Evaluation of Potential Land Treatment Sites

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Pain Farm Site

Prepared for

South Wairarapa District Council

Prepared by

Lowe Environmental Impact

April 2013

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-
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Quality Assurance Statement		
Task	Responsibility	Signature
Project Manager:	Katie Beecroft	
Prepared by:	Katie Beecroft	
Reviewed by:	Hamish Lowe	
Approved for Issue by:	Hamish Lowe	
Status:	Draft	

Prepared by:

Lowe Environmental Impact
P O Box 4467
Palmerston North 4462

| T | [+64] 6 359 3099
| E | office@lei.co.nz
| W| www.lei.co.nz

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1 EXECUTIVE SUMMARY

South Wairarapa District Council (SWDC) is currently investigating options for treatment plant upgrades for its Martinborough wastewater treatment plant (MWWTP) discharge. Options include the incorporation of land treatment for part or all of the discharge from the MWWTP.

A number of potential sites are being evaluated for their ability to assimilate applied wastewater. This report describes the result of an investigation into a council owned block of land known as Pain Farm. A desktop investigation for the site has previously been undertaken (LEI, 2012). The report noted drainage and depth to restrictive layer (likely high groundwater) as limitations for the Site. The presence of an adjacent closed landfill was identified as a management consideration for any irrigation to the site. Further site specific information for the Site was recommended to enable and assessment of irrigation capacity of the site. LEI has undertaken an assessment of the land's capacity at the Pain Farm site to assimilate a discharge from the MWWTP.

- Evidence of soil wetness and presence of fine grained material on the Pain Farm Site indicate there will be limitations to wastewater irrigation on the site. Irrigation can occur but should be limited by soil moisture content above the observed soil pan.

- Elevated groundwater will limit the number of days that irrigation can occur on the site. Further work based on the wastewater volumes to be discharged and climatic data is currently underway to determine actual days of irrigation to the site.

- The soil saturated hydraulic conductivity (K_{sat}) is 50 mm/hr. The unsaturated hydraulic conductivity ($K_{-40\ mm}$) is 4 mm/hr. In order to avoid excessive loss of water, nutrients and other contaminants to adjacent surface water a rate more closely related to the $K_{-40\ mm}$ is recommended. For long term discharge with a short irrigation return time a **rate of up to 9.6 mm/d is recommended for the Pain Farm Site**.

- Based on annual average nitrogen (N) concentration of 22.9 g/m^3 the N applied at the recommended hydraulic loading is equivalent to 2.2 kg N/ha/application event. Further work is required to determine the days of application (currently underway) which will be used to determine the yearly N loading, however assuming a maximum of 90 days of full irrigation the N loading would be in the order of 198 kg N/ha/y which is in-line with inputs (fertiliser, dairy effluent) used for the surrounding rural land. It is expected that if the proposed hydraulic loading rate is not exceeded then the equivalent N loading will be able to be demonstrated to have no more than minor adverse effects on groundwater or surface water in the vicinity of the site.

The site investigation has indicated that in general the Pain Farm Site's soils are able to be used for the discharge of wastewater with careful management. The site is capable of assimilating up to 9.6 mm/d of MWWTP wastewater from an application event. At this rate of application the applied water, nutrients and contaminants should be assimilated by the soil of the site.

The irrigable area of the site is considered to be 53 ha. For a daily maximum application event the site is able to receive and assimilate 5,040 m^3 of wastewater. This is approximately 9 times greater than the average daily flow for the Martinborough Township. It should be noted however, that the actual application depth on any day will be influenced by the depth to groundwater on the site and may be substantially less than the design irrigation rate (9.6 mm/d).

The number of days and actual rate of discharge is needed to determine the average, maximum (dry year) and minimum (wet year) volumes of wastewater to be applied to the site. Additional information is used to determine the annual volume specifically, daily wastewater flow records and daily climate data. This work is currently underway. If sufficient storage is available, and days suitable for discharge are high enough the site may be sufficient to receive a high proportion of MWWTP flows.

2 INTRODUCTION

2.1 Background

South Wairarapa District Council (SWDC) is currently investigating options for treatment plant upgrades for its Martinborough wastewater treatment plant (MWWTP) discharge. Options include the incorporation of land treatment for part or all of the discharge from the MWWTP.

A number of potential sites are being evaluated for their ability to assimilate applied wastewater. This report describes the result of an investigation into a council owned block of land known as Pain Farm. A desktop investigation for the site has previously been undertaken (LEI, 2012). The report noted drainage and depth to restrictive layer (likely high groundwater) as limitations for the Site. The presence of an adjacent closed landfill was identified as a management consideration for any irrigation to the site. Further site specific information for the Site was recommended to enable and assessment of irrigation capacity of the site. LEI has undertaken an assessment of the land's capacity at the Pain Farm site to assimilate a discharge from the MWWTP.

2.2 Scope

This report gives the results of a field investigation of the Pain Farm Site. Information given includes:

- A site description and location information;
- Details of the soil investigation methodology and results of the soil investigation;
- Soil hydraulic parameters measured for the site; and
- The capacity of the site to assimilate MWWTP wastewater during periods of irrigation.

3 SITE DESCRIPTION AND LOCATION

3.1 Site Description

The town of Martinborough is located in the Wairarapa approximately 40 km south of Masterton. A site near to Martinborough and specifically the WWTP has been considered for the establishment of a land treatment system. The Site known as Pains Farm has been investigated due to it being in SWDC ownership. Details of the site are given in Table 1.

Table 1: Location Details, Pain Farm Site

Legal description	Pt. Section 5/Wharekaka DIST
Property address	588 Lake Ferry Road
Map ref, centre of site:	-41.131393, 175.308397
Current owners	South Wairarapa District Council
Area (ha)	84.9839 ha
Distance to WWTP (km)	~2 km by pipe route

Figure 1 (Appendix A) shows the location of the Site. Pain Farm is leased for drystock farming and typically has seasonal fodder crops grown.

3.2 Waterways and Topography

The Site is located on the Martinborough Terrace, an up-faulted block which is dominated by fine grained alluvium. The landform is elevated above the present Ruamahanga River flood plain. The Site is gently rolling with a fall towards the north-west.

Along the north-western boundary a permanently flowing stream runs to the west towards the Ruamahanga River. A number of ephemeral water courses run across the Site towards the stream. A residence on the Site is surrounded by established trees and gardens which would result in some buffering from spray drift. The nearby lifestyle properties also tend to have established wind-breaks around the property boundaries.

An olive grove i.e. a food crop is also located across Lake Ferry Road from the Site.

The Site has an elevation of around 22-25 m above mean sea level.

3.3 Buildings in Locality

A residence is located in centre of the Site and is operated as a bed and breakfast type business. Buildings associated with the refuse transfer station adjacent to the closed landfill are located near to the Site boundary. Rural residential subdivision style properties are located across Lake Ferry Road from the Site with the closest dwellings around 50 m from the Site boundary.

3.4 District Plan

The Site is located within the Rural Zone and Rural (special) Zone.

3.5 Flooding Risk

The District Planning Maps do not indicate that the Site is at risk of flooding.

4 SOIL INSPECTION AND DESCRIPTION

4.1 General

A desktop assessment of the local receiving environment determined that the Site may be suitable for land treatment of wastewater. A field investigation was undertaken and site properties of interest were examined by:

- Site survey;
- Descriptions of 1.5 m cores; and
- Hydraulic conductivity measurement.

Descriptions and results of the investigation follow.

4.2 Site Survey

4.2.1 Purpose

An inspection of the Site was undertaken on the 14th February 2013 by LEI staff. Information gathered during the survey included:

- Current land uses;
- Identification of landforms in investigation areas;
- Land condition;
- Location and type of erosional features; and
- Assessment of similarities and disparities between testing sites.

4.2.2 Site Observations

At the time of the site visit the area had been subject to a long fine spell, with a drought declared one month later. It was considered that soils as observed were likely to be far drier than is typical.

At the time of the survey the Site was in a mix of ryegrass pasture and some fodder crops (chicory and brassicas). There were sheep on the Site, as well as <1 y old dairy heifer replacements.

The water level in the stream at the north-western boundary was within 60 cm of the land surface. On previous visits to the Site the water level has been observed within 20 cm of the land surface. It is anticipated that the stream is recharged from the shallow groundwater. This suggests that the water table is located at a shallow depth towards the stream, at least seasonally.

4.3 Soil Description

4.3.1 Purpose

Following the site survey a representative sample of soil cores were examined and described in the field. Soil core descriptions were undertaken to identify feature soil. The purpose of the descriptions was to obtain information to assess the lateral continuity of subsurface features and identify any impeding horizons in the soil. Changes in soil morphology due to variations in the landform and land use across the site can be inferred and used to identify areas of preference for discharge of wastewater.

4.3.2 Sampling Plan

Locations selected for soil sampling were chosen to represent the variability of the key landform of the Site, being the low floodplain adjacent to the stream and the crests, midslopes and hollows associated with the gently rolling terrain.

Soil cores were taken with a trailer mounted 1.5 m hydraulic soil corer. Short profile descriptions were logged in accordance with standard practice for New Zealand soils (Milne et al., 1995).

4.3.3 Results

Soil descriptions for the Site can be summarised as follows:

- Soil of the flats near the stream: Dark greyish brown (10YR 4/2) silt loam topsoil. Underlain by silt loam and clayey silt. Between 40 and 60 cm a pan was present. Below 80 cm the soil was strongly gleyed and from 85 cm the soil was gravelly.
- Soils of the gently rolling terrain: Were very similar to the above described soil. Lenses of sandy and gravelly material were present at depth with strong mottling throughout the profile and a pan varying from 35-50 cm below the soil surface.

Soil cores observed at the site correspond to Wharekaka mottled fine sandy loam (Mottled Argillic Pallic Soil, NZSC). Within 50 m of the stream saturated conditions were encountered at 0.85 m in the soil. Elsewhere on the site saturated conditions were not encountered within 1.3 m of the soil surface. There was however, extensive evidence of frequent or long duration wetness due to the presence of mottles and manganese nodules below 0.2 m.

4.4 Soil Descriptions: Summary and Implications for Land Treatment

Evidence of soil wetness and presence of fine grained material on the Pain Farm Site indicate there will be limitations to wastewater irrigation on the site. Irrigation can occur but should be limited by soil moisture content above the observed soil pan.

The present land use is not considered to be a limitation to irrigation on the Site, however buffers from residences are likely to be needed. Once buffer distances from permanent watercourses, buildings and property boundaries are taken into consideration the irrigable land area is considered to be around 53 ha.

Elevated groundwater will limit the number of days that irrigation can occur on the Site. Further work based on the wastewater volumes to be discharged and climatic data is currently underway to determine actual days of irrigation to the Site.

5 SOIL HYDRAULIC CONDUCTIVITY

5.1 General

Soil hydraulic conductivity (K) of the soil is a measure of the rate at which water is able to enter soil and move through the profile. K is dependent on several properties including, particle size, mineralogy, degree of packing and pressure head. Direct measurement of hydraulic conductivity can be undertaken by the use of field or laboratory testing methods.

5.2 Purpose

Locations for soil hydraulic conductivity measurement were chosen to represent a fair picture of the landform of the site and can be seen in Figure 2, Appendix A.

The measurement of K was undertaken to allow an assessment of the ability of the site to receive wastewater under varied application regimes being, rapid infiltration into coarse gravels, high rate application to surface soil for cropping and low rate application to surface soils for cropping.

5.3 Testing Methodology

Soil hydraulic conductivity measurements were performed on the 14th February 2013, by LEI staff.

Two testing methodologies were used as follows:

5.3.1 Soil Saturated Hydraulic Conductivity by Double Ring Infiltrometer

For determination of the soils ability to receive wastewater to the soil surface at a high rate K_{sat} was measured using a double ring infiltrometer which is a preferred method for establishing K_{sat} near the soil surface. The double ring method measures vertical flow only, eliminating possible overestimation of infiltration due to lateral flow in the soil.

The rings are seated level in the soil, to a depth of several centimetres, then filled with water; the outside ring first, then the internal ring. Timed recording then measures the rate of water level fall in the inner ring over time to determine K_{sat}.

5.3.2 Soil Unsaturated Hydraulic Conductivity by Plate Permeameter

For determination of the soils ability to receive wastewater to the soil surface at a low rate soil unsaturated hydraulic conductivity ($K_{-40\ mm}$) at the site was measured using a CSIRO plate permeameter apparatus (Perroux and White, 1988). The permeameter method enables measurement of soil near-saturated hydraulic conductivity. Near-saturated soil conditions are favoured over saturated soil conditions in consideration of low rate application sites because:

- Near-saturated conditions more closely reflect typical soil conditions; and
- Saturated hydraulic conductivity may cause overestimation of infiltration due to the initiation of bypass flow under saturated conditions.

The goal of near-saturated hydraulic conductivity tests for wastewater irrigation is to determine the rate at which the soil has the capacity to draw water into the soil matrix whereby the potential for ponding, runoff, excessive wetness and preferential flow (excessive flow through the macro-pores) is reduced. Typically it is desired in a land application system to avoid flow through the larger macro pores. The rate at which water can flow (be absorbed) into the soil avoiding macropores is often defined as the flow rate when the matrix potential is less than –40mm (i.e. $K_{-40\ mm}$) (Sparling et al, 2004).

The plate permeameter comprises a porous plate covered with a membrane. The plate is placed on a levelled soil surface which may have a thin layer of sand added to ensure a good contact between the plate and soil is achieved. Water is held under suction in water towers above the plate. A known suction is applied to the water. The ability of the soil to draw water from the plate reflects the rate at which the soils matrix potential can effectively and sustainably accept the applied water. The soil hydraulic conductivity is determined by a relationship between a measured drop in the water level in the water tower relative to the diameter of the plate.

Measurements of the drop in water level were taken at regular intervals and continued until the drop in water level reached a steady state for at least 3 readings. Replicate tests were performed for each site.

The plate permeameter apparatus results in three dimensional flow of water under the plate (i.e. vertical and horizontal flow is measured). In order to avoid overestimation of soil hydraulic conductivity the measured flow is converted to one dimensional flow (i.e. vertical flow only) using the Woodings (1968) equation. Data obtained from three levels of varying matrix potential (-100, -40 and -20 mm) are used to determine to $K_{-40\ mm}$ for vertical flow.

5.4 Results

A summary of the hydraulic conductivity results is given below. Further results are presented in Appendix C and the test locations are shown in Figure 1 of Appendix A.

5.4.1 Double Ring Infiltrometer Results

The K_{sat} at the surface of the Site was measured in duplicate. The average result for the site was 50 ± 15 mm/hr. This value corresponds to moderate permeability topsoil which reflects frequent cultivation of the topsoil.

Less variability was seen on the Pain Farm site than other sites investigated. This is due to having lower overall permeability and due to frequent cultivation which homogenises the soil somewhat. It is expected that the permeability of the soil at depth will reduce, however for design of a deficit or near deficit irrigation regime the topsoil is the soil volume of interest.

5.4.2 Plate Permeameter Results

The plate permeameter tests were conducted in triplicate. A plot of the $K_{-40\ mm}$ results for the Pain Farm Site are given below in Figure 5.1. The plot shows the soil hydraulic conductivity at three matrix potentials as mentioned in Section 5.3.2 above.

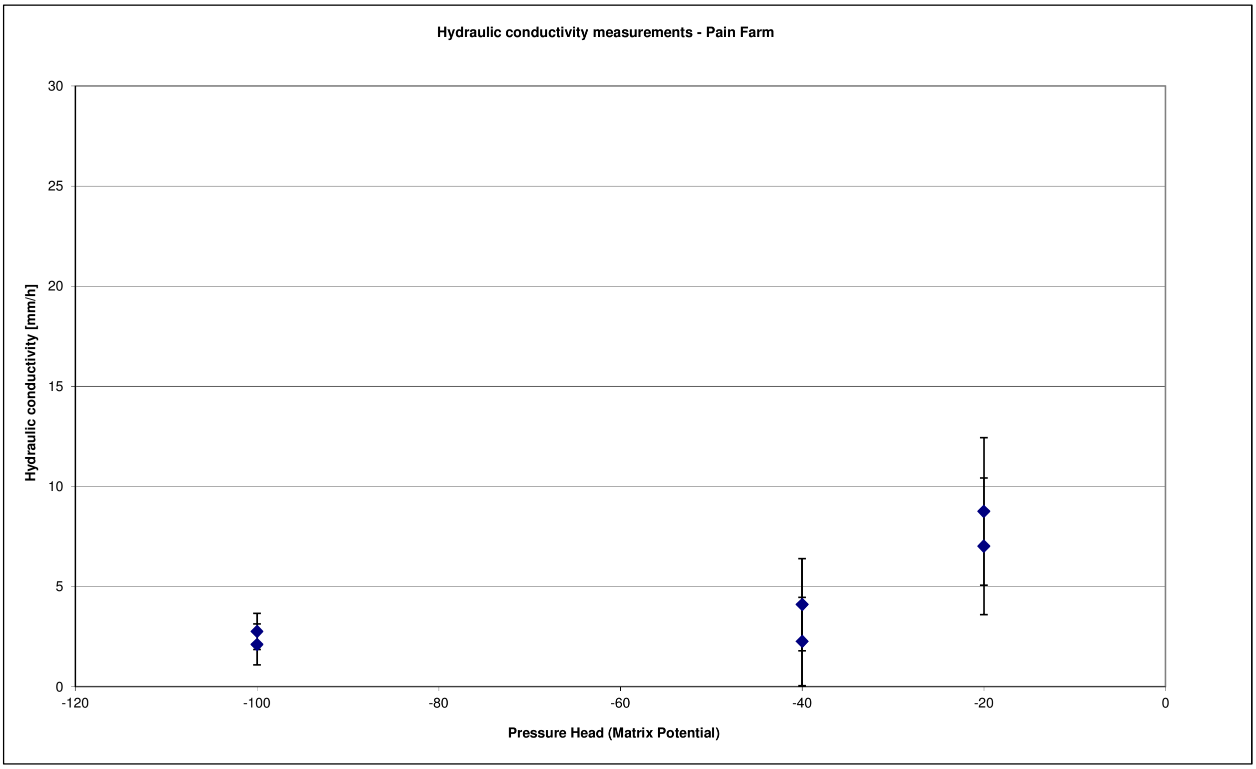

Figure 5.1: Unsaturated Hydraulic Conductivity – Pain Farm Site

Based on the on-site observations, specifically the sub-soil, it is considered that the $K_{-40\ mm}$ value that should be adopted for the site is 4 mm/hr. Any irrigation applied to the site should be at a rate not exceeding 4 mm/hr.

5.5 Determination of Sustainable Hydraulic Loading Rate

In addition to allowing for the ability of water to enter the soil, consideration should be given to the effect of wastewater constituents, as opposed to clean water effects which are typically observed during field measurements. Organic material, solids and nutrients in the wastewater can allow the development of microbial growth commonly referred to as biofilm, which in turn can result in a 'clogging' effect of the soil pores, particularly near the soil surface. This in turn reduces the soil's infiltration capacity. In addition, the salt concentration will influence the soil wetting by altering the water tension.

There are limited empirical methods for developing an 'enriched' water rate from 'clean' water observations. This is because the rate is variable depending on the type of wastewater, nutrient and organic content, soil type, application method and application regime. A range in the order of 4 to 10 % is often used for 'clean' water to wastewater conversion (USEPA, 2006). The conversion rate implied in AS/NZS 1547:2000 ranges from 0.17 to 5 %. Both references mentioned above refer to a conversion between saturated hydraulic conductivity (not unsaturated conductivity) and wastewater application rates.

The need for 'clean' water to wastewater conversion is noted by Crites and Tchobanoglous (1998) who report an empirical method to determine a wastewater rate from a clean water measurement. The measured instantaneous rates can be translated into a daily hydraulic design irrigation rate using the following equation, which is modified from Crites and Tchobanoglous (1998):

$$P\ (daily) = K_{-40\ mm}\ (0.1\text{-}0.3)\ (24\ h/d)$$

Where:
P = the design irrigation rate
Is a function of 10-30% of the $K_{-40\ mm}$
Over 24 hours in the day.

The use of this equation and a conservative 10% function of the unsaturated (not saturated) infiltration rate at $K_{-40\ mm}$ provide a maximum hydraulic design irrigation rate of 9.6 mm/d. At this rate the site is likely to be able to accept water without the generation of adverse effects on the immediate receiving environment and the soils itself. This is considered the maximum rate that can be accepted by the site however, consideration needs to be given to the resulting nutrient loading and the sites attenuation ability, which may result in a reduction of the actual rate.

5.6 Soil Hydraulic Properties: Implications for Land Treatment

The soil saturated hydraulic conductivity (K_{sat}) is 50 mm/hr. The unsaturated hydraulic conductivity ($K_{-40\ mm}$) is 4 mm/hr. In order to avoid excessive loss of water, nutrients and other contaminants to adjacent surface water a rate more closely related to the $K_{-40\ mm}$ is recommended. For long term discharge with a short irrigation return time a rate of up to 9.6 mm/d is recommended for the Pain Farm Site.

5.6.1 Potential Nitrogen Loading

Details of the wastewater discharge quality are given in the Assessment of Environmental Effects prepared for the Martinborough WWTP by SWDC in 2012. Based on annual average nitrogen (N) concentration of 22.9 g/m^3 the N applied at the recommended hydraulic loading is equivalent to 2.2 kg N/ha/application event. Further work is required to determine the days of application (currently underway) which will be used to determine the yearly N loading, however assuming a maximum of 90 days of full irrigation the N loading would be in the order of 198 kg N/ha/y which is in-line with inputs (fertiliser, dairy effluent) used for the surrounding rural land. It is expected that if the proposed hydraulic loading rate is not exceeded then the equivalent N loading will be able to be demonstrated to have no more than minor adverse effects on groundwater or surface water in the vicinity of the site.

6 SITE ASSIMILATIVE CAPACITY AND CONCLUSIONS

The site investigation has indicated that in general the Pain Farm soils are able to be used for the discharge of wastewater with careful management. The site is capable of assimilating up to 9.6 mm/d of MWWTP wastewater from an application event. At this rate of application the applied water, nutrients and contaminants should be assimilated by the soil of the site.

The irrigable area of the site is considered to be 53 ha. For a daily maximum application event the site is able to receive and assimilate 5,040 m^3 of wastewater. This is approximately 9 times greater than the average daily flow for the Martinborough Township. It should be noted however, that the actual application depth on any day will be influenced by the depth to groundwater on the site and may be substantially less than the design irrigation rate (9.6 mm/d).

The number of days and actual rate of discharge is needed to determine the average, maximum (dry year) and minimum (wet year) volumes of wastewater to be applied to the site. Additional information is used to determine the annual volume specifically, daily wastewater flow records and daily climate data. This work is currently underway. If sufficient storage is available, and days suitable for discharge are high enough the site may be sufficient to receive a high proportion of MWWTP flows.

7 APPENDICES

Appendix A Figures
Appendix B Photos
Appendix C Results

APPENDIX A

Figures

APPENDIX B

Photographs