High rate land application as a solution for seasonality

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ABSTRACT

Many NZ communities are moving from traditional discharges of treated wastewater to surface water bodies to various forms of land discharge. When land treatment is used, a key control is the management of soil moisture to protect environmental health and ensure that the discharge to land can occur sustainably in the long term. In many towns with a permanent population and aged sewer networks it is common for peak wastewater flows to occur during winter months when the groundwater table rises and rainfall events are more frequent and longer lasting. Typically this period coincides with high soil moisture and low land treatment potential. At this time the adverse environmental effects of discharges to receiving waters are often low, however it is still undesirable to discharge directly to surface water due to cultural concerns.

An alternative to large storage basins or direct surface water discharge is a high rate land passage system (HRLPS) which enables soil and plant contact to occur prior to surface water contact. The advantages are:

- Minor additional treatment, particularly in reducing suspended solids and BOD;
- Reduction in the need for large and expensive storage facilities; and
- Metaphysical cleansing which allows the restoring of the Mauri of the waterway.

The type of HRLPS that is selected will depend on the soil types present and the landscape position, but may include:

- Open water wetland;
- Vegetated submerged bed wetland;
- Diffusion structure and vegetated swale; or
- Armoured and planted cascade structure.

This paper reviews situations where the different structure types could be adopted, and how they can be used separately and in combination.

Keywords: Land application, high rate land passage, winter wastewater peaks.

INTRODUCTION

New Zealand towns and cities have historically discharged their wastewater to surface water bodies. Over time this has resulted in substantial degradation of the water bodies and as a result wastewater treatment and discharge design has focussed on minimising the impact of the discharge on the receiving water. Improved treatment processes and the ability to store wastewater assists to manage the impact of wastewater discharge but is expensive. Land application of wastewater has emerged as a feasible and affordable alternative to direct water discharge.

Most regional councils indicate a preference for land application of wastewater through Regional Plan and Policy statements despite not having rules to support this preference. Support for land application as an alternative to direct water discharge has come about due to the ability of the land to remove or retain wastewater constituents that degrade waterways thereby reducing the contaminant load to water. A further key driver is the cultural beliefs of Maori, for whom the discharge of wastewater to water is considered to degrade the life supporting capacity of the water.

The gold standard for land discharge is land treatment, whereby the rate of discharge and the management of the site enables near complete removal of wastewater constituents as the waster moves through the biologically active zone of the soil. The main constraints for land treatment are the availability of land, the quality of the land and the storage requirement to allow discharge to be deferred when land discharge is not possible.

When land treatment is used, a key control is the management of soil moisture to protect environmental health and ensure that the discharge to land can occur sustainably in the long term. As a result land discharge during wetter winter months is ceased or substantially reduced. New Zealand towns with a permanent population and somewhat aged reticulation network tend to have a high degree of seasonal variation in wastewater flows due to inflow (predominantly rain water) and infiltration (groundwater) during the wet winter months which results in high winter wastewater flows.

During the winter the adverse environmental effects of discharges are often low and there is potential to incorporate a surface water discharge into the wastewater discharge. However, this does not address cultural concerns. Large storage basins enable wastewater to be stored until conditions are suitable for land treatment, however they require a high degree of geotechnical engineering and expense. An alternative to large storage basins or direct surface water discharge is a high rate land passage system (HRLPS) which enables soil and plant contact to occur prior to surface water contact.

HIGH RATE LAND PASSAGE

Principles of Design

High rate land passage (HRLP) aims to cause wastewater to interact with the soil and plants before entering any surface water body. A combination of infiltration and overland flow occurs. The key processes and benefits of HRLP are:

- The reduction in wastewater derived contaminants by filtration and adsorption, and eventually plant and microbe uptake and conversion;
- Aeration of the wastewater resulting in a reduction in BOD;
- Treatment site life is prolonged by not overwatering treatment areas and storage volume needed is reduced; and
- Most importantly HRLP aims to achieve sufficient contact between the land and the wastewater to effect the metaphysical cleansing attributed to Papatuanuku, restoring or maintaining the mauri (life essence) of the receiving water.

The extent of improvement is dependent on the flow rate and how long the water resides within the HRLPS.

Treated wastewater should be spread evenly over the HRLPS with preferential flowpaths being avoided, thereby maximising residence time and providing for greater contact with the land and vegetation. Vegetation incorporated into the system assists to slow the passage of wastewater through the system. The roots, and micro-organisms around the roots are involved in removing contaminants.

HRLPS Selection and Design

HRLP design begins with what is possible for the site. The design will be prepared with consideration of the following:

- Land area available;
- Slope of the area;
- Soil characteristics;
- Embankment stability to the water source;
- Current land use;
- Ability to maintain the structure; and
- Amount of use it will get throughout the year.

There are two key components; being land passage and discharge. Both components need to be incorporated into any design. Land passage provides for soil and plant contact, and essentially the cleansing and treatment properties of the structure. The discharge component provides for the mechanism which allows the wastewater discharged to reach the receiving water, which may be over a river bank and into a stream, or soakage through gravels into groundwater beside a stream.

The following examples are options that have been prepared for a number of communities, with varying needs and available space. There is potential for more than one option to be used in a HRLPS and for the configuration of each option to be adapted for the site.

Open water wetland

There are a range of open wetland designs which may incorporate such features as meandering paths to limit short circuiting, changes in depth to create different reactive zones, and variations in plant selection. Open water wetlands are well suited to sites with low slopes and fine textured soils. Figure 1 gives an example of an open water wetland layout.

Fig. 1. Open water wetland.

Vegetated submerged bed wetlands

Vegetated submerged bed wetlands (VSB) include a media filled pond which is planted with wetland species. The media is evenly sized to provide pore space through which the wastewater travels. Biofilms on the media and plant roots provide treatment for the wastewater passing through the VSB. VSBs are best for sites with low slopes and fine textured soils. Figure 2 shows an example of a VSB.

Fig. 2. Vegetated submerged bed wetland.

Diffusion structure and vegetated swale

Where there is a gentle slope on the site and a reasonable distance (100-200 m) between the treatment plant and a waterway the use of a diffusion structure which directs the wastewater along a vegetated swale provides a high degree of soil and plant contact. These structures are particularly well suited to sandy or gravelly sites where a large proportion of the discharged wastewater soaks into the swale along its length. Figure 3 shows a diffusion and swale design.

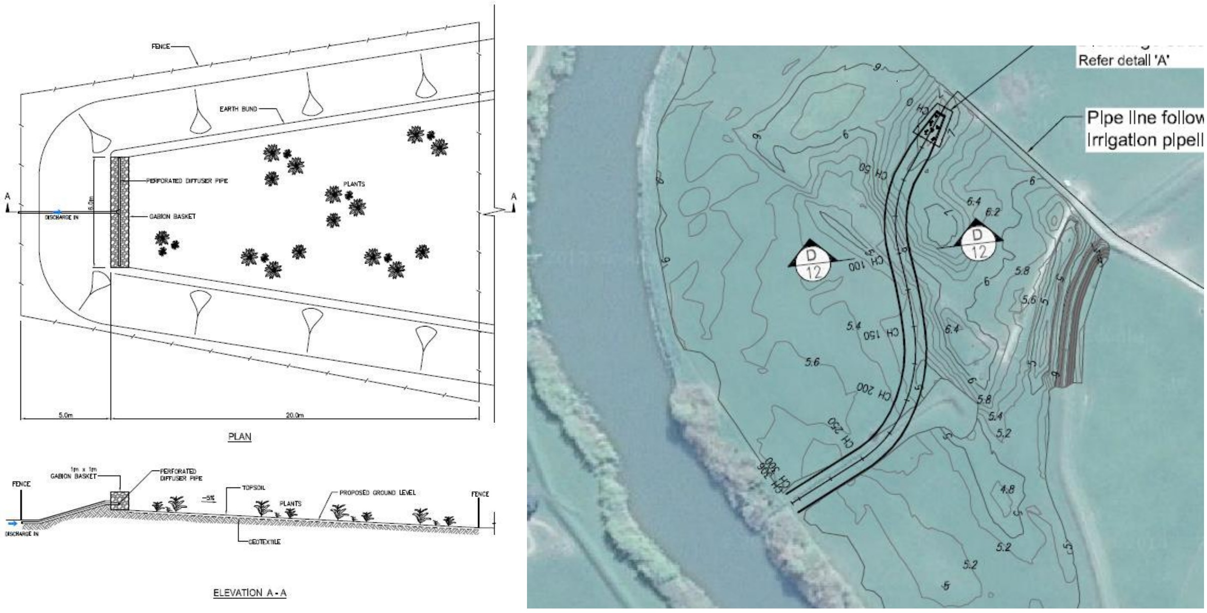

Fig. 3. Diffusion structure and vegetated swale.

Armoured and planted cascade structure

The wastewater is evenly spread along a rock filled structure that spills into a vegetated area for further earth contact. From the vegetated zone the river embankment is stabilised using rip rap for the discharge to filter through before it enters the surface water. This type of HRLPS is well suited to areas where there is a steep slope or limited distance between the treatment plant and a water body. Figure 4 shows cascade structures.

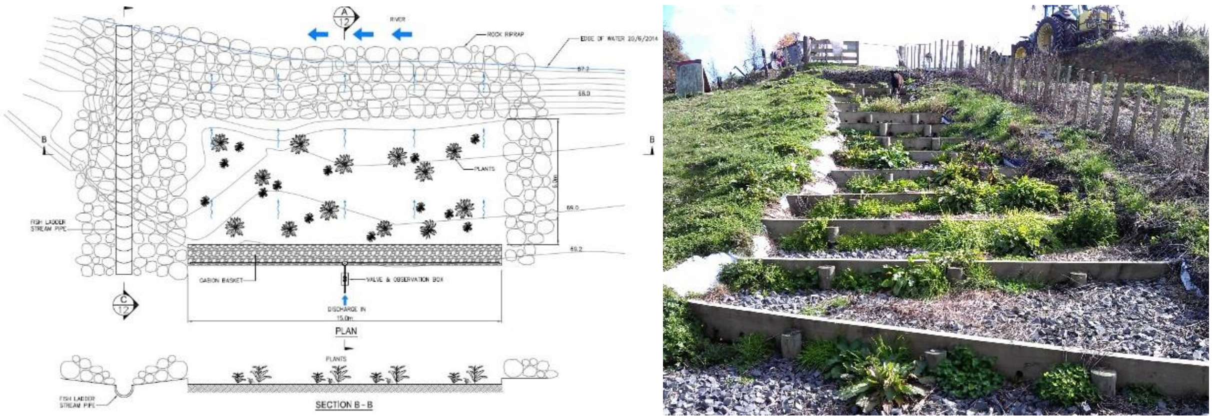

Fig. 4. Cascade structure.

Maintenance

Maintenance is critical to performance of HRLPS. Inspection and timely repair of any structural damage or vegetation deterioration that occurs is a necessity for HRLPS.

Routine maintenance will be focussed on the prevention of blinding of the soil and plant system, where biofilm builds up on the surfaces contacting the wastewater that can lead to eventual blockage of the media and loss of infiltration of wastewater leading to bypass flow. Weeding and plant management, as well as spelling of the discharge area are required to ensure the system is not blocked by weeds and weed roots, that desirable plants are not outcompeted by weeds and that harvest of vegetation occurs to maintain plant vigour and improve nutrient removal.

CONCLUSIONS

HRLPS provide a feasible solution for managing seasonal high wastewater flows associated with winter rainfall and groundwater level rises. While some improvements in wastewater quality are able to be achieved the main benefit of a HRLPS is to address cultural concerns around direct surface water discharge.

The selection of a HRLPS should be unique to the site on which it is to be located, with particular regard to slope, wastewater travel distance and soil type. It is likely that elements of a number of HRLPS can be combined to maximise the contact of the wastewater with the soil and plants. The ongoing performance of the HRLPS is dependent on diligent maintenance and this should be considered in the design.