RAGLAN WASTEWATER SDI DISPOSAL OPTIONS PRE-FEASIBILTY REPORT

May 2021

Prepared by NexGen Water Limited

For WaterCare Waikato

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1 INTRODUCTION

1.1 Pre-Feasibility Background

WaterCare Waikato (WaterCare) has been investigating an upgrade for the Raglan Wastewater Treatment Plant (WTTP), which may involve part, or full, disposal to the land. As part of these investigations WaterCare visited the Pauanui subsurface drip irrigation (SDI) municipal land effluent disposal system early 2021, which is owned by Thames Coromandel District Council (TCDC) and operated by Veolia Water (Veolia). It was considered that many aspects of the Pauanui SDI disposal system may have value adding application at Raglan.

The Pauanui SDI system was designed by Peter Gearing, when he was a Principal and Group Leader of the Auckland Water & Waste Group, at URS New Zealand Limited (URS). Peter has subsequently left URS, but a paper describing the system is attached in Appendix 1, in order to provide background detail and context (to this Report).

Along with Pauanui, Peter (now trading as NexGen Water) has consented and designed the majority of local large scale municipal effluent SDI land treatment systems in New Zealand including: New Zealand Aluminum Smelters Limited; Omaha (including both the golf course and short rotation forest); and Maketu, plus he has conducted large scale SDI research projects at both Waihi Beach (Western BoP District Council) and Rotorua (Whakarewarewa Forest – Rotorua District Council).

Peter is also currently in the final stages of the design, installation and commissioning of a large 30Ha SDI disposal system for Southland District Council, at Te Anau, which also involved detailed HYDRUS2D irrigation soil water and solute (mainly nitrogen) modeling, which was conducted by Professor Freeman Cook. It was largely Peter's and Professor Cook's technical inputs to the consenting process, which assisted in the Resource Consents being granted by Southland Regional Council.

Professor Freeman Cook has recently returned to his native New Zealand from a highly distinguished career in Australia with the CSIRO, and is a recognised world leader in the field of environmental physics and soil moisture (and solute) movement, principally as modelled with the HYDRUS2D hydraulic model.

Subsurface Drip Irrigation (SDI) of treated effluent is significantly different from the more commonly practiced irrigation method of surface drip irrigation with clean water, as utilised in the agriculture industry (such as grape vineyards etc).

Given the specialist nature of SDI, WaterCare have now retained NexGen Water (with Professor Cook) to consider if in their opinion, a Pauanui like SDI solution may have application for the community of Raglan. This Report is prepared in response to this request, as a first stage Pre-Feasibility assessment.

1.2 Pre-Feasibility Inputs

In preparing the Raglan SDI Disposal Pre-Feasibility Assessment, NexGen Water has been provided the following input documents by WaterCare:

- Beca Report titled "Raglan WWTP Optioneering – Short List Design and Costing" dated 5 Feb 2021;
- Resource Consent Waikato Regional Council Permit No. 971309 dated 14 Feb 2005;
- PDP "Raglan Rapid Infiltration Investigation Report" dated Jan 2002;

Where the February 2021 Beca "Raglan WWTP Optioneering" Report also contained as Appendices:

- PDP "Raglan WWTP Discharge Options – Assessment of Land Irrigation" dated Jan 2021;

And,

- Landcare Research "Review of Selected Soils near the Raglan WWTP" dated Aug 2020.

1.3 Scope of the Pre-Feasibility Study

WaterCare has sought that NexGen Water consider the documents provided, and in particular the PDP “Raglan WWTP Discharge Options – Assessment of Land Irrigation” Report, dated January 2021. NexGen Water’s Scope of Work in preparing the SDI Disposal Options Pre-Feasibility Study has been identified as:

(i) Consider the PDP Land Irrigation Disposal Options;
(ii) Consider if a Pauanui like SDI Disposal Option may be compatible with the PDP Report;
(iii) If SDI may be an option – could it involve Public Land (at Raglan);
(iv) If Public Land were deemed potentially appropriate for a Pauanui like SDI solution, how may it conceptually be conceived; and,
(v) If Public Land were considered suitable for SDI, what further investigations may be required.

2 PRINCIPALS OF EFFECTIVE LAND TREATMENT

It is noted that the PDP "Raglan WWTP Discharge Options, Assessment of Land Irrigation" Report, dated January 2021 (PDP Jan 2021) considered the principals of Land Treatment with respect to Raglan (ref s.2.0 & s2.5 principally). However, PDP (Jan 2021) considered forty (40) potential irrigation sites (ref Table 3) and in the context of the following total scheme configurations, being:

(i) *Non-deficit irrigation* (i.e. 100% disposal to land all year round at rates exceeding soil moisture demand;
(ii) *Non-deficit irrigation with alternative discharge* (i.e. seasonal irrigation with an alternative marine discharge during wetter periods);
(iii) *Deficit irrigation with storage* (i.e. 100% disposal to land when soil moisture levels require irrigation);
(iv) *Deficit irrigation with alternative discharge* (i.e. season irrigation with alternative marine discharge).

Accordingly, it is considered potentially beneficial that (in the first instance) in order to objectively Review the Raglan Land Irrigation proposal (with respect to if an SDI option may be feasible), that some key performance parameters of an effective and sustainable land treatment system be provided. This hopefully will provide the reader context to the Pre-Feasibility Methodology, the Conclusions, and any potential Recommendations.

In summary Land Irrigation is quite different from Land Treatment, because if all the treated effluent can not be treated by the land – then some form of direct discharge to water is required in addition. Land Irrigation therefore in effect – just makes a partial use of the treated effluent for an irrigation reuse – when required by the land involved.

Land Treatment however is exactly that, it is not an irrigation system in the classical sense of the term, as it is not simply replacing moisture to a crop (or plant-based system) in times of deficit. Instead, a land treatment system is an integral and important part of an overall wastewater conveyance, treatment and disposal system. It needs to perform year-round, every day, and in an effective and sustainable manner without producing adverse environmental (or social) effects.

In many respects therefore, the critical time to access the potential efficacy of a land treatment system is during the winter rainy season, as this is the antithesis of the requirements of a typical moisture deficit replenishing irrigation system. In winter a few critical factors combine, being:

(i) Typically, the volume of wastewater is increased during rainfall due to infiltration and ingress (I&I) into the conveyance system (both via the public network (i.e. runoff entry into pump-stations or via groundwater into pipes etc) and via domestic gulley traps and stormwater cross connections etc);
(ii) The soil of the disposal area is wet, because the rainfall exceeds the losses of reduced plant evapotranspiration; and,
(iii) The season is typically colder, with consequentially reduced plant (crop) growth, which means if the land treatment system is relying upon crop uptake for nutrient removal, that this is also reduced at this time.

Hence, typically during winter in New Zealand, the land treatment system needs to handle an increased disposal volume at the very time the environment and crop are at their most vulnerable to accept and assimilate (or treat) it.

2.1 Soil Moisture & Solute Movement

As described above, the essence of an effective land treatment system is to apply the treated effluent in both a form and manner that the soil can effectively store and hold it, such that crop uptake can be optimised in order to maximise nutrient uptake.

Therefore, the land treatment system is required to optimise both the movement of soil moisture and applied solutes. However, typically moisture applied to the soil through the irrigation, and the solutes contained within, can move through the soil at different rates.

Accordingly, a thorough understanding of the soil properties and characteristics are essential in order to optimise lateral and vertical (upward and downward) spread of the applied soil moisture and solutes, to maximise plant uptake –

while minimising and avoiding loses to the environment through the applied moisture “daylighting” to the soil surface (from an SDI system) or percolating downward to groundwater (or lower downslope surface water) via leaching.

2.2 Disposal System

The dispersal (or irrigation) method is a further critical factor in determining the long-term sustainability and efficacy of any land treatment system. But equally important are: effective design; operational management; and inclusion of appropriate risk reduction features. With: poor design; and/or poor management; and/or inclusion of inferior technologies (more designed for simple moisture deficit crop irrigation) even the best theoretical systems can fail to perform to specification (and result in adverse environmental effects, ultimately leading to Consent Non-compliance).

Having stated the above, an effective SDI system may offer many advantages as a land treatment dispersal methodology, which may include:

(i) The irrigation (by being below ground), can operate at any time, and not affect farming (or other) operations on the land above (such as a Reserve and / or Airstrip – as is the case with both at Pauanui);
(ii) By irrigating below the ground, the water is introduced to the environment (from each individual drip emitter) more in the form of a three (3) dimensional wetted “squashed” soil sphere (as opposed to a more “carrot” like profile from a surface drip emitter – where (with a surface drip application) the water cannot rise, but only spread outwards and downwards);
(iii) This in turn offers several advantages (with SDI) such as:
  (a) a portion the wetted SDI soil sphere is typically above the dripper, as water and solutes move upward and results in better retention of solutes and water, compared to surface drip;
  (b) evaporative loss of water is reduced and subsurface has a greater crop water use efficiency;
  (c) the concentration of applied solutes (i.e. nitrogen and phosphorous) leached from the profile is also less (Cote et al., 2003); plus,
  (d) any applied salinity (such as sodium from domestic washing machine powders) is typically also (with good irrigation management) pushed to the outer extremities of the wetted sphere front with SDI (hence minimising the effect within the active root zone of the wetted disposal soil volume);
(iv) Further agronomic advantages will accrue to the landowner (i.e. Wainui Reserve for example) by irrigating the treated effluent below the ground, which may include:
  (a) by irrigating below the ground, the plant leaves are kept free of treated effluent, hence no withholding periods prior to harvest; plus,
  (b) the plants will not be potentially cross contaminated by pathogens (i.e. cysts, helminths, bacteria, or viruses);
(v) The system will not be affected by inclement weather (such as rainfall, wind, frost etc) hence minimising buffer storage requirements;
(vi) The SDI system will not produce odours or aerosols (both being important considerations for Raglan Public land options and the nearby community or land users);
(vii) Designed appropriately, the system can be vandal proof (where even though on private property the system will be a critical piece of community infrastructure); and,
(viii) Importantly, given the topography of the proposed irrigation site, SDI (if designed and managed effectively to avoid the treated effluent rising to the soil surface) will mitigate cross contamination of surface rainfall runoff water.

For the above reasons, the proposal to consider SDI as a dispersal methodology for the Public Land of Raglan (i.e. the Airstrip, Wainui Reserve and Raglan Golf Course) is considered entirely appropriate.

However, SDI is not simply the installing under the ground of a typical surface drip irrigation system. Special technologies are required for long-term reliability, such as:

(i) *root intrusion inhibition* to protect both the individual drip emitter outlet orifices and internal emitter labyrinths and pathways (from blockage by external plant root ingress);

(ii) *vacuum relief* to avoid particulate suck back upon system shutdown (which will be of critical importance with this project given the topography of the Wainui Reserve suggested land treatment area); and,

(iii) *non-mobile anti-microbial inner tube linings*, which are important for any SDI system proposed for the disposal of wastewater, as by incorporating a BoD source (in the supply water) this provides the potential for bacterial slime growth (and hence the potential for drip emitter blockage via both growth and sloughed slimes).

It is strongly recommended that technologies to avoid the three (3) issues listed above, be incorporated in any potential Raglan land based effluent SDI disposal solution. These three (3) technologies are also incorporated in the Pauanui SDI system.

2.3 Crop Uptake

As described in the sections above, a further critical component of any land treatment system is the irrigated crop and its uptake. In general, crop-based systems that exclude animals but instead rely upon a “cut and carry” harvesting / management regime, offer improved nutrient removal potential, as nutrient is not recycled back into the land treatment system from animal excrements (i.e. both solid and liquid).

Other important criteria to determining crop uptake are considered as:

(i) Crop species;

(ii) Dry matter yield;

(iii) Percentage of dry matter that is nitrogen and phosphorus;

(iv) Depth and radial spread of crop roots from each plant (important in assisting moisture uptake from the irrigation);

(v) Crop winter activity;

(vi) Crop palatability and suitability as a feed for local livestock.

It is noted that the PDP (Jan 2021) Report describes nutrient loading rates in s.2.5, and in particular with regard to nitrogen provides the plant uptake range of 150 KgN/Ha/year for grazed pasture or forestry, through to 400 to 500 KgN/Ha/yr for a cut and carry cropping system.

Typically grass or lucerne are used in cut and carry systems, and effectively designed SDI should be compatible with both

However, lucerne is reported to have the dual advantages of both high dry matter yields (i.e. potentially up to around 14T DM/Ha/yr – being tonnes of dry matter per hectare per year) and a high nitrogen content (i.e. in the order of 3.6%) that can result (in certain situations) with uptake in the order of 500 KgN/ha/yr uptake.

Lucerne also has the advantage of a deep and vigorous root system.

However, as determined by comparative assessments in the central North Island (for land treatment systems) lucerne does have a disadvantage of low winter growth activity (in the cold).

Crop type may be important for the farming operation contracted to receive the feed from any Raglan cut and carry SDI disposal system, as land owner support and involvement is important for an effective long-term land treatment system.

2.4 Wastewater Treatment

Sewerage conveyance type and treatment plant form are also important aspects of the overall wastewater system, that can impact upon land treatment efficacy.

Sealed small bore systems (either gravity or pressure pump based) tend (if designed, managed and controlled effectively) to have the potential to reduce the volume of wet weather I&I, and hence reduce the wet weather peak flow volume needing to be handled by the land treatment system (such as with the Maketu SDI system). However, these systems (particularly the grinder-based pressure sewer system) tend to "macerate" the sewage solids, hence can result in a higher solids loading on the waste wastewater treatment plant, as inlet screening systems are often less effective in capturing the incoming macerated solids (however this does not appear a consideration for Raglan at this stage, but it may be an issue for consideration in the future).

Total quantum of nitrogen (i.e. TN) as well as the form of output nitrogen from the treatment plant, are very important. Treatment plants tend to either produce nitrogen in the form of either nitrate nitrogen (i.e. aeration-based treatment methodologies, such as sequential batch reactors) or ammonical nitrogen (i.e. less aerated more settled and filtered treatment methodologies).

Total nitrogen volume is important to land treatment efficacy, as the dispersal system will need to be designed to capture as much of the applied nitrogen by the crop as practical, to then be removed from the land-based system by the crop harvest methodology.

Nitrate nitrogen as a solute tends to be mobile and to move more readily through the soil.

Ammonical nitrogen tends to be less mobile and typically is bound by the soil, particularly in winter, then in the warmer summer is converted to nitrate nitrogen and made available for crop uptake.

2.5 Groundwater & Receiving Environment Impacts

As described previously above, there are several aspects to an effective land treatment system, both in terms of initial design and ongoing management & operation.

Sections 2.1 and 2.2 above, describe: (a) the importance of understanding the water and solute movement within the soil; plus, (b) designing and managing the dispersal system (particularly if SDI, as being considered for Raglan) in order to maximise lateral water spread applied from each individual drip emitter (to assist dispersal uniformity and optimised crop uptake) while avoiding applied effluent rising to the soil surface; or percolating and leaching below the active crop root zone (and hence not available for crop uptake).

In a New Zealand winter rainfall can exceed evapotranspiration (as is the case at Raglan). This means that naturally before adding a land treatment system to the site, there will be the potential for percolation of soil moisture through the soil profile to groundwater below.

Add the moisture from the land treatment system and there is potential to increase percolation, which may go down vertically to groundwater, and/or on a slope, move sideways (particularly at the interface of a high drainage capability soil layer to a lower less drainage capability soil – where the soil moisture moves laterally downhill along the interface between the two soil layers).

If soil moisture percolates to ground water, this tends to decrease the depth to the associated groundwater and is referred to as "mounding". This could be particularly important if any "high rate" SDI is considered for Raglan, similar to that at Pauanui.

If the soil moisture moves laterally through the soil sideways (and downslope) at some point it will either come to the surface, or join groundwater.

An important aspect of designing and managing an effective and sustainable land treatment system, is to understand (and minimise or mitigate) the associated environmental effects with respect to groundwater and/or any possible propensity for cross contamination of surface waters (through applied moisture to the soil daylighting to the surface receiving environment).

2.6 Long-Term Sustainability

Accordingly, as described in the sections above, there are many inter-related aspects to a holistic and integrated Land Treatment system, that all need to be designed and managed over time effectively, in order for the system to be sustainable over the long-term.

For example, there is little point in having a well-designed theoretical system, but one where the drip emitters physically block over time with root intrusion and/or bacterial slime growth, because what this will mean, is the application rate at the smaller number of drip emitters continuing to work, will rise above the designed and consented application rate, then as a consequence a smaller actual wetted land treatment area will result (which will negatively impact crop uptake) and unexpected negative environmental impacts will arise (potentially leading to Consent Non-compliance). There are examples of exactly this situation in New Zealand.

The purpose of this SDI Disposal Pre-Feasibility Study therefore, is to assess the Raglan SDI Options with regard to the aspects described above, in order to ensure any SDI Proposal is: of sufficient size (i.e. land area); and is complete & robust (including incorporating appropriate technologies and risk mitigation provisions); to ensure best chance of long-term operation and compliance sustainability.

3 EXISTING RAGLAN LAND IRRIGATION PROPOSALS

In order to effectively assess the PDP (Jan 2021) Land Irrigation Proposals – with respect to if SDI may be an appropriate option – especially on Public Land – in the first instance it may be useful to consider the PDP Land Irrigation Options within the wider Beca (5 Feb 2021) scheme proposals. With this context, one may then consider SDI (particularly if on Public Land) and if considered feasible, how these options may relate to the wider wastewater scheme being considered.

3.1 Beca – Short List Conceptual Schemes

The Beca Report titled "Raglan WWTP Optioneering – Short List Design and Costing", dated 5 Feb 2021 (Beca 5 Feb 2021) Appendix C, summarises the short listed conceptual Raglan wastewater scheme options, as described below;

3.1.1 Shortlisted Conceptual Schemes

Beca (5 Feb 2021) Appendix C "Main Summary No.2" summarises the key shortlisted conceptual schemes as follows

Option M1
Treatment: Existing treatment process and addition of tertiary membrane
Disposal: Discharge to new outfall and diffuser

Option M2
Treatment: MBR and UV treatment
Disposal: Discharge to new outfall and diffuser

Option F1
Treatment: MBR and UV treatment
Disposal: Freshwater diffuse discharge

Option L1
Treatment: Additional tertiary Treatment after existing ponds and UV treatment
Disposal: Discharge to *Public Land* and to new outfall and diffuser

Option L2
Treatment: Existing ponds and UV treatment
Disposal: Discharge to Private Land (storage on Private Land)

Option L3
Treatment: Additional tertiary treatment after existing ponds and UV treatment
Disposal: Discharge to Private Land and to new outfall and diffuser

Option L4
Treatment: MBR and UV treatment
Disposal: Discharge to *Public Land* and to new outfall and diffuser

3.1.2 Summary of Estimated Costs

Beca (5 Feb 2021) Appendix C "Main Summary No.3" summarises the key shortlisted conceptual scheme estimated costs as per the Table 3.1 following:

Table 3.1

Beca Conceptual Scheme Summary

Item	**M1**	**M2**	**F1**	**L1**	**L2**	**L3**	**L4**
Establishment	$70K	$100K	$100	$70K	$70K	$70K	$100K
Treatment	$9,878K	$20,813K	$21,242K	$9,878K	$5,000K	$9,878K	$20,813K
Disposal	$388K	$355K	$257K	$1,894K	$1,990K	$2,163K	$1,894K
P&G	$1,720K	$145K	$200K	$1,970K	$1,175K	$2,015K	$3.795K
Physical SubTotal	**$12.054M**	**$21,413M**	**$21,799M**	**$13.810M**	**$8,235M**	**$14,124M**	**$26,602M**
Fees	$1,041K	$1,886K	$1,917K	$1,182K	$736K	$1,207K	$2,363K
Contingency (30%)	$3,929K	$$6,990K	$7,115K	$4,498K	$2,691K	$4,599K	$8,690K
Estimate SubTotal	**$17,024M**	**$30,300M**	**$30,800M**	**$19,490M**	**$11,662M**	**$19,930M**	**$37,650M**
Land Discharge (PDP)				$5,500K	$47,000K	$22,000K	5,500K
Total Estimate	**$17,024M**	**$30,300M**	**$30,800M**	**$24,990M**	**$58,662M**	**$41,930M**	**$43,150**

It is noted that of these options, apart from M1 which is improved treatment and a new outfall – option L1 (i.e. improved treatment / irrigation to *Public Land* and a new outfall) is the next most economic.

3.1.3 Proposed New Outfall

Beca (5 Feb 2021) Appendix A "Outfall Design" provides a conceptual new Outfall and Diffuser layout and design, proposed to be located very close the current existing outfall (i.e. near the public toilets on Riria Kereopa Memorial Drive).

3.2 PDP (Jan 2021) – Assessment of Land Irrigation Options

As described in s.2 above, the PDP (Jan 2021) Land Irrigation Options Assessment considered four (4) "Long List" options being:

(i)	Non-deficit, all year round:	90Ha - 190Ha, 150,000m^3 of storage;
(ii)	Non-deficit, dual discharge:	80Ha – 110Ha, 20,000m^3 of storage;
(iii)	Deficit, all year round:	260Ha – 570Ha, 300,000m^3 -400,000m^3 of storage;
(iv)	Deficit, dual discharge:	220Ha – 240Ha, 20,000m^3 of storage

A weighted attribute, GIS based, assessment was then undertaken to identify potential irrigation areas within a 10Km radius of the Raglan WWTP. Forty (40) preferred sites were identified and considered. This process resulted in a "Short List" of preferred options being:

(i) Non-deficit irrigation to land – 100% irrigation; and,
(ii) Non-deficit irrigation to land with an alternative marine discharge.

Of these short-listed options, theoretical "clusters" of the preferred 40 sites were identified, along with potential storage dam sites, that may be created within incised valleys. The Non-Deficit options required less land, as the marine discharge would accommodate wastewater in the winter months, in order to avoid oversaturating the soils.

This process then resulted in three (3) “Short Listed” actual land treatment options recommended to be investigated further, being:

(i)	Option 1	Non-deficit 100% to land	$47M (re Beca L2 conceptual scheme);
(ii)	Option 2	Non-deficit with alternative discharge	$22M (re Beca L3 conceptual scheme);
(iii)	Option 3	Non-deficit to *Public Land* with alternative discharge	$5.5M (re Beca L1 & L4).

3.2.1 PDP (Jan 2021) – Irrigation to Public Land

The PDP (Jan 2021) Option 3 (i.e. non-deficit irrigation to *Public Land* with an alternative discharge - re Beca L1 & L4) is described in s.4.3 (of PDP Jan 2021) and is based upon utilizing three (3) *Public Land* areas for irrigation being: Wainui Reserve; the Raglan Golf Course, and the Raglan Airstrip.

Key points noted from PDP (Jan 2021) s.4.3 in relation to any potential SDI options, are considered as being:

(i) The possible irrigable areas of the Wainui Reserve and Golf Course are identified as a maximum of 59Ha and a minimum of 38Ha;
(ii) Where the maximum area also included the Raglan Airstrip;
(iii) The minimum area is more conservative and incorporates a 50m buffer – and excludes areas of potential conflict on the Wainui Reserve (such as: the Amphitheatre, Sound Splash and para-gliding);
(iv) Based upon soil types observed at the Wainui Reserve and Raglan Airstrip it was assumed that irrigation can occur all year round;
(v) However, irrigation to the Raglan Golf Course will only occur during the summer months of December to March;
(vi) The Wainui Reserve may operate on a four (4) day rotation (to allow time for the soils to rest), while the Golf Course may operate on a three (3) day rotation;
(vii) The maximum irrigation capacity is 8mm/day;
(viii) A storage pond of 1,000m^3 has been assumed at the Wainui Reserve, with the Raglan Airstrip and Golf Course assumed as direct on line;
(ix) The irrigation Type has been based upon utilising dripline (to avoid conflict of existing land uses of the public land); and,
(x) From Table 9 (the 2020 annual average) irrigation totals, are predicted as:
  - Wainui Reserve 152,672 m^3/year
  - Raglan Golf course 53,477 m^3/year
  - Raglan Airstrip 77,177 m^3/year
(xi) Table 9 (PDP Jan 2020) therefore infers for 2020 (with an average daily volume of 1,163m^3/day) that:
  - The outfall would have 141,229 m^3/year
  - With the Total 2020 volume 424,495 m^3/year

However, PDP (Jan 2021) s.4.4 (6th bullet) states that the irrigation estimate for *Public Land* is based on dripline irrigation at $30K/Ha. Based upon experience with projects like: Pauanui; Omaha; Maketu; and the current Te Anau – this is considered an underestimation for SDI (and surface drip irrigation may not be a viable option – particularly on the Raglan Airstrip).

3.3 Key Points Noted

In terms of considering a Pauanui like SDI option for Raglan, certain key points from the Beca (5 Feb 2021) Report and the appended PDP (Jan 2021) Assessment, are therefore considered relevant, being:

(i) Non-deficit irrigation to *Public Land,* with an alternative discharge, is one of the three (3) preferred land irrigation options;
(ii) The Wainui Reserve and Raglan Airstrip are considered suitable for an all-year-round discharge to land via irrigation;

(iii) That irrigation of treated effluent to these *Public Land* options, is considered as best achieved via the dripline irrigation methodology and,

(iv) That these *Public Land* options are the disposal options (with a new outfall and diffuser) that form the base of the Beca L1 Conceptual Scheme configuration;

(v) Of the land-based disposal options, Conceptual Scheme L1 is the most economic; but,

(vi) Beca L2 Conceptual Scheme configuration (which included disposal to Private Land and no outfall) incorporated less expensive treatment to that of L1 (by in the order of $4.8M). There may be options worth exploring with an SDI option at Raglan on *Public Land,* that may also realise similar treatment savings as offered by L2.

3.4 Crop Uptake

3.4.1 Nitrogen and Phosphorus Loading Rate

The pasture growth for the Waikato region given optimum pasture growth is 17,625 KgDM/Ha/yr and with nitrogen concentrations of 2.5 and 3%, give uptake of nitrogen between 441 and 529 KgN/Ha/yr. The median total nitrogen (TN) concentration in the Raglan wastewater is 26 mg/L and ammoniacal (NH_4) concentration is 8 mg/L (Beca, 2021, Table 3). Given the 2020 average daily flow rate of 1,163 m^3/day (Beca 2021, Table 4) the area required for uptake of all of the TN by pasture would be 25.0Ha and for the NH_4 would be between 7.7Ha. This does not take into account other loses of nitrogen due to denitrification and volatilization. The peak wet weather flow is greater at 3,175 m^3/day, but then the nitrogen concentration will be lower, and the nitrogen loading is likely to be the same as for the average flow.

The total phosphorus (TP) is given as 5 mg/L for the Raglan wastewater but uptake for pasture will be lower at about 0.5% of phosphorus in the pasture dry matter. The area required for the uptake of the TP is very similar to that for TN of 24.1Ha. The phosphorus adsorption by the soil is unknown but will reduce the phosphorus uptake.

These calculations suggest that an area of less than 25Ha would be required for a cut and carry wastewater irrigation system if all the TN and TP in the wastewater was available for 2020 flows. This area would need to increase to 42Ha by 2055 for the projected flow increase.

Filtering of the wastewater for SDI may reduce the nitrogen and phosphorus concentration in the wastewater and losses of nutrients via other soil processes may mean that a lower area is required than that estimated here.

3.4.2 Hydraulic Loading Rate

The PDP report suggests quite low hydraulic loading rates varying from 800 to 210 mm/yr based on various options (PDP, Jan 2021, Table 1). These were based on a water balance model that had a very low drainage rate of 10 mm/day to 1 mm/day. Only the Wainui reserve site 2 and 15 Te Ahiawai Road site have such low hydraulic conductivities in the subsoil. This assessment results in land areas of up to 570Ha and storages of up to 400,000 m^3. From the nutrient loading rates above a lower area of approximately 25Ha would be required initially and increasing to 42Ha by 2055. The hydraulic loading rates for these areas are then 1,695 mm/yr and 4.64 mm/day. The climate data for New Plymouth was downloaded from NIWA's CliFlo website as this was suggested as the best climate station available for Raglan (PDP, Jan 2021). This shows that on average over a 6,713 day period (from 2/11/1991 to 19/3/2010) average daily drainage (rainfall in excess of ETo) was 14,094 mm or 2 mm/day. The maximum daily rainfall over the period was 118 mm. However, when the daily water balance is considered the majority of the days (4,332) have a negative water balance with ETo being in excess of rainfall (ref Figure 3.1 following) and 1,153 days have a daily water balance of less than 2.5mm. This means that a drainage rate of 10 mm/day would be able to cope with the wastewater plus climate inputs on 82% of the time. The Raglan Airstrip and Raglan Golf Course sites would be able to cope with all rainfall plus wastewater applications according to Table 2 of PDP (Jan 2021).

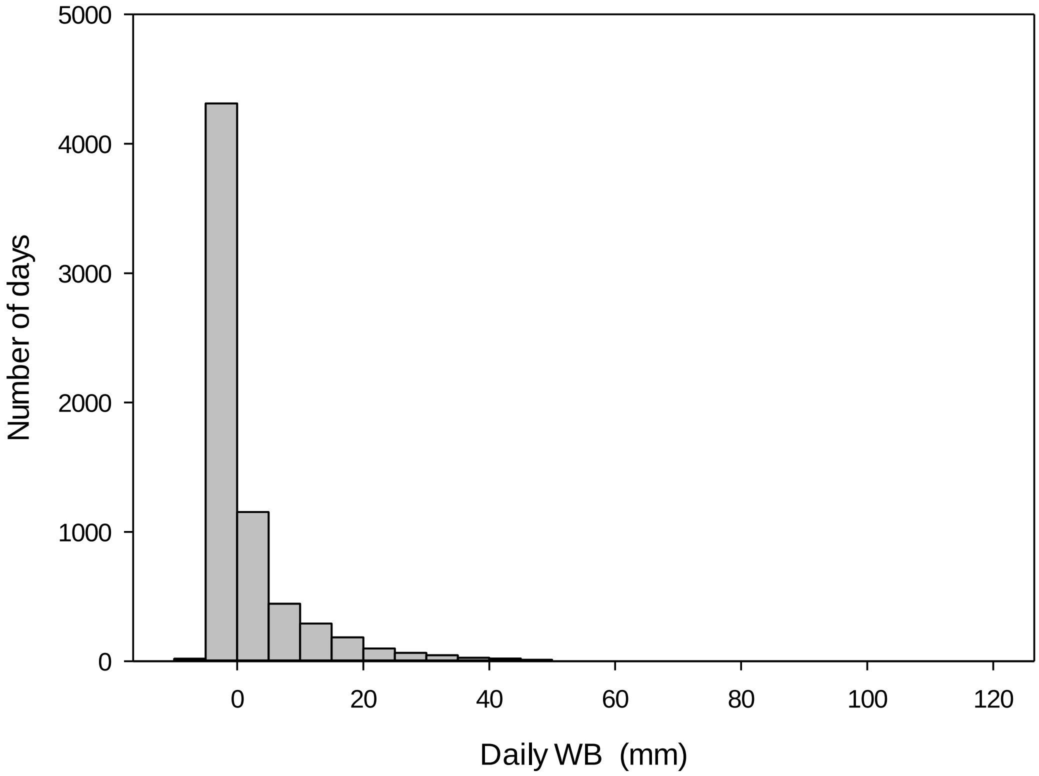


Figure 3.1. Frequency (number of days) for the daily water balance (WB).

4 OPTIONS FOR SDI AT RAGLAN

As described in s.3 of this Report previously, the concept of utilising SDI (in a Pauanui like form) is not incompatible with both the Beca (5 Feb 2021) L1 Conceptual Scheme configuration, and the PDP (Jan 2021) Short Listed Option 3 (i.e. non-deficit irrigation to *Public Land* with an alternative discharge), utilizing the Wainui Reserve, Raglan Airstrip (and potentially also the Raglan Golf Course).

This Section describes the desktop assessment undertaken to consider if such an SDI alternative may be feasible, and if so, how it may be configured.

4.1 Public Land Availability

As described previously, the PDP (Jan 2021) Short Listed Option 3 (i.e. non-deficit irrigation to Public Land in addition to an alternative (marine) discharge), identified three (3) potential Public Land areas, being: the Wainui Reserve; Raglan Airstrip and the Raglan Golf Course. The PDP Report also noted that irrigation to the Raglan Golf Course will only occur during the summer months of December to March, hence the Raglan Golf Course was considered more of a desirable beneficial reuse, rather than an all-year-round integrated land disposal option, given that for eight (8) months of the year, it was not be expected to accept any effluent irrigation.

Accordingly, as described in s.3.4.1 previously, for a Stage 1 (2020) system, for full TN and TP removal (based upon current Beca (5 Feb 2021) water quality data), in the order of 24-25Ha irrigation is required for this Public Land Option to be considered as feasible.

Figure 4.1 attached, describes indicative irrigation areas on: the Wainui Reserve; Raglan Airstrip; and WWTP surrounds; that may total in the order of 24-25Ha.

The areas on the Wainui Reserve have been specifically identified in order to avoid:

(i) The para gliding area;
(ii) The "Sound Splash" precinct;
(iii) The Amphitheatre;
(iv) Key areas of hapu significance;
(v) Key internal roads;
(vi) Steep areas;
(vii) Natural water courses;
(viii) Areas of native bush; and
(ix) The horse-riding track.

The indicative irrigation locations total the actual physical areas as described in Table 4.1 following.

Table 4.1

Indicative SDI Disposal Areas

Wainui Reserve	Ha
A	5.6
B	4.6
C	2.0
D	4.2
E	0.8
F	1.1

Table 4.1 (continued)

Indicative SDI Disposal Areas

Wainui Reserve	**Ha**
Wainui Reserve Subtotal	18.3
Raglan Airstrip	
G	5.5
WWTP Surrounds	
H (In Combination)	0.8Ha
GRAND TOTAL	**24.1**

Figure 4.1. Indicative Potential SDI Areas on Raglan Public Land (totaling in the order of 24Ha).

Therefore, based upon indicative Public Land area availability, a Pauanui like SDI option on the Raglan Airstrip, in conjunction with other Public Land on the Wainui Reserve (for nutrient absorption) and potentially the Raglan Golf Course, plus a marine outfall, is at this stage of the Pre-feasibility Study, considered as potentially feasible.

4.2 SDI to the Raglan Airstrip

One of the keys to the operability and efficacy of both the Pauanui and Omaha SDI community effluent disposal systems, is the ability to use certain areas of local sand for a constant and non-deficit winter discharge (i.e. these dedicated areas are used at an application in excess of winter evapotranspiration). This also has a positive impact upon the reduction in quantum of associated storage.

In this regard, if a Pauanui like disposal system is to be considered for Raglan, then the areas of sand soils will be central to any Pre-Feasibility study. Furthermore, if a key objective is to use *Public Land* for land treatment at Raglan, then the key area for consideration will be the Raglan Airstrip.

4.2.1 Complete Disposal on the Raglan Airstrip

As with Pauanui, the soil at the Raglan Airstrip is sand and is considered likely to be hydraulicly suitable to receive all of the wastewater from Raglan via SDI. This would make it similar to the rapid infiltration basin concept investigated by PDP (Jan 2002), and the technical information in that report is useful in considering this prospective initiative.

Figure 4.1 above describes potential SDI disposal Area G – which is roughly the open landing area of the Raglan Airstrip with a 20m boundary (buffer) to the external property boundaries. At this stage of the Prefeasibility Study, the potential SDI area of the Raglan Airstrip is assumed as 5Ha.

The theoretical area considered for such a disposal, in the first instance (for ease of assessment), is assumed as a rectangular area 82 m wide by 620 m long, giving an area of 5.084Ha (ref Figure 4.2 below).

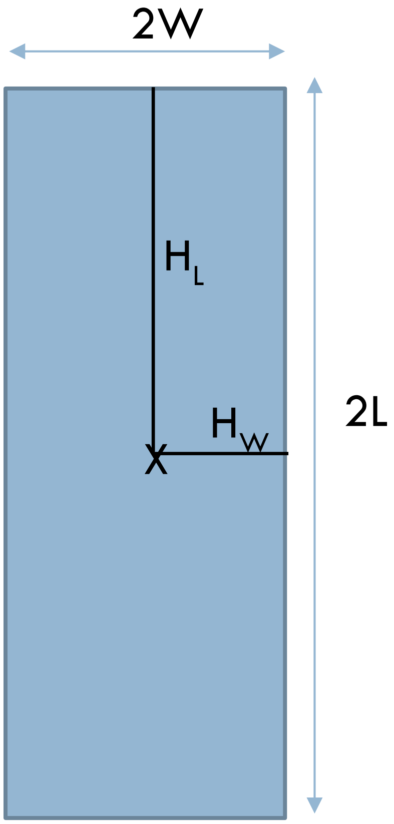


Figure 4.2. Schematic of airstrip irrigation area with width 2W = 82 m, length 2L = 620 m. X marks the center of the area where the maximum water table height (H_m) will occur and H_L and H_W represent the midlines along which the water table height is calculated.

The 2020 daily average flow is 1,163 m^3/day and the projected flow for 2055 is 1,957 m^3/day. The average hydraulic loading to the airstrip would be 22.88 mm/day and 38.49 mm/day for the 2020 and 2055 flows respectively. These hydraulic loads also include 404 mm/yr from the climate inputs. Given these high hydraulic loading rates most of the wastewater would pass through the profile and this is taken as the recharge rate for the groundwater. The groundwater is likely to mound up with this magnitude of recharge and this can be calculated using Hantush (1967) with the data used in these calculations provided in Table 4.2 following.

NOTE: Input data for groundwater mounding. L is half length, W is half width, saturated hydraulic conductivity (Ks), H_0 is the initial water table height above the impermeable layer, Ht is maximum possible water table height and storativity is pore space available to fill.

Table 4.2

Potential Water-Table Height – Raglan Airstrip

Year	L (m)	W (m)	Recharge rate (m/day)	Ks (m/day)	H_0 (m)	Ht (m)	Storativity (m^3/m^3)
2020	310	41	0.02288	6.912	1	5	0.25
2055	310	41	0.03849	6.912	1	5	0.25

The water table height at the center (Hm), at the edge of the width of the area along the midline (end of line H_W in Figure 4.2) and the water table at the edge of the length of area along the midline (end of line H_L in Figure 4.2) are shown in Figure 4.3 following. This shows that in two (2) years the water table would be above the soil surface at the center and at the narrow edge at the center. At the long edge in the midline of the area the water table only rises slightly. To move even 0.05L (15.5 m) from the center at the midline, the rate of rise is reduced as is shown in Figure 4.3.

For the 2055 recharge rate, the rise is even faster. These results indicate that without drainage, that to apply all of the wastewater to the airstrip is not feasible, if no actions are taken to alleviate the ground water mounding. These calculations do not consider that discharge would be occurring at sides of the airstrip to the estuary, but are indicative of the fact that considerable groundwater mounding would occur, and this concurs with the PDP (Jan 2002) Report on rapid infiltration basins.

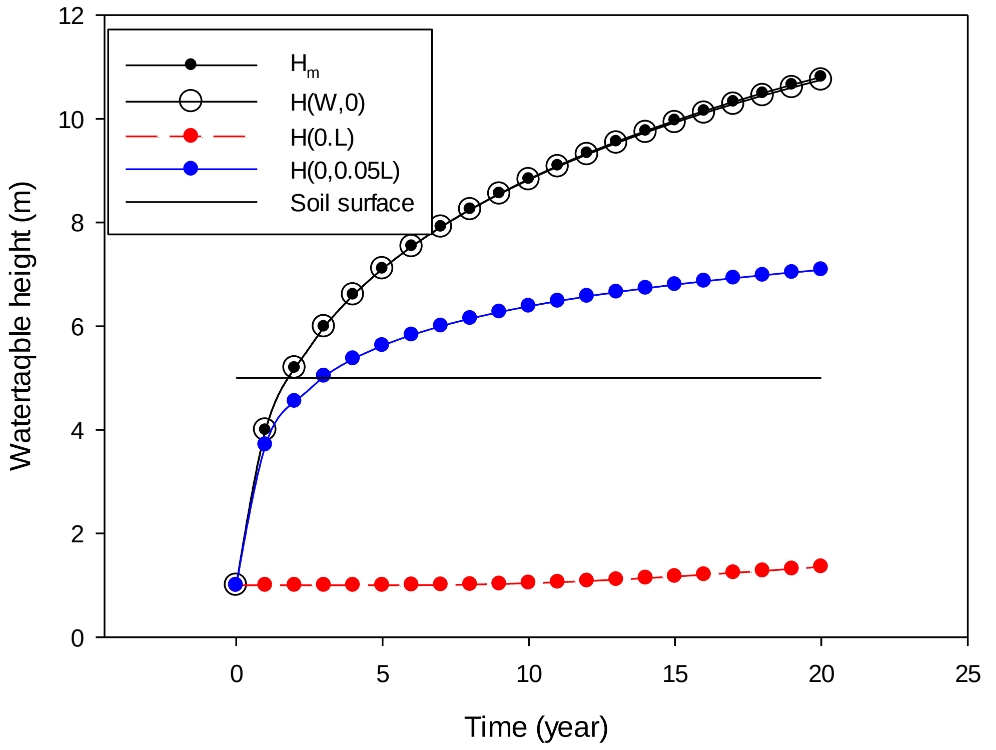


Figure 4.3. Water-table height at the center of the irrigated area (H_m) at the ends of the midlines H(W,0) and H(0,L)) and at the center at a distance 15.5 m from the center along the midline H_L. The soil surface height is also shown as a reference height.

Therefore, for a Pauanui like SDI option on *Public Land* at Raglan to be considered as optimized, it is considered that options to minimize the potential groundwater mounding at the Raglan Airstrip are important. What this may achieve, is that the proportion of total annual volume that may be applied to the Raglan Airstrip may be increased, and as such reducing dependence upon land irrigation to the Wainaui Reserve (particularly in winter) and / or a reduction in storage capacity; or discharge to the alternative marine outfall. One such potential option for the Raglan Airstrip, the FILTER Method, is considered below.

4.2.2 FILTER Method

The FILTER method was developed in CSIRO by Jayawardane et al. (1996, 2001, 2007) and co-workers for the treatment of wastewater to remove nutrients (ref Figure 4.4 following). This method consists of irrigation with wastewater on an area sufficiently large for plant uptake of the nutrients to a level that is deemed safe for discharge to receiving waters. Although devised for flood irrigation, it is adaptable to SDI, or any other form of irrigation.

This system would be useful at the Raglan Airstrip, if the Airstrip was used for an application of a wastewater volume that may result in groundwater mounding, which could then be removed with a drainage system.

The other application where this system may be useful, is that this method would make the otherwise unsuitable Private Land site at 15 Te Ahiawai Road suitable for wastewater disposal, as the low hydraulic conductivity of the subsoil would result in the development of a water table that could then also be removed with a drainage system. The method may also have application for the Raglan Golf Course.

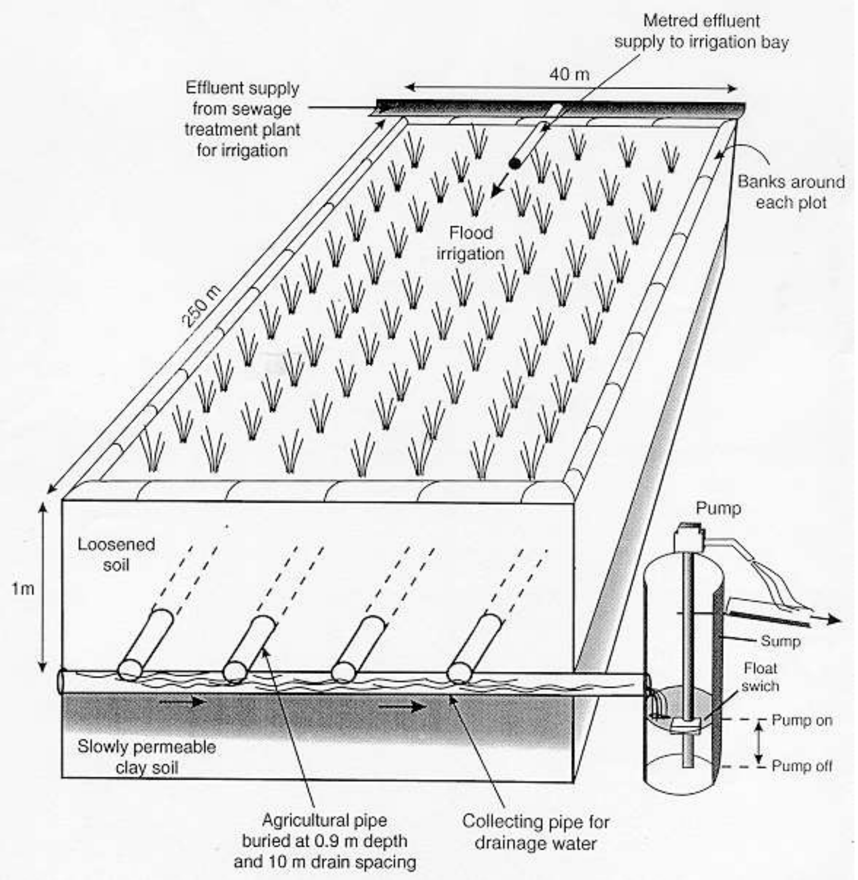


Figure 4.4. Schematic diagram of the FILTER system from Jayawardane et al. (2007), showing the essential features of irrigation and collection of drainage water for discharge.

4.2.3 Complete Disposal at the Airstrip with Combined SDI and FILTER

A Pre-Feasibility assessment for a potential resolution of the groundwater mounding problem for the complete application of the Raglan wastewater to the Raglan Airstrip, has then been assessed by combining the SDI (irrigation) with drainage as follows.

From the topographical information available, the height of the Raglan Airstrip above sea level is likely to be in the range of 5 to 3 m, with a water-table at about 1 m. The drainage system could be designed to keep the water table at a depth of between 0.5 and 1 m. Cook et al. (1998) developed the FILTMOD models to assist with design of the FILTER system and these are used here to consider the required drainage depth and spacing to achieve the desired water-table depth. In the first instance, we consider that the drains will go across the Raglan Airstrip and have a maximum length of 100 m. For drains at 1 m depth and spaced up to 19.2 m apart, the criteria of the maximum water table depth < 0.5 m is met, if the drainage tubing had a minimum of 64 mm in diameter. For small drain spacings the diameter of the drainage pipe can be reduced and at spacings of 0.6 and 1.2 m tubing with a diameter of 23 mm or less would be suitable (ref Table 4.3 following). However, these are only approximate estimates, as at the smaller drain spacings some of the assumptions in drainage equations are violated. More precise estimates can be estimated using HYDRUS2D. These calculations below show that a combination of SDI and FILTER would be possible using the Raglan Airstrip only for the wastewater.

.Table 4.3: Raglan Airstrip Groundwater Depth with the FILTER Method

2020 Flow					**2055 Flow**	
d (m)	**D (m)**	**PD (mm)**	**H_c (m**	**Dh (m)**	**H_c (m)**	**Dh (m)**
2	0.6	14	0.05	0.30	0.06	0.70
		23		0		0.2
	1.2	14	0.10	0.90	0.12	2.4
		23		0.25		0.4
	4.8	14	0.13	9.7	0.18	15
		23		0.9		3.5
	9.6	14	0.29	-	0.41	-
		23		-		12
4	0.6	14	0.05	0.30	0.06	0.70
		23		0		0.2
	1.2	14	0.10	0.90	0.12	2.4
		23		0.25		0.4
	4.8	14	0.25	9.7	0.34	15
		23		0.9		3.5
	9.6	14	0.25	-	0.37	-
		23		-		12

Table 4.3. Calculation of the height of the water-table (Hc) at the center between drains space 2D apart. The depth below the drain to the impermeable layer is d and PD is the diameter of a drainage pipe (where 2 diameters are considered) and Dh is the head loss for 100 m length of pipe. The drain is assumed to be installed at 1 m below the soil surface. The cells with green are feasible applications

The specialist typical SDI tube used in schemes such as Pauanui and Omaha, is normally 16mm outside diameter (OD) with an internal diameter (ID) of 14mm (but larger diameter options are available – as is being installed at Te Anau). Therefore, modified SDI tube could potentially be used for the FILTER drainage system at the Raglan Airstrip, providing all the economic and ease of installation advantages offered by the SDI disposal system, while also potentially providing further advantages (over standard drainage) such root intrusion inhibition and anti-microbial bacterial slime control (improving longevity and reducing ongoing operation risk).

4.2.4 Estimates of Wetting Patterns for the Soils Using WetUp

The wetting patterns formed by the SDI drip emitters are important in the designing of an effective SDI system. WetUp is a model developed to estimate these wetting patterns (Cook et al. 2007, 2017). In this Raglan Pre-Feasibility Study, we have used this model to estimate the wetting front position for the soil properties for the Airstrip and the Wainui Reserve site 1. WetUp requires input data of: the macroscopic length scale (λ); the saturated water content; wetting front water content; and initial water content.

The macroscopic length scales were calculated from the hydraulic conductivity data provided in the PDP (Jan 2021) Report, and were 0.097 and 0.095 m for the Raglan Airstrip and Wainui Reserve site 1 locations respectively. The saturated water content was estimated from the bulk density data in the PDP report (PDP, 2021) and the wet front water content, and initial water content from similar soils in Clapp and Hornberger (1967).

The results were calculated for a 2 L/hr dripper, but as the wetting patterns scale with the volume added, then these can be used for any flow rate using the ratio of the flow rate to that used here. Very similar wetting patterns were found for both the Raglan Airstrip and Wainui Reserve 1 sites (ref Figure 4.5 below).

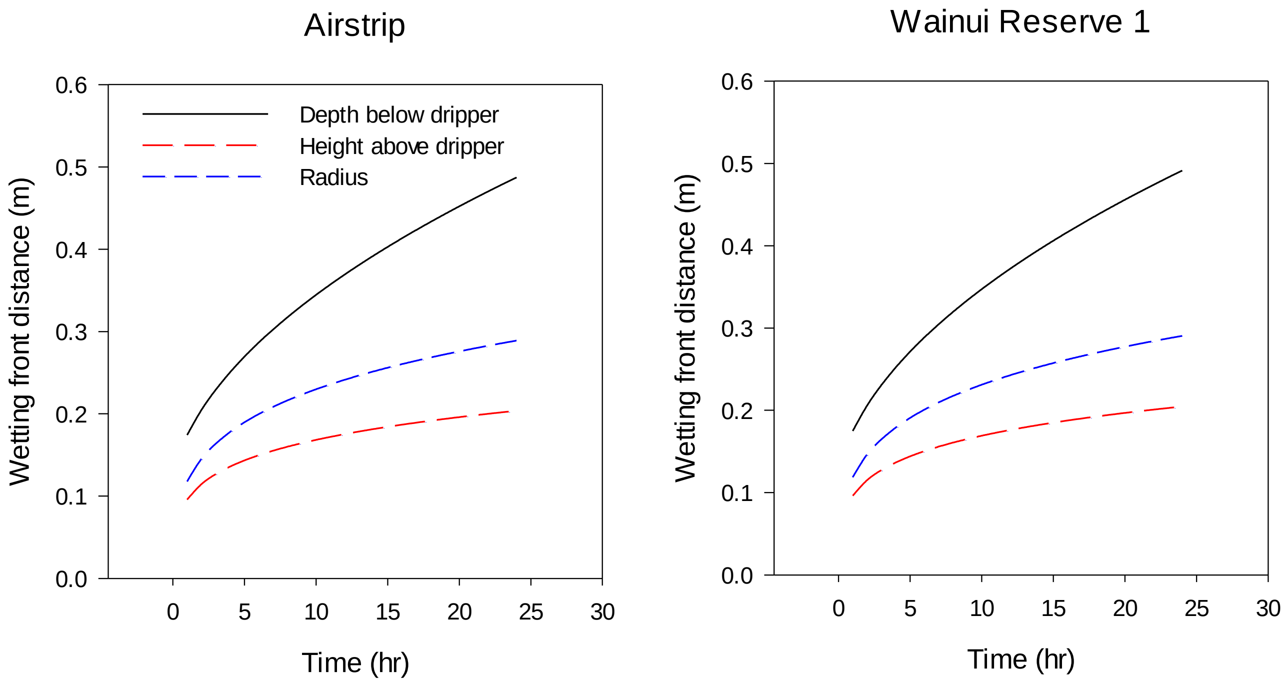


Figure 4.5. Wetting patterns with time for a 2 L/hr dripper for the Airstrip and Wainui Reserve Site 1 soils.

These results suggest that a dripline spacing of about 0.5 m would be appropriate for both soils, and the installation depth should be between 0.15 and 0.2 m below the soil surface. While not exactly the same, these results are in line with other key SDI systems, such as: the Omaha golf course; Pauanui (i.e. Kennedy Park & the Airstrip); and more recently Te Anau. If 20 liters was applied at each application (i.e. 10-hours of operation) then the depth below the dripper of the wetting front would be 0.35 m, giving a total wetting depth of 0.51 and 0.52 m for the Raglan Airstrip and

Wainui Reserve site 1 soils respectively. Given the radius and the volume added, we can approximate this as a depth of application for 20 liters per dripper of 80 mm.

For the option with full nutrient uptake the daily rate of application was 4.64 mm/day, so for the drippers based on the wetting patterns, a rotation could be 80/4.64 = 17-day rotation. For the total application to the Raglan Airstrip the rotation would be 80/22.88 = 3.5 days for 2020 flows, and 80/38.49 = 2.08 days for 2055 flows.

These calculations are indicative of what would be possible, but show that by adjusting the volume added the rotation of application of wastewater to any area in the land treatment area can be adjusted. These results show that a flexible system is possible using these design methods.

Accordingly, it is considered that SDI is a feasible alternative for land treatment for Raglan on the *Public Lands* of the Wainui Reserve and the Raglan Airstrip, where the above dripline configurations are provided simply for just a Pre-Feasibility assessment, and will need to be refined during any further investigations including HYDRUS2D modelling etc.

4.2.5 Potential Raglan SDI Scheme Configurations Utilising Public Land

This Pre-Feasibility Study is provided in order to determine if a “Pauanui Like” SDI land treatment system may be Feasible for Raglan, if only *Public Land* is utilized. It is not intended that this be a Design Report.

There are many factors which affect a final SDI Scheme layout, if an SDI Option is to be considered further, and these may include:

(i) Key local stakeholder and iwi aspirations & objectives;
(ii) Regulatory requirements, as determined by the Regulator during the consenting process;
(iii) Cost;
(iv) Practicality;
(v) Degree to which Future Proofing and community expansion is allowed for;
(vi) Alternative potential future uses for the *Public Land,* that may impact on SDI configurations.

Accordingly, this Pre-Feasibility Study has been conducted in such a manner, so as to consider potential “bookend” scenarios in order to determine the Feasibility of these extreme configurations – where it is quite conceivable that a Final scheme may sit somewhere in-between the “bookend” extremes.

The two “bookend” extremes are considered to be:

(vii) Full nutrient removal via land treatment and we have considered in this assessment the current TN & TP levels (noting that these may well be reduced by future improved treatment) to determine if this is Feasible. Section 3.4.1 (of this Report) considered this scenario, and concluded in the order of less than 25Ha was required to achieve this outcome. Section 4.1 (of this Report) then considered potential land areas on the Wainui Reserve, the Raglan Airstrip; and surrounding the WWTP, and determined (at a desktop Pre-Feasibility level) that 24Ha was potentially indeed probably available.

(viii) The other extreme configuration, was considered to be, if only the Raglan Airstrip was to be used. Section 4.2 (of this Report) considered this scenario and determined that by installing a drainage system (in order to capture and relieve any associated mounding groundwater) that just the Raglan Airstrip may well be Feasible – subject to the captured drainage water being disposed of elsewhere – be that other land irrigation, and / or an adjacent marine outfall.

It is considered very important to NOTE at this point – that any captured drainage water from a Raglan Airstrip SDI system will be:

(ix) Of a very high-quality standard having effectively passed through a 5Ha sand filter, with nutrient capturing via cut and carry grass growing upon it; Plus,

(x) The treated effluent will have passed through Papatuanutu (Mother Earth) before any discharge to a marine outfall - or other land disposal system, and,

(xi) The above may then also allow the Raglan Golf Course to potentially be considered as becoming part of the overall Raglan SDI system, but it may need to be provided in combination with one, or both of, the other "bookend" solutions i.e. the Raglan Airstrip drainage water disposal solution, and / or the Wainui Reserve.

In terms of the potential costs of these "bookend" scenarios:

(xii) It is noted that PDP (Jan 2021) s.4.4 4th bullet – stated that the public land irrigation was based on drip line irrigation at $30K/Ha; and,

(xiii) s.5.2 – Short-Listed Preferred Option 3 (Non-deficit irrigation to public land with alternative discharge) was estimated at $5.5M; where,

(xiv) Beca (5 Feb 2021) then incorporated this $5.5M land disposal estimate into the conceptual scheme L1 configuration.

It is considered that $30K/Ha for effective SDI is an under estimation, where one may consider more appropriate rough order of magnitude estimates to be:

(xv) For SDI in the order of 0.5m dripline spacing at $150K/Ha, and,

(xvi) For SDI in the order of 0.5m dripline, plus small diameter drainage at $225K/Ha.

Using these indicative rough order of magnitude estimates, the two SDI Pre-Feasibility "bookend" scenarios become:

(xvii) 24Ha of SDI @ $150K/Ha at $3.6M; and,

(xviii) 5Ha of SDI with FILTER (and small diameter drainage) @ $225K/Ha at $1.35M.

These costs will exclude externals such as conveyance, pump stations, controls etc, but provide an indicative rough order of magnitude for a Pre-Feasibility assessment.

Based upon the above, SDI is considered from this desktop assessment to be technically and financially feasible for Raglan, if just the Public Land were to be utilized.

4.2.6 Raglan Golf Course

As noted in s.4.1 previously, the PDP Report (PDP Jan 2021) concluded that irrigation to the Raglan Golf Course may only occur during the summer months of December to March, hence it was not really proposed as an all-year-round integrated land disposal option.

This however may be an over simplification of the contribution that the Raglan Golf Course may provide, an overall integrated Raglan community disposal solution.

Tables 4.4 & 4.5 and Figure 4.6 following, describe potential fairway and "out of play" landscape areas (i.e. those shaded in orange on Fig 4.6), that may be considered for SDI of treated Raglan effluent to the Raglan Golf Course.

In summary, there may be in the order of 13Ha of potential fairways, and a further 4.0Ha of out of play areas that are to be landscaped, where the landscape plants may also benefit from SDI.

Table 4.4: Indicative Raglan Golf Course Fairway Area

Fairway No.	Fairway Width (m)	Area (ha)
1	30	1.1
2	30	0.9
3	40	1.1
4	30	0.3
5	30	0.6
6	30	0.3
7	40	1.6
8	20	0.3
9	30	1.0
10	30	0.6
11	30	0.7
12	30	0.3
13	30	0.9
14	20	0.3
15	30	0.4
16	30	1.0
17	30	1.0
18	30	1.0
	Total	**13.4**

Table 4.5: Indicative Raglan Golf Course Non-Played Area

Planting Areas of the Rough	Area (ha)
1	0.2
2	0.4
3	0.3
4	0.9
5	0.6
6	1.4
7	0.1
8	0.1
Total	**4.0**

Accordingly, this 13 – 17Ha of potential *Public Land* irrigation is considered worthy of further detailed investigation, especially when the Raglan Golf Club has expressed a desire to be a participant in any investigation into potential land disposal of Raglan treated effluent.

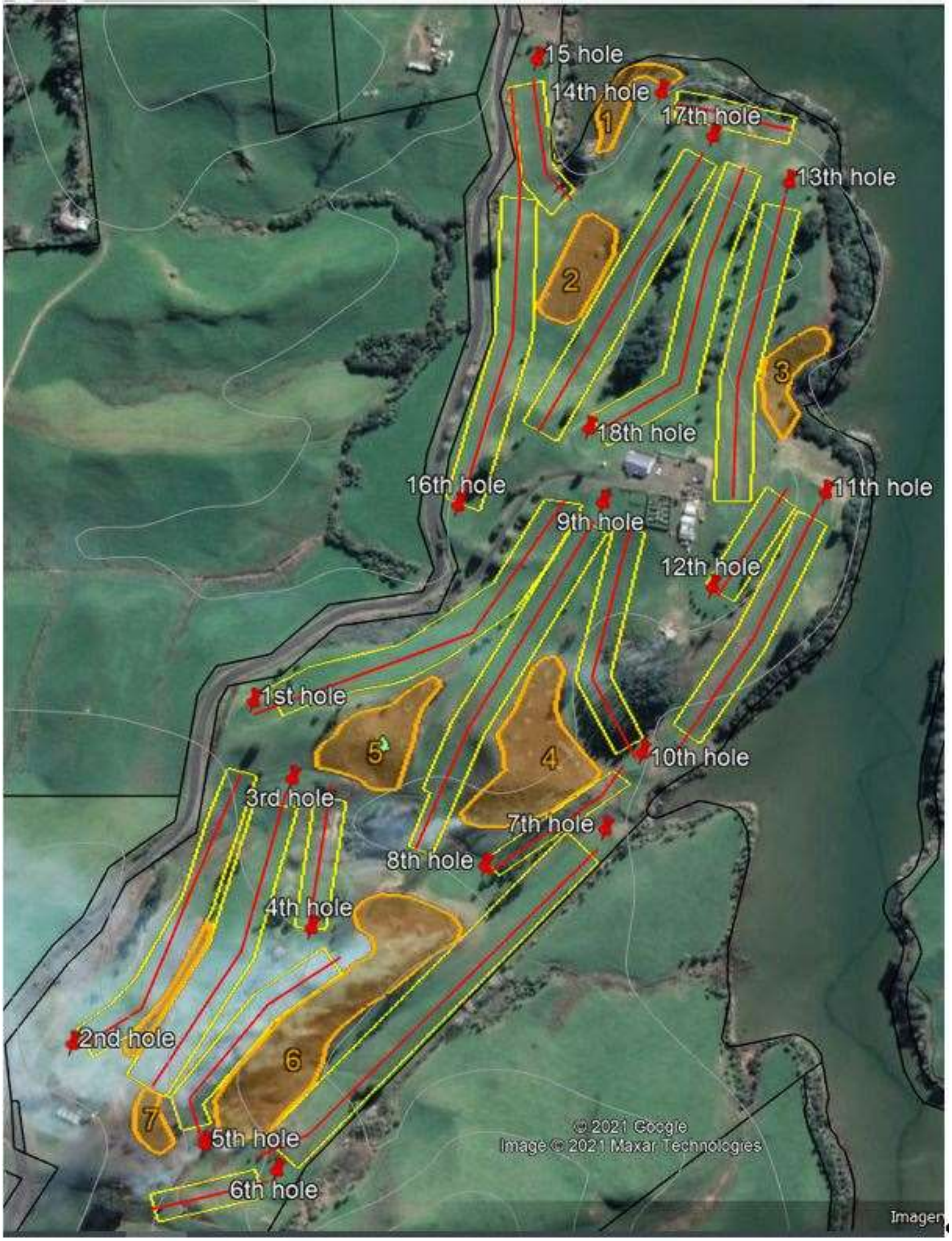


Figure 4.6. Indicative Raglan Golf Course Fairway & Potential "Out of Play" SDI Areas.

As described in s.4.2.5 previously, in the order of 24-25Ha of irrigation is required for complete nutrient removal via land disposal. Hence at 13-17Ha, the Raglan Golf Course does not provide a full solution in its own right, but in combination with either / or both of the Raglan Airstrip and / or part of the Wainui Reserve, in theory, this total land area may be able to be identified and utilised. The key to utilisation of the Raglan Golf Course, will be winter and times outside the optimal summer irrigation months of December to March.

As stated s.4.4 of the PDP Report (PDP Jan 2021), irrigation to the public land (with the exception of the Airstrip) i.e. Wainui Reserve and Raglan Golf Course, is considered to be on imperfectly drained soils with a field capacity drainage rate of 1mm/day. This means, that without any soil modification or additional drainage, and not allowing for any evapotranspiration, the Raglan Golf Course may, during months outside of the December to March peak irrigation demand period, provide in the order of 130-170m^3/day disposal capacity with no deleterious golfing or environmental impacts considered likely.

s.3.4.2 of this Report goes further, and suggests that when including climate data, on the majority of occasions the Raglan Golf Course is expected to provide a drainage rate of 2mm/day or more (i.e. 260-340m^3/day plus). Given the hydraulic conductivity values in the PDP Report (Jan 2021, Table 2) drainage of 10mm/day would not be an overly optimistic estimate. In addition, on the majority of days, the climate data suggests that there may also be positive evapotranspiration capacity.

Summary, the Raglan Golf Course may potentially be able to utilise the treated effluent for the majority of the year to some capacity, while providing a positive beneficial irrigation reuse to the fairways and landscape areas during the summer months.

The above has excluded the tees and greens for reuse purposes. The tees are expected to be a small area.

The greens however, are understood to have an existing pop-up type spray irrigation system, supplied by the community potable water supply. A further option to potentially improve the contribution of the Raglan Golf Course, may be to consider a concept of providing a FILTER (as described in s.4.2.2 & 4.2.3) on Golf Course land (or pumping from the Airstrip) and capturing and storing drainage water, and using this for greens irrigation in lieu of potable water. This may increase the potable supply available to the Raglan community for growth, and reduce the ongoing operational costs to the Raglan Golf Club

Therefore, on the basis of a potentially willing participant and the fact that the Raglan Golf Course may be integrated with either stand-alone “bookend” solution (i.e. Airstrip and / or Wainui Reserve), it is recommended that the option to use the Raglan Golf Course be investigated further.

4.2.7 Implications for Treatment, Conveyance & New Outfall Location

If an SDI option is considered feasible and worthy of further investigation, then there are potential implications in terms of the Beca (5 Feb 2021) conceptual L1 scheme configuration.

Treatment

Typically, SDI systems operate within the order of 100-120micron filtration.

Oxidation pond algae is often considered in New Zealand to range in size from 2-micron – 50-micron.

NexGen Water has trialed a filter in New Zealand, where analysis and extrapolation of Particulate Distribution Analysis (PSA) demonstrated in the order of 95% of particulate may be removed at 5-micron, and in the order of 98% at 1-micron.

As stated in s.3.4.1 (of this Report) total nitrogen (TN) and total phosphorous (TP) will have a proportion associated with wastewater particulate which will be removed if the particulate quantum is also reduced.

Pathogens can be controlled by both disinfection and UV. Appropriate disinfection may have advantage for SDI reliability, as demonstrated elsewhere in New Zealand.

If an SDI solution is configured without a direct discharge to a marine outfall (i.e. by passing through an SDI with drainage system first) then there may be economies to be achieved by not over treating the wastewater.

Conveyance

The form of the conveyance may change dependent upon how any SDI scheme may ultimately be conceived.

Figures 4.6 (i) – (iii) following provides an indicative conceptual conveyance option. Key points may include:

(i) It may allow for the Wainui Reserve and the Raglan Airstrip to have separate mainlines (from the WWTP). This may mean any SDI to the Wainui Reserve is not over treated, as it will not result in any discharge to a marine outfall, or direct discharge to a natural watercourse;

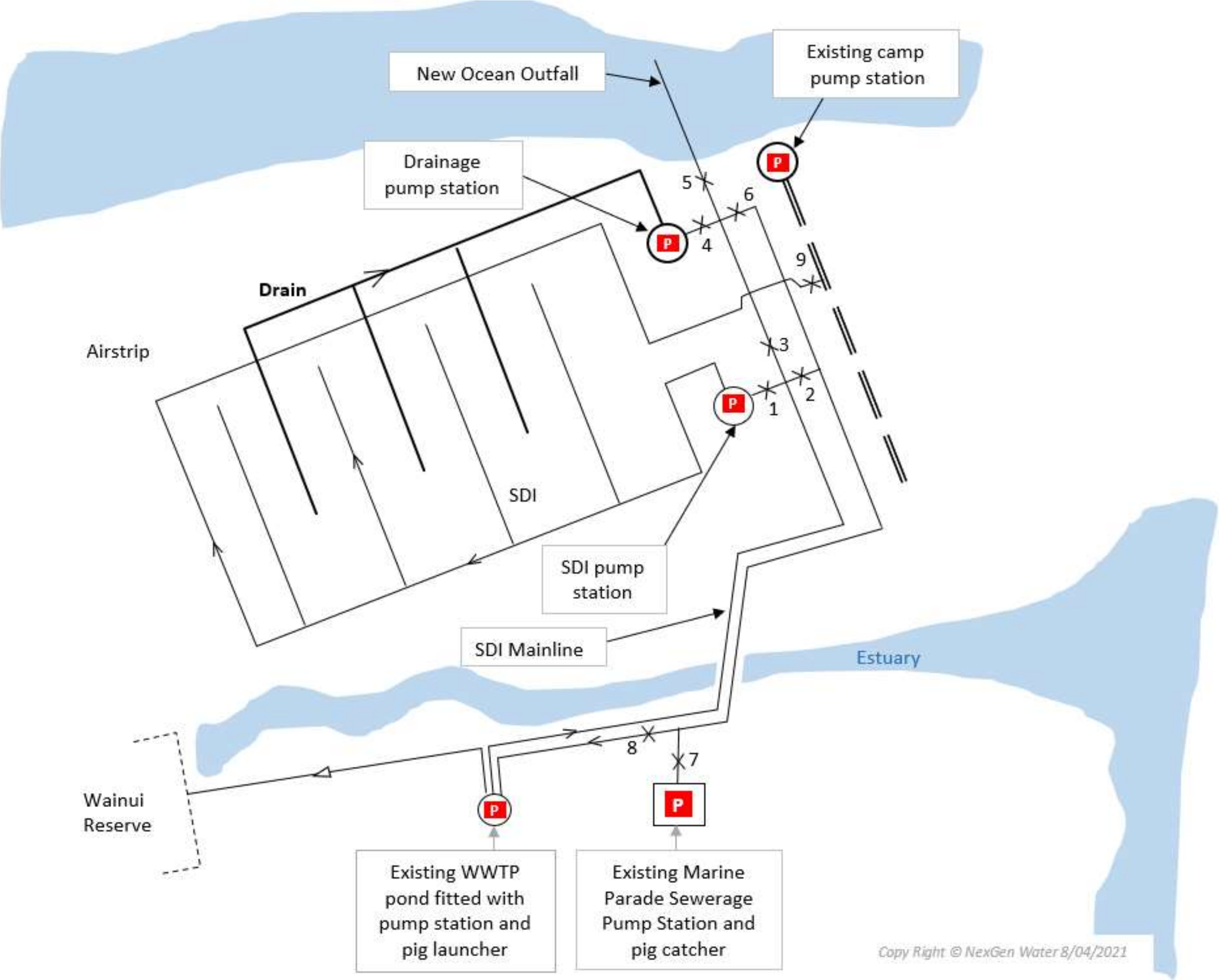
(ii) It may be considered appropriate to install (at the same time as the mainline to the Raglan Airstrip) a second return mainline pipe (i.e. one from the Raglan Airstrip to the WWTP), as this may allow for future potential reuse (for irrigation purposes) on private land, of the collected high quality Raglan Airstrip SDI drainage water. This may have the advantage of providing a mechanism for future reuse (maybe involving private land) and hence a corresponding reduction in any volume discharged through any new marine outfall;

(iii) The SDI mainline(s) should also have the provision to be pigged (in order to mitigate bacterial slime build-up over time), and this may be achieved via providing for pig launching at the WWTP and pig retrieval (at the distal, or Raglan Airstrip end). In the first instance, it is considered feasible that the pig retrieval may be potentially possible at the existing Marine Parade pump station, and the existing large diameter sewerage reticulation used to return the dirty water back to the WWTP (in an efficient manner not necessarily requiring extra new capital piping or pumping equipment) with this to be thoroughly assessed during any subsequent investigations.

New Outfall Location

Beca (5 Feb 2021 - Appendix A), assumed and provided a new Outfall and Diffuser concept, to be located near to the existing structure. If an SDI scheme were to be considered further (particularly one involving the Raglan Airstrip) then it may also be considered appropriate to investigate a potential alternative new outfall location, say one off the end of Marine Parade adjacent the Raglan Airstrip (ref Figure 4.7 (i-iii) following). Such a location may be considered to offer advantages, particularly if any SDI on the Raglan Airstrip were to be involved.

Figures 4.7 (i) –(iii) Conceptual SDI Conveyance & New Outfall



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Valve Positions		
	Open	Closed
Normal Operation	1,4,5,7,9	2,3,6,8
Pigging	2,7	1,3,6,8,9
Emergency Outfall	3,5	1,2,4,6
Returning Drainage for Future Community Reuse	1,4,6,8	5,3,2,7,9
Drainage Water to Outfall	4,5	6,3,2

5 CONCLUSIONS

As described in s.1.3 (of this Report), NexGen Water has been asked to consider (in particular) the Beca (5 Feb 2021) "Raglan WWTP Optioneering – Short List Design and Costing" Report, which also included as an Appendix, the PDP (Jan 2021) "Raglan WWTP Discharge Options – Assessment of Land Irrigation" Report.

NexGen Water was requested to then assess the Land Irrigation Disposal Options proposed, and to a Pre-Feasibility level, determine:

(i) If a "Pauanui like" SDI Disposal Option may be compatible with the PDP Report;
(ii) If SDI may be an option – could it involve just Public Land (at Raglan);
(iii) If Public Land were deemed potentially appropriate for a Pauanui like SDI solution, how may it conceptually be conceived; and,
(iv) If Public Land were considered suitable for SDI, what further investigations may be required.

5.1.1 Is SDI Compatible with the PDP (Jan 2021) Report

As described in s.3.2 (of this Report), this PDP (Jan 2021) Report resulted in three (3) preferred and "Short Listed" land treatment options recommended for further investigation, being:

(i)	Option 1	Non-deficit 100% to land	$47M (re Beca L2 conceptual scheme);
(ii)	Option 2	Non-deficit with alternative discharge	$22M (re Beca L3 conceptual scheme);
(iii)	Option 3	Non-deficit to *Public Land* with alternative discharge	$5.5M (re Beca L1 & L4).

PDP (Jan 2021) Option 3 was based upon three (3) Public Land irrigation options, being: The Wainui Reserve; the Raglan Airstrip and the Raglan Golf Course. PDP further noted that:

(iv) Based upon soil types observed at the Wainui Reserve and Raglan Airstrip, it was assumed that irrigation can occur all year round at these sites;
(v) That irrigation to the Raglan Golf Course may only occur during the summer months of December to March; and,
(vi) The irrigation Type was assumed as dripline (to avoid conflict of existing land uses of the public land).

Drip irrigation options on Public Land were then incorporated into the Beca (5 Feb 2021) L1 and L4 conceptual schemes.

SDI on Raglan Public Land is therefore concluded as being compatible with both the Beca (5 Feb 2021) "Raglan WWTP Optioneering – Short List Design and Costing" Report, and the PDP (Jan 2021) "Raglan WWTP Discharge Options – Assessment of Land Irrigation" Report.

5.1.2 Could an SDI Option at Raglan Involve Only Public Land

As described in s.3.1.1 (of this Report), Beca (5 Feb 2021) identified the key shortlisted conceptual schemes involving drip irrigation on Raglan Public Land as:

Option L1
Treatment: Additional tertiary Treatment after existing ponds and UV treatment
Disposal: Discharge to *Public Land* and to new outfall and diffuser

Option L4
Treatment: MBR and UV treatment
Disposal: Discharge to *Public Land* and to new outfall and diffuser

Accordingly, Beca (5 Feb 2021) and PDP (Jan 2021) concluded that drip irrigation on Public Land at Raglan may be a feasible option, in combination with a new outfall and diffuser.

Furthermore, as described in s.3.4 (of this Report), when considering current wastewater data, it was estimated that an area of less than 25Ha would be required for a cut and carry SDI wastewater irrigation system, if all the TN and TP in the wastewater for 2020 flows was to be removed by land treatment. This area would theoretically need to increase to 42Ha by 2055, in order to allow for the projected flow volume increase.

Effective filtering of the wastewater for SDI may reduce the nitrogen (TN) and phosphorus (TP) concentration in the wastewater, plus losses of nutrients via other soil processes, therefore may mean that smaller land areas may be required than those estimated above.

Figure 4.1 (of this Report) then described indicative irrigation areas on: the Wainui Reserve; Raglan Airstrip; and WWTP surrounds; that may total in the order of 24-25Ha.

The areas on the Wainui Reserve have been specifically identified in order to avoid:

(i) The para gliding area;
(ii) The "Sound Splash" precinct;
(iii) The Amphitheatre;
(iv) Key areas of hapu significance;
(v) Key internal roads;
(vi) Steep areas;
(vii) Natural water courses;
(viii) Areas of native bush; and
(ix) The horse-riding track.

s.4.2.6 (of this Report) considered the Raglan Golf Course and concluded that 13-17Ha of land may be available, which may also provide disposal capacity to some degree (without deleterious effects) on the majority of days year-round, and as a potentially willing participant to any Raglan community disposal scheme, and being on *Public Land,* the Raglan Golf Course may well be integrated with either of the stand-alone "bookend" solutions (i.e. in combination with either / or the Raglan Airstrip and / or Wainui Reserve).

It is therefore considered, that at a Pre-Feasibility desktop study level, for a Raglan wastewater Stage 1 (2020) SDI system, providing for full TN and TP removal (based upon current Beca (5 Feb 2021) water quality data), in the order of the 24-25Ha irrigation of Public Land that may be required, and that this appears available for the SDI, hence the SDI Option on Public Land may be concluded as feasible.

5.1.3 How May a Conceptual Raglan SDI Solution on Public Land be Configured

Section 4 (of this Report) then considered how an SDI solution may conceptually be configured if only *Public Land* were to be used. Section 4.1 considered a 24Ha full land treatment option and s.4.2 considered the Raglan Airstrip in more detail. WetUp modelling was used to consider potential SDI layout configurations to produce indicative Pre-Feasibility design parameters for review.

Section 4.2 then described use of the PDP "Raglan Rapid Infiltration Investigation Report" (PDP Jan 2002) as source input data for an assessment into if the Raglan Airstrip on its own, may provide an SDI solution. A CSIRO FILTER concept was then assessed using a FILTMOD model, to determine if at a Pre-Feasibility level, potential associated ground-water mounding (as a result of high-rate irrigation and the impermeable percolation barrier resulting from the tidal influence) may be feasible.

Section 4.2.5 then considered these two (2) potential "bookend" SDI scheme configuration scenarios (i.e. 24Ha for full land treatment and just the 5Ha Raglan Airstrip on its own) in order to determine SDI Feasibility, noting that it is quite conceivable that a Final scheme may sit somewhere in-between the "bookend" extremes, and potentially include the Raglan Golf Course.

These two (2) "bookend" SDI scheme configurations were then compared to the PDP (Jan 2021) – Short-Listed Preferred Option 3 (i.e. non-deficit irrigation to public land with alternative discharge) which was estimated at

$5.5M, where, this land disposal estimate was then incorporated into the Beca (5 Feb 2021) L1 conceptual scheme configuration.

Using indicative rough order of magnitude estimates, the two SDI Pre-Feasibility "bookend" scenarios were indicatively assessed as:

(i) 24Ha of SDI at $3.6M; and,
(ii) 5Ha of SDI with FILTER (and small diameter drainage) at $1.35M.

Conceptually, the Raglan Golf Course may be integrated with either of these "bookend" configurations.

Based upon the above, SDI is considered from this desktop assessment to be both technically and financially feasible for Raglan (if just the Public Land were to be utilized), with indicative potential Scheme Configurations provided.

5.1.4 Is a "Pauanui Like" SDI Solution Feasible for Raglan utilizing Public Land

Section 4.2.6 then considered how a "Pauanui Like" high-rate SDI solution, (involving the Raglan Airstrip as at Pauanui) may be conceptually conceived including:

(i) A new and appropriate conveyance scheme that may incorporate:
  - Pig launching & retrieval to maintain and keep the SDI delivery mainline clean;
  - A return pipeline to the WWTP to provide for potential future Raglan Airstrip SDI drainage reuse on other Private Land;
  - Use of existing sewerage infra-structure for the return (to the WWTP) of dirty exhaust pig water;

(ii) Small pipe drainage on the Raglan Airstrip to provide high quality drainage water which:
  - Passes the effluent through Papatuanuku before any other discharge (i.e. to a marine outfall);
  - Voids potential ground-water mounding resulting from high-rate irrigation to the Airstrip;

(iii) An alternative (to the Beca (5 Feb 2021), and adjacent new marine outfall location;
(iv) Potential to revisit and consider treatment options with a view to simplifying; reducing CAPEX; reducing OPEX; incorporating disinfection for SDI reliability; as well as reducing TN, TP and pathogens.

Such a "Pauanui Like" SDI conceptual Scheme may be referred to as an L1(SDI) type scheme

It is therefore concluded by this SDI Pre-Feasibility Study, that a "Pauanui Like" L1(SDI) conceptual scheme is not only feasible on Public Land at Raglan, but that such a solution (as described in this Pre-Feasibility Study) may offer many important advantages over and above the original L1 scheme configuration.

6 RECOMMENDATIONS

As a result of this desktop Pre-Feasibility Study, a land disposal scheme at Raglan utilsing SDI on Public Land is concluded as both technically and financially Feasible, and that a “Pauanui Like” solution involving the Raglan Airstrip may be able to be conceived. Such a solution may also be compatible with both the Beca (5 Feb 2021) and PDP (Jan 2021) Reports, but may have sufficiently important differences from the original L1 conceptual scheme, that it may have its own Conceptual Scheme designation – i.e. L1(SDI). In order to refine the SDI Option for more detailed consideration, further investigations are Recommended below – which in essence follows three separate and distinct aspects being: (i) Consultation; (ii) Detailed site & technology investigations; (iii) Optimised Conceptual Scheme layout.

6.1 Consultation

Given the fact that this is potentially a large community project, with many key stakeholders, it is suggested that in tandem with further detailed technical investigations, that important aspects of the consultation process be completed simultaneously, as the outcomes of the consultation process may affect the final form of the L1(SDI) Conceptual Scheme layout. This consultation may include:

(i) ***Iwi***. For example, is a partial marine outfall acceptable, especially if the water released through this method (to the environment) is highly treated collected drainage water from the Raglan Airstrip FILTER (i.e. it will have passed through Papatuanutu (Mother Earth) first);

(ii) ***Regional Council;*** what standard of effluent quality would be acceptable for release to the marine environment (i.e. in particular what total nitrogen (TN) & total phosphorous (TP) level may be required – noting that the existing Permit is silent on these parameters);

(iii) ***Raglan Airstrip Management;*** is the use of the Raglan Airstrip for a “Pauanui Like” SDI solution acceptable, and are any particular assurances for this use required;

(iv) ***Waikato District Council and the Wainui Reserves Management team;*** is irrigation to the Wainui Reserve considered desirable, or not, and if yes, what are the preferred areas that may best benefit from treated effluent re-use;

(v) ***The Raglan Golf Course;*** while the Golf Course had previously been considered to only accept irrigation for four (4) months of the year (and therefore not form part of the year-round L1(SDI) Conceptual scheme) this is now considered as potentially an over simplification, and that the Raglan Golf Course may provide 13-17Ha of useful *Public Land* for not only summer beneficial re-use – but also other potentially interesting year round disposal options – including possibly using drainage water for green irrigation in lieu of the current potable water supply. Consultation to develop these concepts to working proposals are suggested;

(vi) ***Local Landowners;*** PDP (Jan 2021) noted several private land irrigation options available, is there any appetite from these land-owners (or in fact any other nearby local land-owners) for any potential future beneficial ruse irrigation;

6.2 Site & Technology Investigations

Feedback from the consultation process is expected to give good guidance into how a L1(SDI) Conceptual Scheme may be laid out – for example:

(a) Is use of the Raglan Airstrip (with SDI) and the FILTER drainage collection concept, acceptable;
(b) If so, is the marine outfall acceptable;
(c) What standard of TN & TP is expected for any new marine outfall;
(d) Is part of Wainui Reserve likely to form part of an L1(SDI) Scheme – and if so where and with what land area and potential pasture management regime;
(e) Is part (or all) of the Raglan Golf Course likely to form part of an L1(SDI) Scheme – and if so where and with what land area and potential turf, irrigation & drainage management regimes;

  - (f) Is there interest to use collected FILTER drainage water for beneficial reuse Raglan Golf Course irrigation, via the existing sprinkler system (tees & greens?);
  - (g) Is there any private land owner interest in potential future re-use of collected FILTER drainage water;

Hence, based upon feedback from the consultation process, a more detailed and targeted site & technology investigation plan may be embarked upon, but this is likely to include:

- (i) A detailed site soil investigation at the Raglan Airstrip and any key other potential irrigation sites (such as Wainui Reserve and the Raglan Golf Course);
- (ii) A detailed investigation into the current (and potential future – ref viii below) wastewater quality;
- (iii) A detailed HYDRUS2D model of both the Raglan Airstrip – and any land deemed appropriate on the Wainui Reserve and / or Raglan Golf Course;
- (iv) A site-specific physical trial of small diameter drainage technologies;
- (v) A site-specific groundwater investigation across the Raglan Airstrip;
- (vi) A more site specific and detailed FILTMOD model incorporating site specific results from the above investigations;
- (vii) If appropriate, (as resulting from the consultation process) a site-specific wastewater treatment filtration technology option trial (seeking to consider reduction of: capital; complexity; and OPEX, as compared to the original L1 conceptual scheme);

6.3 Optimised L1(SDI) Conceptual Scheme Layout(s).

Based upon the outputs of the above two (2) Recommendations, preliminary design of key L1(SDI) components are recommended to be undertaken, and costed, including:

- (i) Appropriate treatment;
- (ii) Indicative irrigation layouts (Raglan Airstrip / Wainui Reserve / Raglan Golf Course);
- (iii) Indicative Raglan Airstrip (and possibly also Raglan Golf Course) FILTER and collection drainage layouts;
- (iv) Indicative Mainline(s) including:
  - (a) Mainline route to the Raglan Airstrip;
  - (b) Any return future proofing mainline from the Raglan Airstrip to the WWTP;
  - (c) Pigging & SDI flush collection conveyance;
  - (d) Any mainline(s) to the Raglan Golf Course;
  - (e) Any mainline to the Wainui Reserve;
- (vii) Indicative new outfall and diffuser (assuming different from the original L1 conceptual scheme).

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Subsurface drip irrigation conserves water, solves disposal issues

Subsurface drip irrigation (SDI) for disposal and reuse of treated effluent has significant advantages for communities limited in disposal options. **Peter Gearing** of Ecogent Ltd. and **Rodney Ruskin** of Geoflow Inc. explain how a New Zealand coastal community resolved technical, social, and environmental challenges, while conserving water to meet the needs of a growing community. Three very different areas with different needs successfully used SDI, thereby demonstrating the versatility of the technology for dispersal and reuse.

The seaside residential community of Pauanui, New Zealand relies on subsurface drip irrigation (SDI) to dispose of secondary ultraviolet (UV) treated effluent as part of a beneficial reuse project.

Pauanui is on a narrow sand bar located on New Zealand's North Island. The peninsula is a beautiful region visited by international and local vacationers. In order to protect the peninsula's pristine environment, the Thames-Coromandel District Council (TCDC) commissioned a new community sequential batch reactor water resource recovery plant at Pauanui-Tairua.

"The Pauanui community has, from the outset of consultation for the resource consent for wastewater reuse, expressed their desire for the wastewater to be used beneficially in the community for irrigation rather than simply disposed of," said TCDC Project Engineer Gordon Reynolds. "The consequence of this reuse requirement was a set of very high quality standards for the wastewater from the treatment plant."

The disposal of the treated effluent from the new plant had to resolve several technical, social, and environmental challenges before it could be accepted as the solution. The original treatment plant used aerated ponds with disposal via surface-applied, high-rate sand beds hidden under wooden covers in the median strip of one of the community's main streets.

Commissioned in December 2009, the new system was designed to cope with larger future flow rates, thereby requiring an improved disposal system. Other issues – such as blinding of the sand surface with biological growth, complaints about the aesthetics of the system, and sea disposal – were also considered. The Maori are opposed to sea disposal; land disposal is their preferred methodology.

One solution was to construct spray irrigation systems within forested plantations. Unfortunately, landowner resistance, capital and operational costs, problems with plantation management, poor soil drainage capacity, and the steep topography of the land excluded this option.

SDI enabled treated effluent from the Pauanui-Tairua treatment facility to be beneficially used – particularly for long, hot, dry summer irrigation in this restricted potable water area.

SDI option

Geoflow's technology of drip emitters – impregnated with both a sustained, slow-release herbicide to prevent root intrusion and an anti-microbial agent used in the dripline lining to reduce propensity for bacterial slime growth – meant that drip irrigation could be considered as a viable disposal option.

The SDI option brought many advantages to the treated effluent reuse, including:

- No public contact with the treated effluent
- No aerosols and no odors produced from the irrigation
- Disposal occurs while the irrigation areas are in public use, which simplifies system operation and effluent storage needs
- No need to purchase new lands for disposal
- Disposal is neither negatively affected by wind nor by cross contamination of surface rainfall runoff

Because Pauanui is an area with restricted potable water, a beneficial irrigation reuse solution combines the advantages of saving potable water currently used for community irrigation, while also irrigating community areas not previously watered.

The SDI system irrigates Kennedy Park, the community air strip, and road medians. It also has future potential to supply two golf courses and grassland behind the beach foreshore. All irrigation is via buried drip lines with electronic valves controlling each area. The irrigation has automated self-cleaning filter chambers and a pigging system to assist in keeping mainlines clean and prevent residue from building up.

The system is automated to rotate irrigation depending on fluctuations in output flow, applying different irrigation rates to different areas. It is designed to contend with the high flows resulting from extreme rainfall conditions and from summer holiday crowds.

System features and site-specific issues

The system configuration overcomes numerous issues unique to each site: namely, the specific needs of Kennedy Park, the airstrip, and the Vista Paku median systems, which all required different irrigation configurations and application rates, management regimes, and priorities for beneficial reuse. Additionally, the system needed to be built through the middle of a community going about its daily business, and also had to consider an operating wastewater treatment plant.

The original disposal system needed to be decommissioned and the wastewater immediately sent to the new system. The reuse system needed to be both unobtrusive and compatible with all other users and requirements – such as Parks and Reserves regarding maintenance as well as the Community Board and other key local stakeholders in terms of aesthetics, noise, odor, and other issues.

While the irrigation system provides beneficial reuse in periods of summer drought, it also handles effluent volumes in rainy periods without negatively affecting the medians,

> In every respect this design has met the targets required whilst including a substantial allowance for future-proofing.
>
> TCDC Project Engineer
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The system configuration overcomes numerous issues unique to each site: namely, the specific needs of Kennedy Park, the airstrip, and the Vista Paku median systems, which all required different irrigation configurations and application rates, management regimes, and priorities for beneficial reuse. Additionally, the system needed to be built through the middle of a community going about its daily business, and also had to consider an operating wastewater treatment plant.

The original disposal system needed to be decommissioned and the wastewater immediately sent to the new system. The reuse system needed to be both unobtrusive and compatible with all other users and requirements – such as Parks and Reserves regarding maintenance as well as the Community Board and other key local stakeholders in terms of aesthetics, noise, odor, and other issues.

While the irrigation system provides beneficial reuse in periods of summer drought, it also handles effluent volumes in rainy periods without negatively affecting the medians,

> In every respect this design has met the targets required whilst including a substantial allowance for future-proofing.
>
> TCDC Project Engineer
> Gordon Reynolds

air strip, or park. The wet periods require simple and easily implemented disposal, whereas, previously, the maximum predicted wastewater influent volume was so large that long-term storage was not a viable option.

The irrigation control system is integrated into both the wider treatment plant control system, and is compatible with TCDC's remote supervisory control and data acquisition (SCADA) telemetry system, and the reuse system meets requirements to log irrigation volumes to each individual area for resource consent purposes.

The daily flow rates currently range from 1,000 cubic meters per day (m^3/d) during non-holiday periods to 4,000 m^3/d during summer holidays. System capacity is currently measured at 11,300 m^3/d, but easily expandable to 20,000m^3/d.

Irrigation pump station

The underground irrigation pump station is located below a driveway with trucks parked on top. The station incorporates multiple dry well, vertically-mounted, centrifugal, multistage pumps and a wet well with automatic level-detection to effectively manage flow, capacity, and sudden changes in volume.

The irrigation system has banks of automatic field valves of approximately similar flow rates.

As the level rises within the pump-station when the treatment plant releases a batch of treated effluent, the control system detects the water level and automatically matches the number of pumps and active irrigation to suit.

The pump-station is designed to accommodate future growth.

Mainline design and volume management

The issues of large mainlines, typically low velocity during low-flow periods and bacterial slime growth, have been handled using a specialized mainline "pigging" system, which is the propulsion of a plug through pipes to perform cleaning functions; automatic self-cleaning filters in the irrigation fields themselves; and subsurface drip technology incorporating anti-microbial inner tube linings.

The mainline pigging system uses pipe sizes ranging from 160 millimeters to 355 millimeters – incorporating angles, bends, tees, manual valves, and more, and involving some very deep receiving manholes (including one that is estimated to measure deeper than 6 meters).

This system has already enabled successful pipe cleaning from bacterial slime and has allowed safe operation of launching and pig retrieval. The system has been designed to return all dirty flushed water back to the treatment plant through the existing sewer network, while also allowing full operator access for maintenance.

System controls

The control system incorporates a combination of wireless and hardwired automatic controls. The operators select the priority for the day – such as wet-weather mode, or dry-summer-peak mode, or other preset standards – and the system automatically sets the irrigation priorities throughout its entirety. It then runs automatically and sequentially around the irrigation zones as effluent becomes available from the water resource recovery facility.

At this time, no other commercial community effluent SDI system that operates in this order of application rates is known. The 2.4-acre Kennedy Park receives a moderately high rate of approximately 100 millimeters per day. The 14.83-acre airstrip handles an irrigation rate based on evapotranspiration, while the median strip can receive up to 1,500 millimeters per day.

The median system required a unique design and special techniques for installation due to the close spacing of the driplines required to achieve the high application rate. A close-spaced dripline was supplied by Geoflow, and a new high-rate disposal media bed was designed.

The newly developed areas also needed innovative engineering to ensure the curb design prevented stormwater from accessing the fields (and vice versa), and to maintain road integrity and strength.

Research for future expansion

Given the potential risk of applying treated effluent to the Pauanui sand aquifer, technical assessments were carried out to determine the possible effects on groundwater and surface water quality prior to the final selection of the disposal and reuse strategy in Pauanui. The identified risks to human health and the environment include pollution of potable water from water wells, contact within the groundwater discharge and surface water mixing zone, consumption of contaminated shellfish, and aerosols from spray irrigation of contaminated groundwater at the golf courses. The assessment demonstrated that risks were low after the installation of the SDI system, while it also identified solutions for future increased reuse at Pauanui that maximizes benefits to all stakeholders.

It was of primary importance to quantify loading rate in the initial assessment of reuse options both for design purposes and to assess the risks of breakout or ponding. Furthermore, the induced hydraulic gradients associated with groundwater mounding were critical to establishing the velocity and dilution factors important to contaminant transport in the aquifer.

Between 2003 to 2004 a trial SDI system – measuring 300 meters long and 30 meters wide – was installed and operated at rates that varied from 70 to 150 millimeters per day. A network of groundwater monitoring wells was also installed and water level and water quality data was collected from October 2003 to October 2004. Soil moisture probes were used to measure saturation at 10-centimeter-depth increments in the top 1 meter of the soil profile within the irrigation field.

Extensive two- and three-dimensional groundwater modeling was undertaken to assess the likely degree of groundwater mounding associated with the reuse at various application rates. Calibration of the flow models was achieved using observational data from the trials and compliance monitoring, data collected from a seven-day pump test of the municipal supply boreholes, and from the seasonal water level record from around an additional 30 other piezometers located around the peninsula.

Water quality data from the wells used for historic compliance monitoring at Vista Paku allowed direct observation of the aquifer's ability to reduce bacteria through filtration. The assessment of risk associated with pathogens for the proposed land reuse was undertaken using groundwater models to calculate travel times to determine die-off rates based on the predicted seepage velocities. The modeled scenarios indicated that following the high level of wastewater treatment prior to land reuse, pathogen concentrations would not present a risk to human health under any exposure pathways after reduction by dispersion effects, further microbial die-off, filtration, and absorption.

In order to further understand the actual risks that may be presented by viruses in groundwater (given the theoretical die-off times could be up to 12 months), TCDC's consultants undertook a collaborative research program with the Institute of Environmental Science and Research in New Zealand. Throughout the field experiments to measure viral die-off, consents were obtained to inject inert viruses, bacteria, and tracer chemicals at two sites during a number of pilot and live tests. The experiments were completed in 2009 and the results support extremely high removal rates of viruses, with adsorption being identified as the key mechanism for the attenuation.

Sound scientific data, complex predictive analysis using modern industry tools, and leading-edge scientific research confirmed the safety and effectiveness of the design and operations of the Pauanui beneficial reuse system. It also demonstrated the harmony of science and engineering in achieving the sustainable objectives set by the TCDC and the community.

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Events 2015

June

7-10 Anaheim, California, USA
ACE15, Annual Conference & Exposition, organized by American Water Works Association
www.awwa.org

8-10 Washington, DC, USA
Water and Energy 2015: Opportunities for Energy and Resource Recovery in the Changing World, organized by WEF, European Water Association, Japan Sewage Works Association
www.wef.org/WaterEnergy

15-16 Singapore
Workshop on Water Reuse Policies for Direct and Non-Direct Potable and Industrial Users
Organized by National University of Singapore, Institute of Water Policy, National Environmental Research Institute
E: spphctq@nus.edu.sg

August

4-8 São Paulo, Brazil
FENASAN Brazil 2015: 26th National Congress and Exhibition on Sanitation and Environment Services.
Includes WEF International Pavilion
www.fenasan.com.br

17-19 San Francisco, California, USA
Smart H2O Summit 2015: Sustainable Water Solutions.
Held in partnership with The Water Innovation Project
www.smarth2osummit.com

23-28 Stockholm, Sweden
World Water Week in Stockholm
Organized by Stockholm International Water Institute
www.siwi.org

30- September 4 San Diego, California
IDA World Congress 2015: Desalination & Water Reuse, Renewable Water Resources to Meet Global Needs
www.idadesal.org

August

9-11 Santa Marta, Colombia
58th International Congress of Water, Sanitation, Environment, and Renewable Energy, Organized by The Colombian Association of Sanitary and Environmental Engineering (ACODAL)
Includes WEF International Pavilion
www.acodal.com

September

13-15 Seattle, Washington, USA
30th Annual WateReuse Symposium
www.watereuse.org

15-18 Johannesburg, South Africa
IFAT Environmental Technology Forum Africa: Water, Sewage, Refuse, and Recycling Solutions for the Mining and Construction Industry
Includes WEF International Pavilion
www.ifatforum-africa.com

26-30 Chicago, Illinois, USA
WEFTEC 2015, 88th Annual Water Environment Federation Technical Exhibition & Conference
www.weftec.org

October

13-16 Koblenz, Germany
International Conference on Water Resources Assessment and Seasonal Prediction
Organized by the German Federal Institute of Hydrology and the German IHP/HWRP Secretariat
www.worldwaterbalance.org

19-22 Dead Sea, Jordan
4th Water and Development Congress and Exhibition, organized by International Water Association
www.iwa-network.org/WDCE2015

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June 25

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modifications in the feed, permeate, and reject piping.

During DO-HS a few processes take place simultaneously on the membrane:

Fouling lifting and sweeping: The high-salinity solution moves into the feed-brine side of the membrane, where foulants are deposited during normal RO membrane operation. Due to the high salinity, permeate cannot be produced. On the contrary, permeate is sucked up into the feed side, increasing its volume and thus increasing feed-brine velocity. Thus, two forces are active at the same time. The first force is the permeate water passing the membrane surface from the permeate side to the feed-brine side, lifting the foulants from the membrane surface. The second force is the cross membrane velocity in the feed-brine side, which sweeps the foulants out to the concentrate outlet. The combination of the increased feed velocity with the lifting of the fouling provides a strong cleaning effect of the contaminants deposited on the membrane surface.

Bio-osmotic shock: Bacteria are covered by a semi-permeable membrane similar to the RO membrane. The high osmotic pressure solution sucks the water from the bacteria and dehydrates them. This is the oldest salt curing method, which people have used for centuries.

Conclusion

After ten years of successful operation, IDE Technologies Ltd is going to offer the IDE PROGREEN and the DO-HS cleaning method in plants built and operated by other original equipment manufacturers.

Authors' Note

Dr. Boris Liberman, IDE Technologies' VP and CTO for membrane technologies, contributed this article along with Operational Solutions Services Manager, Miriam Brusilovsky and Manager Nathan Louzon in the Customer Support Department.

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Best sustainable solution

"In every respect this design has met the targets required, whilst including a substantial allowance for future-proofing," Reynolds said. "Wastewater reuse is a controversial and emotive problem for all communities and this solution is the best sustainable solution achieved to date in New Zealand. For Thames-Coromandel District Council, it is particularly problematic with five-fold seasonal increases in population in its coastal resort settlements."

The communities receiving the effluent were so pleased with the benefits of their new irrigation systems that they are seeking an increase in allocation in order to expand their irrigated areas.

"From a client perspective, it has been an excellent outcome as it has satisfied the desires of the community, the need to protect the environment, the requirement to conserve water, and to meet the future needs of a growing community," Reynolds added.

The SDI method of treated effluent disposal combined with reuse as shown by this system has advantages for situations where it is considered appropriate to dispose of the effluent in areas in close proximity to (or actively used by) the public.

In June 2010, the Pauanui beneficial reuse system won a prestigious local New Zealand INGENIUM (Engineers for Public Assets) Award – noted as "Highly Commended" in the projects category of more than $2-million. Today, in 2015, the system is continuing to work well.

Authors' Note

Rodney Ruskin is the CEO at Geoflow, Inc., based in Corte Madera, California, United States.

Peter Gearing worked as a consultant to design the Pauanui system, and is now a senior environmental engineer at Ecogent Ltd. in Auckland, New Zealand.

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