through the root zone (subsurface flow) or amongst the stems (surface flow). The Floating Treatment Media (FTM) consists of water tolerant plant species grown onto geo-synthetic textiles that provide structural strength, flotation, and a rooting matrix for initial plant development. The key treatment processes occurring within the FTW as promoted by suppliers include: (i) the exposed root systems that uptake nutrients into the plant structure which is later harvested and removed from site, (ii) the root and floating media provide large surface areas for the development of biofilms containing communities of attached-growth micro-organisms responsible for a number of important treatment processes (similar to a fixed film substrate), and (iii) the root structures physically trap particulates within the water column. Biomass that builds up under the FTM sloughs off as heavy particles that are more amenable to settling. Baffles are also used in combination with FTM to provide flow control through the system both horizontally and vertically, minimising short-circuiting, enhancing full mixing and increasing hydraulic retention times by promoting longer flow paths.

Historically the purpose of FTW within wastewater pond systems has been for polishing of suspended solids and to assist with minimising algae growth. However more recently, nutrient removal has become a focus. New installations are relying on aerobic and anoxic zones in combination with the FTM and Fixed Biofilm Attachment Surfaces (FBAS) within the treatment ponds to enable the nitrification and de-nitrification of wastewater to achieve TN removal. The use of synthetic porous textile curtains or BAS for nitrifying bacteria attachment in combination with aeration upfront of the FTM appears to assist in enhancing nitrification processes, whereas beneath the FTM anoxic zones develop promoting the necessary conditions for denitrification. Some form of re-oxygenation of the water leaving the FTW is generally required either through aerators or a passive cascade outlet structure (if required in consent).

Published data on the treatment performance of the various FTW applications is however limited. Niekerken[6] notes that based on international literature, total nitrogen removal within FTW appear to be reasonable with studies showing up to 85% removal, however phosphorus removal has been shown to be less effective (40%)[9]. Much of the scientific research on floating and constructed wetland treatment in New Zealand has focused on stormwater treatment and their use as a wastewater treatment technology is relatively recent. A trial wetland was constructed at the Featherston wastewater treatment plant (FWWTP) in 2010 and was monitored for approximately three years. Unfortunately this pilot system did not perform well, with some reduction in TSS, E.coli and BOD_5 observed but little change in terms of nitrogen or phosphorus removal[10]. A comparison of the performance from other FTW systems installed in New Zealand targeting nutrient removal has been undertaken by AWT (2013)[11]. Results show promising removal performance for BOD, TSS and Ammonia, although the level of improvement does appear to diminish in the warmer summer months. The data available however is very limited[12] and thus the long-term performance reliability of FTW cannot be accurately determined at this stage.

FTWs are a passive / low energy process, and are a good retrofit option for pond treatment systems. They are fairly unaffected by fluctuations in water levels within the pond and are relatively easy to maintain. The cover and shelter

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[9] Adrian van Niekerken, Can Waste Stablisation Ponds Challenge Advanced Biological Wastewater Treatment Processes', unknown date, unknown conference proceeding.

[10] It is noted the trial was not set-up to target for nutrient removal.

[11] AWT Water Ltd, Martinborough WWTP - Consent Application Technical Review, Letter prepared for SWDC, 22 March 2013.

[12] Hunterville WWTP only 1 years' worth of post commissioning data was available at the time of review.

provided by the FTM promotes conditions conducive to settling by reducing turbulence and light, thus assisting with algae management. FTW have low capital and operation expenditures compared to other high rate treatment plant options, and they can be configured to address a range of performance objectives. For example, the addition of coagulation dosing following the FTWs can target Phosphorus removal, whilst the addition of bottom deployed aeration is shown to achieve improved nutrient reduction. Due to the existing pond base variation (identified by *g2e*, 2013) and the existing sludge accumulation, the installation of bottom deployed aeration would need to be carefully considered, in particular the risk of sludge re-entrainment.

FTW however have a limited track record in New Zealand and overseas with wastewater treatment, particularly with regard to nutrient removal and their long term sustainability and reliability. FTW are difficult to process control if problems arise at the plant or in the event of external influences, and thus specific effluent quality targets are difficult to guarantee.

FTW has not been considered further because of the treatment performance uncertainties with respect to nitrogen and phosphorus removal provided by this process, two key constraints at MWWTP. FTW may be considered a suitable option in combination with land treatment, although as identified in the LEI (2014) assessment, land treatment in this case is not nutrient limited. Therefore, there is no real need for pre-treatment of nutrients prior to land treatment. Installation of FTW could therefore result in potential sunk costs to SWDC in the long-term if 100% land treatment were pursued.

Floating Covers

Installation of light impermeable cover around the plant outlet to reduce algae and TSS prior to UV disinfection has been considered. Covered floating wetlands or hexagonal floating plastic discs are examples of floating covers used at other plants. SWDC have purchased floating wetland rafts which are currently installed as a trial system at Featherston. It is proposed to relocate these to the final maturation cell of the MWWTP to provide some improvement in algae removal. The level of improvement is difficult to quantify, however, there is minimal cost involved in relocating the wetland rafts to Martinborough and thus it is considered a positive re-use of existing redundant infrastructure. The floating wetland rafts from Featherston will not completely cover the final maturation cell at Martinborough. Other methods to cover the remainder of the final maturation cell such as hexagonal floating plastic discs is currently being costed as a potential alternative or adaptive response. See also the comments regarding UV disinfection below, regarding the relative effectiveness of UV following algal reduction.

Options for Treating Pond Effluent

A number of treatment solutions to enhance the pond effluent (i.e. pond add-on solutions) were considered to improve the overall treatment process. Again, many of these pond add-on solutions would not be acceptable as standalone options and would need to be considered in combination with other add-on or in-pond solutions, and are not necessary in a land treatment regime for Martinborough.

Soil Beds

In a soil bed system, effluent is intermittently dosed via a distributed network over the surface of soil beds constructed on a specific slope and is filtered down through the sloping bed under gravity.

A trial of soil beds was undertaken at Carterton WWTP, and initial results (although it is noted the data set is limited to 2 months) showed reasonable removal of TSS, TP and BOD_5, however nitrogen removal was limited. Therefore soil beds used at MWWTP are likely to be limited in their ability to ensure the necessary reductions in ammonia and total nitrogen limits.

Experience from operating soil bed systems shows that, over time, the capacity of soil beds would become saturated with phosphorus and solids, resulting in a degradation in effluent quality until replacement of the soil were to be undertaken. The life expectancy of soil beds is uncertain, and therefore could result in significant ongoing opex costs through media sourcing and disposal of potentially contaminated soils.

This option has not been adopted because of the uncertainty in long-term performance of soil beds, operating costs, and ability to achieve the high level of nitrogen removal likely to be required in the long-term.

PETRO

The PETRO (Pond Enhanced Treatment and Operation) system utilises a multiple pond system in conjunction with a trickling filter or activated sludge process. The system is comprised of a deep primary facultative pond followed by shallow secondary oxidation ponds in combination with either an activated sludge or trickling filter secondary treatment process. The primary pond-based stage of the process is aimed at removing a substantial portion of the organic load. The secondary trickling filter or activated sludge process stage is aimed at nutrient removal followed by a solids/liquids separation system.

The modification of the MWWTP to install a PETRO process would require some pond modifications, and the installation of pump stations and new process units at the plant. Whilst this option is likely to reduce reactor sizes and costs when compared with more conventional activated sludge processes, there is a risk of excessive algal growth in the ponds causing process or settleability issues in the trickling filter or activated sludge process and the removal of degradable carbon could limit the nutrient removal potential in the secondary treatment stage, unless a carbon source were added. This process could potentially introduce significant quantities of algae which would make filtration prior to disinfection problematic. Furthermore, recent and relevant trials conducted by SWDC at FWWTP have not shown satisfactory treatment results, and the level of Phosphorus removal is also uncertain.

This option has not been adopted because of the large uncertainties regarding the process and its ability to remove key nutrients (especially phosphorus) as highlighted by past trials.

Sand Filtration

Sand filtration beds remove colloidal and particulate material in accordance with the properties of the filter (e.g. grain size, bed depth and applied surface loading rate). The filter acts through entrapment and adhesion to arrest the solid material and trap them on the surface of or within the body of the media or medium. In some applications it is necessary to pre-treat the effluent flowing into a sand bed to ensure that the particulate solids can be captured. Pre-treatment can comprise of pH adjustment, coagulation and/or flocculation. Sand filters used for treatment of secondary treated municipal wastewater can be located as a final polishing stage where the sand traps residual suspended material and bacteria and can provide a physical matrix for denitrification (conversion of nitrates into nitrogen gas) in conjunction with upstream carbon dosing.

Sand filters become clogged with flocculent and or entrapped solids after a period in use and they are then backwashed or pressure washed to remove this material. This backwash water is typically run into settling tanks to allow the backwashed solids to settle and the supernatant returned to the ponds with the solids being dewatered and disposed as solid waste. Alternatively, the backwash could be returned to the head of the works for settlement in the ponds.

Trials conducted in Carterton in 2003, using Dynasand filters and a range of coagulants showed a limited improvement in effluent quality with only very high coagulant doses showing a marked improvement. Further trials were to commence in 2012, however the results have not been reviewed.

For MWWTP a large sand bed filtration system would be required to cope with the large flows and additional pumping for the backwashing cycles would be required. The sand bed filtration process is likely to work very satisfactorily for particulate contaminants. Phosphorus could also be precipitated using upstream metal salt coagulants (Aluminium, Iron) dosing although the level of removal is uncertain without further bench scale trials being undertaken.

This option has been discounted because of the large uncertainties regarding its nutrients removal performance, the likely filter size and comparative cost, along with the difficulties associated with filtering of algae with this type of process.

Membrane Filtration

Membrane filtration uses a semi-permeable membrane to separate suspended solid and colloidal solid materials according to their physical properties when a pressure differential is applied across the membrane. Membrane filtration results in effluent virtually free of TSS and with the proper selection of membranes and membrane pore sizes, the process can be effective in the removal of microorganisms (e.g. microfiltration and ultrafiltration membranes target removal of protozoa, bacteria and most viruses) and certain organic species.

Membranes would remove the solids fractions of the pond effluent, supported by trials undertaken at Carterton in 2007, there is however no capacity for nutrient removal in terms of nitrogen or phosphorus. Improvement of nitrogen removal would require addition of aerobic nitrification and denitrification steps. Phosphorus removal could be achieved by metal salt dosing (alum or ferric) prior to membrane filtration.

At the MWWTP a Membrane Filter would be installed on the discharge of the pond and solids filtered out by the membrane would be recycled to the ponds and accumulate there. The ponds would therefore require more frequent desludging. The membrane unit would also need to be large to treat the plant peak flows, and power consumption would be high due to the permeate being pumped through the membranes.

This option has not been discounted because of the lack of impact it would have on the soluble contaminants (especially nitrogen) and due to the fact SWDC already have in place a UV disinfection unit to address pathogen reduction.

UV Disinfection

Ultra Violet (UV) disinfection, like membranes, target the reduction of pathogens in the effluent. Effluent is passed through a channel or pipe fitted with an array of bulbs emitting UV light at a frequency that causes damage to the genetic structure of bacteria, viruses, and other pathogens in the effluent as they flow past the bulbs, making them incapable of reproduction. This process can be affected by shielding (shading) from solids, thus in some systems such as pond systems, pre-filtration may be necessary in order to meet high levels of pathogen reduction. The key disadvantages of UV disinfection is the need for frequent lamp maintenance and replacement as well as ongoing power costs.

UV disinfection was installed at MWWTP in December 2011, and thus is already in use. The unit was designed for a target 3 log reduction in pathogen count. Following initial commissioning three separate plant malfunctions occurred resulting in non-compliance in *E.coli* consent limits. These operational issues have now been resolved (NZET, 2013)[13], and through more regular lamp inspection and cleaning, and the application of an appropriate dose rate the system appears to be working well and achieving a median *E.coli of* 100cfu/100ml. An absolute limit for pathogens is considered unachievable for a treatment process of this nature, therefore, it is recommended that a median consent limit be proposed.

Improving the feed water quality to the unit by installing a new inlet screen and other methods of cover on the final maturation pond to lower algae concentrations will assist in providing greater reliability in pathogen reduction in the long-term.

Other methods of disinfection such a chlorination or ozone have not be considered for the current consent as they would unnecessarily duplicate the existing UV functionality.

Constructed Wetlands

A conventional constructed wetland is a surface-flow wetland, where plants are rooted in soil and water flows at a shallow depth through the array of plants and is open to the atmosphere. A sub-surface wetland involves plants growing in a bed of soil and porous media (typically gravel), with water flowing through the bed and the array of plant roots.

With specific design, some reduction in BOD_5 and TSS can be expected. In addition, wetlands have been shown to remove phosphorus, however, typically during early stages of establishment through uptake by the growing plants and/or through adsorption to sediments in sub-surface wetlands. Phosphorus removal, however seldom exceeds 1-3 mg/L and at certain times of the year wetlands can release phosphorus that has been accumulated over the growing season. Extensive nitrogen removal typically requires long hydraulic residence times in wetlands (greater than 14 days), thus resulting in large land area requirements and significant upfront construction costs. Regular harvesting is also required to remove the nitrogen and phosphorus from the system that has accumulated in the wetland via plant uptake.

Construction of a specially designed treatment wetland on the outlet of the MWWTP ponds was considered. The wetland would require significant land and physical works, while providing similar treatment performance as a FTW. Although this is a land contact process, thus to some extent addresses cultural values, it is not expected that the effluent quality would consistently and reliably meet effluent quality requirements for a discharge to surface waterways, particularly for nitrogen removal, and ongoing maintenance and harvesting of the wetlands can be difficult and expensive. Additionally, there is a recognised risk from experience that if the wetland were to follow the existing UV disinfection plant that pathogen levels

[13] NZET, South Wairarapa District Council Martinborough Sewage Plant Annual Report 2012-2013 – Final, July 2013

could potentially increase through external wildlife influences (i.e. wetlands have a tendency to attract waterfowl). For these reasons, this option has not been considered further.

Options for partial or complete replacement of the Oxidation Ponds

A number of options involving the partial or complete replacement of the existing pond system have also been considered for improving effluent quality at MWWTP and comprise of high rate treatment process solutions. These are discussed below.

Membrane Bioreactor

In Membrane Bioreactor (MBR) processes wastewater is treated in a series of anaerobic/anoxic/aerobic treatment zones similar to a conventional activated sludge plant before entering the membrane tank for solids liquid separation. Membrane Bioreactors operate very similar to conventional activated sludge processes except that microfiltration membranes are used for solid/liquid separation instead of a clarifier. The pore size of the membranes is sufficiently fine to provide disinfection, although a multiple barrier approach using both membranes and UV disinfection may also be appropriate.

The installation of an activated sludge and membrane filtration process at MWWTP would provide an extremely high level of treatment including nutrient removal and disinfection. MBRs have a small footprint area thus land area requirements would not be an issue for MWWTP. MBR processes are however expensive to install (high rate WWTP + cost of membrane trains) and operate (power for pumping + chemical usage for membrane cleaning) and generally more costly than conventional high rate wastewater treatment. Membrane filters can be blinded with grease or abraded by suspended grit and lack a clarifier's flexibility to pass peak flows.

A MBR treatment process would be a viable alternative to land treatment in the case of MWWTP. However, as SWDC's long-term wastewater strategy is to move to land treatment to address community and cultural concerns, and considering that SWDC already owns land capable of providing sustainable land treatment, the option for MBR treatment has been discounted.

Sequential Batch Reactors

Sequential Batch Reactors (SBRs) treat wastewater in a batch process. The reactor operates in a sequence of timed phases of filling, aeration, anoxic reaction, anaerobic reaction, settling, and decanting in the same tank. An SBR separates the treatment steps in time (sequential time phases in the same tank) in contrast to a conventional activated sludge process which separates the treatment steps in space (simultaneous reaction in separate tanks with a continuous throughflow). SBRs typically have more than one reactor and the batch process is offset in time across the reactors such that only one reactor at a time is filling.

The installation of an SBR plant at MWWTP would provide a high level of treatment including nutrient removal, but would require tertiary treatment such as the existing UV disinfection system for pathogen removal. SBRs can deal with higher flow variations than MBRs, however their sizing is still very dependent on the peak flows they will need to process. Similar to the MBR option, an SBR is a proven robust and reliable treatment solution and would be a viable alternative to land treatment. However, as SWDC's long-term wastewater strategy is to move to land treatment to address community and cultural concerns, and considering that SWDC already owns land capable of providing sustainable land treatment, the option for SBR treatment has been discounted.

Summary

In order to obtain the necessary certainty of a long term consent for a discharge from the MWWTP there is a requirement to demonstrate that the future discharge results in no significant adverse impact on the Ruamahanga River. Based on the approach used elsewhere in the Wairarapa the river water quality outside of the zone of reasonable mixing would need to be returned to near-to background concentrations of measured contaminants under mean annual low flow (MALF) conditions. Further, the ecological investigations suggest the mixing zone would need to be small enough to avoid restrictions to fish migration.

The in-pond and add-on pond improvements considered would achieve some level of improvement in the overall effluent treatment, and in combination could potentially achieve a higher level of contaminant removal. However the degree of treatment performance is difficult to quantify with any certainty and is unlikely to provide significant long-term sustainable and reliable improvements in effluent quality necessary to meet the assimilative capacity of the Ruamahanga River. Furthermore, some aspects of operability and reliability are questionable, and would likely require further trials.

The majority of the pond upgrade options have therefore been discounted due to their low overall cost-benefit ratio in respect to achieving a quantifiable improvement in treatment quality and it is considered greater benefits can be achieved through the staged removal of effluent from the river during low river flow conditions and migration to land application.

Where the main driver for upgrading wastewater treatment plants has been increasing requirements around effluent quality, high rate treatment activated sludge systems have been the most common option favoured by other Councils, as documented in a review by CPG[14]. High rate treatment processes as described above, are robust well proven technologies and would greatly improve the overall effluent quality. Though high rate treatment options have comparatively high capital and operational costs compared to the pond based solutions described, they would produce the most reliable effluent quality and from a technical perspective present a suitable alternative to land treatment. However, an analysis of the long-term operational costs of high rate treatment plants when compared with land treatment shows that treatment plants are unlikely to be economical in Martinborough[15].

LAND TREATMENT

Land application or land treatment is where wastewater is applied at a rate that allows the soil and plant system to utilise most of the applied water and nutrients, and pathogen attenuation occurs in the soil or on the surface of the land due to natural processes such as disinfection from sunlight.

Land located near to the MWWTP is flat to gently undulating and therefore well suited to wastewater irrigation infrastructure. It is also unlikely to be subject to slope instability issues. The land comprising recent alluviums are well drained and suitable for wastewater irrigation with only minor limitations for land treatment, whilst land comprising of uplifted Martinborough terraces with finer textured soils due to Aeolian material have restricted drainage and limitations for irrigation that would require careful management.

SWDC commissioned a preliminary assessment of options for effluent disposal to land[16]. This desktop investigation identified the most appropriate areas for potential land application as being:

- The area directly surrounding Martinborough between the confluence of the Huangarua River with the Ruamahanga River, and the area known as the Martinborough Terraces;
- A wedge of land extending from Ferry Road at approximately Kelly's Stream, south for around 1.7km; and
- Land in the vicinity of Dyerville following the Terraces with Dry River.

In addition, a comparative assessment was also undertaken in respect of Pain Farm land owned by SWDC near Ferry Road and concluded that Pain Farm is suitable for land treatment, with some limitations and careful management to:

- Avoid soil damage due to excessive irrigation or cultivation and traffic on wet soils;
- Ensure drainage to groundwater in excess of the unirrigated rate is minimised so that groundwater elevation and direction of movement is not impacted.

The assessment concluded that Pain Farm has constraints which mean the number of days per year on which wastewater application can occur is likely to be less than for the alternative "most appropriate" sites (as listed above).The assessment concluded that Pain Farm is relatively less suitable than other areas in the Martinborough Surrounds.

Further evaluation of the proportion of MWWTP flows and storage requirements for a range of land treatment scenarios was undertaken (LEI (2014)[17]. The scenarios considered land treatment on the MWWTP adjacent land (5.3ha irrigable land), Pain Farm block (53ha irrigable land) and Golf Course (33ha irrigable land). The analysis was based on field investigations and historical flow and treated effluent quality data (albeit a limited dataset, thus allowing indicative calculations only). In addition combined water and land, and deferred water only discharge scenarios were also

[14] CPG Ltd, Horizons Regional Council, Recent History and Rationale for Wastewater Treatment Plant Upgrades, November 2009.
[15] AWT Water Ltd, South Wairarapa Integrated Wastewater Scheme Technical Review, Final, August 2013.
[16] LEI, Martinborough WWTP Land Application Option Assessment, prepared for SWDC, January 2012.
[17] LEI, Martinborough WWTP Land Discharge Scenarios and Assessment of Environmental Effects, prepared for SWDC, Final, March 2014.

evaluated. An empirical water and nutrient budget was developed which concluded the limitation for land treatment of Martinborough's wastewater to be hydraulic loading rather than the treated effluent quality (nutrient loading). This means that improvements to treatment performance would unlikely result in changes to the land area or storage requirements and the focus would rather be on network improvements to reduce I/I and consequently overall flows.

Of the identified land areas:

- Pain Farm is capable of receiving the entire yearly flow from MWWTP;
- Martinborough Golf Course is capable of receiving 90% of the entire yearly flow;
- MWWTP Adjacent land is capable of receiving 24% of the yearly flow; and
- The Golf Course and MWWTP combined is capable of receiving the entire yearly flow from MWWTP.

For a deficit type scheme a maximum storage volume to avoid any surface water discharge of between 63,000m^3 and 154,000m^3 would be required, with the least storage volume required when combining Pain Farm and MWWTP adjacent land.

Options to reduce the pond storage considered, have included:

- a contingency discharge / high flow discharge to water (i.e. 37,600m^3 to contain 90th percentile cumulative volume with discharge to MWWTP adjacent and Pain Farm) during times when the environment is likely to have sufficient assimilative capacity;
- part-time water discharge to Ruamahanga or rapid infiltration disposal into river gravels which would likely require an improvement in wastewater quality, in particular nutrient reduction prior to discharge; and/or
- further I/I investigation and network rehabilitation to reduce overall flows.

Based on this analysis, SWDC has taken the approach of staging a land treatment scheme, with a focus on removing discharges to the Ruamahanga during low flow conditions and applying to MWWTP adjacent land in the short-term. Significant investment is required to reticulate the remaining flows to Pain Farm and develop sufficient storage for a deficit irrigation scheme with no direct discharge to water. Development of the Pain Farm treatment scheme has therefore been deferred to stage 2, in conjunction with provision of a high flow discharge to water. Stage 2 has been further staged with a focus on irrigating as much effluent to Pain Farm prior to commissioning the deferred storage providing a prioritised programme for enabling the removal of as much effluent from the river as possible. Overall, SWDC is committed to diverting treated effluent flows from water onto land. Land irrigation will provide significant environmental benefits to the Ruamahanga River in the long-term from the completed removal of contaminants to surface water and treatment of nutrients via a sustainable cut and carry operation. Furthermore, this option is consistent with the long-term wastewater strategy adopted by SWDC

COMBINED LAND AND WATER DISCHARGE (CLWD)

The principle of CLWD is that wastewater is discharged into a river or stream at times of higher river/stream flow, but is applied to land at times when river/stream flow is low. Advantages of CLWD are:

- In dry weather, an irrigation application to land can avoid discharge to water, when the receiving flow is low and its sensitivity to contaminants is greatest.
- Depending on the land area available, WWTP upgrades to provide significant nutrient reductions may not be needed as critical in-stream parameters are less sensitive during high flow.
- Contaminant removal via soil and plant processes from irrigation of wastewater to land and potential to obtain a financial return from a cut and carry cropping operation.
- Avoid the need for large storage requirements when soil may be saturated following wet weather or winter periods, as river/stream flow should be sufficiently high to offer a reasonable degree of dilution to the wastewater, and recreational use of the waterway is less likely to be taking place.

- The cost of operating a dual discharge system can be offset by the cost savings of not providing for winter storage when irrigation may be suspended.

There are, however, some disadvantages. These include:

- Two sets of wastewater discharge infrastructure are required, this can be more expensive, depending on storage requirements.
- The system becomes more complex to operate than a single discharge option, requiring management, decision making, monitoring and accountability to be better than is typically required for a single discharge and can lead to increased risk of operator error.

Consideration has been given to operating a CLWD in the short term by applying pond treated effluent to the MWWTP adjacent block and maintaining a discharge to the Ruamahanga River. This option is capable of achieving a removal of up to 24% of the annual flow and would result in a significant environmental benefit in the short-term, particularly during low-flow conditions where the impacts of the discharge on water quality and contact recreation values are greatest.

ALTERNATIVE OF A COMBINED VERSUS INDIVIDUAL SCHEMES

SWDC engaged AWT[18] to evaluate the economic feasibility of combining the Greytown, Martinborough and Featherston WWTPs into a single site for either a combined land irrigation or combined high rate treatment plant scheme. The addition of Carterton flows was also considered for a combined land irrigation option.

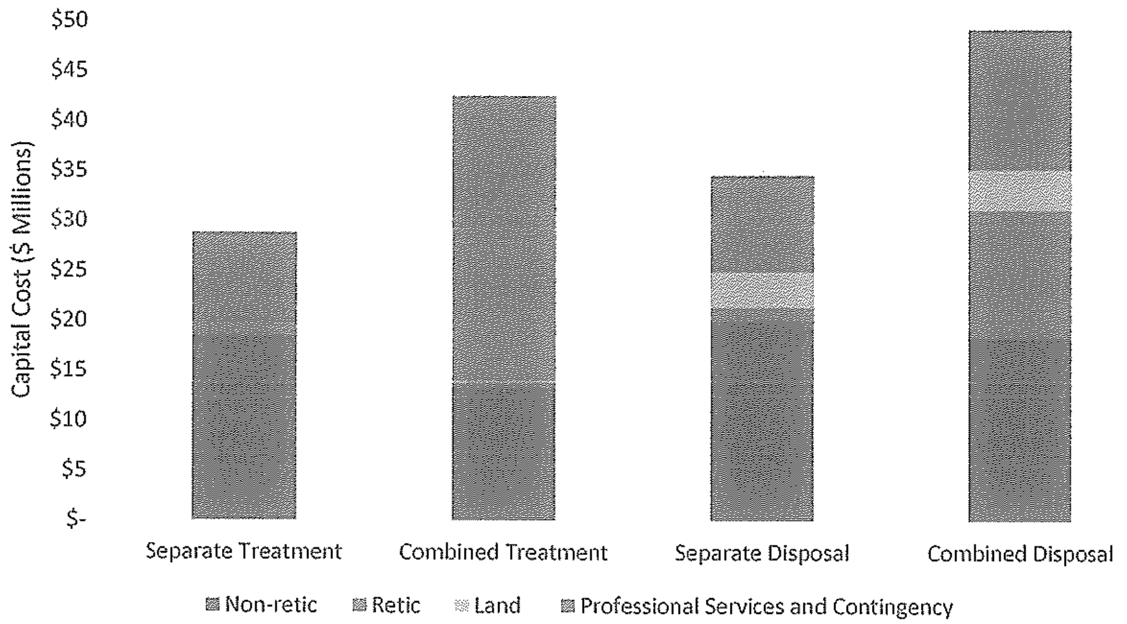

Figure 1: Comparison of capital cost estimates by infrastructure type

While some economies of scale could be achieved through a combined scheme, it was shown that greater capital investment would be required than three separate schemes due to the significant investment in reticulation infrastructure required (refer to Figure 1).

[18] AWT Water Ltd, South Wairarapa Integrated Wastewater Scheme - Technical Review, report prepared for SWDC, Final, August 2013.

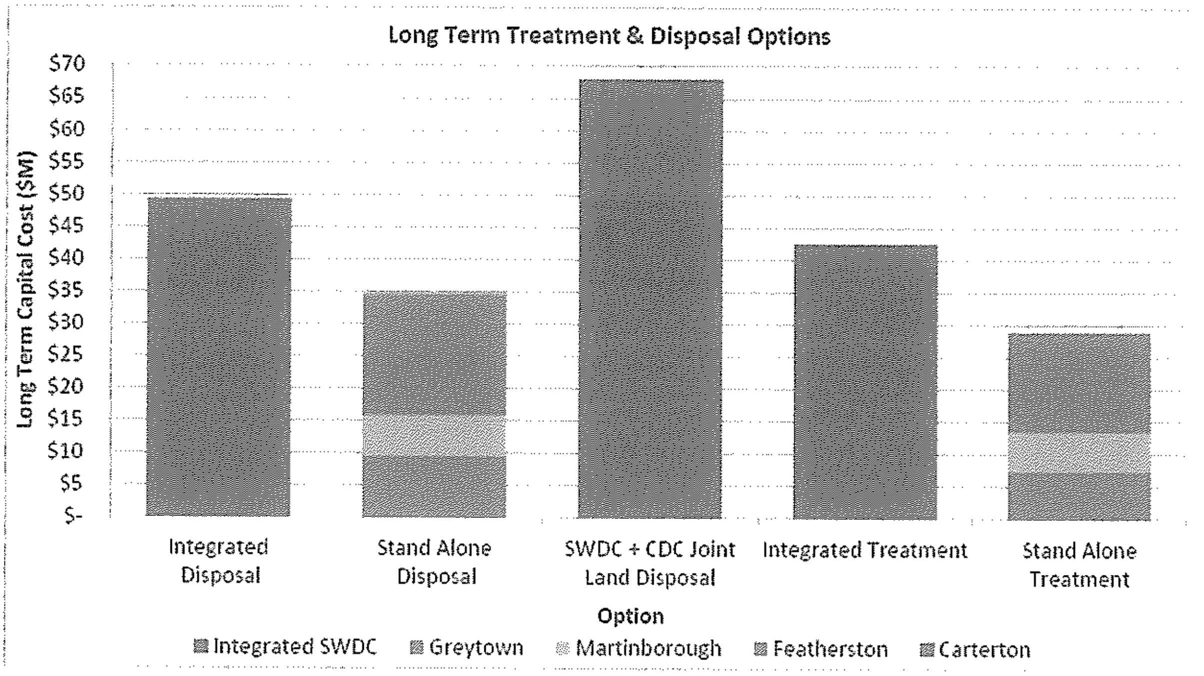

Figure 2: Summary of long term treatment and disposal options by town

Furthermore, the addition of Carterton increased the joint land disposal scheme capital costs by approximately 28%, which is consistent given Carterton would contribute approximately 30% of the flow into the scheme (Figure 2).

As a result of this high level analysis, SWDC have decided to pursue three separate community wastewater schemes.

ALTERNATIVE STAGING OPTIONS

The current wastewater strategy apportions budgeted expenditure across the three SWDC WWTPs as follows:

Table 1: Apportioned expenditure for SWDC Wastewater Schemes

	Stage 1 – Current LTP (up to 2022)	Stage 2 – Future LTPs (2022 – 2047)	Sub-Total by Plant
Greytown	$5.38M	$4.75M	$10.13M
Martinborough	$1.15M	$5.10M	$6.25M
Featherston	$3.8M	$11.90M	$15.8M
Sub-Total by Stage	$10.33M	$21.75M	$32.18

The expenditure has been spread across the three WWTPs with the intention that works undertaken at each plant will have a noticeable impact on flow and/or quality from the existing pond schemes within the current LTP, while planning for and building infrastructure that will contribute to the long-term wastewater strategy over future LTPs.

An alternative staging option considered, was to sequentially upgrade each plant, focusing Councils resources, for example, on one treatment plant upgrade every ten years. This option however was discounted due to likely consentability issues. All three WWTPs have existing consents which have concurrently expired. If SWDC diverted all its LTP funds to one plant, it was anticipated that re-consenting the other two plants would be unfeasible, particularly as all plants are currently at risk of non-compliance with existing consents and would not satisfy RMA requirements. As discussed earlier, the 'Do Nothing' option was unacceptable to SWDC. Sequential plant upgrade is not considered likely to be the "Best Practicable Options" in terms of the RMA.

Furthermore, the cost of upgrading Featherston WWTP is significant (approximately $15.4M - $18.8M if I/I reduction was not undertaken). Construction and commissioning of either a long-term high rate treatment or disposal option would not be achievable within a single LTP period due to SWDC's limited rating base. This would result in deferred financial resources for Martinborough or Greytown over a 15yr or more period. Thus a strategic, effects-based method of staging upgrade works across all three urban plants was considered more appropriate than sequentially staging the individual

WWTP upgrades. This effects-based staging focuses in the short-term on the removal of discharges from Martinborough and Greytown to the Ruamahanga River during low flow conditions and reduction in I/I from Featherston to enable a more affordable solution of treatment to be considered.

EVALUATION

A comparative assessment of the suitability of each option for MWWTP was undertaken and is presented in the Multi Criteria Analysis matrix attached. The Multi-Criteria Analysis assesses each option described above and prescribes a weighting against selected criteria such as treatment performance, cost, reliability and operability in terms of importance. The adopted option reflects this assessment, being an affordable staged approach to land treatment over the short to medium-term with the aim of achieving full time land treatment, and which when considering all relevant factors across the three plants, the relative receiving environments, and affordability, is considered to present the best practicable option.

Regards,

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Reviewed by

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Martinborough WWTP Options - Multi-Criteria Analysis - All Options - Key Parameters

KEY

4	Excellent
3	Good
2	Fair
1	Poor
0	Not possible

Parameter	Wt	Do Nothing	Desludging	Flow / Permeable Curtains	Overflow / Flow Control Weirs	Coagulant Addition	Raising Pond Embankments	Inlet Screen	Floating Cover / Wetlands	Pond Deployed Aeration	Enzyme and Microbial Culture
			Pond Enhancement								
Feasibility											
Improvements of plant performance	4	0 No Improvement	1 Minimal	3 Likely	3 Likely	3 Likely	2 Possible	3 Likely	3 Likely for E.Coli	2 Possible	2 Possible
Improvement in receiving environment water quality (ie. meets existing consent compliance)	4	0 No Improvement	1 Unlikely	2 Possible	1 Unlikely	2 Possible	1 Unlikely	1 Unlikely	3 Likely for E.Coli	1 Unlikely	1 Unlikely
Nitrogen removal	3	0 Unlikely	0 Unlikely	0 Unlikely	0 Unlikely	0 Unlikely	0 Unlikely	0 Unlikely	1 Uncertain	0 Unlikely	1 Uncertain
Phosphorus removal	3	0 Unlikely	0 Unlikely	0 Unlikely	0 Unlikely	4 Possible if Al or Fe salts are used	0 Unlikely	0 Unlikely	1 Uncertain	0 Unlikely	1 Uncertain
Capex	3	4 No cost	3 Moderate	3 Moderate	4 Limited	3 Limited. Becomes redundant if land irrigation is implemented.	2 High	4 Relatively low	4 Low if just reusing wetlands from Featherston & covering last maturation cell	3 Moderate	3 Moderate
Opex	2	4 No additional cost	4 Low	4 Low	4 Low	1 Continuous dosing required -> expensive	4 Low	3 Moderate	3 Moderate	3 Moderate	1 Continuous dosing required -> expensive
Operation	1	4 No change	4 Easy	4 Easy	4 Easy	3 Relatively easy	4 Easy	3 Relatively easy	4 Easy	4 Easy	3 Relatively easy
Reliability	4	0 No change	4 One-off desludging will likely improve treatment capacity for next 5 - 10 years	2 Uncertain in terms of nutrient remval	2 Uncertain in terms of nutrient remval	2 Good for particulate contaminants and TP. No impact on TN removal	1 Uncertain	4 Unlikely to improve nutrient removal but provides improved effluent for filtration and irrigation	2 Uncertain	2 Uncertain in terms of nutrient removal	2 Uncertain
Solids production	1	3 Little/ No effect	4 Sludge removed	3 Little/ No effect	3 Little/ No effect	1 Moderate/High	3 Little/ No effect	4 Reduced rubbish in pond	3 Little/ No effect	3 Little/ No effect	2 Moderate
Summary		27 Not recommended. Risks of non-compliance with consent and s107. Inconsistent with long term strategy	49 Not recommended. Not enough sludge in pond to warrant desludging at this stage	52 Not recommended. Uncertain outcome in terms of contaminant removal, particularly nutrients	51 Possible option. Uncertain outcome in terms of contaminant removal, particularly nutrients	55 Not recommended. High Opex and no Nitrogen removal improvement	37 Not recommended. Option provides no direct benefit for improving treatment standard.	57 Recommended. Long term treatment and operational benefits	63 Recommended. For final maturation cell only to reduce algae prior to UV	42 Not recommended. Uncertain outcome in terms of nutrient removal to low levels	42 Not recommended. High Opex and high uncertainties

Martinborough WWTP Options - Multi-Criteria Analysis - All Options - Key Parameters

KEY

4	Excellent
3	Good
2	Fair
1	Poor
0	Not possible

		Pond Effluent Treatment					Replacement of Pond Treatment System		Alternative Disposal Methods		I/I Rehabilitation
Parameter	Wt	Soil Beds	Pond with PETRO system	Sand Filtration with Coagulation	Pond with Membrane Filtration	Constructed Wetlands	MBR	SBR	Discharge to Land Only	Combined Land and Water Discharge	Targeted I/I Rehabilitation
Feasibility											
Improvements of plant performance	4	3 Likely	3 Likely. High Algae risk though.	3 Likely for particulate contaminants.	3 Likely for particulate contaminants.	2 Possible	4 Very Significant improvements	4 Significant improvements	0 No change in plant performance	0 No change in plant performance	2 Possible
Improvement in receiving environment water quality (ie. meets existing consent compliance)	4	1 Unlikely	3 Likely	3 Likely for E.Coli & DRP	3 Likely for E.Coli & DRP	1 Unlikely	4 Likely significant improvements	4 Likely significant improvements	4 Removes all load from receiving waters	3 Removes some load from receiving waters	2 Possible (less flow, greater HRT in pond)
Nitrogen removal	3	2 Uncertain/Moderate	3 Moderate/good, may need carbon dosing	0 Unlikely, some removal due to removal of particulate nitrogen	0 Unlikely, some removal due to removal of particulate nitrogen	2 Uncertain/Moderate	4 Very good	4 Very good	4 Discharging current N levels to land is acceptable	3 Removes some load from receiving waters	0 Unlikely
Phosphorus removal	3	2 Possible until soil saturation	1 Uncertain. Possible additional biomass uptake	3 Possible if Al or Fe coagulants are used. Will impact the filter sizing though.	3 Possible if Al or Fe coagulants are used. Will impact the membrane sizing though.	1 Uncertain	4 Possible, using biological or chemical P removal	4 Possible, using biological or chemical P removal	4 Discharging current P levels to land is acceptable	3 Removes some load from receiving waters	0 Unlikely
Capex	3	3 Moderate	2 Relatively high	2 Relatively High.	2 Relatively High. Large unit, pumping, chemical dosing	2 Relatively High.	1 Very high	1 Very high	1 Very high	2 Relatively High	2 Relatively High.
Opex	2	2 Uncertain, soil may need regular replacement	2 High	2 High. Backwash pumping and coagulant dosing.	2 High. Pumping and chemical usage.	3 Moderate, maintenance, replanting, harvesting	1 Very high	2 High	4 Moderate - potential for crop income	3 Some potential for crop income	4 Low
Operation	1	3 Relatively easy	1 Complex to operate	2 Some complexity	2 Some complexity	3 Relatively easy	1 Complex to operate	1 Complex to operate	2 Some complexity	2 Some complexity	4 Easy
Reliability	4	2 Uncertain in terms of nutrient removal	2 Moderate to High nutrient removal. Risk of high TSS/BOD because of algae	2 Uncertain in terms of nitrogen removal	2 Uncertain in terms of nitrogen removal	2 Good, provided maintained and harvested but unlikely to reach TN/TP removal target	4 Very reliable	3 Reliable	2 Reliable. Risk of extreme wet weather & infrastructure failure causing issues.	3 Reliable	4 Reliable
Solids production	1	1 Moderate/High, will produce contaminated soil for disposal	0 High	1 Moderate/High	1 Moderate/high	2 Moderate	0 High	0 High	3 Little/ No effect	3 Little/ No effect	3 Little/ No effect
Summary		53 Not recommended. Uncertain outcome in terms of nutrient removal to low levels.	55 Not recommended. Costly option without guarantee in terms of nutrient improvement.	54 Not recommended. Uncertain outcome in terms of nutrient removal to low levels.	54 Not recommended. Uncertain outcome in terms of Nitrogen removal to low levels.	46 Not recommended. Uncertain outcome in terms of nutrients removal to low levels.	78 Possible option. Lowest treatment risk but high Capex, complex maintenance high OPEX.	76 Possible option. Low treatment risk but complex operation, high Capex, high OPEX.	64 Possible option in the long term. High Capex but removes all load to the receiving waters.	59 Recommended. High Capex, removes most load to receiving water but retains emergency discharge.	53 Recommended. I/I reduction will lower cost of long term options.