Note: Subsurface Drip Irrigation

This note provides detail on subsurface drip irrigation (SDI) methodology. SDI is a land discharge option under investigation as part of the Waikato District Council (WDC) Raglan Wastewater Treatment Plant Upgrade and Consenting Project. At the time of writing, a prime site of investigation for the project is located in the vicinity of Maungatawhiri Road (see Image 1 below).

This note seeks to clarify how SDI could be a feasible discharge solution if suitable Raglan soil is secured for the project. It focuses on how such a discharge option avoids any effect on neighbouring bores, where Image 2 demonstrates setbacks of such bores from the investigation site property boundaries.

1. Selection of Areas needed for SDI

Specific area selection within a property is needed for the installation of SDI fields given the need for a series of strategically placed dripper lines beneath the ground surface. Images 3 and 4 provide an example of SDI fields at Pauanui. With this example, the green grass in a dry summer within a local public reserve is shown. For any theoretical Raglan solution, a 'cut and carry' crop would be selected, where Lucerne is a common choice, given that it is a deep-rooted, temperate, perennial pasture legume species, well adapted to SDI methodology. Cut and carried pasture may be a viable alternative species also.

Any SDI system design is site specific. At the site of investigation, a theoretical design would consist of a number of separate and distinct areas of suitable soils where fields can be installed (approx. 20ha). The topography needed for SDI is generally flat to rolling. At the site of investigation, such criteria mean areas on the tops (or upper slopes) of the hills have suitability. This is important for reasons that will be outlined below.

2. Selection of the Method of Application

Technically, the SDI method has been selected for applying the highly treated wastewater to the soils for the following reasons:

- There are no odour problems;
- There is no spray drift or aerosol problems;
- No mixing with any surface runoff will occur;
- Irrigation is possible in winter (i.e. rain & windy conditions), where winter storage at the WWTP site, and a 'relief valve' would ensure that mounding, or surfacing of water, is avoided.

The dripper systems used need to be specialised to handle wastewater and prevent both root intrusion and bacterial slime into the drippers. These are not simple agriculture dripper systems, instead, they incorporate specialised and sophisticated technologies which have been proven to work in these types of systems in NZ for well over 20 years.

3. Loading Rates and Design Criteria

There are several steps required in planning the land treatment so that it will be efficacious in utilising the highly treated effluent and meeting environmental standards. A brief description is given here but more detail can be found in Cook et al., 2021; Moore et al., 2018; Pang, 2009, which are attached.

3.1 Hydraulic Loading

This is worked out from both the analysis of:

- the climate data, to determine a potential water balance for the site (Rainfall - Potential Evapotranspiration) and;
- the statistics of rainfall and evapotranspiration. This will indicate if adding more water to the site in terms of irrigation is sensible or not.

The soil is assessed for hydraulic conductivity. For the site of investigation, the soil is a volcanic ash with high saturated hydraulic conductivity (Ks). To provide a safety margin we use only between 10-30% of the Ks value for the design irrigation rate. This means that there is 90% to 70% of the Ks available for rainfall, which means that any increase in runoff is unlikely (i.e. in contrast to that occurring presently from the existing weather). To provide further infiltration capacity, any area would be split into blocks with a 6-to-8-day rotation.

The Ks value and other soil physical parameters are used in determining the size of the wetting pattern, which is used to determine the depth the drippers will be placed to prevent wetting of the surface. From these calculations, an area required to meet the hydraulic loading rate is determined (Ah).

3.2 Nutrient Loading

The highly treated effluent will contain very low concentrations of nutrients, particularly nitrogen and phosphorous. In designing the system, we use the amount of nitrogen or phosphorus applied to determine the total amount of treated effluent applied to the site. This is done in a manner where the total applied treated effluent will not exceed the plant nutrient uptake, plus other nutrient losses such as gaseous loss for nitrogen (from nitrification and denitrification) and absorption into the soil minerals for phosphorous.

The 6-to-8-day rotation is used to provide time for the plants to take up the nutrients before the next SDI cycle occurs. From these calculations, the area of land required for plants to take up the nitrogen and phosphorus in the wastewater is determined (Ac).

3.3 Microbiological Loading

The use of subsoil dripper irrigation for highly treated effluent has the advantage of putting it below ground level. When a large rainfall event occurs, the highly treated wastewater will not be mixed with the runoff water so there will be no microbes from a wastewater origin in the runoff water and hence no contamination of surface water.

The volcanic ash soil that has been chosen contains a soil mineral called allophane. This has a large effect on the transport of both virus (20 log/m) and bacteria (5.48 log/m). At one meter from the source, we would not expect to find any viruses in the surrounding surface or groundwater, even if the initial virus concentration at the source was extremely high. If the initial concentration of bacteria at the dripper is 100,000 (10^5), then by the time the soil water reaches a distance of 1 metre, the concentration will be so low that we would expect to find only 1 bacteria. Previous investigations of the site have shown that there is no groundwater within several meters of the soil surface. Therefore, we can expect that any microbes from the highly treated wastewater will be present in negligible amounts by the time the soil water reaches the groundwater and should not be measurable.

Further, a membrane bioreactor (MBR) system is proposed for the wastewater plant, and this will put out wastewater with a faecal coliform load of less than 5 cfu/100ml. The concentration of faecal coliforms in fresh and marine waters that will cause no observable adverse effects for example is 40 cfu/100ml (Ministry of Environment, 2003 - #8 attachment).

Therefore, we can determine an area of land that would be able to disinfect the highly treated wastewater (Am). The subsurface drip irrigation of wastewater into this allophanic soil is highly unlikely to produce any microbiological risk to either surface or groundwater.

3.4 Actual Loading

The loading used in designing the wastewater irrigation fields will be the value from the hydraulic, nutrient or microbiological assessments which results in the requirement of the most area. This means that if the hydraulic loading was the most critical (which is likely the case with the site of investigation) then the nutrient and microbiological loading would be less than the maximum that could be theoretically possible. Finally, there will be at least a 20 m buffer distance from an SDI field to any surface water, potential surface water, or any local bores.

4. Detailed Modelling

Following this initial design based on the loadings, more detailed modelling of the transport of water and solutes through the soil will be undertaken. This will determine if, especially in winter, any risks to the environment are present.

This modelling will use multiple runs with different climate data and, determine the rate of leaching of water, nutrients and microbes into the groundwater. From this analysis, irrigation scenarios where the amount of leaching would be unacceptable can be identified and avoided through the best practice operation of SDI fields. This modelling will also look at the possible mounding of groundwater and transport of water to downslope areas. Following this modelling the design will be evaluated to determine if:

a) Any changes are required at the treatment plant to reduce the nutrient concentrations or microbial concentrations;
b) If extra storage may be required at the treatment plant during wet periods;
c) If the area of land is adequate to meet the required attenuation of the highly treated effluent.

Any necessary modifications will be made to the design to avoid any adverse effects on the environment. The existing professional view is that given the site evaluation undertaken to date, there is an ability for:

- soils to be utilised for SDI for the length of any discharge consent issued while;
- upholding the protection of the environment during this time.

5. Similar Schemes that are Operating in New Zealand

In terms of similar local New Zealand SDI municipal solutions, we can provide a few key local examples i.e. (project/location/installation date):

New Zealand Aluminium Smelters Ltd	Tiwai Point, Southland	1998
Jones Road plantation & golf course	Omaha, North Auckland	2000
Technology NZ Research SDI Trial	Waihi Beach, Bay of Plenty	2000
Pauanui community scheme	Pauanui, Coromandel	2008
Kepler Farm	Te Anau, Southland	2021

We provide some background to each of the above as attached. Some key points of each relevant to Raglan we believe may be:

NZAS Tiwai *(ref #1 Attachment)*

- Has operated effectively since 1998 - demonstrating longevity and sustainability if appropriate technologies are incorporated;
- Located on the DoC Conservation estate immediately adjacent to the smelter, and also near the drinking water take-off bore;
- Also located immediately adjacent Awarua Bay where oyster farms were being planned;
- Hence critical environmental performance required – remains consistently within consent parameters;

Omaha *(ref #2 Attachment)*

- Under the fairways and some tees of the southern 9-hole golf course;
- Immediately adjacent to the pristine Whangateau Harbour & DoC native Kahikateatea conservation estate;
- Shallow groundwater & very close to upmarket residential beach properties;
- Demonstrates longevity and a high level of environmental performance & compliance;

Waihi Beach Trial *(ref #3 Attachment)*

- Undertaken with Western BoP District Council and Forest Research (now Scion);
- Thoroughly monitored: (i) irrigation performance with relatively untreated wastewater; (ii) full environmental effects including groundwater and virus control; and, (iii) short rotation (eucalyptus) forestry response;
- Proven effective if appropriate technologies are incorporated;

Pauanui *(ref #4 Attachment)*

- Consented by Environment Waikato (same consenting authority as Raglan);
- Operates in Vista Paku main road median / the airstrip / and Kennedy Park;
- Adjacent the Tairua Estuary – an important receiving environment;
- Operates near adjacent drink water bores;
- Demonstrates longevity and a high level of environmental performance & compliance;

Te Anau *(ref #5 Attachment)*

- Similar scale to the proposed Raglan scheme;
- Immediately adjacent to Manapouri Airport and Lake Manapouri;
- Nitrogen in groundwater is a key local issue through the consenting process;
- Demonstrates cut & carry management (as proposed for Raglan) and effective operation (if appropriate technologies are incorporated);

6. Summary

The risk to the harbour, adjacent waterways and any neighbouring property from this theoretical SDI scheme is considered negligible given that:

- Mixing of wastewater with surface runoff water will be avoided with SDI;
- The allophanic soil will cause any water transported to the groundwater to have de minimis concentrations of virus and bacteria, especially as the highly treated effluent will have low values due to the use of a membrane bio-reactor at the wastewater plant;
- The combination of a 6-8 day rotation and use of an area of land that is greater than, or equal to, the area required for plant uptake of nutrients, which means groundwater concentrations of nitrogen and phosphorus will be low;
- Accordingly, also any local bores outside a 20m distance from any of the theoretical irrigation areas, will be unaffected by nutrients or microbes (where it is understood that the closest bore is beyond 500m from the irrigation area).

7 March 2023

IMAGES

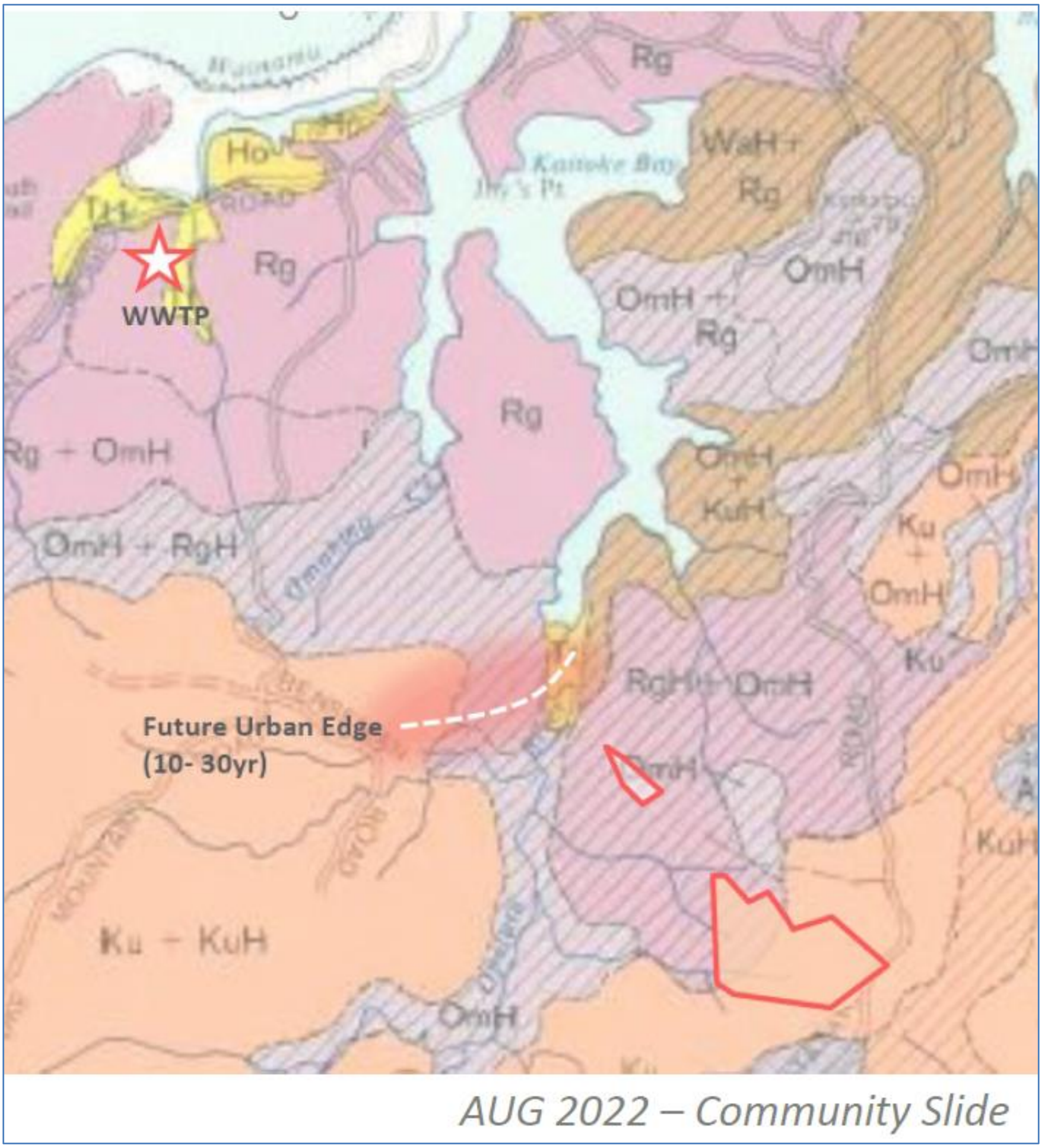

Image 1 SDI area of investigation (note, any theoretical system would require approximately 20ha of subsurface irrigation fields within the area shown. The proposed areas are outlined in red.

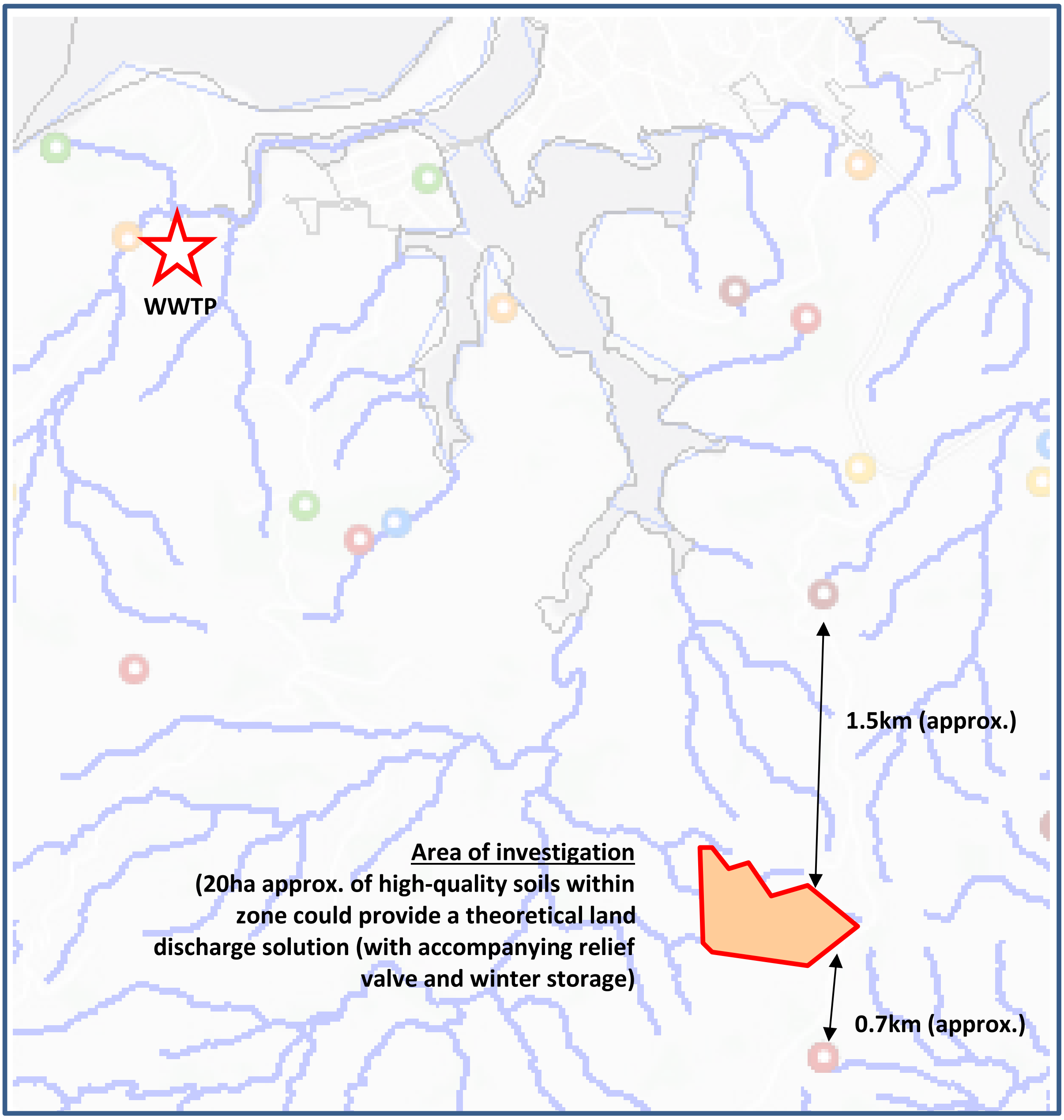

Image 2 From Waikato Regional Council Portal – Consented Bore locations, with the area of investigation overlay

Images 3 and 4: Pauanui SDI methodology to be replicated with any Raglan land discharge solution