Should Your Community Use Land Treatment and How Much of It?

Hamish Lowe[1], Katie Beecroft[1] and Erin Ganley[2]

[1]Lowe Environmental Impact Limited, PO Box 4667, Palmerston North
[2]Horowhenua District Council, Levin
Corresponding author. Email: hamish@lei.co.nz

ASTRACT

The development of long term sustainable community wastewater discharge options requires the progressive establishment of sound factual information. This information should describe limitations and management considerations for water and land receiving environments.

Water environments can be just as sustainable as land environments when considering quadruple bottom-lines; being environmental, social, economic and cultural values. Using both water and land environments can be a good compromise to more fully optimise quadruple bottom-line objectives.

This paper provides an analysis of two processes used to explore discharge options for a number of Manawatu communities. The first process develops scenarios to decide on the split between land and water discharges, where water only, land and water and land only discharge options were considered. The process considers the merits of avoiding discharges under nominated low flow regimes, and the use of storage to reduce unacceptable management and environmental effects. The process also identifies land area requirements and hydraulic and nutrient loading rates.

The second process is a land selection assessment using geographic information system (GIS) technology to identify preferable areas for land application. It incorporates fundamental resource information to build a multilayer picture of limitations and preferred application areas. These areas can then be targeted for further investigation.

This paper will demonstrate how the scenario and land selection processes are developed and applied to small communities facing the dilemma of whether to continue with water discharges or switch to land application.

INTRODUCTION

Horowhenua District Council (HDC) is responsible for the provision and management of wastewater treatment for the Horowhenua District. Currently HDC are reviewing wastewater treatment and discharge systems at a number of its communities. Foxton Beach WWTP discharges wastewater to land. Foxton WWTP discharges to Foxton Loop of the Manawatu River. Shannon WWTP discharges into a tributary of the Manawatu River.

As part of developing long term sustainable wastewater discharge options for these communities, there is a need to progressively establish sound factual information that describes the limitations and management considerations should discharges commence or continue to occur to land and water environments. These communities are spatially separated and therefore land available is not necessarily in common between them. Of the land that is available it has variable size, topography, soil texture, drainage, land use and management. These factors require consideration when deciding on which areas to evaluate further for land treatment.

DEVELOPMENT OF SCENARIOS

Background

A range of logical scenarios whereby land and water can be used independently or jointly to manage discharges from Shannon, Foxton and Foxton Beach has been developed. These scenarios span the realistic range of options for land and/or water discharges.

This approach requires the modelling of key components, such as:

- Climatic data
- River flows
- Wastewater flows

This modelling utilises a water balance approach where for a nominated day a decision is required to assess if a river discharge is possible or land application is possible, and if not the discharge is placed in storage.

For the land application component, a water balance approach which computes the land area needed based on a prescribed irrigation depth and return period. For the river discharge it takes into account the amount of water that can be discharged by identifying a nominated flow under which no water discharge can occur. During times when river flow is low, below half median flow (HMF), and no discharge is possible, or the soil conditions are too wet and no land application can occur, water is diverted to storage; with the modelling calculating the volume of storage needed. The available options are summarised in Figure 1.

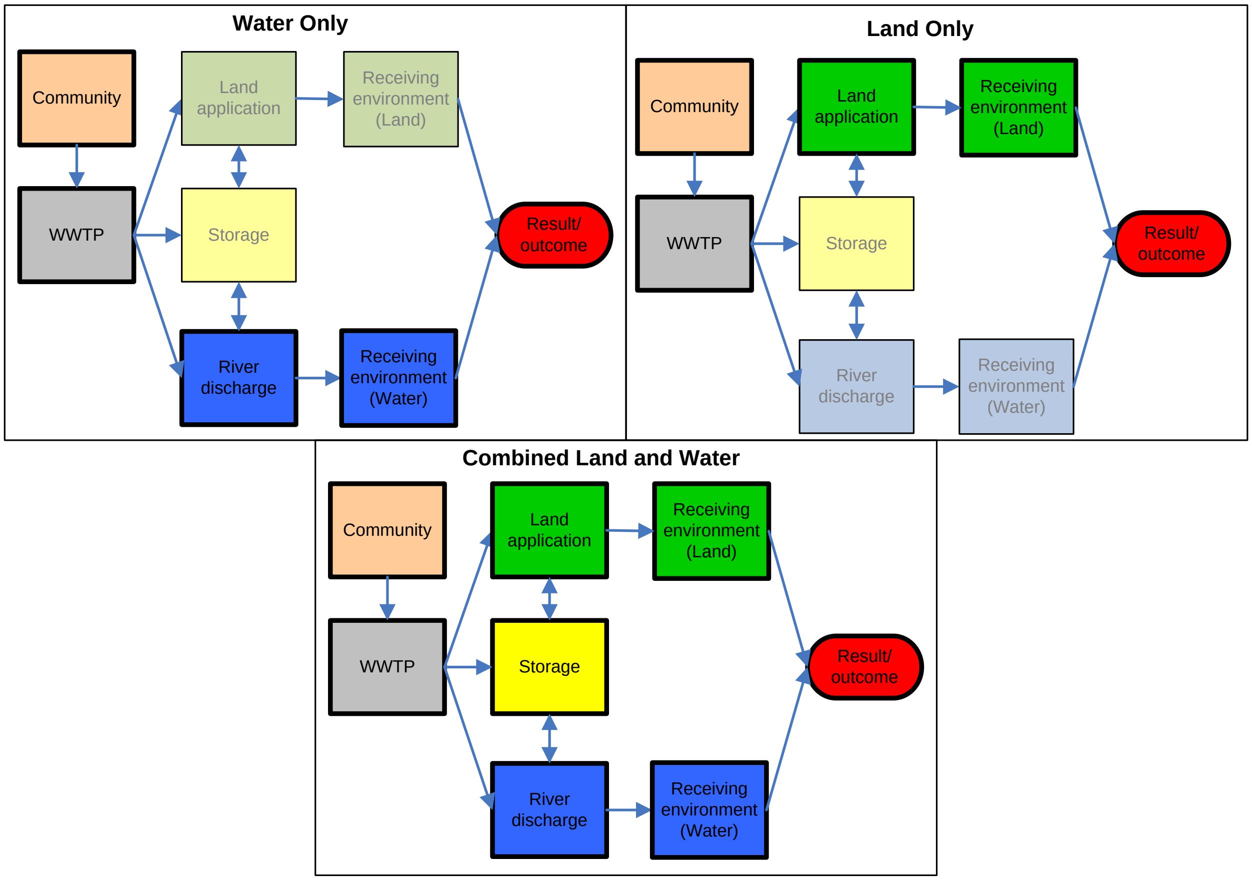


Fig. 1. Available Options for Discharging

There are variations with the estimates of discharge durations (land and water) and land area requirements. This is because the datasets available are of limited duration (only 4 years of wastewater flows are available for the Shannon discharge) and will not cover all combinations of climatic, river flow and soil moisture conditions. As a result, the land areas calculated and volumes discharged should be considered indicative only and used as a relative comparison when evaluating the various scenarios.

Key Findings – Shannon Only

The following key conclusions can be drawn from this assessment of the scenarios for wastewater discharges from Shannon:

- Year round surface water discharge is possible; however, storage (14,500 m^3) would be appropriate to assist with ensuring effects are minimal.
- Option 1 - To maintain a surface water only discharge and avoid low flow conditions (below HMF), 14,500 m^3 of storage is required.
- Option 2a and 2b - Land application is possible without using a surface water discharge, but significant storage is needed. Approximately 160,000 m^3 is needed for a deficit non-river discharge system and 140,000 m^3 for a non-deficit non-river discharge system. Land areas would range from 65 to 40 ha for deficit and non-deficit respectively.
- Option 3a - If a combined land and water discharge (CLAWD) system is used and preference is to discharging to land when flows are below HMF and then all discharge is

to water above HMF, the storage volume is 4,000 m^3. The associated land areas would be 5 ha under non-deficit conditions.

- Option 3b - If a CLAWD is used and preference is to discharging to land whenever possible, including flows only above HMF, the storage volume is 5,500 m^3. The associated land area would be 23 ha under non-deficit conditions.

Disposal is not a realistic option for Shannon. Not only are there no soils which have sufficient permeability, but there is a high groundwater level which would likely result in adverse effects from mounding.

Table 1. Summary of Discharge Options.

Option	**1**	**2a**	**2b**	**3a**	**3b**
Discharge	River	Land	Land	CLAWD	CLAWD
Type of irrigation	None	Deficit	Non-deficit	Non-deficit	Non-deficit
Area	0 ha	65 ha	40 ha	5 ha	23 ha
Time to land	0 %	100 %	100 %	15 %	57 %
Storage	14,500 m^3	160,000 m^3	140,000 m^3	4,000 m^3	5,500 m^3

Assumptions

With any modelling there can be a high degree of variability depending on the accuracy of the information used. Some of the assumptions and considerations with the modelling include:

- Data set duration – modelling duration is limited by the data set of the shortest duration. There are three main data sets; being wastewater flows, river flows and climate data. The wastewater monitoring has a duration of four years, with modelling of actual data only possible over a four year period. Care is needed to ensure extreme wet and dry conditions are used to enable a full range of climatic conditions to be assessed; but care is needed to ensure they do not unnecessarily bias the results.
- Integrity of data sets – many data sets have occasional 'gaps' as a result of non-collection, meter failure etc. Where this is for a short duration average data can be used to plug the gaps. Gaps of longer duration can be problematic for the accuracy of the analysis.
- Synthetic data generation – in order to increase modelling accuracy synthetic data can be generated. This means artificially creating datasets. This is typically limited to wastewater flows as most rural wastewater discharges have only been metered in the last 4 – 6 years. This process requires normalisation of flows to identify a base flow without the influence of infiltration and ingress, and then adding ingress based on seasonal trends and infiltration in response to rainfall events.

Additional Considerations

The land areas calculated are net irrigation areas, and greater areas should be provided to allow for management flexibility. The extent of the additional area will depend on the farm used and consideration of buffers to neighbours and waterways etc.

With treated municipal wastewater, loading rates for deficit and non-deficit irrigation systems will result in insufficient nutrient applications for most crop types. Supplemental nutrient applications (fertiliser) will typically be needed to maximise (or even sustain) crop performance.

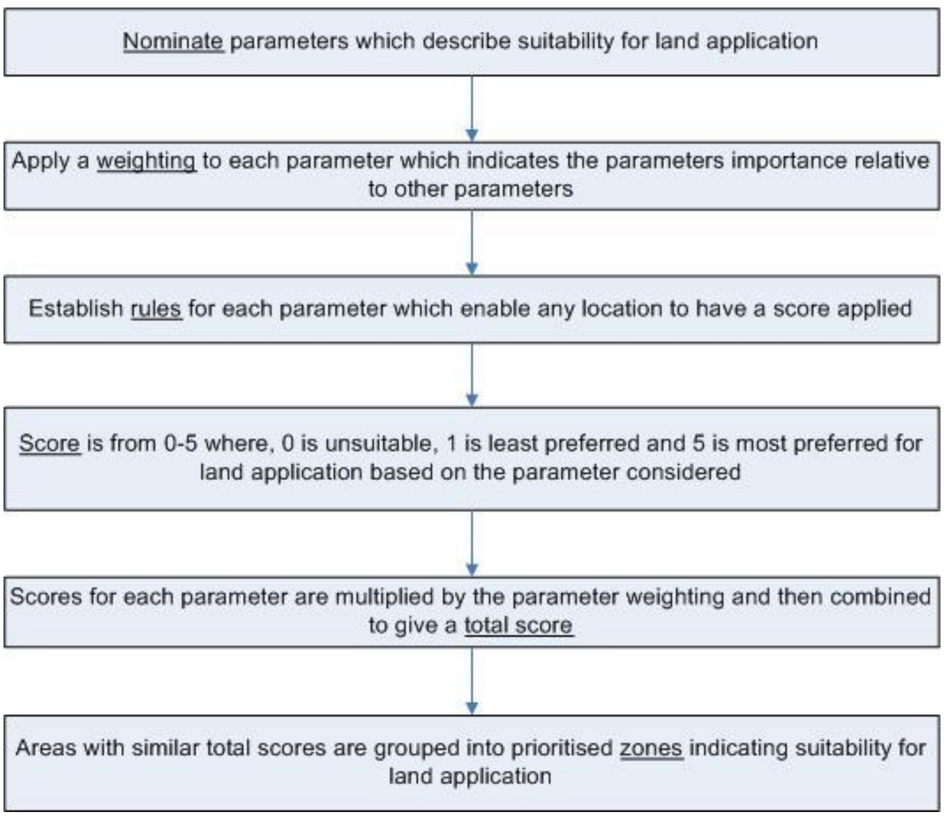
The limiting factor for the loading rate is the hydraulic loading. Consequently additional treatment to lower the nutrient concentrations is not considered to be a requirement for Shannon. However, depending on land management disinfection of the wastewater may be required.

IDENTIFICATION OF LAND

The Process

The suitability of land for wastewater application is dependent on a range of factors. These factors and their importance to the evaluation process are dependent on the community and nature of the area.

The process undertaken to determine the ability of areas around Shannon, Foxton and Foxton Beach to receive wastewater is summarised as follows:



The parameters selected for assessment of land application sites in the Horowhenua district are given below.   The parameters are all weighted equally:

- Land use:
  - Nutrient uptake;
- Soil attributes:
  - Soil drainage and permeability;
  - Depth to restrictive layer;
  - Slope and stability;
- Hydrological and hydrogeological attributes;

- Mounding risk; and
- Flood return interval.

A GIS system has been used to take the base information for the various parameters and score common characteristics, with the scores being able to be added together to get an overall combined score (total). This total score can then be grouped into bands to indicate a preference of area to pursue further. For example:

- Zone A – No significant limitations are experienced within areas of this rating zone. Zone A represents the preferred zone for siting of a land treatment system;
- Zone B – Minor limitations are experienced within areas of this rating zone. Zone B is likely to be well suited for land treatment;
- Zone C – Some limitations are experienced within areas of this rating zone. Zone C is suitable for land treatment when appropriately managed;
- Zone D – Significant limitations are experienced within areas of this rating zone. Land treatment is likely to be possible within Zone D however costs and management requirements are expected to be greater than other zones; and
- Zone E – Severe limitations to land treatment are experienced within areas of this rating zone. It is likely that cost and management requirements would be prohibitive to the establishment of land treatment in Zone E.

While equal weighting has been applied in this instance to each parameter, refinement of the prioritisation process can be used to give a higher weighting to more significant parameters.

This desktop land prioritisation assessment method has been used as a first step in the design process for a wastewater application to land scheme. Additional stages are required to supply detail about preferred land areas and project engineering considerations, such as reticulation routes and costs. The additional information contains a level of detail which is not considered feasible or appropriate for a desktop assessment of regional suitability for land application of wastewater.

Results

The investigation concluded that, in general, there is suitable land available for the establishment of a land treatment system for all the Horowhenua discharges, but with varying suitability over a range of distances. Extensive areas of land in the vicinity of Foxton, Foxton Beach and Levin including the Pot site indicate that pursuing land within the higher ranked areas should be the first choice for HDC. This is shown in the orange areas of Figure 2.

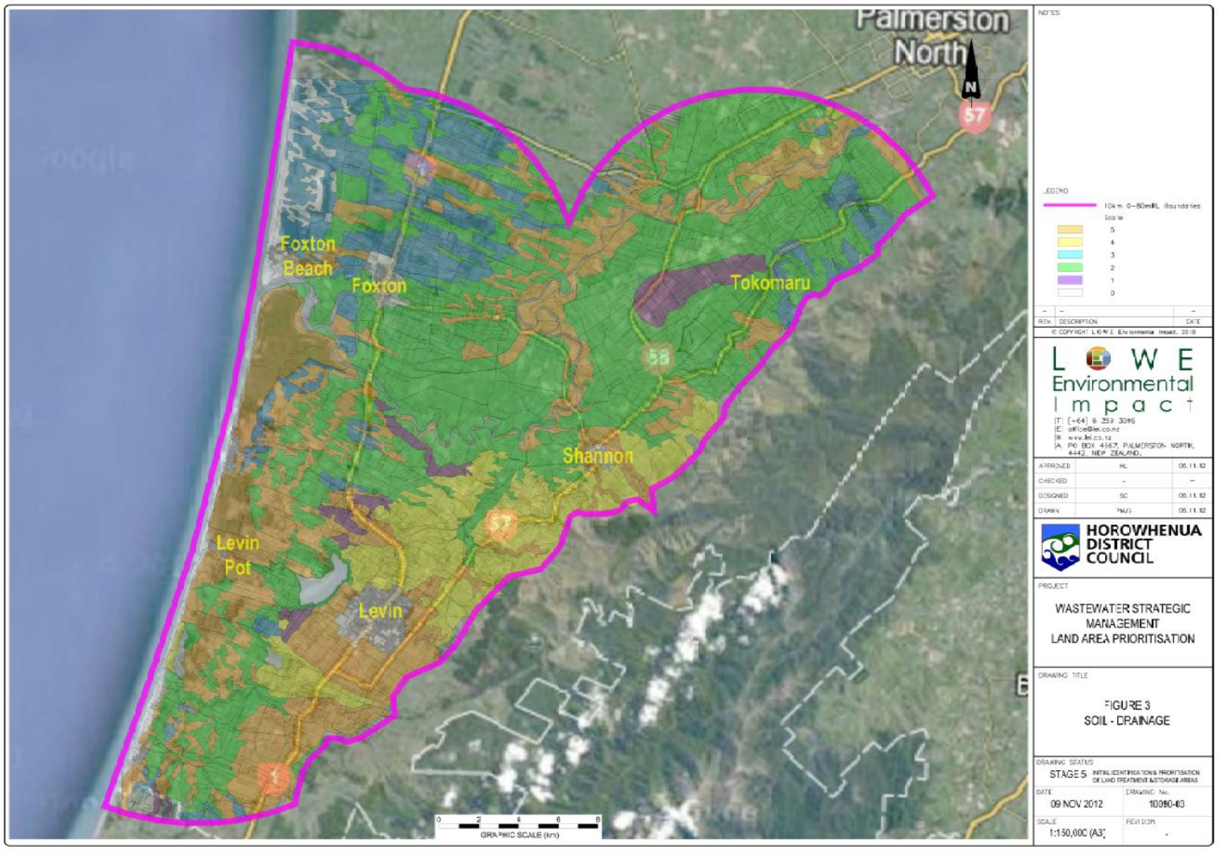


Fig. 2. Land Suitability Prioritisation in the Horowhenua District (Soil Drainage)

Compared to the other communities in the investigation area, Shannon has less land available that is well suited to land treatment of wastewater. Near to the Shannon WWTP the land is the least suitable for wastewater irrigation, however there are isolated 'pockets' of land which could be used; this being dependent on the area actually needed. The orange areas in Figure 3 show the location of more suitable land areas.

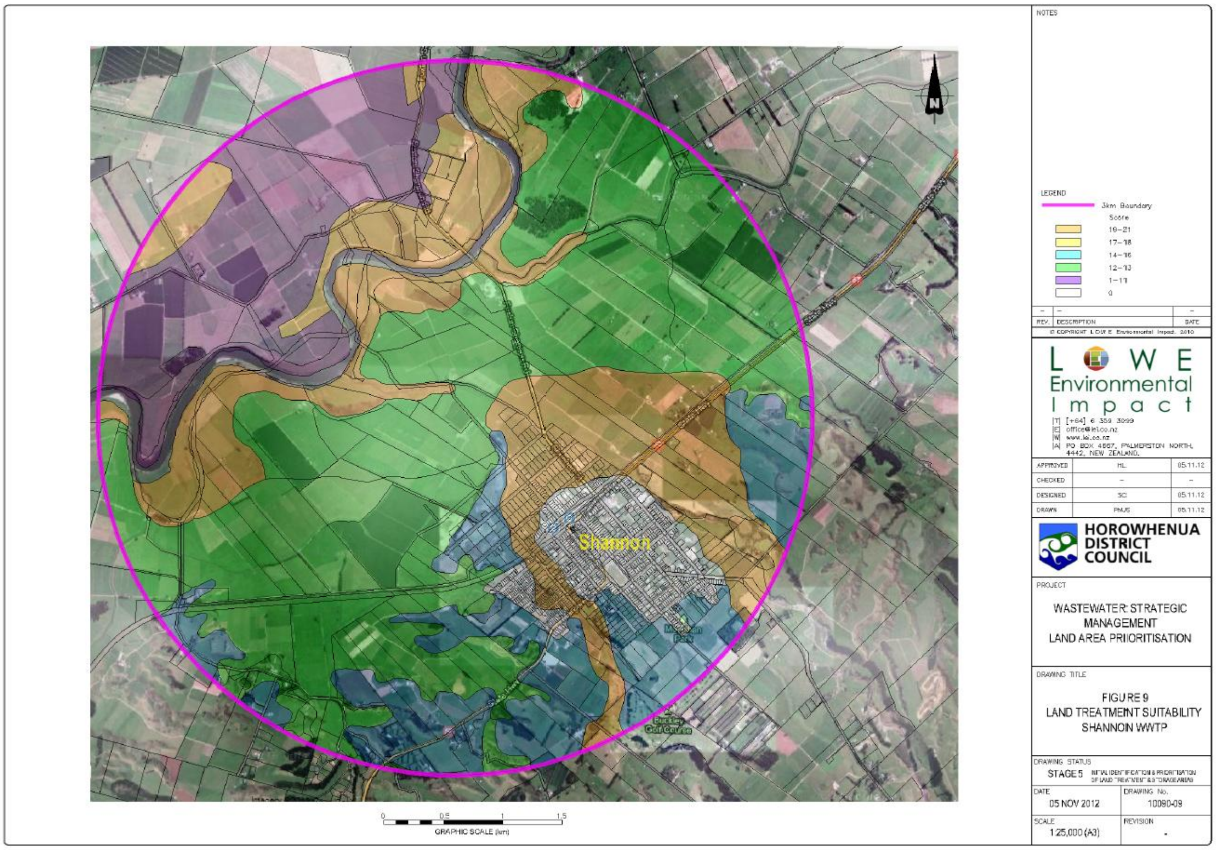


Fig. 3. Land Suitability Prioritisation Around Shannon

Next Steps
The next step in selecting land is to limit the land areas examined. Within the selected areas the following should be considered:

- Land parcel sizes and ownership;
- Special use considerations e.g. known heritage sites;
- Potential buffers; and
- Approximate reticulation routes.

CONCLUSION

A series of tools are available to assist with identifying the location and areas that can potentially be used for land treatment.

The location of land can be determined using a multilayer GIS based approach which adds together scores for land parameters to develop a ranking system, thereby identifying more favourable areas for use.

The extent of land area needed is dependent on a number of factors, with a key driver being the ability to utilise a partial water discharge and incorporate storage. A dynamic model which allows pairing of matched daily data can be used to determine the daily discharge volume to land

and water under different climatic and river conditions. A series of scenarios can be developed, and in the case of the Shannon community it is clear that 100 % land application requires significantly more land area and storage than scenarios which utilise combined land and water discharges.