Masterton District Council

Riversdale Sewage Scheme Denniston and Tatham Options

LAND DISPOSAL OPTIONS

Prepared By ....
Dave Taylor
Environmental Engineer

Reviewed By ....
Peter Keller
Principal Engineer

Opus International Consultants Limited
Environmental Division
Level 5, Majestic Centre
100 Willis Street, PO Box 12-003
Wellington, New Zealand

Telephone: +64 4 471 7000
Facsimile: +64 4 499 3699

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1 Recommendations

Opus recommends forestry crops due to feasibility issues. Forestry requires minimal maintenance and has the highest rate of water loss. Grazing is perceived to have significant problems with nitrogen loading and pugging. Cut and carry crops have high nitrogen removal, however this is not required for this site as hydraulic loading has been found to be the limiting factor. There is the potential for higher profits from grass and cereal crops; however they also require extensive management with stricter health regulations and harvesting up to 5x per year. This may not be sustainable in the future as maintenance budgets decrease and attention starts to wane.

Issues and advantages/disadvantages as discussed in this report were discussed with Bob Longhurst of AgResearch.

2 Introduction

In New Zealand the primary concerns when disposing of effluent to land are nitrogen loading, hydraulic loading and public health. The hydraulic loading is limited by the rate water is lost from the soil profile by leaching and evapotranspiration (EVT) (loss of water to atmosphere by plant respiration and evaporation).

The nitrogen loading is limited by the rate of conversion in the soil profile, acceptable leaching and uptake by plants. These variables can be heavily influenced by the crop selection for a particular site.

3 Hydraulic loading

Hydraulic loading is determined by soil conditions, precipitation, and evapotranspiration. The loading is limited to what can be applied without ponding or surface runoff occurring. This will require a monitoring system to balance the irrigation rate with the water holding capacity of the soil.

The soil conditions were found to be sand and gravel marine deposits with some silt and clay with a cap of thick loess, palaeosol and tephra. This was assumed to be constant across the various proposed disposal areas. These soils have low permeability meaning that the water loss to leaching is likely to be low; however, this will require soil infiltration tests to confirm before detailed design. Preliminary testing found sites in the general area to have a hydraulic conductivity of 0.10 to 0.45 m/day (AS/NZS 1547:2000, Appendix 4.1F), However further testing will be required to confirm this. This corresponds to a recommended design irrigation rate of 20 to 25mm/week (AS/NZS 1547:2000, Table 4.2A4). This standard is designed for domestic, on-site systems, thus with more rigorous engineering and monitoring to determine soil water deficit and thus, degree of irrigation possible, these limits can be revised.

Evapotranspiration will vary significantly depending on the site conditions; sun light hours, wind and crop type. The proposed sites are exposed, receiving strong winds and good sun giving a high evapotranspiration potential. These factors have the potential to increase the water uptake of 2-5 mm/day from leaching in winter to 10-15 mm/day from leaching and evapotranspiration in summer according to weather conditions. Figure 1.1 shows a graph of evapotranspiration and rainfall. It should be noted that the expected evapotranspiration will be higher at the proposed site as the data is for Te Ore Ore just outside Masterton city. The period of maximum effluent disposal is late

December to early April when 125m^3/d is applied. During December to April evapotranspiration is higher than rainfall thus assisting the loss of water and reliability of the system as irrigation rates of greater than 2-5mm/day should be possible. During winter, when rainfall is greater than evapotranspiration, the pond in and out flows are reduced, therefore the system is less dependent on good weather.

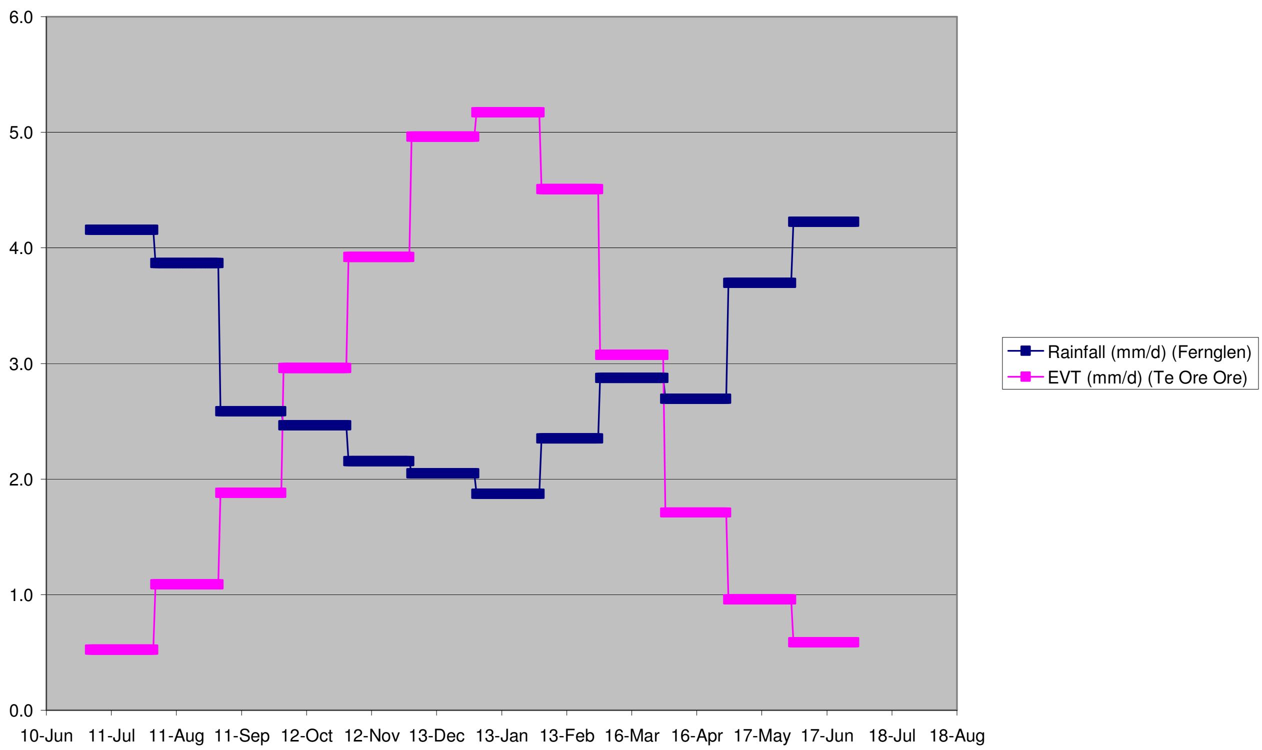

Figure 1.1 EVT and rainfall data for Fernglen and Te Ore Ore

The design hydraulic loading has been set at 2mm/day. This is a conservative estimate based on the unpredictability of rainfall and evapotranspiration. A higher average loading may be possible but nitrogen loading becomes a critical criteria as rates approach 5mm/d, see next section. The max buffer outflow is 125 m^3/d. This results in a required land area of

$(125\ m^3/day) / (0.002\ m/day) = 62{,}500\ m^2 = 6.3\ ha$

To this figure an allowance needs to be made for buffer zones, access roads, and stand-down areas required. This will vary according to the crop and irrigation technique chosen.

4 Nitrogen loading

In effluent application to land the limiting factor can be the ability of the land and crop to remove applied nitrogen. Historically, in the Wellington region, a figure of 150kgTN/ha/yr was the accepted loading rate. Now the standards are more effects based, however this remains as a commonly accepted figure. The nitrogen uptake by crops varies from 35-700kgTN/ha/yr depending on the environmental conditions and crop type.

The yearly effluent flow has been estimated at 27,000m^3/year based on a sewage production of 150L/p/day and summing the number of days people were expected to reside at the Riversdale settlement. This assumes that the current occupancy pattern continues. The nitrogen concentration in the pond effluent is designed at a maximum of 30 gTN/m^3 and the assumed consentable limit for nitrogen application is 150kgTN/ha/yr. This gives a minimum required land area for nitrogen assimilation as

($27{,}000m^3$/year x 0.030 $kgTN/m^3$) / (150 kgTN/ha/year) = 5.4 ha

Therefore at an application of 2mm/day water is the limiting factor. However, if this is increased to 5mm/day nitrogen becomes the limiting factor. These issues should be taken into account when choosing a crop.

5 Risks

The risks of groundwater contamination are expected to be low due to the slow infiltration rate, high adsorption capacity of clay cover and large depth to water table (estimated at >10m). There are no recorded users of groundwater in or downstream of the proposed irrigation area thus reducing the impact of any leakage that did occur. There is potential for runoff into the adjoining gullys via either overland flow during rain events or from seepage. However, any water that reaches these gullys will have first gone through treatment both in the pond and soil. Further treatment is possible if the gully bottoms are planted as wetlands.

6 Crop Options

There are two main options for crops. A cut and carry system which removes crop matter from the site or grazing where nutrients are returned to the soil via excrement with nitrogen being of particular concern. The Department of Health has set out the following guidelines for the application of effluent to land (Department of Health 1992);

Fodder crops and pasture

- <10,000 faecal coliforms per 100mL
- Pastures to be free from ponding
- No harvesting or grazing for 48 hrs after irrigation
- Treatment process must remove helminths
- Warning signs around irrigated area

Irrigation of forest

- No quality restrictions
- No public access for 48hrs after irrigation
- Warning signs around irrigated area

6.1 Grazing (cattle or sheep)

Sewage effluent may be used to irrigate pasture as long as the pasture is not used for dairy. Fonterra has indicated that it will not accept milk from cattle allowed to graze on land irrigated by effluent due to concern over the reaction of foreign markets. This stance has recently been softened a little but required effluent quality is difficult to achieve without very sophisticated treatment. There is also the concern that this could extend to sheep and beef pasture in the future.

Although pasture grasses may take up as much as 700 kgN/ha/yr, much of this will be returned to the soil as manure and urine, resulting in a much lower net uptake of nitrogen than if the pasture was taken off site. Grazing can cause issues with pugging of the soil during wet periods reducing the infiltration rate thus increasing the required land area. Grazing also requires a relatively high level of maintenance with a sequence of fields on an irrigate, stand down, graze rotation. As there must be a 48 hr stand down period between irrigation and grazing this will require a minimum of 3 fields with buffer zones and races in between. The stock will probably be on a 6 day rotation requiring moving every 2 days.

6.2 Cut and carry

This method removes the biomass produced from the site, thereby removing the nutrients with it. Crops include greenfeed grasses, cereal crops and forest crops. Vegetable and fruit crops are not recommended due to health concerns.

6.3 Greenfeed

This involves growing a crop for use as feed at an off site location. The main crops are perennial grasses, annual grasses and lucerne. Inherent in this option is the need for a local buyer as the large volumes produced make long distance transport economically unviable. Greenfeed crops have very high nitrogen removal capabilities of 500-600 kgN/ha/yr. This has the potential to significantly reduce the land area required if the soil can absorb sufficient water. All green feed grasses require harvesting 3-5 times per year to ensure maximum yield.

6.4 Cereal

Cereal crops have the advantage over pasture that they are removed in one operation and have a higher nutrient concentration per kilo of dry matter thus lowering transport costs. Cereal crops have a nitrogen removal capacity of 150-250kgN/ha/yr, which can be increased if the leaf and stem is also removed (as silage). They also have periods during which irrigation is impractical due to harvesting requirements. Cereal crops also require frequent cultivation. This option will in most cases require spray irrigation resulting in issues with spray drift.

This option is most practical on the Tatham site due to irrigation requirements (see next section), soil characteristics and slope. It is likely that cereal crops would have to be combined with some other form of cropping to provide year round disposal.

The largest potential benefit from crops is the increased revenue. However due to the long transport distance, lack of harvesters and low selling price this benefit is greatly reduced. When considered with the high management required crops become a less attractive option

6.5 Forest Crops

Forestry plantations have a number of advantages for land treatment systems including:

- Low maintenance requirements
- No annual harvesting required
- Can be grown on poor quality soils
- Minimal health restrictions (allowing maximum flexibility in treatment performance)

High water loss has been observed from forested catchments when compared with arable crops. This is thought to be due to increased rainfall interception resulting in greater evaporation due to high surface leaf area. This is not expected to influence the evapotranspiration rate of irrigated water for this application as drip irrigation is proposed. However interception will still increase rainfall evaporation rates, potentially allowing greater effluent irrigation rates.

The current trend for plantation species is to opt for short rotation forestry. This utilises the coppicing ability of species such as eucalypts, willows and poplars to produce pulpwood and/or energy wood on a 3-8 year rotation with the same stem being used for multiple rotations. Short term rotation forestry has the advantage of reducing the establishment period, having relatively high nitrogen uptake and early cash flow. However there are issues with having to remove the irrigation system or use a system that can withstand the harvesting process.

Sewage effluent has also been used on long rotation pulpwood and/or energy wood regimes (10-20 year rotations) and saw log or veneer log regimes (>25 year rotation). These have longer stand down periods at establishment and greater disturbance at cropping, however cropping is also not required as frequently.

Species selection and regime selection will be strongly influenced by the market potential for a particular product. Other factors considered will be ease of establishment, expected growth rate, compatibility with intensive irrigation, nutrient uptake and management requirements. Radiata pine is the most common plantation forestry species for New Zealand, and thus has the largest body of data on such factors as growth rates, likely markets, economic returns and silivicultural costs. Pine has an uptake of 35-140kgN/ha/yr. Long rotation forestry also has an establishment period of 2 years without irrigation. This is reduced for shorter rotation lengths. Eucalypts, willows and poplars have an uptake of 150-300kgN/ha/yr and the coppicing ability removes the need to replant between rotations.

The application of wastewater to native forest is normally used where there are existing stands of forest. Trees have a maximum nutrient and water uptake during the growth phases. Thus removal efficiency could become problematic once maturity is reached. Many natives are also very slow growing and as a result will have lower nutrient uptake. However, once established native forest will require minimal management and will provide an ecological resource for the surrounding area. The area required will also be reduced as no alternative options will be required during harvesting.

Forestry crops can require a long establishment period. This can vary from 0-5years and allows the trees to set proper roots. The period depends upon the time till harvest, tree type, and wood quality required. In general pines need a longer establishment time. This is because pines are 'lazy' i.e. they will preferentially develop surface roots where water is readily available. This makes them susceptible to wind throw. Short rotation forestry requires a shorter establishment period. This is because they are less susceptible as there is a lower chance of a high intensity event and the total mass above ground when harvested is lower. Typical establishment time for long rotation pine is 5 years. This reduces for short rotation forestry proportional to the local conditions and intended growth period. Eucalypts have a shorter establishment period, which is more dependent on the soils although 0-1.5 years would be considered reasonable. Past experience has shown that eucalyptus can be planted to coincide with the start of irrigation with minimal problems. Problems experienced have been related to rabbits, resulting in the trees requiring protection while young and some species of eucalyptus struggling. This can be mitigated by planting a variety of species then replacing those that die off.

7 Irrigation Options

There are a number of options for the application of effluent to land however these can be split up into two main categories, spray and drip irrigation.

7.1 Spray Irrigation

There are a number of methods of spray irrigation however many are unfeasible due to the nature of the site. The preferred options include travelling guns, long-lateral systems, and solid set systems.

Advantages of spray irrigation systems

- Medium to low operating costs for low pressure systems.
- Filtration of effluent is less critical.
- Can have low capital costs.

Disadvantages to spray irrigation systems

- Potential for spray drift.
- Can have high labour input depending on system chosen.
- High operating costs for high pressure systems.

The biggest concern with spray irrigation is the potential for spray drift. This makes this option probably unfeasible on the Denniston site and problematic on the Tatham site. Due to this factor it is recommended that drip irrigation is used if practical for a given crop choice.

7.2 Drip irrigation

Drip irrigation is split into two categories, surface and subsurface. Surface drip is appropriate for forestry while subsurface is feasible for both forestry and pasture.

Advantages of drip irrigation

- Negligible potential for the creation of odours and aerosols.
- Low level of management required.
- Low operating cost.
- Effluent applied directly to root zone.

Disadvantages of drip irrigation

- High level of filtration required.
- Filter failures are difficult to fix in subsurface systems due to emitter blockage.
- Can have high capital cost.
- Root intrusion needs to be managed.
- Lower evapotranspiration losses.
- Less even application over land area.

Drip irrigation is the preferred option as smaller buffer zones are required resulting in less land area. However the final choice will depend on the crop chosen and consenting issues.

8 References

Department of Health, 1992, Public Health Guidelines for the Safe Use of Sewage Effluent and Sewage Sludge on Land