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Featherston Wastewater Treatment Plant Resource Consent Applications - Response to Request for Further Information (s92)

2 June 2017

Dear Nicola,

Thank you for providing the Section 92 request for further information dated 19 April 2017 on the resource consent applications for the proposed Featherston Wastewater Treatment Plant (WWTP) discharges to land, water and air submitted on 1 March 2017. This letter and appendices has been prepared on behalf of South Wairarapa District Council (SWDC) and provides a response to that request.

1 Groundwater Mounding

WRC Question:

Have you prepared any groundwater mounding assessments for the site? It is our experts opinion that this is important to carry out given there are gleyed soils (which indicate potential for water logging) at both Site A and Site B.

Response:

GWS Ltd has undertaken an assessment of potential mounding effects using modelling to predict the change in water levels due to the proposed land discharge regime. A full description can be found in Appendix 1 to this letter. In summary:

- During summer the unsaturated thickness is between 1.4 to 3.1 m;
- During winter the unsaturated zone thickness reduces to 0.9 to 1.5 m;
- The results of the modelling indicate that groundwater levels will rise between 1 to 1.35 m as a result of drainage from irrigation and rainfall.
- The greatest mounding is likely to occur in the southernmost irrigation area and the least is to occur in the northern irrigation area.
- During summer this amount of mounding is unlikely to result in surface breakout, however, in winter surface breakout is likely to occur within localised topographic depressions. This is a natural phenomenon observed to take place in certain areas of the site currently during winter conditions.

During winter, infrequent land applications of treated wastewater (not every year) at only very low application rates have been proposed (up to 2% of the 55mm/d recommended irrigation rate – LEI *pers comm* 31 May 2017). Given the expectation that some discharge from the irrigation fields could take place locally during winter, a high level of management has been incorporated into the discharge regime to address and mitigate any potential effects from breakout. These management measures have included; limiting the rate of treated wastewater applied during these months, the ability to avoid areas with visible ponding and

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provision of suitable buffer distances for irrigation from locations where breakout is expected, the application of best land management practices, and a proposed suite of comprehensive surface and groundwater monitoring conditions. These measures have been incorporated into the proposed conditions of consent (refer to Part 1C of the main AEE).

It is envisaged that by implementing the proposed management measures described, will ensure that any potential risk associated with groundwater mounding effects from the land application of wastewater can either be resolved or managed such that the associated effects to the environment are no more than minor.

2 Overseer Modelling

WRC Question:

Have you undertaken any Overseer modelling for nutrient application and leaching? Our experts consider this is important work to be carried out for the different scenarios mentioned in the application such as stocking rates/types of stock, cut and carry, cropping (including applying nutrients against good practice) given there is additional fertiliser to be added in addition to the wastewater nutrients and the soils are free draining. We would note that Overseer assumes best practice on application of nutrients and there are some concerns that deferred irrigation is not best practice so we would also like to know how this has been taken into account in the modelling.

Response:

LEI have undertaken further modelling using Overseer to predict annual nitrogen leaching rates. A full description of the inputs and results of this Overseer modelling is presented in Appendix 2 of this letter. In summary, the modelling predicts that the proposed irrigation regime is expected to result in lower leaching rates of TN than the existing situation (dairy operation) whether it is managed as a grazed system or cut and carry operation. The modelled nitrogen leaching values for the three scenarios modelled are:

1. Baseline: 63 kg N/ha/y;
2. Grazed and irrigated with wastewater: 43 kg N/ha/y; and
3. Cut and carry and irrigated with wastewater: 21 kg N/ha/y.

Scenarios 2 and 3 are considered to best represent the likely future management of the site.

3 Soil Sampling

Question:

In the section of the AEE where soils are discussed there is reference to site investigations and soil mapping undertaken for Sites A and B by LEI. Can you please provide us with these soil maps and also indicate what scale was the mapping done at? Also what sampling scale of core samples and observations were used and clarify any laboratory test or observations that were conducted at the time to help confirm mapping and the soil classification.

Response:

Site investigation reports are presented in:

- Appendix 3 – LEI, *Evaluation of Potential Land Treatment Sites - Featherston Wastewater Treatment Plant* Site, April 2013 – **Site A**; and
- Appendix 4 – LEI, *Site Investigation – Hodder Farm, Featherston Wastewater Treatment Plant*, November 2015 – **Site B**.

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Contained within these reports is detailed descriptions of the investigations undertaken. A soil distribution map is provided as Figure 5.1 of the Site B investigation report based on a site walk-over including profiles and holes.

LEI have in addition provided a summary table of the parameters relied upon in determining the irrigation regime and whether the parameters were adopted from site observation, field or laboratory measurement, or literature values. This summary, is presented in Table 7 of Appendix 2 to this letter.

Finally, Appendix 5 to this letter, provides a 1:10,000 S-Map soil map. This system is progressively replacing the older 1:50,000 soil maps. The S-Map was not available at the time of the Site Investigation and a correlation between old naming and new is given in Table 7 of the memo.

We believe the above and associated appendices addresses the matters raised in the above question.

4 Assumption regarding Inflow and Infiltration

4.1 Question:

Storage balancing modelling is discussed in the AEE, however, our experts have indicated it is hard to understand the level of detail that was undertaken from the description in the AEE. The modelling is based on the assumption that I and I will be reduced by 35% and this is a very important and significant assumption to make. Our expert believes they would expect to see some sensitivity analysis around this and consideration of some other scenarios and the effect on flow balancing and discharge to Donald's Creek in the event that the flows cannot be reduced by 35%. There seems to be no Plan/Strategy in place if flows were to work out higher than modelled in the future.

4.2 Response:

4.2.1 Introduction

It is agreed that there will be some uncertainty regarding the effectiveness of the inflow and infiltration reduction (I/I) program and that the 35% reduction in I/I is a key assumption. However, it is Mott MacDonald's opinion that the current application includes sufficient commitments and contingency including; the review of the effectiveness of the network rehabilitation works, adaptive management measures, numerical discharge limits, and monitoring of the receiving environment, that additional modelling of scenarios is not required. These commitments are discussed below.

4.2.2 Proposed I/I works

The focus of the I/I works program is on areas that were identified as having very high I/I during the night-time survey. The proposed part of the network for I/I works represented approximately 85% of the I/I but only 23% of the network length (see Appendix 4A Section 3, of the Main AEE).

The predicted I/I reduction achievable through network rehabilitation was estimated from the understanding of the networks current GWI contributions and application of an industry standard reference. Values were based on standard levels of rehabilitation, whilst bearing in mind the large variation in effectiveness seen in case studies as follows:

a. 50-60% reduction in GWI if public manholes and public pipes were rehabilitated
b. 65-75% reduction GWI if private laterals were also rehabilitated

The cost benefit of I/I reduction to the total capital cost of WWTP upgrade options was assessed and the optimal ADF reduction was found to be in the order of 35% for a land application scheme. The reduction could be achieved by various extents and levels of rehabilitation i.e. high levels of rehabilitation in fewer catchments or lower levels of rehabilitation in more catchments. The I/I reduction was based on taking the average of the projected high and low effectiveness scenarios (55% reduction for public mains and manholes and 70% if laterals were also included). It is acknowledged that actual reductions could be more or less based on how effective the rehabilitation work is.

In order to manage the risk relating to the uncertainty around I/I reduction a number of consent conditions and commitments have been proposed in the AEE, these are presented in Part 2 Section 4.1.5 and Part 1C of the Main AEE respectively, and briefly discussed below.

4.2.2 Proposed I/I Reduction Management Plan

SWDC have committed to developing an IIRMP within the first year of consent being granted as per the proposed conditions of consent presented in Part 1C of the Main AEE. The IIRMP will provide a roadmap for confirming the extent the extent of I/I in the sewer network, the investigations to be undertaken to confirm the most efficient, cost effective and non-disruptive methods for rehabilitation, a detailed works programme and monitoring and reporting of I/I reduction.

4.2.3 Review and adaptive management

The proposed review and adaptive management measures, as presented in Section 4.1.5 of the AEE, include:

- A review of the efficacy of Stage 1 land treatment (within 3 years of its implementation) in order to determine whether or not the commencement of Stages 2A and 2B should be advanced; and
- A review of the efficacy of the Stage 2B land treatment (within 3 years of its implementation) in terms of avoiding, remedying or mitigating adverse effects of the discharges to the environment.

With the following actions:

- If the Stage 1 Review confirms the effects on the environment, and in particular water quality and ecological effects remain significant then implementation of Stage 2A will be brought forward from 10 years to 7 years and Stage 2B from 20 years to 15 years from commencement of the consent.
- If the Stage 1 Review confirms the targeted reduction in ADF due to I&I rehabilitation works will not be achieved (based on works undertaken to date) and the risks of constructing the deferred storage are unattainable or other unforeseen design and management difficulties are identified that are unresolvable, then the Review Report will confirm one of the following (or any other suitable alternative identified at the time) as the substitute long-term solution supported by the necessary evidence:
  - A combined land and water discharge with contingency discharge flows directed to the Tauherenikau River;
  - A land discharge with excess flows directed to Rapid Infiltration;
  - Re-reticulation of the network with land treatment; or
  - Combination summer land application and high rate treatment for discharges to Donald Creek.

Where an alternative approach is required, a programme will be included in the Stage 1 Review Report, variation to consents will be obtained, and full commissioning of that solution would be undertaken within 15 years of the commencement of this consent. This process will ensure that the best practicable option will be commissioned within the proposed timeframes, but provides the ability for evidence based adaptive management.

4.2.4 Other Proposed Consent Conditions

In addition to the IIRMP and adaptive management measures, other proposed consent conditions (Part 1C of the AEE) have been developed to monitor the actual effects on the receiving environment (presented in Schedule 2 of the proposed consent conditions), including:

- A reduction in the consented average and 90th percentile discharge after the I/I works are completed (after Stage 2A);
- Limits on the volume and quality of wastewater discharged to land;
- Limits on the discharge quality for BOD_5, TSS, NH4-N, TN and DRP;
- Targets and triggers for instream water quality and ecological values;
- Annual reporting requirements.

Should any of the monitoring conditions not met the proposed consent conditions an investigation into the actual effects of the discharge on the receiving environment is required.

4.2.5 Sensitivity Analysis

To support the options evaluation undertaken, LEI have assessed and concluded that the land available has the potential to receive 100% of the current annual wastewater flow from the FWWTP, however this would require a substantial storage volume to enable 100% of the flows to be discharged sustainably to land (~422,000 m^3 storage pond). Therefore, it is in SWDC's best interest to reduce the I/I in the network through targeted network rehabilitation works to ensure manageable storage volumes are achieved and reduce land area requirements and overall scheme costs.

4.2.6 Summary

There will be some uncertainty regarding the reduction of I/I that will be achieved. However, the I/I works target areas with significantly degraded network infrastructure and it is Mott MacDonald's opinion that a good level of remediation will be achieved. In addition the AEE includes review of the scheme after completion of Stage 1 and Stage 2 and adaptive management measures should the efficacy of the Scheme, including review of the I/I works, be demonstrated to not meet the predicted reduction in flows and effects on the environment. Therefore, it is Mott MacDonald's opinion that there is sufficient contingency built into the management measures that further modelling of the effects based on different I/I reduction scenarios is not required.

5 Water quality assessment against PNRP and RFP

5.2 Questions:

Appendix 13b of the Assessment of Environmental Effects (AEE) provides a useful analysis of the relevant water quality and ecological standards in the Regional Freshwater Plan and the Proposed Natural Resources Plan. It would be useful to expand on this table and provide a clear assessment against these standards for each stage. For example -

1. *assessment of existing ecological data against the 20% QMCI change (PNRP Policy P71). Is this standard currently met downstream of the zone of reasonable mixing? Will it be met under the various phases of the proposal (accepting this will have to be based on expert opinion)? As it is, the ecological assessment report (Appendix 11b) makes reference to significant changes etc, but no specific reference to this standard. Given this standard is in the PNRP, we feel an assessment should be provided and it would be useful to compare all existing data (Coffey, Forbes and River Lakes) to the standard;*
2. *an assessment of existing water clarity data against the 33% change standard, and an assessment of whether the discharge is likely to comply in the future;*
3. *an assessment against the PNRP DO standards, and also comment on how future compliance with this standard will be assessed; and*

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4. *a summary table of existing and future/expected compliance with the various standards listed in Appendix 13B.*

5.3 Responses

5.2.0 Background

A table summarising compliance with the PNRP and Freshwater Plan is provided in Appendix 6. It should be noted that Donald and Abbott Creeks are not listed as being managed for recreation and fisheries, only guideline A8.1 in the Freshwater Plan is applicable.

The discharge represents a small volume of water and low percentage of contaminant loads, compared to other inflows, into Lake Wairarapa. As a result, the assessment of effects on Lake Wairarapa determined that the current and future effects of the discharge on Lake Wairarapa are/will be less than minor (refer to Section 6.4.6 of the AEE) and the discharge will be compliant with all conditions of the PNRP and Freshwater Plan for Lake Wairarapa, therefore a summary table for Lake Wairarapa has not been provided.

The current and future discharge regimes have been modelled by LEI and is presented in Section 6.4.4.3 of the main AEE, and summarised below:

- Existing: Currently the WWTP discharges to Donald Creek 97% of the time in summer and 100% of the time in winter;
- Stage 1: Reduction to 56% of the current discharge volume. Frequency of the discharge will reduce to 12% of the time in summer and 89% of the time in winter; and
- Stage 2B: Reduction to 6% of the current discharge volume. Frequency of the discharge reduced such that there is no discharge in summer and a frequency of 7% of the time in winter, and may not discharge at all in some years.

5.2.1. Assessment against PNRP QMCI guideline

A detailed review of the QMCI scores for current and future compliance is provided in Appendix 7 of this letter. In summary:

- The difference between upstream and downstream QMCI scores in Donald Creek during some summer surveys is greater than 20%. However, the difference between upstream and downstream sites was less than 20% during spring sampling.
- The downstream QMCI scores in Abbott Creek was greater than 20% higher than upstream in October 2016. However, the downstream QMCI score was 3% lower than the upstream site in November 2016.
- The difference in QMCI scores between the upstream sites in Donald Creek (100 m upstream and 50m upstream) was greater than 20% in 2013 indicating that natural variation can result in differences between sites of greater than 20% and QMCI scores cannot be used in isolation as a single metric to assess ecological condition.
- The professional opinion of Keith Hamill (Aquatic Ecologist) is that after Stage 1B the discharge will not result in a greater than 20% in QMCI scores, however, greater than 20% change may be measured due to natural variation.

5.2.2. Assessment of Visual Clarity in Donald and Abbott Creeks against the PNRP and Freshwater Plan

Discharge quality

Currently the discharge is at times impacting on downstream clarity in Donald Creek and this may be impacting on clarity in Abbott Creek. The primary screening and residence time in the ponds at the WWTP will continue to result in some removal of particulates from the wastewater prior to discharge. However, it is likely that at all

Stages, as with the current situation, the discharge will still contain some particulate matter when discharging to Donald Creek. It is thought, but not confirmed, that the majority of the particulate matter discharged will be algae. It is known that algae adsorb light weakly but scatter it strongly and it is likely that algae is largely responsible for reduction in clarity downstream of the discharge. The proposed WWTP upgrades does not include a final polishing step to remove particulates, including algae prior to any discharge to Donald Creek. If such a system was required the cost to the SWDC and rate payers would be an additional $6 million approximately (based on high level costing evaluation prepared by Mott Macdonald).

The PNRP and FWP

Policy P71 of the PNRP states:

The adverse effects of point source discharges to rivers shall be minimised by the use of measures that result in the discharge meeting the following water quality standards in the receiving water after the zone of reasonable mixing:

(a) below the discharge point compared to above the discharge point:

- *20% in River class 1, or*
- *33% in River classes 2 to 6,*

Donald Creek and Abbott Creek would be considered River Class 5 and 4 respectively and therefore the policy P71 requires compliance with the less than 33% change in clarity guideline.

The Wellington RFP states:

A8.1 After reasonable mixing, the contaminant, either by itself or in combination with other contaminants, is not likely to cause any of the following effects:

5. Any conspicuous change in the colour or visual clarity.

Origin of Guidelines

The MfE (1994) "Resource Management Water Quality Guidelines No. 2" document describes the process by which the guidelines for visual clarity were developed. The guideline relating to change in clarity was based on aesthetic values. The MfE (1994) determined that the point at which the majority of people will detect visual change in clarity for a Class A water body (a pristine water body) is a 10 to 15% change, and that a conspicuous change would be at some point above the detectable change.

Based on this, for a class A water body, the MfE (1994) recommend a guideline of <20% change in visual clarity. For other water bodies, it was determined that public acceptance of clarity decreased with an increase in turbidity of between 50% and 100%, which equates to approximately 33% to 50% change in clarity. It was therefore recommended that the guideline for non-pristine water bodies was for <33% to 50% change in clarity. The PNRP rule appears to be taken from this assessment. In addition, a 33% change would also represent a conspicuous change under the Freshwater Plan.

As no data or studies exist relating to the ecological impacts due to change in clarity it was then assumed, by the MfE (1994), that the protection of aesthetics (<33% change) would in turn protect aquatic ecology. However, short periods of time with low visual clarity naturally occur in water ways, particularly during storm events, and ecological receptors are not likely to be sensitive to short term declines in clarity.

It should also be noted that Donald Creek is not known to support extensive recreational activities and these activities are more likely to occur in summer months and unlikely to occur during storm events.

Difficulty with clarity prediction

It is theoretically possible to model visual clarity by converting visual clarity measurements to a conservative parameter known as the beam attenuation coefficient. Typically, the equation from Davies-Colley (1988) has been used. However, this equation was developed from measurements in 10 streams across New Zealand and may not be representative of the relationship for systems dominated by Algae.

In addition, there are currently no measurements of clarity for the discharge. Potentially a relationship between turbidity and clarity or suspended solids and clarity could be determined for the downstream site, and this used to predict the clarity of the discharge based on suspended solids or turbidity measurements in the discharge. However, as with the above the relationship between turbidity/suspended solids and clarity for the discharge may not be the same as for the downstream site, and predicting the clarity of the discharge based on suspended solids or turbidity measurements would introduce further uncertainty into the assessment.

Given that there are only a small number of data points for upstream and downstream clarity (19 measurements), no measurements for the discharge and that the optical properties of the discharge may differ from the optical properties of the upstream and downstream site, it is Mott MacDonald's opinion, that modelling of water clarity, without further data collection, may not provide a robust assessment. Therefore, a more qualitative approach to the issue of clarity has been provided below.

Ecological Assessment

The ecological assessment (Sections 6.4.4.15 and 6.4.4.16 of the Main AEE) determined that the current discharge is significantly impacting on ecological values during summer months, but only has a minor to moderate effect during winter.

Current and future effects of the discharge on visual clarity

Existing situation

Based on 17 sampling events undertaken by SWDC between 2012 and 2016, the reduction in clarity was greater than 33%, as measured by a black disc, 74% of the time (see Section 6.4.4.9 of the main AEE).

Stage 1

Following Stage 1 upgrades the majority of the discharge volume will occur during winter (~95%) with infrequent discharges during summer months (~12% of the time). It is possible that following Stage 1 the discharge will result in a reduction in downstream clarity of greater than 33%. However, this would be infrequent during summer, when recreational activities may be occurring, and when there is potential for ecological effects to occur.

During winter, the Creeks are unlikely to be used for recreation and protection of aesthetic values is not considered a priority. In addition, given that the effects on ecology during winter is currently minor, it is considered unlikely that changes in clarity due to the discharge will result in significant effects on ecology during winter months when the upstream clarity is likely to be reduced due to runoff.

Stage 2B

Following Stage 2B upgrades the discharge to Donald Creek volume will be significantly reduced to approximately 6% of the current situation. In some years there will be no discharge and in those years when discharge occurs it will only occur infrequently in winter, approximately 7% of the time, after high rainfall events. It is likely that during this time the upstream clarity is already degraded due to runoff.

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However, following Stage 2B, it is possible the visual clarity downstream of the discharge could be reduced by more than 33% when the discharge is occurring after storm events if the upstream clarity improves faster than the discharge clarity. As this would occur infrequently and for short periods of time in winter, the effect on aesthetic values (as there are unlikely to be recreational activities during winter) and ecological values (as ecological receptors are unlikely to be sensitive to short term changes in clarity) would be considered less than minor.

Summary

The proposed WWTP upgrade would result in a significant reduction in the volume of water discharged to Donald Creek and Abbott Creek over time. This will in turn significantly improve the water quality in the Creeks. As no additional active removal process for suspended sediment is currently proposed prior to discharge it is possible that the discharge will still result in a reduction in clarity of over 33%. However, the Creeks are not extensively used for recreation and short term reductions in clarity occur naturally in river systems and this short-term change is unlikely to negatively impact on aquatic ecology. In addition, at Stage 2B there will be a very low frequency of discharge to Donald Creek during winter and in some years, there will be no discharge. Therefore, although there may be some effect on downstream clarity due to the discharge at Stage 2B these effects are expected to be less than minor with respect to recreational values and aquatic ecology and the significant additional cost required to further reduce the impact on clarity is not considered necessary.

5.2.3 Dissolved Oxygen

An assessment of the current and future discharge on the dissolved oxygen (DO) concentration of Donald Creek is presented in Section 6.4.4.14 of the main AEE and summarised here, with respect to the PNRP.

Policy P71 of the PNRP states:

The adverse effects of point source discharges to rivers shall be minimised by the use of measures that result in the discharge meeting the following water quality standards in the receiving water after the zone of reasonable mixing:

(b) a 7-day mean minimum dissolved oxygen concentration of no lower than 5mg/L, and

(c) a daily minimum dissolved oxygen concentration of no lower than 4mg/L.

Effects of Discharge on the DO concentration in Donald and Abbott Creeks

The DO of the discharge was measured routinely downstream in the discharge from 2006 to 2016. During that time there was only one downstream measurement below 5 mg/L, the most stringent guideline from the PNRP, and this measurement was 4.7 mg/L (see Figure 1).

The discharge quality with respect to DO and BOD (which can result in DO depression downstream due to microbial respiration) is unlikely to change significantly due to the Staged development. However, as the development progresses there will be significant reductions in discharge volumes and frequency (as described above in Section 5.2.0) reducing the potential effects on Donald and Abbott Creek.

Therefore, given the current discharge is not significant impacting on the DO concentration downstream of the discharge, and the discharge frequency and volume will decrease with the development it is considered likely that the discharge will be fully compliant with the PNRP Policy P71 for DO.

However, it should be noted that all DO monitoring data was collected during daylight hours and any depression in DO during the night-time is currently unknown, but not considered to be an issue for the development due to the significant reduction in discharge that will occur.

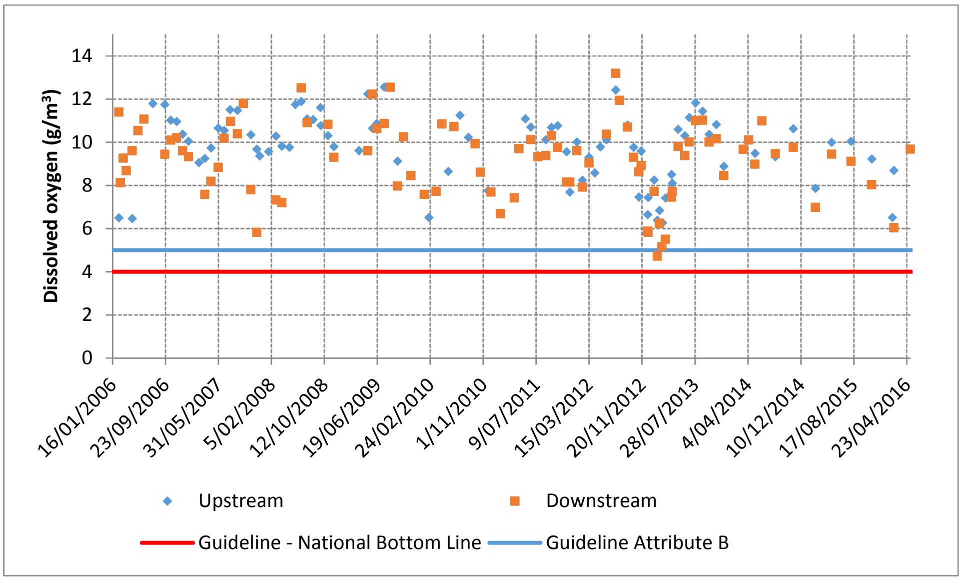

Figure 1: Dissolved oxygen concentration

4.3 Conclusion

The Section 92 request has been addressed in the above discussion and appendices attached to this letter. Should you have further queries do not hesitate to contact the undersigned.

Yours Sincerely,

Craig Campbell
Senior Environmental Consultant

Sarah Sunich
Senior Environmental Consultant

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A1: GWS Groundwater Mounding Assessment

1st June 2017

South Wairarapa District Council

PO Box 6
Martinborough 5741
New Zealand

Attention: Bill Sloan

Subject: Assessment of Groundwater Mounding Effects Related to Proposed Land Discharge Area for the South Featherston WWTP

Dear Bill,

1. Background

We understand that an application for a land discharge consent associated with the operation of the Featherston WWTP was lodged with the GWRC and that this is currently being processed. A S92 request for further information has since been issued, and it has been asked that a groundwater mounding assessment be undertaken. The following letter report summarises the results of the groundwater mounding assessment.

2. Description of Environment

The general environmental setting is described by LEI (February, 2017). The following provides a summary of the key assumptions adopted from this work and, where available, presents additional or new information related to the hydrogeologic setting.

2.1 Site Topography

A detailed site elevation model was not available at the time of preparing this report. However, some elevation information is available in the GWRC GIS database, allowing profiling of the site to be undertaken. Figures 1 of the attachments show the general elevations in the area and section locations. Across the discharge area there is reasonable topographic relief with elevations ranging from a low of 14 m RL in the south to a peak height of 27.5 m RL in the north. Across all areas depressions exist resulting in up to 3 m change in relief across the area along east west sections. These depressions are natural surface water pathways and table drains have been constructed locally to allow drainage to the south into the Longwood Water Race system. Figure 2 shows the topographic profiles across the land area.

The site relief is of importance in this assessment as it ultimately determines the depth of unsaturated zone present above the water table and, therefore, the degree of mounding that can be allowed before surface breakout occurs.

2.2 Hydrogeology

The hydrogeology of the general area is described by LEI. There is limited data available in relation to the groundwater system in the site area and much has been assumed from previous work. The range of groundwater levels measured from three piezometers monitored by Professional Groundwater and Environmental Services (2016) are included in Table 1 and their location is shown on Figure 3 along with an interpretation of the piezometric surface.

Table 1 Groundwater Monitoring Data

		Groundwater Levels			
Location	**Ground Level**	**Summer[1]**	**Winter[2]**	**Summer**	**Winter**
	(m RL)	Depth (m BGL)		Elevation (m RL)	
P1	18.60	2.60	1.34	16.00	17.26
P2	15.50	3.10	1.48	12.40	14.02
P3	14.00	1.38	0.88	12.62	13.12
1 - Measured by PGES April 2016					
2 - Measured by LEI November 2015					

No winter groundwater levels were measured in the PGES report for the piezometers identified in their report. However some information on winter groundwater levels was obtained through monitoring of other piezometers located near the WWTP as identified in the LEI report. In the absence of having seasonal monitoring data, the winter levels measured by LEI have been adopted as being indicative of the seasonal range expected. Generally, there is likely to be in the order of 0.5 to 1.5 m seasonal variation in groundwater levels across the area.

Based on the interpreted groundwater level elevations and the land surface profile, the depth of unsaturated zone present on the ridges is > 3m and < 1.0 m in the depressions. Generally speaking, there is a reduction in unsaturated zone thickness to the south where the topographic relief flattens and the water table and the land surface come closer to converging. Aerial photographs support the southern area being low lying that may discharge groundwater locally at times of the year as evident by the table drain network that exists. For the purposes of this assessment a critical unsaturated zone depth of 1.4 m has been adopted as the tolerable limit of mounding before surface breakout of groundwater is expected. This limit is based on avoiding surface breakout of water during summer conditions as noted at P3.

The aquifer parameters used in this assessment have been derived from previous work (LEI 2017, and PGES, 2016). The key inputs are as follows:

Aquifer Thickness = 40 m
Vertical Hydraulic Conductivity (Kv) = 4 m/d
Horizontal Hydraulic Conductivity (Kh) = 12 m/d
Conductivity Ratio (Kv/Kh) = 0.3
Specific Yield (Sy) = 0.2
Hydraulic Gradient (i) = 0.003 - 0.005

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These aquifer properties have been applied globally to the analytical and numerical models that have been used to calculate the groundwater mounding effects.

2.3 Scheme Properties

The layout of the areas to be irrigated is included as Figure 4 and the drainage rates were provided by LEI and are presented in Table 2. The drainage rates represent total depth of drainage from below the root zone from both irrigation and rainfall and are based on daily records of rainfall and evapo-transpiration, as well as daily irrigation. These data come from a model which discharges the entire annual volume of treated wastewater to land and so is a conservative estimate of the drainage during late winter/spring seasons.

Table 2 Average Monthly Drainage Depth Below the Root Zone (mm)

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Monthly	19	18	26	67	90	130	159	109	59	83	24	22
Daily	0.61	0.64	0.84	2.23	2.90	4.33	5.13	3.52	1.97	2.68	0.80	0.71

These values have been used as input parameters to the analytical and numerical models that have been used to calculate the groundwater mounding effects. It is of note that the higher drainage rates noted from May to August are largely a result of higher rainfall recharge during this period and are not a function of irrigation as only very low application rates will be applied during winter months.

3. Assessment of Effects

3.1 Methodology

Assessing the effects to groundwater has involved the use of a number of analytical methods. Initial analytical calculations were undertaken using Hantusch (1967), which was then followed by the development of numerical groundwater models in both SEEP/W and MODFLOW software packages. Steady state flow conditions were calibrated to the interpreted piezometric surface. This provided the initial conditions for the transient model runs that simulated daily irrigation. Further details on analytical and numerical model inputs are provided in the technical addendum to this report. All of the calculated model results are expected to be conservative as true unsaturated flow is not represented and therefore the actual changes in groundwater levels are expected to be less than those predicted. The results of this assessment are summarised as follows.

3.2 Mounding Effects

Three scenarios were modelled to allow a baseline determination of water level response between the models these were; 2.2 mm/d representing the average annual drainage rate, 5.1 mm/d representing maximum drainage rate and variable drainage rates as presented in Table 2. The results of these calculations are summarised in Table 3. The observation point used to determine mounding results are located at the centre of the irrigation blocks as shown on Figure 5.

Table 3 Groundwater Mounding (m) for Various Model Scenarios

	Hantush		SEEP/W			MODFLOW		
	2.2 (mm/d)	5.1 (mm/d)	2.2 (mm/d)	5.1 (mm/d)	Var Cycle (mm/d)	2.2 (mm/d)	5.1 (mm/d)	Var Cycle (mm/d)
Obs A	0.88	1.96	0.87	1.79	1.21	0.86	1.65	1.34
Obs B	0.48	1.08	1.01	1.56	1.33	0.82	1.67	1.20
Obs C	0.40	0.91	1.22	1.90	1.35	0.72	1.50	1.18
Obs D	0.52	1.19	1.04	1.81	1.12	0.66	1.43	0.99

Overall the models returned similar results in terms of the magnitude of mounding expected to occur. The results indicate that the greatest mounding likely to occur in the southernmost irrigation area and the least to occur in the northern irrigation area. This is largely a function of the relative size and layout of each area.

The results of this analysis indicate that groundwater levels will rise to a maximum of between 1 to 1.35 m as a result of drainage from the irrigation and rainfall. In the context of the unsaturated thickness available to accommodate these rising water levels (critical thickness of 1.4 m), during summer this amount of mounding is unlikely to result in surface breakout given the 1.4 to 3.1 m unsaturated thickness present. During winter, however, this unsaturated zone thickness reduces to 0.9 to 1.5 m under which circumstances it is likely surface breakout will occur within localised topographic depressions. This is a natural phenomenon observed to take place in the area during winter conditions in any case.

Given the expectation that some discharge from the irrigation fields is expected to take place locally during winter, a high level of management will be required to address associated potential effects. These could include; limiting the rate of treated wastewater applied during these months, provide suitable buffer distances for irrigation back from locations where breakout is expected, and put appropriate surface and groundwater monitoring in place. We understand most of these measures are proposed as conditions of the discharge consent.

It must be stated that there remains a reasonable amount of uncertainty in this assessment. This uncertainty relates to elevation control, characterisation of the unsaturated zone depth distribution over the site and understanding of the geologic conditions at depth. Due to these uncertainties, and the apparent sensitivity of mounding in relation to aquifer properties, a cautious approach to development of the land treatment system should be taken.

It is therefore recommended that a staged approach to land application be undertaken to provide an understanding of the actual mounding effects through monitoring of groundwater levels. This monitoring will enable a direct understanding of changes in groundwater levels and quality in response to irrigation rates and these learning's can be used to revise the understanding of potential risks to other land areas developed in the future. Once sufficient data is available, model predictions can be revised and calibrated to the actual response observed and applied to areas yet to be developed. This approach would allow the opportunity to adjust loading rates accordingly to site variability, while ensuring that ponding and surface breakout of wastewater does not occur.

4. Recommendations

The following recommendations are proposed for each new area of irrigation developed during the staged development of additional land treatment fields. At each location the following should be undertaken:

- Obtain site elevation survey

- Install groundwater monitoring wells to enable characterisation of:
  - Depth to groundwater across the site and seasonal variation
  - Soil profile description across the site
  - Aquifer stratification
  - Aquifer hydraulic properties
- Undertake verification of model predictions and, if necessary, revise model predictions for future development of irrigation areas.

It is envisaged that by implementing these recommendations that any potential risk associated with groundwater mounding effects from the land application of wastewater can either be resolved or managed such that the associated effects to the environment are no more than minor.

5. References

Professional Groundwater and Environmental Services. July 2016. Stream Bed Conductance Study at Two Sites in the Wairarapa Valley. Report prepared for the Greater Wellington Regional Council.

Lowe Environmental Impact. February 2017. Assessment of Environmental Effects of Discharge of Featherston Treated Wastewater to Land. Report prepared for the South Featherston District Council.

6. Closure

Should you have any further questions please contact the undersigned.

Chris RJ Simpson
B.Sc, M.Sc, CEnvP

Director - Hydrogeologist

For and on behalf of GWS Limited

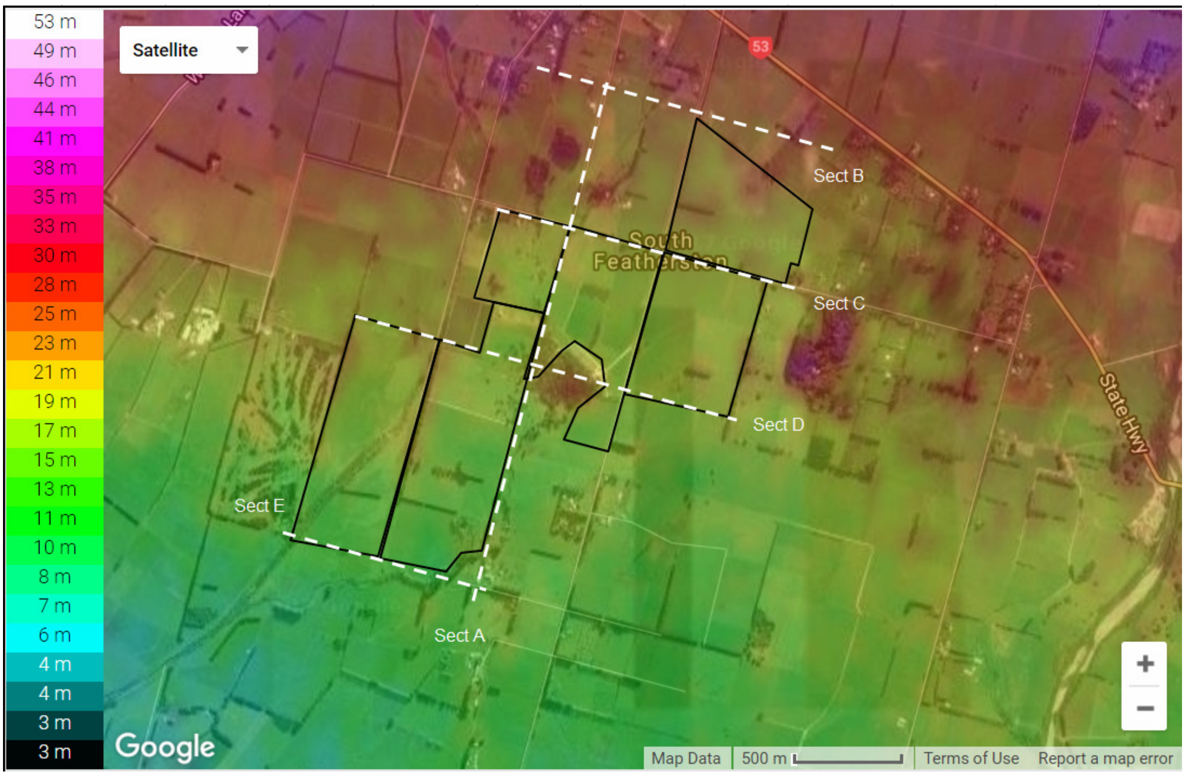

Figure 1 Topographic Elevation in Site Area

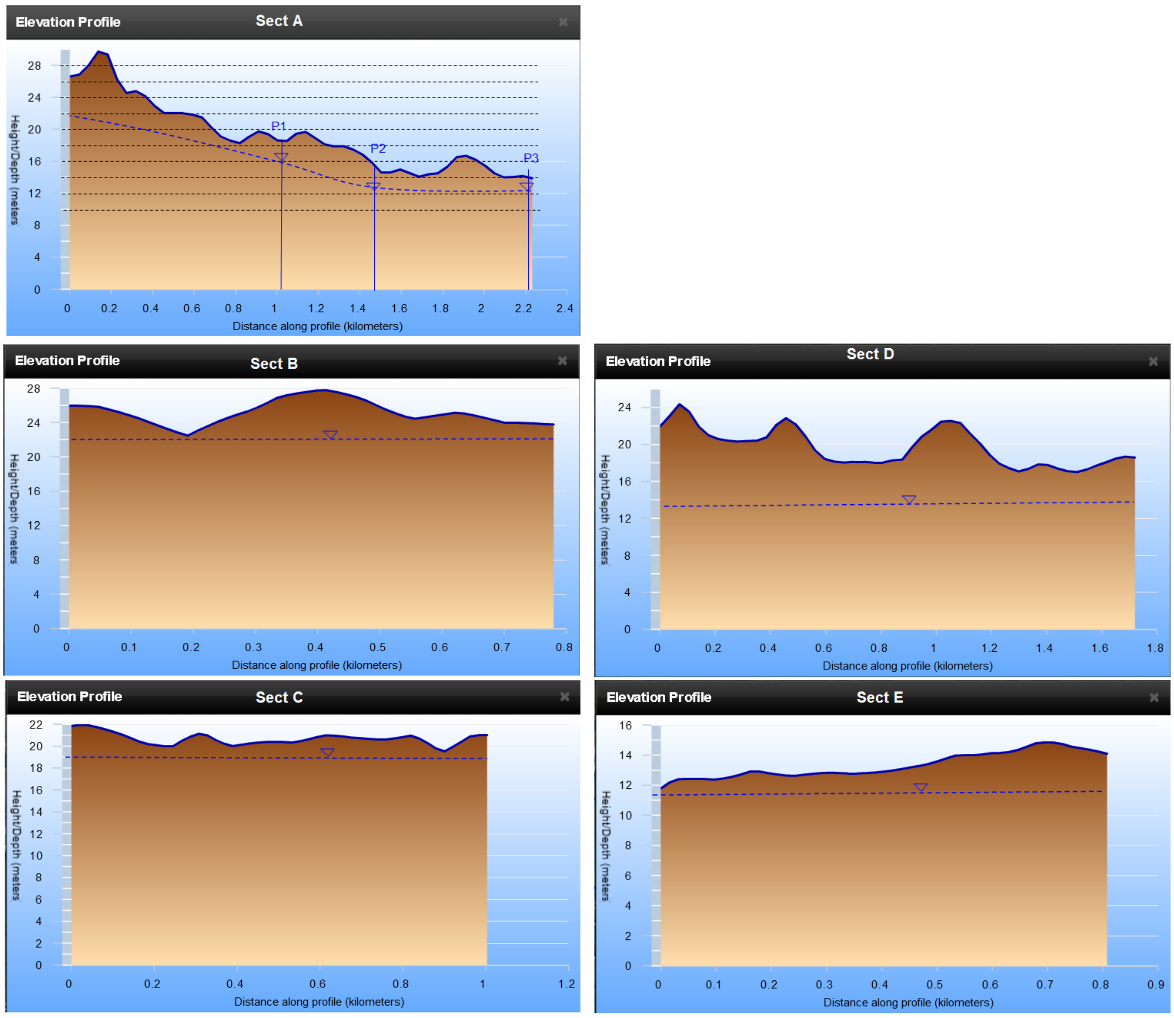

Figure 2 Topographic Profile Sections

Figure 3 Interpreted Piezometric Surface Map

Figure 4 Land Treatment Areas

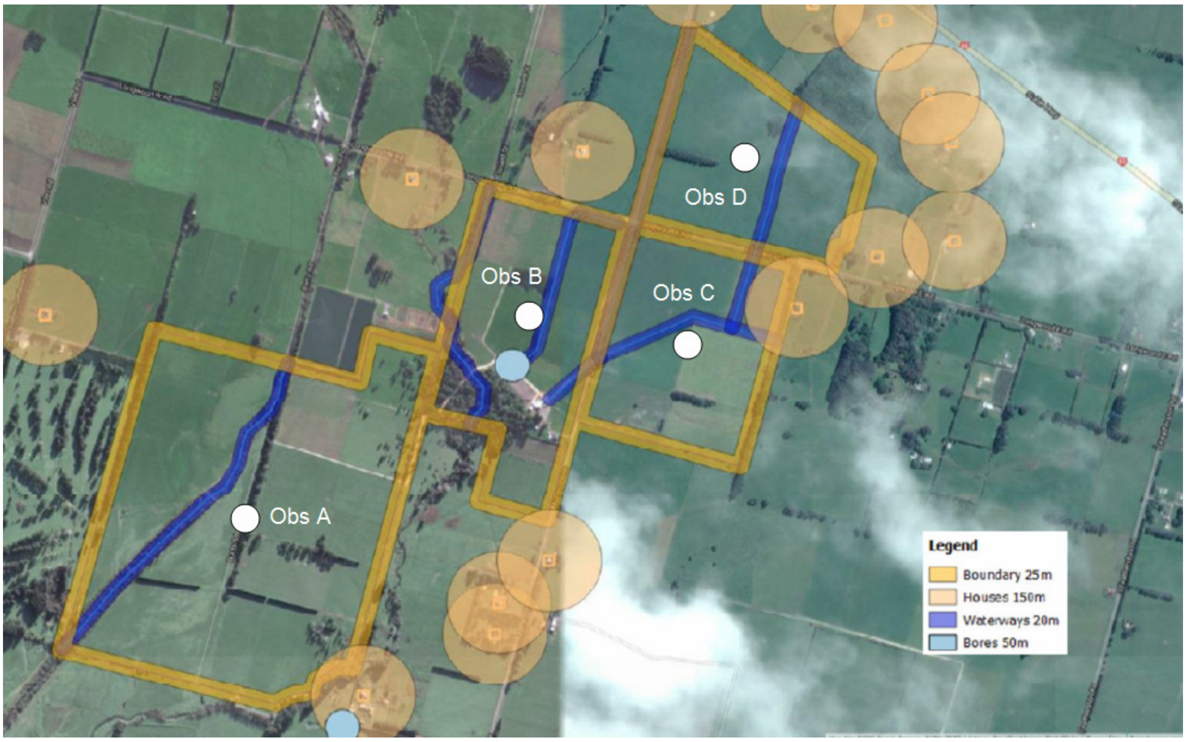

Figure 5 Model Observation Locations

Technical Addendum

Groundwater Mounding Assessment

Groundwater Mounding Calculations

An initial assessment was undertaken using Hantush(1967) to assess the extent of groundwater mounding effects in relation to the shape of the size and shape of the irrigation areas under the proposed loading regime. The Calculated results are as follows.

Obs A at 2.2 mm/d

Inputs

w (Percolation Rate): 0.0022 [L/T]
K (Hydraulic Conductivity): 12 [L/T]
S (Specific Yield): 0.2 [-]
t (Time): 365 [T]
h_i (Initial Saturated Thickness): 40 [L]
a (Length of Recharge Area): 975 [L]
b (Width of Recharge Area): 805 [L]

****KEEP UNITS CONSISTENT****

Calculate

Results

****Note that because of estimations of an integral function, this is an estimate****

Maximum hydraulic head: 40.88216939 [L]
Increase in hydraulic head: 0.88216939 [L]

Obs A at 5 mm/d

Inputs

w (Percolation Rate): 0.005 [L/T]
K (Hydraulic Conductivity): 12 [L/T]
S (Specific Yield): 0.2 [-]
t (Time): 365 [T]
h_i (Initial Saturated Thickness): 40 [L]
a (Length of Recharge Area): 975 [L]
b (Width of Recharge Area): 805 [L]

****KEEP UNITS CONSISTENT****

Calculate

Results

****Note that because of estimations of an integral function, this is an estimate****

Maximum hydraulic head: 41.96706637 [L]
Increase in hydraulic head: 1.96706637 [L]

Obs B at 2.2 mm/d

Inputs

w (Percolation Rate): 0.0022 [L/T]
K (Hydraulic Conductivity): 12 [L/T]
S (Specific Yield): 0.2 [-]
t (Time): 365 [T]
h_i (Initial Saturated Thickness): 40 [L]
a (Length of Recharge Area): 900 [L]
b (Width of Recharge Area): 450 [L]

****KEEP UNITS CONSISTENT****

Calculate

Results

****Note that because of estimations of an integral function, this is an estimate****

Maximum hydraulic head: 40.47910525 [L]
Increase in hydraulic head: 0.47910525 [L]

Obs B at 5 mm/d

Inputs

w (Percolation Rate): 0.005 [L/T]
K (Hydraulic Conductivity): 12 [L/T]
S (Specific Yield): 0.2 [-]
t (Time): 365 [T]
h_i (Initial Saturated Thickness): 40 [L]
a (Length of Recharge Area): 900 [L]
b (Width of Recharge Area): 450 [L]

****KEEP UNITS CONSISTENT****

Calculate

Results

****Note that because of estimations of an integral function, this is an estimate****

Maximum hydraulic head: 41.07910837 [L]
Increase in hydraulic head: 1.07910837 [L]

Obs C at 2.2 mm/d

Inputs

w (Percolation Rate): 0.0022 [L/T]
K (Hydraulic Conductivity): 12 [L/T]
S (Specific Yield): 0.2 [-]
t (Time): 365 [T]
h_i (Initial Saturated Thickness): 40 [L]
a (Length of Recharge Area): 730 [L]
b (Width of Recharge Area): 475 [L]

****KEEP UNITS CONSISTENT****

Calculate

Results

****Note that because of estimations of an integral function, this is an estimate****

Maximum hydraulic head: 40.40207331 [L]
Increase in hydraulic head: 0.40207331 [L]

Obs C at 5 mm/d

Inputs

w (Percolation Rate): 0.005 [L/T]
K (Hydraulic Conductivity): 12 [L/T]
S (Specific Yield): 0.2 [-]
t (Time): 365 [T]
h_i (Initial Saturated Thickness): 40 [L]
a (Length of Recharge Area): 730 [L]
b (Width of Recharge Area): 475 [L]

****KEEP UNITS CONSISTENT****

Calculate

Results

****Note that because of estimations of an integral function, this is an estimate****

Maximum hydraulic head: 40.90910819 [L]
Increase in hydraulic head: 0.90910819 [L]

Obs D at 2.2 mm/d

Inputs

w (Percolation Rate): 0.0022 [L/T]
K (Hydraulic Conductivity): 12 [L/T]
S (Specific Yield): 0.2 [-]
t (Time): 365 [T]
h_i (Initial Saturated Thickness): 40 [L]
a (Length of Recharge Area): 585 [L]
b (Width of Recharge Area): 700 [L]

****KEEP UNITS CONSISTENT****

Calculate

Results

****Note that because of estimations of an integral function, this is an estimate****

Maximum hydraulic head: 40.52477065 [L]
Increase in hydraulic head: 0.52477065 [L]

Obs D at 5 mm/d

Inputs

w (Percolation Rate): 0.005 [L/T]
K (Hydraulic Conductivity): 12 [L/T]
S (Specific Yield): 0.2 [-]
t (Time): 365 [T]
h_i (Initial Saturated Thickness): 40 [L]
a (Length of Recharge Area): 585 [L]
b (Width of Recharge Area): 700 [L]

****KEEP UNITS CONSISTENT****

Calculate

Results

****Note that because of estimations of an integral function, this is an estimate****

Maximum hydraulic head: 41.18723658 [L]
Increase in hydraulic head: 1.18723658 [L]

Numerical Modelling

Model Description

An assessment of groundwater effects has been undertaken using two separate numerical modelling packages; SEEP/W and MODFLOW. The conceptual model is highly simplified and assumes a single layer, monolithic geological conditions representing the upper aquifer system only. The models have been developed as being transient with hydraulic properties and steady state piezometric surface calibrated to the available observational data. The calibrated models have been used to determine the extent of effects presented.

Model Setup

The model grid is shown on Figure 1 and has the following dimensions:

Model Extent (X-Y plane): 5.5 x 5.5 km
Model Thickness (Z Plane): 40 m
Model Elevation: 30 mRL to 3 mRL
Central grid size: 30 x 30 m
Outer grid size: 60 x 60 m

The model grid has been set to assume no-flow to the east and west at the catchment perimeter, with groundwater moving in a predominant north to south direction.

Material Properties

The calibrated model material properties are as presented in the Table 1 below..

Table 1 Model Material Properties

Parameter	Zone 1 (white)	Units
b	40	*m*
Kh	12	*m/d*
Kv	4	*m/d*
Kh/Kv	0.3	
T	350	*m2/d*
S	0.2	

The material properties adopted are simplified based on the aquifer Transmissivity (T) and Storativity parameter defined by LEI (2016). These values for Hydraulic Conductivity (K) and Storativity (S) represent the adopted parameters for the final modelling scenarios.

Boundary Conditions

The models have two static boundary conditions; a constant head boundary at the northern model extent set at 28 m RL (set through calibration) and constant head boundary at the southern model set at 0 m RL representing Lake Wairarapa.

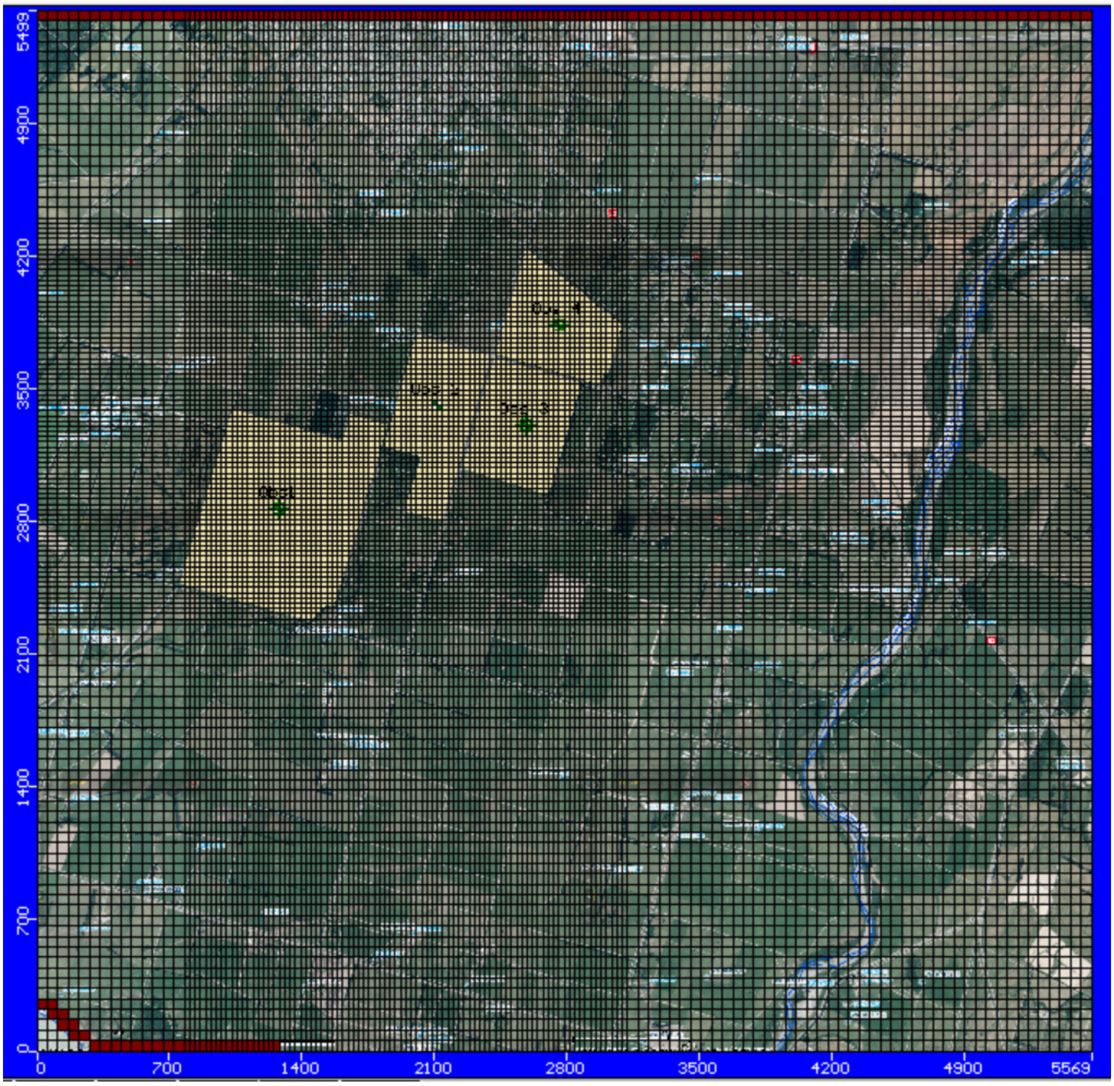

Figure 1 Model Domain Showing Grid Set-up and Constant Head Boundaries

Model Boundary Functions

Irrigation to the disposal fields was simulated in the model by applying a constant recharge flux of 2.2 and 5.1 mm/d for annual average and peak loading, as well as applying a monthly schedule as a recharge boundary function. The model was set-up with daily time steps with durations simulated from between 10 to 30 years.

Model Calibration

An initial model calibration was fitted by replicating the general head distribution and gradients from the interpreted piezometric surface map was produced from known groundwater level information at a few locations. Overall a good model calibration was fitted to the observation. It is noted that the groundwater conditions simulate winter high groundwater levels as seasonal groundwater level information was not available at the time of undertaking this assessment. The model was not, therefore, calibrated under transient conditions. Figure 2 provides the calibrated steady state model output.

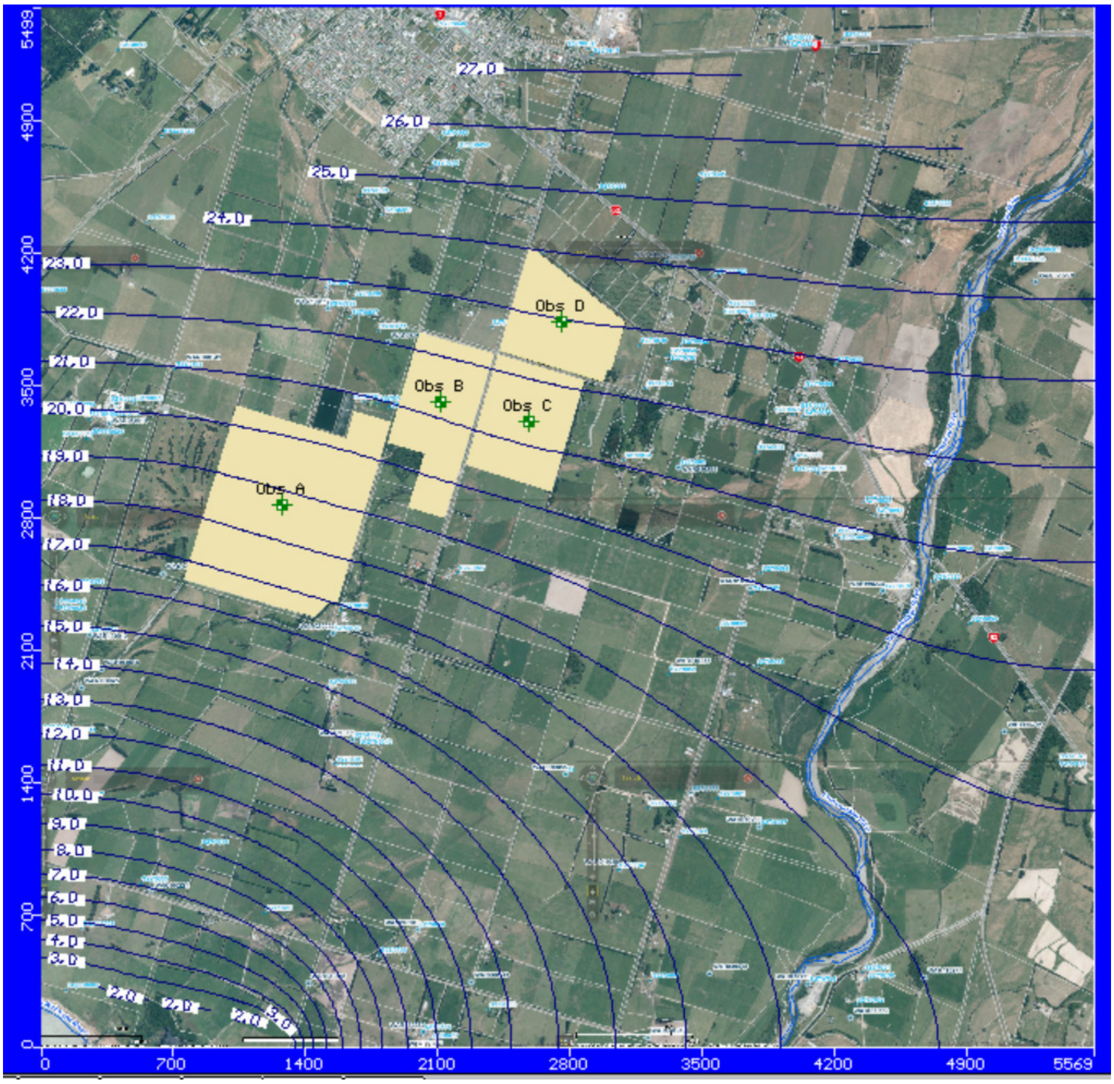

Figure 2 MODFLOW Steady State Head File

Model Sensitivity

A limited sensitivity analysis has been undertaken by taking the calibrated base model and altering various input parameters. This process has shown that the effects of mounding are most sensitive to the Kh/Kv ratio ie. the extent of anisotropy caused by layering in the upper aquifer. The model is also sensitive to drainable porosity or specific yield.

Model Results

The results from the numerical models have been used to assess the amount of mounding expected to occur. The results of the variable irrigation rates are considered to be the most realist values. Figure 3 provides an example of results obtained from variable irrigation rates.

Table 2 Summary Numerical Modelling Results

	SEEP/W			MODFLOW		
	2.2 (mm/d)	5.1 (mm/d)	Var Cycle (mm/d)	2.2 (mm/d)	5.1 (mm/d)	Var Cycle (mm/d)
Obs A	0.87	1.79	1.21	0.86	1.65	1.34
Obs B	1.01	1.56	1.33	0.82	1.67	1.20
Obs C	1.22	1.90	1.35	0.72	1.50	1.18
Obs D	1.04	1.81	1.12	0.66	1.43	0.99

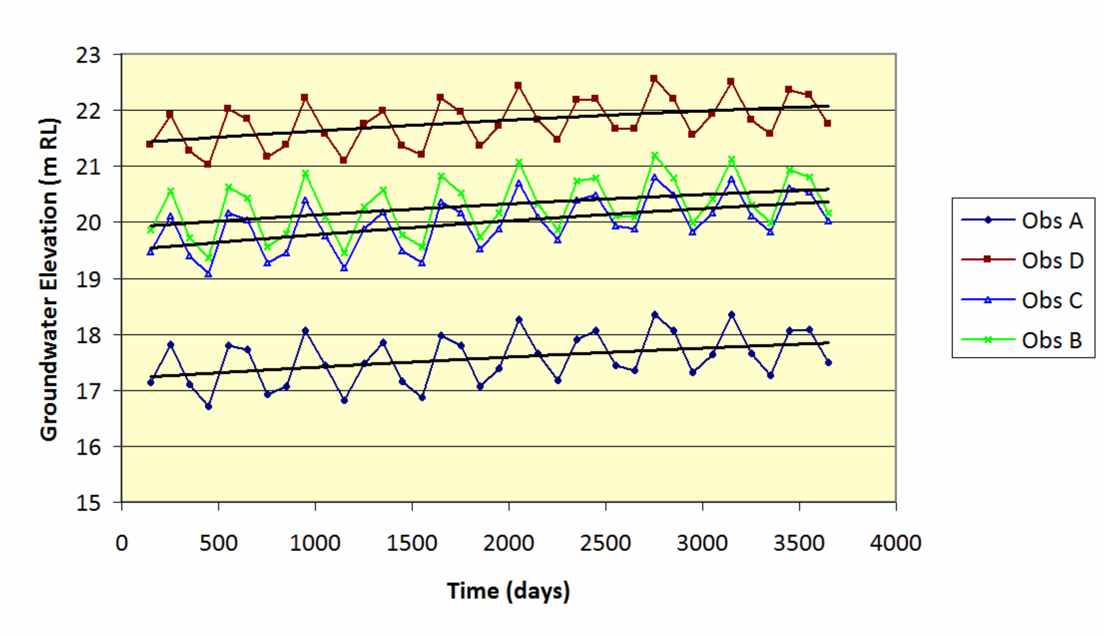

Figure 3 Example Model Results with Variable Cycle Irrigation

MOTT MACDONALD

A2: LEI Overseer Nitrogen Leaching Assessment

MEMORANDUM

To:	Bill Sloan, South Wairarapa District Council; Sarah Sunich, Mott MacDonald
From:	Katie Beecroft
Date:	18 May 2017
Subject:	Featherston WWTP Discharge Consent – S92 reponse

INTRODUCTION

Following on from lodging an application for Resource Consent to discharge wastewater to land from the Featherston Wastewater Treatment Plant (WWTP), Greater Wellington Regional Council (GWRC) has undertaken an expert review and provided a request for further information under Section 92 of the Resource Management Act 1991 (RMA).

Lowe Environmental Impact has assisted SWDC with the field investigation of sites, determination of land assimilative capacity, design of a discharge regime and assessment of the effects of the proposed discharge regime. Mott MacDonald, on behalf of SWDC has requested for LEI to prepare information as requested by GWRC. This technical memo outlines a response to questions relating to the discharge site and land application scheme.

The Section 92 request for information includes five questions. Responses to questions 1, 4 and 5 are to be prepared by Mott MacDonald and Groundwater Services Ltd, with the remaining questions detailed below.

QUESTION 2 – NITROGEN LEACHING VALUES

GWRC has asked:
2. Have you undertaken any Overseer modelling for nutrient application and leaching? Our experts consider this important work to be carried out for the different scenarios mentioned in the application such as stocking rates/types of stock, cut and carry, cropping (including applying nutrients against good practice) given there is additional fertiliser to be added in addition to the wastewater nutrients and the soils are free draining. We would note that Overseer assumes best practice on application of nutrients and there are some concerns that deferred irrigation is not best practice so we would also like to know how this has been taken into account in modelling.

Nitrogen leaching has been evaluated for the site using an empirical nitrogen budget. The nitrogen budget used is an in-house spreadsheet model developed a number of years ago specifically for a wastewater application system and peer reviewed by Aqualinc staff. This budget was used in preference to Overseer due to its ability to give reliable estimates with limited information about the farming system. Details of the outputs are given in Section 4.13.1 of the Land Application AEE (Appendix 7 of the Consent Application).

To assist with GWRC evaluation of the consent, Overseer scenarios have been prepared and are described below.

In preparing the Overseer scenarios the following approach has been followed:

- **Use of good practice** – All model entries reflect good practice management of nutrient application, and of stock management. The scenarios modelled are realistic and achievable for the site.

- **Data entry for deferred irrigation** - Deferred irrigation is the basis of the application regime in the "Farm Dairy Effluent Design Standards and Code of Practice. There are numerous methods within Overseer to enter irrigation, and a number of them can accommodate a deferred irrigation regime approach. It is our preference to use a monthly application depth, since this is in line with Overseers' use as a long-term annualised average model.

Overseer Model Scenarios
Modelling has been undertaken using Overseer Version 6.2.3 (current at 15/05/2017).

As described in the Land AEE (Appendix 7), the land application system proposed allows for a range of land management options. For the purpose of this exercise, three scenarios out of multitudinous options have been evaluated. They are:

- Baseline – this is the management of the farm for 2013/2014 evaluation year. Actual farm information is used.
- Grazed, moderate input – irrigated with drystock grazing. Nutrients to be supplied by wastewater and minor additional fertiliser on unirrigated areas.
- Cut and carry, optimum N – irrigated with cut and carry pasture. A limited amount of grazing of drystock occurs and optimum pasture growth targeted i.e. targeted fertiliser applications are planned.

Baseline Scenario
The baseline scenario uses actual farm data for the 2013/2014 season. The farm had been operated as a dairy farm at this time. The nutrient losses from the farm as managed until SWDC acquired it are considered to be the benchmark for nutrient losses following conversion to a land application system.

Key input data for the baseline Overseer scenario was:

- **Property Report 2015** – detailed data regarding the farm layout, management, stocking, production and fertiliser inputs;
- **Climate** – using the Overseer Climate Station Tool, with a bearing of 41.138778°S, 175.324886°E, the climate data generated was in-line with the reported data (AEE);
- **Soil Data** – soils were assigned according to the S-Map siblings which can be correlated with the soils identified during the site investigations (Table 7 below). Soil test data comes from the property report;
- **Irrigation** – irrigation was by sprayline. Irrigation data was not available and so a typical deficit irrigation programme was assumed and inputted.

Blocks were assigned based on soil type, management history (including effluent blocks) and whether or not they had been irrigated. Blocks are shown in Table 1.

Table 1: Baseline Scenario – Blocks

Block name	Type	Effective area (ha)
Rang_18b.1 Dry	Pastoral	25.9
Bram_8a.1 Irrigated	Pastoral	2.5
Tait_42a.1 Irrigated	Pastoral	25.2
Selw_42a.1 Dry	Pastoral	7.3
Selw_25a.1 Dry	Pastoral	4.8
Selw_25a.1 irrigated	Pastoral	5.6
Darn_17a.1 Irrigated	Pastoral	11.9
Darn_17a.1 Dry	Pastoral	30.8
QE2	Trees and Scrub	4.8
Maize	Fodder Crop	-
Kaia_19a.1 Irrigated	Pastoral	4.3
Darn_9a.1 Dry	Pastoral	4.3
Rang_18b.1 Irrigated	Pastoral	16.5
Darn_17a.1 Silage Irrigated	Pastoral	10.4
Darn_17a.1 Silage Dry	Pastoral	19.6

The modelled Overseer scenario gave outputs for the whole farm, shown in Table 2. Note this does not include Site A (as defined in the Consent Application) and does include two small areas that are no longer part of the property.

Table 2: Baseline Scenario – Whole Farm Nutrient Budget 2013/2014

(kg/ha/yr)	N	P	K	S	Ca	Mg	Na
Nutrients added							
Fertiliser, lime & other	146	29	0	34	71	0	0
Rain/clover N fixation	64	0	2	4	3	6	23
Irrigation	4	0	3	4	16	4	17
Nutrients removed							
As products	58	10	13	3	14	1	4
Exported effluent	0	0	0	0	0	0	0
As supplements and crop residues	0	0	0	0	0	0	0
To atmosphere	**47**	**0**	**0**	**0**	**0**	**0**	**0**
Volatilisation - fertiliser	0	0	0	0	0	0	0
Volatilisation - other	2	0	0	0	0	0	0
Denitrification - background	1	0	0	0	0	0	0
Volatilisation from urine	31	0	0	0	0	0	0
Denitrification from urine	13	0	0	0	0	0	0
To water	**62**	**1.1**	**6**	**41**	**77**	**8**	**25**
Leaching - urine patches	49	0.0	3	0	39	0	0
Leaching - other	13	0.2	3	41	39	8	25
Runoff	0	0.8	0	0	0	0	0
Direct (animals, drains)	0	0.0	0	0	0	0	0
Direct pond discharge	0	0.0	0	0	0	0	0
Border dyke outwash	0	0.0	0	0	0	0	0
Septic tank outflow	0	0.0	0	0	0	0	0
Change in farm pools							
Plant Material	-9	-1	-8	0	-1	-1	0
Organic pool	48	13	0	-1	0	0	0
Inorganic mineral	0	0	-33	0	-5	-8	-9
Inorganic soil pool	7	6	26	0	5	9	21

Leaching values for the farm of 62 kg N/ha/y are typical. ECan reference files for a typical irrigated dairy system on similar soils (Darn_1a.1) and 300 mm less rainfall, leaching values of 63 kg N/ha/y are attained. Therefore, the calculated 62 kg N/ha/y is reasonable for the farm system modelled. As shown in Table 2, urine patches are the predominant source of leaching.

Grazed, Moderate Input Scenario

Following the commencement of wastewater irrigation, the farm will most likely cease to be managed as a dairy farm. While the wastewater from FWWTP will be UV treated, and will have a low level of pathogens, the testing regime and existing monitoring data will not meet the California Health Law, Title 22 requirements listed by Fonterra as water quality suitable for irrigation to dairy pastures (NB other dairy companies often quote the Fonterra policy also).

There is scope for the site to be managed for drystock grazing. A realistic farm management system has been modelled, based on LEI experience and benchmarked against the ECan Reference Overseer Files. The management is based on good practice, with best or exceptional practice not adopted to ensure that the scenario doesn't result in leaching losses which can't be achieved in practice.

Key assumptions are:

- A breeding herd of cattle are farmed;
- No additional nitrogen fertiliser is applied to the irrigated blocks, but some nitrogen fertiliser is applied to buffer areas. A small amount of additional phosphorus is applied across the site as super phosphate;
- Irrigation is applied as soon as soil conditions are suitable. In practice, it is likely that the wastewater in storage will be managed to retain a greater volume of irrigation water for summer. The impact of managing the distribution of wastewater across the season will be to lower the pore volume applied, resulting in lower leaching. Modelling irrigation to be applied as soon as soil conditions allow provides extra conservatism to the modelling;
- One cut for baleage occurs across Site B. Three cuts are taken off Site A;
- Only winter grazing (June, July, August) occurs on Site A.

Blocks were modified from the Baseline Scenario to be assigned based on soil type, new irrigation distribution (Irr = irrigated, Buf = buffer). In addition, some areas were divided by their location to form additional blocks. Blocks are shown in Table 3.

Table 3: Grazed, Moderate Input scenario – Blocks

Block name	Type	Effective area (ha)
Buf_Rang_18b.1	Pastoral	8.0
Irr_Mid_Bram_8a.1	Pastoral	4.6
Irr_Mid_Tait_42a.1	Pastoral	21.3
Buf_Selw_25a.1	Pastoral	1.9
Irr_E_Selw_25a.1	Pastoral	6.0
Irr_NE_Darn_17a.1	Pastoral	19.0
Irr_Mid_Darn_17a.1	Pastoral	14.9
QE2	Trees and Scrub	3.6
Maize	Fodder Crop	-
Irr_Darn_9a.1	Pastoral	4.3
Irr_Rang_18b.1	Pastoral	30.4
Irr_E_Darn_17a.1	Pastoral	12.8
Buf_Darn_17a.1	Pastoral	30.9
Irr_A_Bram_8a.1	Pastoral	8.0
Buf_Bram_8a.1	Pastoral	5.7
Buf_Tait_42a.1	Pastoral	4.0
Buf_Darn_9a.1	Pastoral	1.5

The modelled Grazed, Moderate Input Scenario gives outputs for the whole farm, shown in Table 4.

Table 4: Grazed, Moderate Input – Whole Farm Nutrient Budget 2013/2014

(kg/ha/yr)	N	P	K	S	Ca	Mg	Na
Nutrients added							
Fertiliser, lime & other	70	37	0	24	51	0	0
Rain/clover N fixation	50	0	2	4	3	6	23
Irrigation	0	0	0	0	0	0	0
Nutrients removed							
As products	8	2	1	1	4	0	0
Exported effluent	0	0	0	0	0	0	0
As supplements and crop residues	28	4	26	2	8	2	1
To atmosphere	**24**	**0**	**0**	**0**	**0**	**0**	**0**
Volatilisation - fertiliser	0	0	0	0	0	0	0
Volatilisation - other	0	0	0	0	0	0	0
Denitrification - background	1	0	0	0	0	0	0
Volatilisation from urine	17	0	0	0	0	0	0
Denitrification from urine	6	0	0	0	0	0	0
To water	**43**	**1.0**	**5**	**27**	**63**	**11**	**32**
Leaching - urine patches	24	0.0	1	0	19	0	0
Leaching - other	18	0.1	3	27	44	11	32
Runoff	0	1.0	0	0	0	0	0
Direct (animals, drains)	0	0.0	0	0	0	0	0
Direct pond discharge	0	0.0	0	0	0	0	0
Border dyke outwash	0	0.0	0	0	0	0	0
Septic tank outflow	0	0.0	0	0	0	0	0
Change in farm pools							
Plant Material	-9	-1	-8	0	-1	-1	0
Organic pool	20	12	0	-1	0	0	0
Inorganic mineral	0	0	-36	0	-5	-8	-9
Inorganic soil pool	6	19	15	0	-16	1	-1

Leaching values for the farm of 43 kg N/ha/y are 30 % lower than the current farm practice. Compared to ECan reference files for a typical irrigated sheep and beef system on similar soils (Darn_1a.1) and 300 mm less rainfall with leaching values of 34 kg N/ha/y these values are higher, but not excessive for the farm system modelled.

Cut and Carry, Optimum N Scenario

SWDC may decide to operate the wastewater application system as a cut and carry operation, as has been done elsewhere in New Zealand, notably in Taupo. It should be noted that the management constraints for this site are more restrictive than for the Taupo scheme (as detailed in Section 3 of the Land AEE (Appendix 7).

As described for the preceding scenario, a realistic farm management system has been modelled based on LEI agronomist suggestions and benchmarked against the ECan Reference Overseer Files. The management is based on good practice, as best or exceptional practice has not been adopted to ensure that the scenario doesn't result in leaching losses which can't be achieved in practice.

Key assumptions are:

- Pasture is cut for baleage from the site;

- Cattle are used to assist with management of the buffers, and to graze across the site during the winter months when minimal irrigation occurs;
- Additional nitrogen fertiliser is applied to the irrigated blocks to an annual loading of around 300 kg N/ha/y. Around 80 kg N/ha/y is applied to buffer areas. A small amount of additional phosphorus is applied across the site as super phosphate; and
- Irrigation is applied as soon as soil conditions are suitable. As with the previous scenario, by modelling irrigation as soon as soil conditions allow, extra conservatism is applied to the modelling.

Blocks were the same as for the grazed, moderate input scenario. Blocks are shown in Table 5.

Table 5: Cut and Carry, Optimum N Scenario – Blocks

Block name	Type	Effective area (ha)
Buf_Rang_18b.1	Pastoral	8.0
Irr_Mid_Bram_8a.1	Pastoral	4.6
Irr_Mid_Tait_42a.1	Pastoral	21.3
Buf_Selw_25a.1	Pastoral	1.9
Irr_E_Selw_25a.1	Pastoral	6.0
Irr_NE_Darn_17a.1	Pastoral	19.0
Irr_Mid_Darn_17a.1	Pastoral	14.9
QE2	Trees and Scrub	3.6
Maize	Fodder Crop	-
Irr_Darn_9a.1	Pastoral	4.3
Irr_Rang_18b.1	Pastoral	30.4
Irr_E_Darn_17a.1	Pastoral	12.8
Buf_Darn_17a.1	Pastoral	30.9
Irr_A_Bram_8a.1	Pastoral	8.0
Buf_Bram_8a.1	Pastoral	5.7
Buf_Tait_42a.1	Pastoral	4.0
Buf_Darn_9a.1	Pastoral	1.5

The modelled Cut and Carry, Optimum N Overseer scenario gives outputs for the whole farm, shown in Table 6.

Table 6: Cut and Carry, Optimum N – Whole Farm Nutrient Budget 2013/2014

(kg/ha/yr)	N	P	K	S	Ca	Mg	Na
Nutrients added							
Fertiliser, lime & other	206	48	0	38	79	0	0
Rain/clover N fixation	35	0	2	4	3	6	23
Irrigation	0	0	0	0	0	0	0
Nutrients removed							
As products	4	1	0	0	2	0	0
Exported effluent	0	0	0	0	0	0	0
As supplements and crop residues	178	27	161	14	52	15	7
To atmosphere	**8**	**0**	**0**	**0**	**0**	**0**	**0**
Volatilisation - fertiliser	0	0	0	0	0	0	0
Volatilisation - other	0	0	0	0	0	0	0
Denitrification - background	2	0	0	0	0	0	0
Volatilisation from urine	5	0	0	0	0	0	0
Denitrification from urine	1	0	0	0	0	0	0
To water	**21**	**1.1**	**3**	**27**	**47**	**11**	**32**
Leaching - urine patches	5	0.0	0	0	4	0	0
Leaching - other	16	0.0	3	27	43	11	32
Runoff	0	1.1	0	0	0	0	0
Direct (animals, drains)	0	0.0	0	0	0	0	0
Direct pond discharge	0	0.0	0	0	0	0	0
Border dyke outwash	0	0.0	0	0	0	0	0
Septic tank outflow	0	0.0	0	0	0	0	0
Change in farm pools							
Plant Material	-9	-1	-8	0	-1	-1	0
Organic pool	32	12	0	1	0	0	0
Inorganic mineral	0	0	-60	0	-5	-8	-9
Inorganic soil pool	6	8	-95	0	-12	-11	-7

Leaching values for the farm of 21 kg N/ha/y are 66 % lower than the baseline farm practice. The limiting of animals from the site significantly reduces the amount of N leached in urine patches. In addition, the removal of supplements from the site results in a large amount of the applied nitrogen being unavailable for leaching.

Summary of Nitrogen Leaching Values

Modelling of feasible farm management options has been undertaken using irrigation data from the proposed wastewater land discharge system. The scenarios modelled present the current land use and two potential options for future land use. Nitrogen leaching values, being the critical output for determining effects to the environment, for the whole farm are:

- Baseline: 63 kg N/ha/y;
- Grazed and irrigated with wastewater: 43 kg N/ha/y; and
- Cut and carry and irrigated with wastewater: 21 kg N/ha/y.

These scenarios are considered to best represent the likely future management of the site. The values for the baseline scenario vary from those given in Section 4.13.1 of the Land AEE (Appendix 7) due the use of actual data for the current farming operation which indicated it is a higher input system than assumed for the previous analysis.

The leaching values indicate a net reduction in nitrogen lost from the farm compared to the previous management as a dairy farm.

QUESTION 3 – SITE INVESTIGATION INFORMATION

GWRC has asked:
3. In the section of the AEE where soils are discussed there is a reference to site investigations and soil mapping undertaken for Sites A and B by LEI. Can you please provide us with these soil maps and also indicate what scale was the mapping done at? Also what sampling scale of core samples and observations were used and clarify any laboratory test or observations that were conducted at the time to help confirm mapping and the soil classification.

Following discussion with Rob Docherty (Pattle Delamore Partners) on 16/05/2017, this question has been further refined to providing an explanation of what parameters were relied upon in determining the irrigation regime, and whether the parameters were adopted from site observation, field or laboratory measurement or literature values.

Site Investigation reports as described are attached. A summary of the key parameters and their origin is given in Table 7. Refer also, to Section 4.5 of the Land AEE (Appendix 7),

Table 7: Parameters for Determining Irrigation Regime

Landform unit	**Coarse elevated plain**	**Coarse lower plain**	**Wet lower plain**	**Source**
Soil series name	Tauherenikau stony silt loam	Opaki and Greytown silt loam	Ahikouka silt loam	**In field evaluation**
S-Map soil sibling	Darn17 a.1 Darn9 a.1 Selw25 1.a Selw42 a.1	Bram8 a.1 Rang18 b.1	Tait42a.1	**S-Map database**
Area available for irrigation (ha)[1]	53	42	21	Field mapping and desktop GIS
Daily irrigation rate (mm/d)[2]	From most limiting measurement: Up to 55 mm per event Site B Up to 19 mm per event Site A			From field measurement of unsaturated hydraulic conductivity
Limiting consideration	No significant limitations	Shallow depth to groundwater (~1 m)		Field observation (soil profiles) and measured depth to groundwater (on farm piezometers)
Soil unsaturated conductivity (mm/hr)	10 ±0.5 14 ±NA (lab)	8 ±5 (Site A) 8 ±3 (Site B)	8 ±5	Field measurement (plate permeameter) and Landcare soil physics lab measurement "(lab)"
Soil saturated conductivity (mm/hr)	172 ±31 133 ±50	240 ±120 (Site A) 71 ±22 (Site B)	33 ±14	Field measurement (double ring infiltration)
P Retention (%)	19	35	35	S-Map data sheets

[1]Buffers excluded
[2]Based on soil hydraulic conductivity only. Additional controls have been applied to manage depth to groundwater limitations – notably, incorporation of climate data and irrigation rotation/return period.

CONCLUSION

We trust the information supplied in this technical memorandum provides the necessary answers for questions raised by GWRC.

Regards,
Katie Beecroft

A3: LEI, *Evaluation of Potential Land Treatment Sites - Featherston Wastewater Treatment Plant* Site, April 2013 – Site A

Evaluation of Potential Land Treatment Sites

-

Featherston Wastewater Treatment Plant Site

Prepared for

South Wairarapa District Council

Prepared by

Lowe Environmental Impact

April 2013

Evaluation of Potential Land Treatment Sites
-
Featherston WWTP Site

South Wairarapa District Council

This report has been prepared for the **South Wairarapa District Council** by Lowe Environmental Impact (LEI). No liability is accepted by this company or any employee or sub-consultant of this company with respect to its use by any other parties.

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Ref: RE-10075-SWDC-Land Evaluation-FWWTP-130219-KB_hl_fin

Job No.: 10075

Date: April 2013

TABLE OF CONTENTS

1 EXECUTIVE SUMMARY

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

At present SWDC own a block of land adjacent to the FWWTP. This property is referred to here as the FWWTP site. A desktop investigation for the site has previously been undertaken (LEI, 2012). The report noted drainage and depth to an underlying restrictive layer in the soil as limitations for the site and recommended additional site specific information for the site was needed. LEI has undertaken an assessment of the land's capacity at the FWWTP site to assimilate a discharge from the FWWTP. The results of the investigation are as follows.

- The flat grade of the land was considered to be well suited to wastewater irrigation. However the gentle fall towards Donald's Creek will require sufficient buffer distance to be maintained. Once buffer distances from the waterways and property boundaries are taken into consideration the irrigable land area is considered to be around 8 ha.

- The predominantly coarse grained soils are well suited to receiving and transmitting irrigated wastewater. Investigations indicated that while the soil was free-draining there was evidence of frequent saturation at shallow depth, most likely due to groundwater. Elevated groundwater will limit the number of days that irrigation can occur on the site. Further work based on the wastewater volumes and 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 240 mm/hr. The unsaturated hydraulic conductivity ($K_{-40\ mm}$) is 8 mm/hr. The large difference between the K_{sat} and the $K_{-40\ mm}$ reflects the high proportion of gravel though-out the observed soil profile. This indicates that the soil is capable of draining applied water at a relatively high rate, however contact time with the soil is low and the ability to remove applied nutrients and contaminants will be low at high rates of application. 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 not exceeding 19 mm/d is recommended for the FWWTP site.

- Based on an annual average nitrogen (N) concentration of 8.9 g/m^3 the N applied at the recommended hydraulic loading is equivalent to 1.7 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 120 days of full irrigation the N loading would be in the order of 200 kg N/ha/y. This is in-line with the surrounding rural land use, especially dairy farms. 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 Donald's Creek.

The investigation concluded that the Site is capable of assimilating up to 19 mm/d of FWWTP wastewater from an application event. At this rate of application the applied water, nutrients and contaminant should be assimilated by the soil of the Site.

The irrigable area of the site is considered to be 8 ha. For a daily maximum application event the Site is able to receive and assimilate 1,520 m^3 of wastewater. 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.

2 INTRODUCTION

2.1 Background

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

At present SWDC own a block of land adjacent to the FWWTP. This property is referred to here as the Site. 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 and recommended additional site specific information for the Site was needed. LEI has undertaken an assessment of the lands capacity at the FWWTP site to assimilate a discharge from the FWWTP.

2.2 Scope

This report gives the results of a field investigation of the FWWTP 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 FWWTP wastewater during periods of irrigation.

3 SITE DESCRIPTION AND LOCATION

3.1 Site Description

The town of Featherston is located in the Wairarapa approximately 35 km south-west of Masterton on SH2. A site near to Featherston and specifically the WWTP has been considered for the establishment of a land treatment system. Details of the site are given in Table 1.

Table 1: Location Details, FWWTP Land

Legal description	Lot 2 DP 342631
Property address	Donald Street
Map ref, centre of site:	-41.134445, 175.324826
Current owners	South Wairarapa District Council
Area (ha)	12.5985 ha
Distance to WWTP (km)	< 100 m

Figure 1 (Appendix A) shows the location of the site.

3.2 Waterways and Topography

The site is located on the alluvial plain between the Rimutaka Ranges and Lake Wairarapa. The distance to the foothills is around 2 km to the west. Lake Wairarapa is around 4 km to the south of the Site.

Donald's Creek, a small stream traverses approximately the East Boundary of the Site. The Site is predominantly flat with a gentle fall towards Donald's Creek. There is minor topographic variation due to low (<0.5 m) hummock and swale topography associated with the alluvial plain that the Site is located on.

The Site has an elevation of around 20 m above mean sea level.

3.3 Buildings in Locality

A residence is located near the northern boundary of the Site, but is understood to be vacant presently. A service building is located on the adjacent FWWTP. The nearest residence to the Site is located off Longwood West Road, around 300 m north-east of the site boundary. Other residences are located at least 500 m away. Other buildings such as dairy sheds are located greater than 250 m away from the Site.

3.4 District Plan

The Site is located within the 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 15th 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 ryegrass pasture. The grass cover was good and in general the site appeared green compared to other areas of the district. The proximity to the ranges is likely to influence the rainfall amount, and also the small distance between the ranges and the major water body will influence the rate and amount of groundwater flowing past the Site.

The FWWTP is located directly adjacent to the southern boundary of the Site. The main treatment ponds are located above the level of the Site.

A water take was observed on Donald's Creek within the Site boundaries. A small (approx. 1 m) permanent dam structure had been constructed from which water can be pumped. At the time of the site visit the pump was working continuously, suggesting that the water may be used for irrigation. If the Site is used for irrigation of wastewater the application will need to be designed so that the end use of the water take is not compromised.

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 hummock and swale topography. In addition sampling locations were chosen to determine what if any variation occurs in the sub surface with increasing distance from Donald's Creek.

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:

- Soils of the hummocks: Very dark greyish brown (10YR 3/2) silt loam topsoil. Underlain by loamy sand and gravel which gets progressively more gravelly. The gravel is up to 50 mm and sub-angular to sub-rounded. Occasional manganese deposits and light coloured mottles.
- Soils of the swales and land near to Donald's Creek: Very dark greyish brown (10YR 3/2) silt loam topsoil (0-20 cm) underlain by gravelly silt with mottling and becoming more clayey with depth. Below 70 cm the soil was strongly gleyed, and saturated conditions were encountered at 110 cm.

Soil cores observed at the site correspond to Opaki Brown Stony Loam (Mottled Orthic Brown Soil, NZSC). Variations observed across the site correspond to finer grained material in lower lying areas, with higher organic matter content apparent. Soils on the higher parts of the site, towards the west the predominant land feature, have a drainage class of 4 (moderately drained). Soils in the swales had a drainage class of 3 (imperfectly drained).

4.4 Soil Descriptions: Summary and Implications for Land Treatment

The flat grade of the land was considered to be well suited to wastewater irrigation. However the gentle fall towards Donald's Creek will require sufficient buffer distance to be maintained. Once buffer distances from the waterways and property boundaries are taken into consideration the irrigable land area is considered to be around 8 ha.

The predominantly coarse grained soils are well suited to receiving and transmitting irrigated wastewater. However, near to Donald's Creek the water table was encountered at around 1 m and mottling, low chroma colours and manganese nodules at shallow depths indicate that the soil is frequently saturated. Given the free draining nature of the soil the saturation is likely to be due to high groundwater. 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.

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 240 ± 120 mm/hr. This value corresponds to a high permeability soil which reflects the high proportion of gravel and sand in the soil. Variations within the site are due to slightly coarser soils on hummocks with finer grainer material of lower permeability being deposited in the shallow swales. For design purposes the lower value of K_{sat} should be adopted.

5.4.2 Plate Permeameter Results

The plate permeameter tests were conducted in triplicate. A plot of the $K_{-40\ mm}$ results for the FWWTP site is 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.

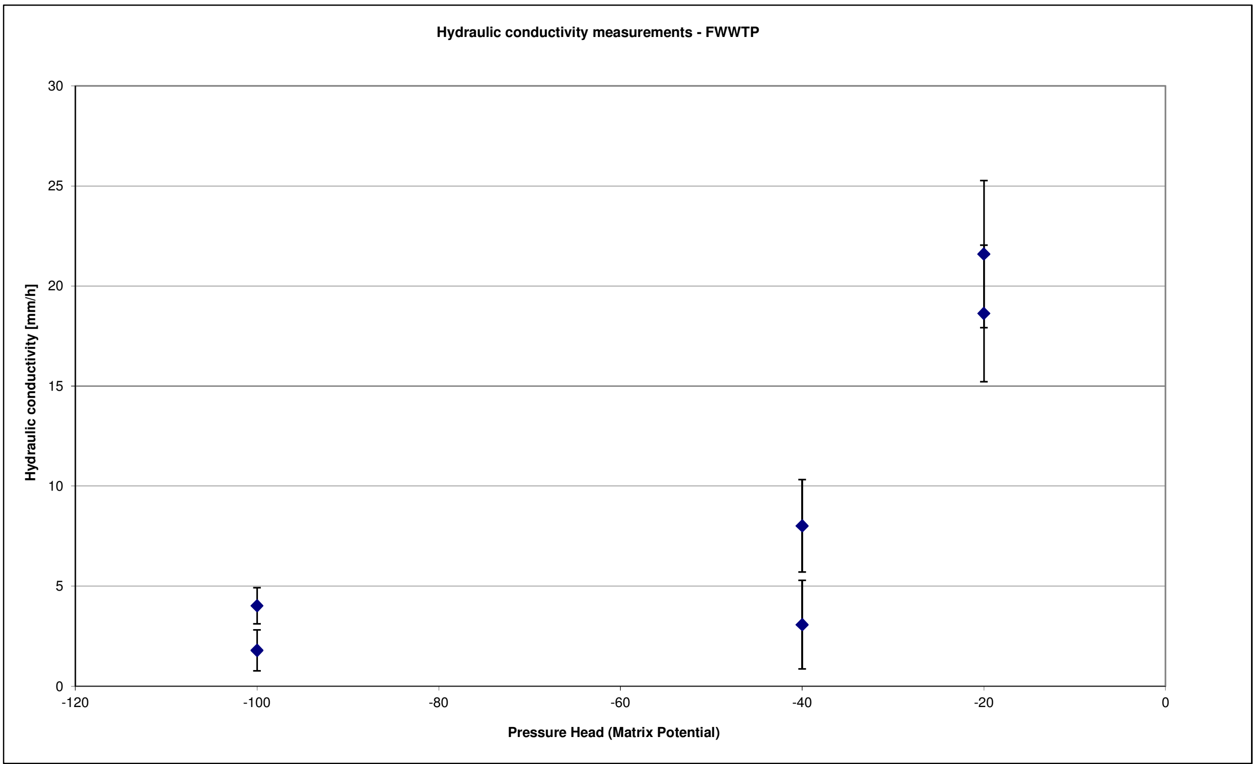

Figure 5.1: Unsaturated Hydraulic Conductivity – FWTWTP Site

Based on the on-site observations, specifically the sub-soil conditions and predominantly flat land form, it is considered that the $K_{-40\ mm}$ value that should be adopted for the site is 8 mm/hr. Any irrigation applied to the site should be at a rate not exceeding 8 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 19 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 large difference between the K_{sat} at 240 mm/hr and the $K_{-40\ mm}$ at 3 to 8 mm/hr reflects the high proportion of gravel and sand though-out the observed soil profile. This indicates that the soil is capable of draining applied water at a relatively high rate, however contact time with the soil is low and the ability to remove applied nutrients and contaminants will be low at high rates of application. 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 19 mm/d is recommended for the FWWTP site.

5.6.1 Potential Nitrogen Loading

Details of the wastewater discharge quality are given in the report "Featherston Community Waste Water Treatment Plant (Proposed operation, upgrade and maintenance to 30 June 2020) Application for Resource Consents, Activity Description and Assessment of Environmental Effects" *Geange Consulting, May 2012*. Based on annual average nitrogen (N) concentration of 8.9 g/m^3 the N applied at the recommended hydraulic loading is equivalent to 1.7 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 120 days of full irrigation the N loading would be in the order of 200 kg N/ha/y which is in-line with the surrounding rural land use. 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 Donald's Creek.

6 SITE ASSIMILATIVE CAPACITY AND CONCLUSIONS

The site investigation has indicated that in general the Site's soils are suited to the discharge of wastewater. Groundwater elevation is likely to limit the number of days per year that irrigation can occur. The site is capable of assimilating up to 19 mm/d of FWWTP wastewater from an application event. At this rate of application the applied water, nutrients and contaminant should be assimilated by the soil of the site.

The irrigable area of the site is considered to be 8 ha. For a daily maximum application event the site is able to receive and assimilate 1,520 m^3 of wastewater. 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.

7 APPENDICES

Appendix A Figures
Appendix B Photos

APPENDIX A

Figures

LOWE Environmental Impact

Figure 1: Site Location

Scale:	Not to scale		
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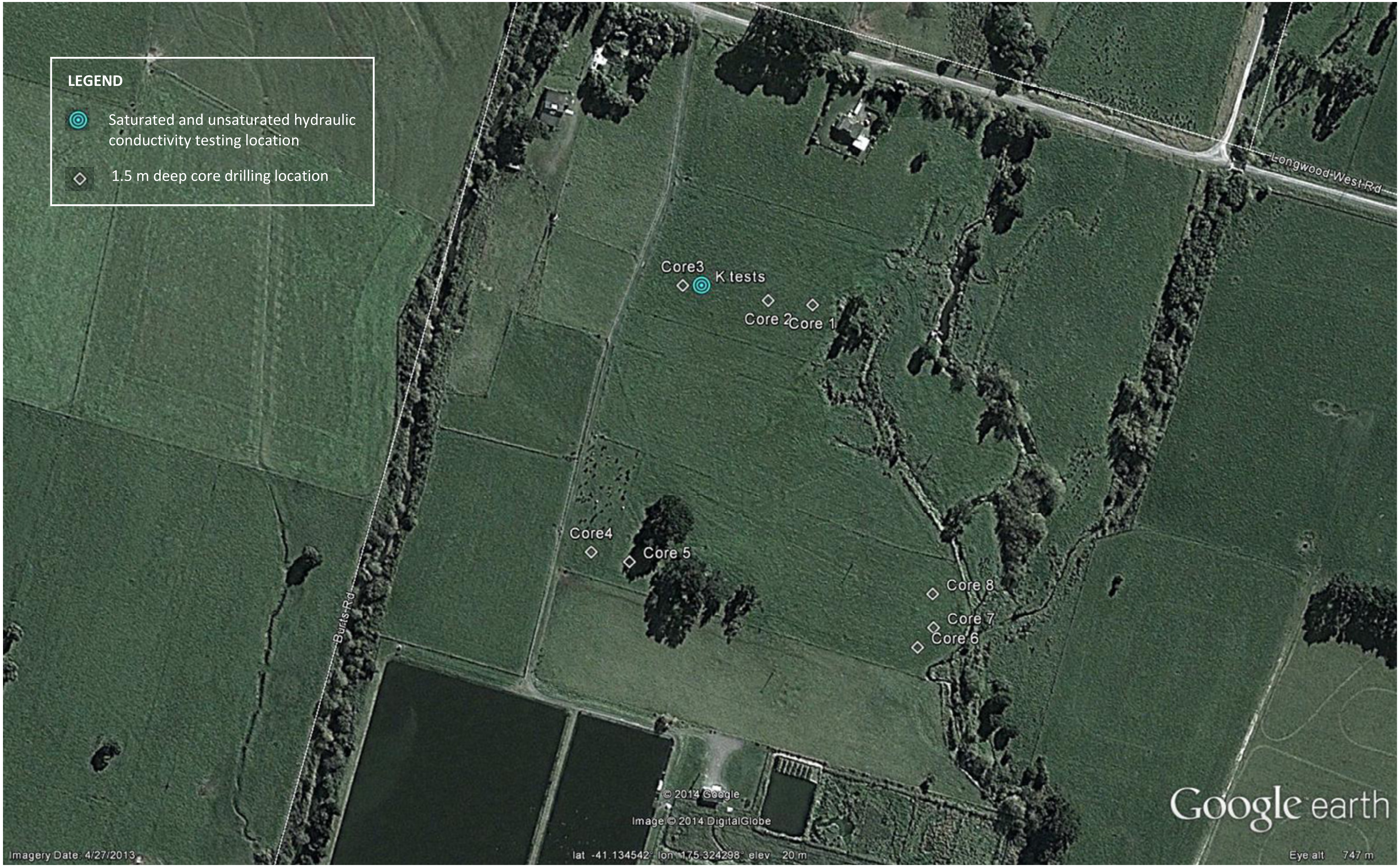

LOWE Environmental Impact

Figure 2 – Sampling Locations

Scale:	Not to scale		
Drawn by:	KB	Date:	02-04-2013
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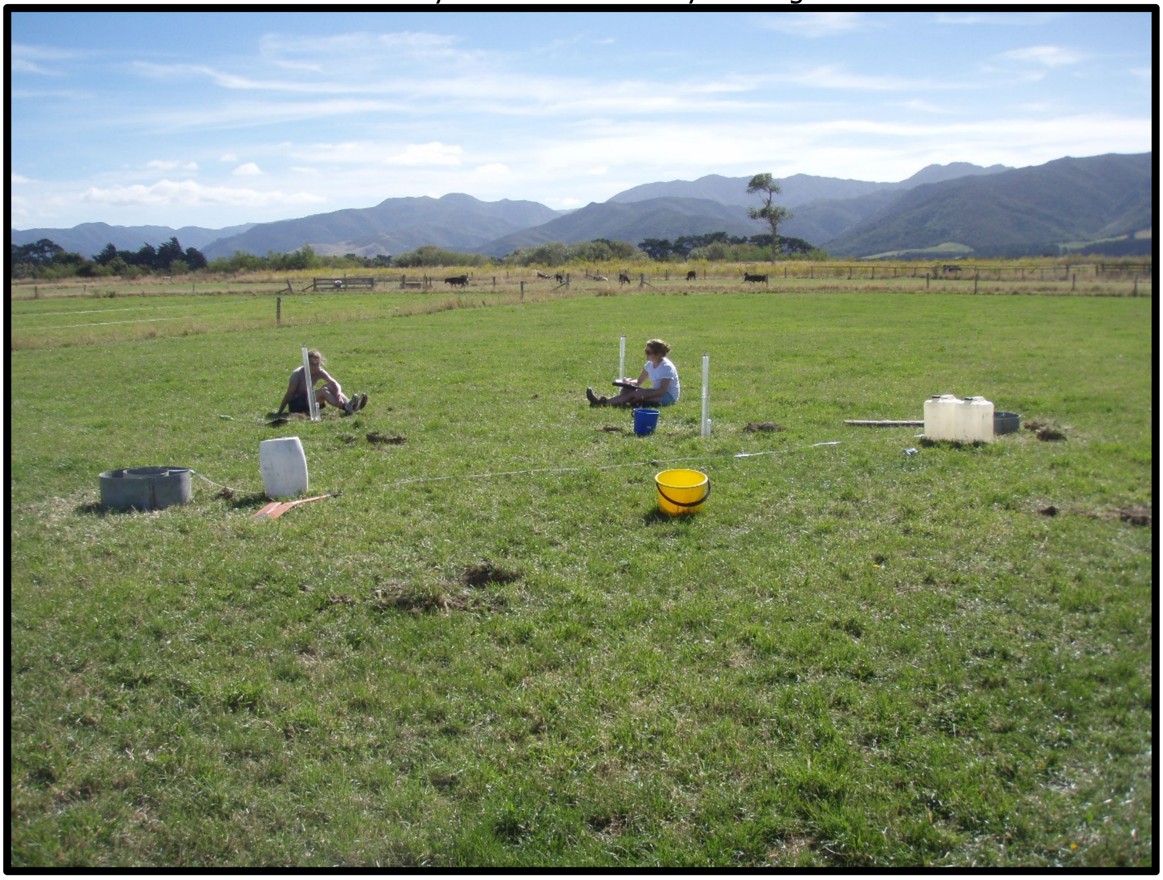
APPENDIX B

Photographs

Appendix B: Site Photos

Soil Cores

Soil Hydraulic Conductivity Testing



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A4: LEI, *Site Investigation – Hodder Farm, Featherston Wastewater Treatment Plant*, November 2015 – Site B

Site Investigation – Hodder Farm,

Featherston Wastewater Treatment Plant

Prepared for

South Wairarapa District Council

Prepared by

Lowe Environmental Impact

November 2015

Site Investigation – Hodder Farm, FWWTP
South Wairarapa District Council

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1 EXECUTIVE SUMMARY

South Wairarapa District Council (SWDC) currently has an application for consent to discharge Featherston wastewater treatment plant (FWWTP) effluent with Greater Wellington Regional Council (GWRC). Following the SWDC purchase of land near to the FWWTP the consent application was placed on hold to enable the development of a land discharge option.

This report characterises the land that has been purchased for land application and evaluates how the land can receive the FWWTP wastewater sustainably. The main output of this stage is a description of the assimilative capacity of the soil receiving environment.

The investigation includes:

- Prepare desktop information for the site, including published soil maps and existing reporting;
- Site walk-over to map key landform variations, management differences and waterways;
- Description of sub-surface soil conditions;
- In-situ testing of soil hydraulic properties;
- Sampling for testing of soil physical properties; and
- Review of soil fertility data.

Key observations for the Hodder Farm site are:

- The site is predominantly flat and gently sloping to the south, with micro-topographical features associated with movement of waterways across the area;
- The variation in elevation across the site is around a 10 m increase from the south to the north. Within paddock variation is around 1 m;
- Soil types reflect alluvial emplacement with finer grained soils in lower lying areas and coarser soils in slightly elevated areas. Soils are very gravelly to the north. In lower areas soils are coarser close to the streams;
- Waterways cross the farm, including natural (Donald's Creek, Otauira Stream), and constructed (Longwood Water Race, farm drains);
- Wet areas are present on the south-eastern side of Otauira Stream; and
- The farm was predominantly firm under foot during the site visit despite 14 mm rain during the site inspection, and 23 mm rainfall a week prior to the site visit.

Soil profiles were described at three locations across the site. Each profile was located near to a drain, to enable the profile depth to be maximised. A result of this is that saturated conditions were noted at 70 to 80 cm depth. The depth to groundwater is likely to be greater away from drains, which have a large catchment being the most downstream extent of the Longwood Water Race. Measured groundwater depth between the FWWP ponds and Donald's Creek varied between 0.88 m and 1.48 m below the soil surface.

Dominant soils described for the Hodder Farm site were:

- **Tauherenikau shallow stony silt loam** – Typic Firm Brown Soil; and
- **Ahikouka silt loam** – Typic Recent Gley Soil.

Unsaturated hydraulic conductivity, being a measure of how water moves through the soil under tension (no gravity drainage), varied from 8 mm/hr to 14 mm/hr. Saturated hydraulic conductivity, being a measure of how water moves through soil under gravity, was 133 mm/hr and 172 mm/hr for the gravelly soils and 33 mm/hr and 71 mm/hr for the finer soils.

Soil chemistry results are typical for a farm of this type. Mapped phosphorus retention is low to medium.

Key conclusions and recommendations for wastewater irrigation design are:

- The soil types observed on the site are suitable for irrigation of wastewater;
- The large difference between K_{sat} and K_{-40}, particularly on the coarser soils, indicates that excessive drainage may occur if K_{sat} rates are adopted for irrigation design. It is recommended that K_{-40} is used as an instantaneous application rate and for determination of a design daily irrigation rate
- Recommended design daily irrigation rate across the site varies from 58 mm/d to 101 mm/d. For ease of management it is recommended that a single application rate is adopted across the site. Adoption of a daily irrigation rate not exceeding 58 mm/d is recommended;
- Monitoring of macroporosity and Olsen P on a two to five year frequency is recommended;
- Additional groundwater information is needed to evaluate the management implications of shallow groundwater. However in the absence of additional groundwater data the use of a deferred application i.e. 58 mm should not be applied on every day to the site, is recommended; and
- Areas with artificial drainage will need to be managed to avoid bypass flow; and
- There are no limits to land management options based on the soil properties. Decisions regarding land management may need to be decided based on end-user requirement (e.g. Fonterra policies regarding wastewater irrigation to dairy farms).

2 INTRODUCTION

2.1 Background

South Wairarapa District Council (SWDC) currently has an application for consent to discharge Featherston wastewater treatment plant (FWWTP) effluent with Greater Wellington Regional Council (GWRC). Following the SWDC purchase of land near to the FWWTP the consent application was placed on hold to enable the development of a discharge programme incorporating land application.

The wider receiving environment for the discharge from FWWTP has been described and evaluated for the existing consent process. Additional information regarding the land receiving environment for the land purchased, known as Hodder Farm, is needed. SWDC has asked Lowe Environmental Impact to determine the assimilative capacity of Hodder Farm. Initial desktop investigation has previously been completed. The next stage is filed investigations of the Hodder Farm Site. This information will be used to assist with land application design and to determine land management options.

2.2 Scope

This report details the investigations carried out by Lowe Environmental Impact (LEI) on 3 and 4 November 2015. The report describes the following.

- Section 3 outlines the site investigation undertaken;
- Section 4 describes the Investigation Area;
- Section 5 describes the method and results of soil physical testing, including soil hydraulics;
- Section 6 describes the soil chemistry;
- Section 7 summarises groundwater testing; and
- Section 8 discusses the findings of the report and provides a summary.

Terms that are used throughout the report are:

- Investigation Area – referring to the wider area encompassing all the farm purchased by SWDC as defined in the Location Map Section 4.1;
- Site – referring to the location within a paddock at which sampling and testing was undertaken. Where appropriate, sites are also referred to as testing locations.

3 SITE INVESTIGATION DESCRIPTION

3.1 General

Characterisation of the Investigation Area soils and landforms is key to an understanding of the capability of the site to accept wastewater irrigation over the long term. The following gives an account of the field programme which was conducted over the period 3 – 4th November 2015.

A detailed property report prepared by New Zealand Real Estate (NZR, 2014) provided data that assists with this investigation. Some supplied information was assessed as part of the site investigation. The NZR (2014) report is referenced in this report. NZR (2014) refers to the Investigation Area as Otawira Dairy Farm.

3.2 Soil and Site Mapping

A field survey of soil type distribution was undertaken to truth the existing soil map shown in the Property Information (NZR 2014), and compared to published maps (S-Map and Fundamental Soil Layer). Surface water flow paths, water ways and wet areas were identified. Vegetation along the waterways was also identified. Three soil profiles were described that were considered representative of the site.

3.3 Soil Physical Testing

Textural tests were carried out at four sites and triplicate intact soil cores were taken from the surface soil (0 – 100 mm) and analysed for bulk density and macroporosity by Landcare Research at one site (detailed in Section 6.2). Other sites were too stony to enable intact core samples to be taken.

3.4 Soil Hydraulic Testing

Field measurement of soil saturated hydraulic conductivity was undertaken using double ring infiltrometers. Soil unsaturated hydraulic conductivity was also measured at the same locations using plate permeameters. The four sites identified for physical testing had 3 replicate saturated hydraulic conductivity tests and 2 replicate unsaturated hydraulic conductivity at each site.

4 DESCRIPTION OF INVESTIGATION AREA

4.1 Location and Surrounding Area

The main entry to Hodder Farm (the Investigation Area) is off Murphys Line, 1.6 km south of Featherston. The Investigation Area is in close proximity to a wide range of activities and landscape features. At it's northern edge, it is less than 1 kilometre from Featherston township. The Featherston WWTP and Featherston golf course are adjacent and Murphy's Line bisects the property. Otauira Stream and Donald's Creek are significant water courses through the property and Lake Wairarapa is just over 2 km south. The 2 water courses are identified by a variety of names and the ones used in this report are referenced from Land Information New Zealand (LINZ). Otauira Stream is also known as Abbotts Creek. Donald's Creek is sometimes identified as Boar Creek and it is important to recognise references to other names to recognise the range of activities that occur along this water course; including the former town water supply and the discharge from the treatment ponds.

Figure 4.1: Investigation Area (map developed from Greater Wellington Regional Council C/-Masterton, Carterton, and South Wairarapa District Councils)

4.2 Site Selection for Investigation and Sampling

Site selection for testing was guided by the soil maps sourced prior to the site investigation, and by the site walk-over.

Based on the landforms present and accepting management history is consistent across the farm, four (4) sites were identified as suitable and as representative of the Investigation Area as a whole. These are identified by squares in Figure 4.2. The triangles in this figure are the soil profile locations described in Section 5.2 and are located in convenient drains that provided suitable depiction of the area.

Most of the Investigation Area to the west of Murphys Line has sprinkler irrigation set up. It is understood that the irrigation is relatively new and has not been considered influential to differentiate the soil characteristics. The soil types have been the main criteria to help select sites for soil testing.

Figure 4.2 Soil Testing Sites

Paddock numbering used to describe the sampling locations is shown on a paddock map supplied by NZR (2014), and is given in Appendix A. Irrigation area is also shown on the same map. A brief description of key site details is as follows:

- Site 1 (Paddock 25): Represents the areas on the east side of Murphys Line and north of the drain where 'Profile 1' was located. These areas are slightly for elevated and gravelly. The land is flat with little variation across the landscape.

- Site 2 (Paddock 17): Represents the areas on the southern side of the drain and Site 1. The landform is similar to Site 1 but slightly more undulating and less gravel in the topsoil.

- Site 3 (Paddock 3): Represents the areas that slope towards Otauira Stream. This is slightly elevated to land around it with neighbouring paddocks away from the Stream at a lower elevation.

- Site 4 (Shed Paddock): Represents the areas on a slightly lower surface elevation, and flat. This area is most likely to drain into Donald's Creek by comparison to Site 3 draining into Otauira Stream.

5 SITE AND SOIL MAPPING

5.1 General

The site and soil mapping was undertaken to compare the on-site distribution of soils to 1:50,000 published maps and to identify features which will influence a wastewater discharge design.

5.2 Topography and Landforms

The Investigation area is located on an alluvial fan that extends from the near-by ranges to Lake Wairarapa. The Investigation Area has a gentle fall from north to south, with an elevation change of around 22 m to 12 m above mean sea level.

Within the Investigation Area the land is flat to gently sloping with a low hummock and swale topography (around 1 m), typical of the alluvial emplacement of material.

5.3 Comparison with Published Soil Maps

Prior to the site visit, information was gathered to direct the testing programme design. Soil maps were obtained for the site from NZR (2014), which reflect the farmers experience of the site (farm scale), and from the Landcare's LRIS Portal (1:50,000 map scale).

A site walk-over was conducted including description of soil profiles and smaller holes for delineation of soil boundaries. The site walk-over concluded that soil type distribution largely followed the pattern of distribution given in the NZR (2014) report. Some variation occurred with regard to the amount of gravel in the topsoil in the north-eastern areas of the Investigation Area. Figure %.1 shows the distribution of soils over the site.

Note on the paddocks adjacent to the golf course a dominant drain has been dug and large wet areas exist.

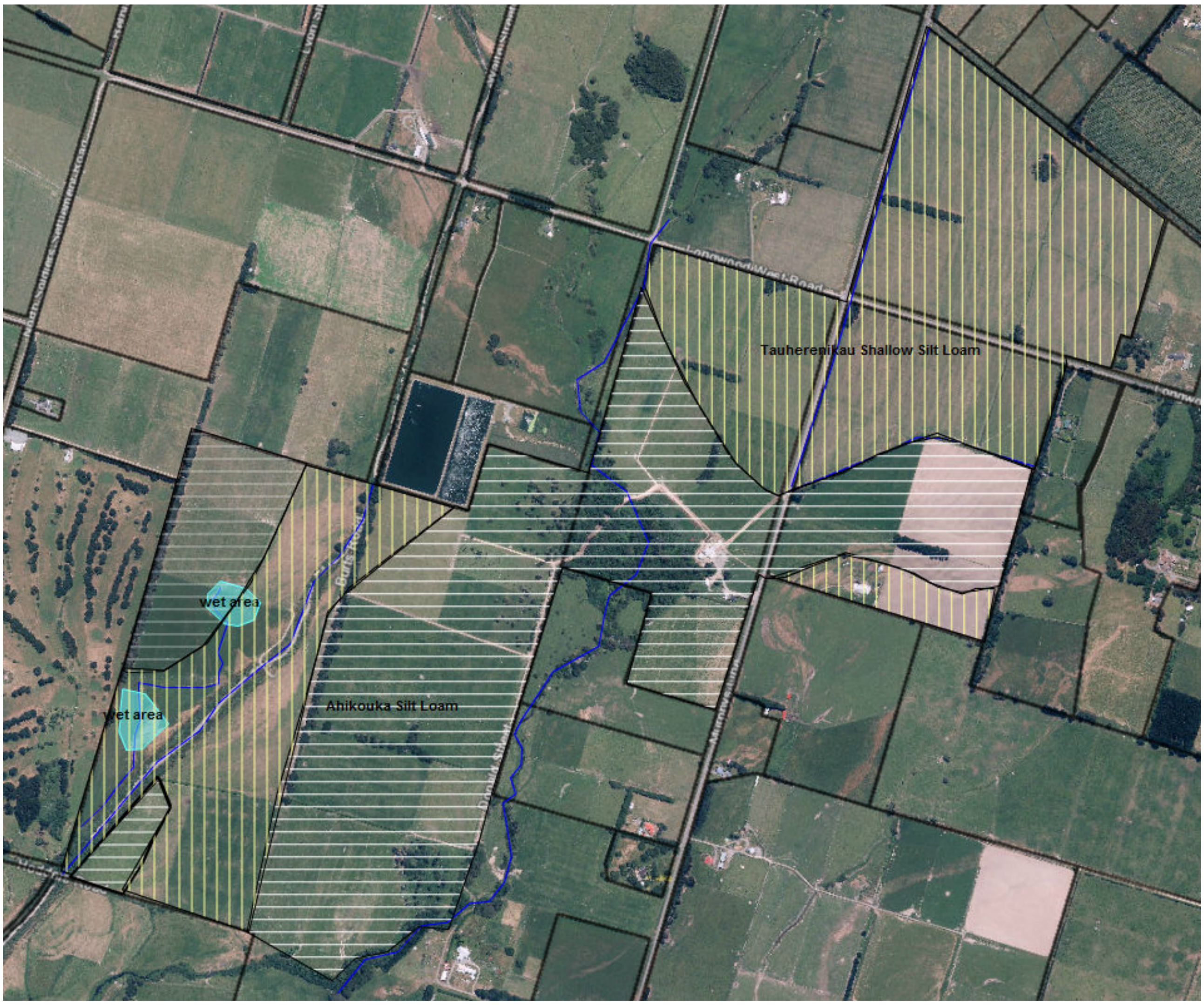


Figure 5.1: Soil Distribution

5.4 Soil Profiles

The soil was observed and described in accordance with Milne *et al.* (1995). Figure 4.2 shows the location of the soil profiles and Figure 5.2 presents the profiles described below. The weather conditions at the time of the inspection were very windy, then rain and cold. The soil profile was slightly moist.

All three profiles had similar general descriptors as listed in the table below. The soil profiles are similar to the soil profiles that represent the Tauherenikau shallow stony silt loam and the Ahikouka silt loam that is identified for the farm (NZR, 2014). Variations to these descriptions did occur particularly regarding higher clay content. This is likely to reflect the variability across the area resulting from surface water changing pathways and depositing material across the landscape. The longer standing time of water over an area will cause the greater percentage of finer particles deposited.

Table 5.1: Soil Profile Descriptors

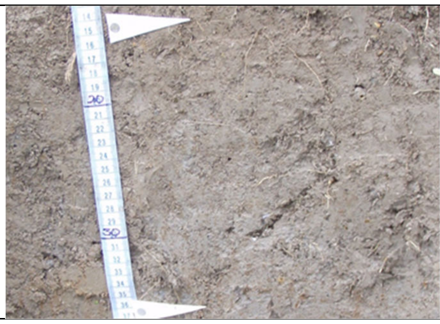
Land use	Intensive pasture dairying
Date sampled	04/11/2015
Land use history	Intensive pasture and maize
Present vegetation	Pasture
Slope degrees	00 - 03
Landform	Fan
Annual rain (mm)	950 - 1050 mm
Elevation (m)	0 m
Parent material	Hard sandstone
Sampled by	SC

Figure 5.2: Soil Profiles: Site 1; Site 4; Site 5

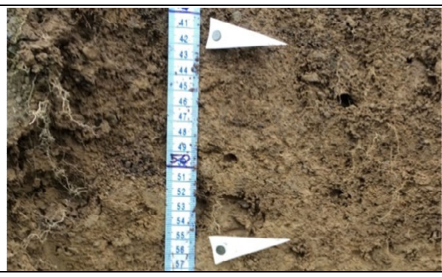
Soil	Tauherenikau Shallow Stony Silt Loam
	As identified in property report
Location	**GPS 882 Site 1 drain Murphys Line**
Drainage	Moderately well drained (S map, Landcare)
Topsoil depth (cm)	10
Limiting horizon	none

Horizon	**Depth (cm)**	**Description**	**Image**
A	0 - 10	Very dark grey (10YR 3/1) silty clay; slightly gravelly; very coarse gravel; slightly sticky; very plastic; weak soil strength; many fine roots; indistinct wavy boundary; dry.	
B	10 - 30	Very dark grey (10YR 3/1) silty clay; very slightly gravelly; slightly sticky; very plastic; weak soil strength; many fine roots; indistinct wavy boundary; dry.	
B	30 - 50	Very dark greyish brown (10YR 3/2) silty clay; very gravelly; very coarse gravel; slightly sticky; very plastic; weak soil strength; common fine roots; indistinct wavy boundary; moist.	
B	50-70	Very dark grey (10YR 3/1) silty clay; very gravelly; very coarse gravel; slightly sticky; very plastic; weak soil strength; abundant thick roots; indistinct wavy boundary; moist.	
B	70+ Water level	Mottling only at water level	

Soil	Ahikouka Silt Loam
	As identified in property report
Location	**GPS 876 Site 4 (Area similar to Site 4) drain to Donald's Creek**
Drainage	Poorly drained (S map Landcare)
Topsoil depth (cm)	10
Limiting horizon	none

Horizon	**Depth (cm)**	**Description**	**Image**
A	0 - 10	Dark greyish brown (10YR 4/2) sandy clay; slightly gravelly; fine gravel; slightly sticky; very plastic; weak soil strength; friable; many fine roots; moderately moist; no mottling.	
AB	10 - 15	Dark greyish brown (10YR 4/2) sandy clay; slightly gravelly; coarse gravel; slightly sticky; very plastic; weak soil strength; friable; many fine roots; moderately moist; no mottling.	
B	15 - 36	Dark yellowish brown (10YR 4/6) sandy clay; slightly sticky; very plastic; weak soil strength; friable; many fine roots; moderately moist; few mottles.	
B	36 - 48	Dark greyish brown (10YR 4/2) silty clay; slightly sticky; very plastic; weak soil strength; friable; few roots; moderately moist; abundant mottles.	
B	48 +	few roots; wet; many mottles.	

Soil	Ahikouka Silt Loam
	As identified in property report
Location	**GPS 877 Site 5 (Area similar to Site 3 with stones near surface) drain to Abbots Creek**
Drainage	Poorly drained (S map Landcare)
Topsoil depth (cm)	28
Limiting horizon	none

Horizon	Depth (cm)	Description	Image
A	0 - 28	Very dark grey (7.5YR 3/1) sandy clay loam; very gravelly; medium gravel; slightly sticky; very plastic; weak soil strength; very friable; many fine roots; slightly moist; no mottling.	
AB	28 - 41	Very dark grey (7.5YR 3/1) sandy clay loam; very gravelly; medium gravel; slightly sticky; very plastic; weak soil strength; very friable; many fine roots; slightly moist; no mottling.	
B	41 - 56	Brown (7.5YR 4/3) sandy clay loam; very gravelly; coarse gravel; slightly sticky; moderately plastic; weak soil strength; many fine roots; slightly moist; few mottles.	
B	56 - 70	Dark yellowish brown (7.5YR 4/4); sandy clay loam; very slightly gravelly; coarse gravel slightly sticky; very plastic; slightly firm soil strength; very friable; few roots; moderately moist; medium common mottles light.	
B	70+	Water level at 80 cm possibly perched on clay, not actual groundwater level; fine gravel; non-gravelly; Few roots; coarse abundant mottles.	

5.5 Water Courses

There are two main water courses that cross the Investigation Area: Otauira Stream and Donald's Creek. Both water courses have a consistent baseflow of water throughout the year in the vicinity of the Investigation Area. There are several drains that have been dug throughout the property and the NZR report (2014) indicates artificial drainage has recently been installed on 8 hectares on the paddocks at the most south east corner of the Investigation Area. The drains over the north east side of the farm are part of the regional Longwood Water Race Scheme. The drains appear to be dredged on a regular basis to keep clear due to the observation of soil mounded on the drain edge. Large wet areas exist on paddocks west of Otauira Stream. All wet areas, drains and streams are identified on the Figure 5.3.

Otauira Stream is fenced off with a 20 m buffer each side. There is access into this buffer area with electric gates but it does not appear animals have entered for some time. A race runs along one embankment inside the 20 m buffer. Vegetation in this buffer area includes willow, lupin, gorse and fennel.

Figure 5.3: Water Courses and Wet Areas

6 SOIL PHYSICAL HEALTH

6.1 General

Soil physical properties assist to predict the resilience of soils to management and inputs.

6.2 Soil Density and Porosity

Soil physical properties are given in Table 6.1. The 0 – 100 mm intact soil core samples were only collected from Site 2 because the stones at other sites limited the ability to collect samples.

Table 6.1: Soil Physical Properties

Testing location	Particle density (g/cm^3)	Dry bulk density (g/cm^3)	Porosity (%)	Macroporosity, -5 kPa (%)
Site 2 sample 1	2.60	1.17	55	10
Site 2 sample 2	2.60	1.24	52	9
Site 2 sample 3	2.62	1.27	52	8

The physical properties between each sample are relatively consistent as expected from the same location.

Bulk density is around 1.2 g/cm^3 as would be expected for a Recent dominated soil such as occurs over the Investigation Area. The range of 0.7 – 1.4 g/cm^3 is designated as typical for Recent soils (Sparling et al. 2008). The bulk density reflects organic matter and mineral influence on the drainage and aeration of a soil. This young soil has limited organic matter development so the bulk density is more likely to reflect the mineralogy.

The macroporosity just falls inside the 'acceptable' range as allocated by Sparling et al. (2008). The acceptable range of 8 – 30 % indicates sufficient aeration for productive growth and water capillarity without excessive drainage. Site 2 soil that lies at the lower end of this macroporosity range suggests careful management of the soil to limit structural damage will be important.

The physical properties at Site 2 are not likely to limit the use of low-rate irrigation.

6.3 Soil Hydraulic Testing

The soils ability to retain or drain applied water is governed by the infiltration rate and permeability of the soil. Soil hydraulic conductivity (K) is a measurement of infiltration and permeability. An understanding of the soil's hydraulic conductivity is needed to enable the development of application rates suitable for the long term sustainability of an irrigation regime.

6.3.1 Soil Hydraulic Conductivity Testing Methods

Testing locations for soil K were chosen to represent the two soil types occurring over the Investigation Area.

Saturated Hydraulic Conductivity

For determination of the soils ability to receive wastewater to the soil surface at a high rate, soil saturated hydraulic conductivity (K_{sat}) was measured using *in-situ* double ring infiltration test (ASTM D3385-09). Triplicate tests were performed at each site.

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. Timed recording then measures the rate of water level fall in the inner ring over time to determine K_{sat}. Results of the K_{sat} testing are given in Table 6.2 below.

Unsaturated Hydraulic Conductivity

Unsaturated K was measured using plate permeameters 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.

The hydraulic conductivity at $K_{-40\ mm}$ was analysed by Landcare Research using the one intact soil core that was taken from the surface soil (0 – 100 mm) at Site 2.

6.3.2 Soil Hydraulic Conductivity Results

Results of the soil K testing are given in Table 6.2. Site 2 had only one plate $K_{-40\ mm}$ test carried out due to high wind conditions causing the apparatus to fall over. For this reason no standard deviation could be determined. The limited data must be considered as a general guide only.

Table 6.2: Soil Hydraulic Conductivity (K) Results

Testing location	Soil saturated hydraulic conductivity, K_{sat} (mm/hr)	Soil unsaturated hydraulic conductivity, K_{-40} (mm/hr)	Maximum daily irrigation rate, wastewater (mm/d)
Site 1	172 ± 31	10 ± 0.5	72
Site 2	133 ± 50	14	101
Site 3	71 ± 22	8 ± 3	58
Site 4	33 ± 14	8 ± 5	58

Both the K_{sat} and the $K_{-40\ mm}$ were similar at Sites 1 and 2; and similar at Sites 3 and 4, although Site 4 was significantly lower compared to all other sites. Sites 3 and 4 with K_{sat} around 50 mm/hr correspond to moderate permeability topsoil whereas Sites 1 and 2 at around 150 mm/hr indicate a faster rate of infiltration.

To establish a maximum irrigation rate that can be received by the soil over a long term without causing soil damage, a conversion needs to be made to allow for the application of "enriched" water which has elevated levels of other constituents (cations, anions, complex organic molecules). A value of 30 % of the K_{-40mm} has been adopted in-line with the recommendations of Crites and Tchobanoglous (1998) to provide a maximum irrigation rate. It should be noted that this maximum rate only considers the long term protection of soil health. In the case of the Featherston soils, a further consideration is the protection of groundwater and surface water that groundwater discharges to.

The intact core from Site 2 provided the results as presented in Table 6.3. Typically results produced from the laboratory analysis produce faster rates of hydraulic conductivity due to the size of the sample tested, resulting in a higher irrigation rate reommendation. However it is recommended to accept more conservative irrigation rates to avoid potential loss to groundwater.

Table 5.3: Site 2 Hydraulic Conductivity

Testing location	Grav. Water content (-5 KPa) (%w/w)	Vol. water content (-5 KPa) (%v/v)	Grav. Water content (%w/w)	Vol. water content (%v/v)	Hydraulic conductivity K_{-40} (mm/hr)
Site 2 sample 1	39	45	32	37	40
Site 2 sample 2	34	43	29	37	14
Site 2 sample 3	35	44	29	37	20

The hydraulic conductivity indicates a wide range of variability from the four sites analysed in the field and results from the laboratory analysis from Site 2. The results suggest the areas allocated with the two different soil types do not need to be treated with different irrigation rates. Decisions regarding irrigation rates will need to take into account this variability and select conservatively to accommodate areas that have the most limiting characteristics.

7 SOIL CHEMISTRY

7.1 Soil Chemistry Sampling

Sampling of soil for soil chemical analyses was carried out by the farms Ballance fertiliser rep in October 2013 and July 2014. The results of the tests were supplied with the NZR report (2014). This section provides an evaluation of soil analysis results, and their implications for wastewater irrigation.

7.2 Soil Chemistry Results

The results from soil testing are given in Table 6.1 and the analysis reports can be found in the NZR report (2014). It is assumed numbers relate to paddocks. These numbers were referenced on the NZR (2014) paddock map (Appendix A). Samples were also taken at Sites identified as 43 +44 and 70 + 71 but these are not identified on the paddock map.

Soil samples were taken from 0 - 75 mm depth that is most typical of pastoral soil testing.

Results from two sampling occasions are tabulated in Table 7.1.

Table 7.1 Soil Sampling Results

Paddock	Year	pH	Olsen P	SO_4-S	K	Ca	Mg	Na	CEC	BS
units		pH units	mg/L	mg/kg	me/100 g					
4 5	2013	5.9	37	4	0.25	18.3	1.45	0.14	30	67
	2014	5.9	32	6	0.24	17.5	1.25	0.17	29	68
14 15	2013	5.6	21	4	0.23	9.7	1.10	0.11	21	54
	2014	5.6	20	3	0.26	9.3	1.06	0.1	20	53
19 24	2013	6	36	3	0.41	13.1	2.36	0.21	25	64
	2014	6	24	4	0.57	12.7	2.12	0.22	26	61
30 31	2013	5.8	24	4	0.32	9.6	1.56	0.18	19	60
	2014	5.8	24	3	0.33	7.6	1.36	0.14	17	65
43 44	2013	6	29	4	0.45	11.1	1.77	0.19	21	63
	2014	6	27	3	0.31	10.3	1.79	0.15	21	61
70 71	2013	5.7	26	3	0.30	11.4	1.50	0.14	20	66
	2014	5.7	21	4	0.34	9.1	1.13	0.11	18	60

pH
All Sites recorded pH units between 5.6 to 6, which are acceptable levels for pastoral soils. Below 5.8 is getting low and this occurred only at paddocks 14 + 15 (Site 1) and 70 + 71 with 5.6 pH units. Each Site maintained the same pH value for the two years they were sampled.

Soil Phosphorus
Results of soil testing for available phosphorus (Olsen P) ranged between 21 mg/L to 37 mg/L which are adequate for pasture. Sites recording above 35 mg/L are getting high and occurred in 2013 at paddocks 4 + 5 and 19 + 24. Paddocks 30 + 31 (Site 1) maintained the same Olsen P

in both years sampled whereas all other samples dropped slightly but not below the optimum production range.

No phosphorus retention data was found for the Investigation Area therefore data allocated to the area as 'typical average' has been adopted using Landcare S-Map reports. These maps allocate a low to medium phosphorus retention for the Investigation Area. The farm area east of Murphys Line has topsoil with low phosphorus retention at an average of 19% and west of Murphys Line has topsoil with medium phosphorus retention at an average of 35%. This P retention reflects the adequate Olsen P concentrations identified in the soil tests.

The limited capacity of the soil to retain phosphorus alerts to the need for conservative nutrient loading from the wastewater irrigation to avoid losses of P groundwater.

Soil Sulphate

Sulphate sulphur (SO_4-S) soil concentrations are very low with the maximum reached at paddock 4 +5 (Site 3) with 6 mg/kg but most Sites varied between 3 and 4 mg/kg over the 2 years sampled. Typically pastoral soils should be between 10 and 12 mg/kg SO_4-S.

7.3 Cation Status and Cation Exchange Capacity

The cation exchange capacity is moderate across the farm. Results for the soil cation status are shown in Figure 6.1. Base saturation (the proportion of soil exchange sites which are occupied by cations) was 60 to 68 % for all Sites with the exception of paddocks 14 + 15 being lower at 54 %.

High levels of exchangeable calcium (Ca) and magnesium (Mg) were measured across the site, which may suggest the farm has had regular lime applications over time. Potassium (K) levels are very low over much of the farm. Existing sodium (Na) values are typical.

7.4 Exchangeable Sodium Percentage

The exchangeable sodium percentage (ESP) in the soil is often of interest for wastewater irrigation schemes. There is currently no wastewater irrigated to the farm (apart from dairy effluent) and so this measurement reflects an ESP baseline.

Based on the cation data supplied in Table 7.1, ESP for the Investigation Area is 1.1% on average. Less than 6% is non-sodic. There is currently no risk of soil damage due to sodium in the soil.

ESP is not expected to be a concern for the Investigation Area since the soil of the site is not saline, the soil mineralogy doesn't include appreciable amounts of sensitive clays, and because municipal wastewater is not known for high sodium levels.

7.5 Summary of Soil Chemistry

The key implications of the soil chemical analysis results are:

- The moderate to low capacity for phosphorus sorption means that phosphorus may leach to groundwater if concentrations increase significantly;
- The SO_4-S in the topsoil is very low. This may indicate there is drainage of sulphates through the soil profile and also reflect the potential loss of nitrates to groundwater. Further investigation may be necessary to qualify this;
- The nitrogen status is unknown for the Investigation Area;

- Cation exchange capacity is moderate for most Sites;
- Sodium and ESP is not expected to be a concern at the Investigation Area.

8 GROUNDWATER

8.1 General

A groundwater investigation was not part of the scope for the Site Investigation, however, piezometers were noted on the site and the opportunity to sample them was taken. Some observations follow.

8.2 Site Observations relating to Groundwater

Mottling in the soil profile noted in the southern sites (and in previous investigations of an adjacent site) suggest a high seasonal groundwater table (~1 m depth). During description of soil profiles standing water was encountered at depths < 1 m. However, at these locations, soils observed were near to drains with large catchment areas. This suggests standing water may be related to water in drains and depth to groundwater may increase with increasing distance to the drains.

8.3 Groundwater Sampling

It was noted that the Site contained what appeared to be groundwater monitoring bores or piezometers. Further investigation and, if possible, sampling of the piezometers was decided on. The appearance of the piezometers was that they were in good condition and properly installed. At least one piezo was not capped (the cap was on the ground nearby), and therefore caution must be taken in the interpretation of the results. No information regarding their purpose, installation or monitoring was able to be obtained.

8.3.1 Sampling Locations

Piezometer locations are shown on Figure 8.1 below. A total of 3 samples were taken.

Figure 8.1: Piezometer Locations

8.3.2 Method and Analysis

Samples were extracted in accordance with best practice. Standing water level and total bore depth was measured using a contact probe. A peristaltic pump was used purge the piezos and extract samples. Three bore volumes were purged from the piezometers prior to taking a sample for analysis. Samples were pumped straight to the sampling containers which were to be sent to the analysing laboratory.

Before sampling and between locations the inside and outside of tubing was cleaned using decon and distilled water rinse.

8.3.3 Results

Table 8.1 gives the analysis results.

Table 8.1: Groundwater depth and quality near the site

Bore	Total depth	Depth to water	Temp	Conductivity	Chloride	Ammoniacal Nitrogen	Nitrate Nitrogen	Dissolved reactive Phosphorus	E. coli
	m	m	°C	mS/m @ 25°C	g/m³	g/m³	g/m³	g/m³	MPN/ 100 mL
Piezo 1	4.40	1.34	11.0	12.4	17.4	0.034	1.47	0.029	< 1
Piezo 2	4.54	1.48	11.3	12.1	17.1	0.017	1.24	0.026	1
Piezo 3	4.14	0.88	11.5	12.2	17.3	0.018	1.68	0.019	2

8.4 Summary of Groundwater Analysis

The water quality results suggest that groundwater quality in the vicinity of the site is not adversely impacted by the current activities. Measured values are far below concentrations in the nearby ponds. The quality of the groundwater is unlikely to prevent any use.

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

The soil and site investigation has led to the following conclusions:

- The soil types observed on the site are suitable for irrigation of wastewater;
- The large difference between K_{sat} and K_{-40}, particularly on the coarser soils, indicates that excessive drainage may occur if K_{sat} rates are adopted for irrigation design; and
- There are no limits to land management options based on the soil properties. Decisions regarding land management may need to be decided based on end-user requirement (e.g. Fonterra policies regarding wastewater irrigation to dairy farms).

9.2 Recommendations

Recommendations based on the Site Investigation are as follows:

Irrigation

- A conservative application rate is applied due to the variability across the site and low P retention at some locations;
- One application rate for the whole Investigation Area;
- K_{-40} should be used as an instantaneous application rate and for determination of a design daily irrigation rate;
- For ease of management it is recommended that a single application rate is adopted across the site. Adoption of a daily irrigation rate not exceeding 58 mm/d is recommended; and
- Areas with shallow groundwater or artificial drainage will need to be managed to avoid rapid drainage. This can be achieved using deferred irrigation.

Farm Management

- Monitoring of phosphorus levels every two years;
- Evaluate macroporosity at least every five years, particularly as the macroporosity measured was at the lower end of the acceptable range at 8 to 10 %. Should a reduction in macroporosity occur over time, then mitigation may be required. This may include the avoidance of irrigation of a site following grazing for at least 48 hours and avoiding grazing for at least 24 hours following irrigation; or monitoring soil moisture and inclusion of a soil moisture trigger to allow irrigation to occur. It should be noted that these measures are not required at this time based on the investigation outcomes.

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11 APPENDICES

Appendix A: Paddock & Irrigation Map

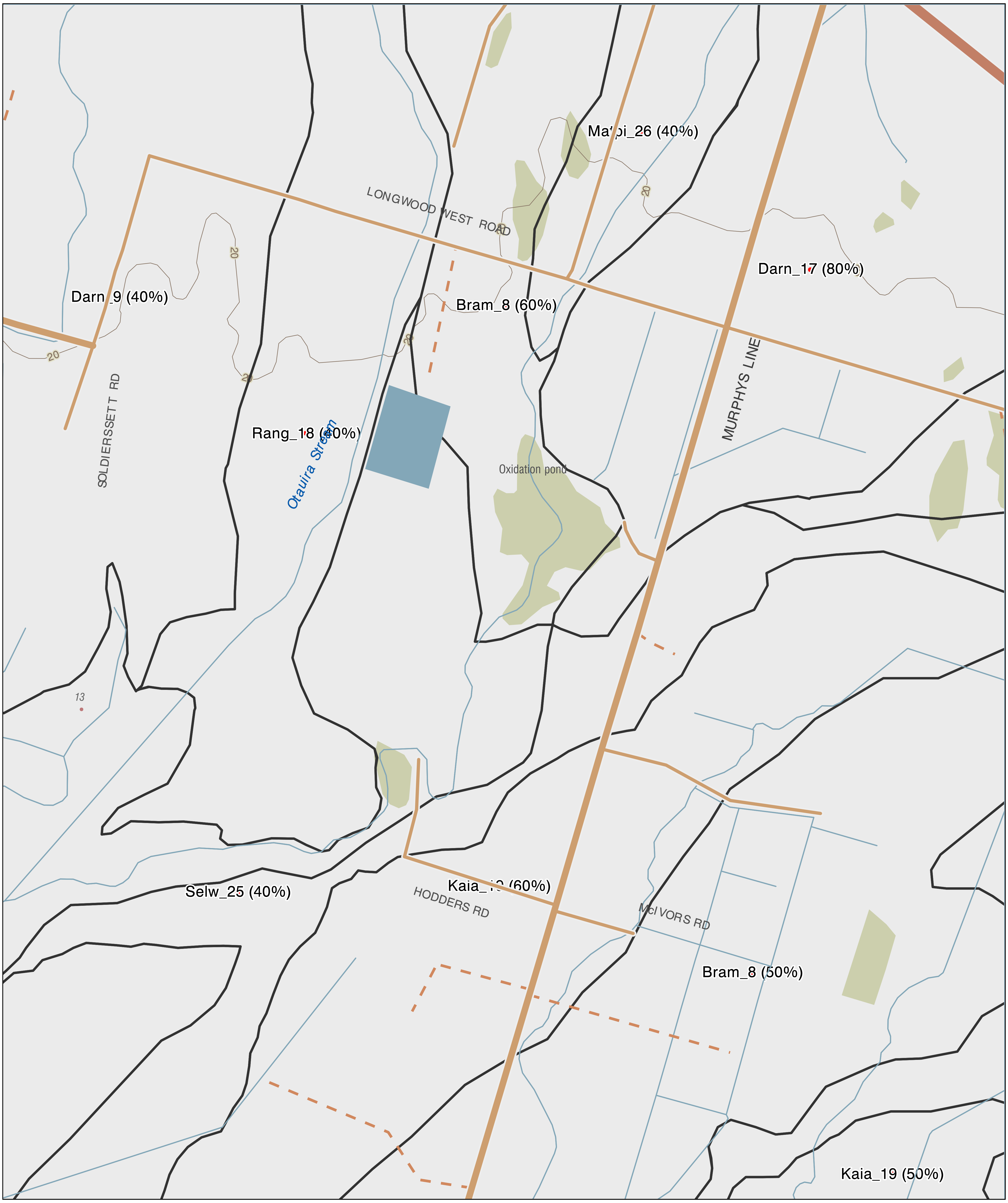
APPENDIX A

Paddock & Irrigation Map

Paddock Map and Irrigation Area

MOTT MACDONALD

A5: Landcare 1:10,000 S-Map soil map



S-mapOnline
Fast, simple access to New Zealand soils data

Landcare Research
Manaaki Whenua

Scale: 1:10,000

0 100 200 300 400m

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Printed: 13:11:13 PM Thu, 25 May 2017

Legend

S-map Polygons & Labels

S-map soil data

S-mapOnline
Fast, simple access to New Zealand soils data

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A6: Compliance of Donald Creek and Abbot Creek with the Proposed Natural Resources Plan and Freshwater Plan

MOTT MACDONALD

Assessment of Donald Creek and Abbott Creek with the Greater Wellington Freshwater Plan

Water quality standard	Compliance (N-No; Y-Yes;)				
	Existing	Stage 1A	Stage 1B	Stage 2A	Stage 2B
6. A8.1 water quality standards established in sections 70 and 107 of the Act					
7. The production of conspicuous oil or grease films, scums or foams, or floatable or suspended materials	N	N	Y	Y	Y
8. Any conspicuous change in the colour or visual clarity. *(See Section 5.2.2 in the main body of this Letter for discussion relating to effects on visual clarity)*	N	N	Partially compliant, low frequency of exceedance during summer.	Partially compliant, low frequency of exceedance during summer.	Fully compliant in summer, potential for some short-term exceedances during winter in some years.
9. Any emission of objectionable odour.	Y	Y	Y	Y	Y
10. The rendering of freshwater unsuitable for consumption by farm animals.	Y	Y	Y	Y	Y
11. Any significant adverse effects on aquatic life.	N	N	Y	Y	Y

MOTT MACDONALD

Assessment of Donald Creek and Abbott Creek with the PNRP's Policy 71 Assessment

Water quality standard	Compliance				
	Existing	Stage 1A	Stage 1B	Stage 2A	Stage 2B
a. below the discharge point compared to above the discharge point					
i. a decrease in the QMCI of no more than 20%, and	N	N	Y	Y	Y
ii. a change in pH of no more than ±0.5, and	Y	Y	Y	Y	Y
iii. a decrease in water clarity of no more than: 33% in River classes 2 to 6, and	N	N	Partially compliant, low frequency of exceedance during summer.	Partially compliant, low frequency of exceedance during summer.	Fully compliant in summer, potential for some short-term exceedances during winter in some years.
iv. a change in temperature of no more than: 3°C in any other river, and	Y	Y	Y	Y	Y
b. a 7-day mean minimum DO concentration of no lower than 5mg/L, and	Y	Y	Y	Y	Y
c. a daily minimum DO concentration of no lower than 4mg/L.	Y	Y	Y	Y	Y

A7: River Lake QMCI S92 response

Mott MacDonald New Zealand
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Memo

TO	Sarah Sunich (Mott MacDonald)
COPY	
FROM	Keith Hamill (River Lake Ltd)
DATE	19 May 2017
FILE	
SUBJECT	**Featherston WWTP discharge application: response to section 92 Further Information request. QMCI**

Dear Sarah

Background

This memo provides information to address the first bullet point of item 5 of the request for further information from Greater Wellington Regional Council (GWRC) with respect to the Assessment of Environmental Effects (AEE) for the Featherston Wastewater Treatment Plant (WWTP).

Item 5 requested that the applicant expand on Table 13b of the AEE and provide a clear assessment against the standards in the Regional Freshwater Plan and the Proposed Natural Resources Plan (PNRP) for each stage. "*For example – assessment of existing ecological data against the 20% QMCI change (PNRP Policy P71). Is this standard currently met downstream of the zone of reasonable mixing? Will it be met under the various phases of the proposal (accepting this will have to be based on expert opinion)? As it is the ecological assessment report (Appendix 11b) makes reference to significant changes etc, but no specific reference to this standard. Given this standard is in the PNRP, we feel an assessment should be provided and it would be useful to compare all existing data to the standard*;"

PNRP Policy P71 Quality of discharges states:

> "*The adverse effects of point source discharges to rivers shall be minimised by the use of measures that result in the discharge meeting the following water quality standards in the receiving water after the zone of reasonable mixing:*
>
> *a. below the discharge point compared to above the discharge point:*
>
> *i. a decrease in the Quantitative Macroinvertebrate Community Index of no more than 20%, and …*"

Response

Appendix 13B of the AEE (Mott MacDonald) summarised the effects of the discharge according to different policy requirements. This summary stated that the discharge will not meeting the QMCI criteria (P71 a (i)) during stages 1A, but will meet the QMCI criteria during stages 1B, 2A and 2B.

This summary was based on information in the ecological reports. I have provided further discussion on the QMCI index below but note that QMCI is just one measure of ecological health and this discussion should be read in the context of the ecological reports (Hamill 2017). It should also be noted that the statistical test applied by Hamill (2017), the Equivalence Test defined a 'practically important' change as +/-20%. This allows a statistical comparison with the QMCI Rule in Policy 71 for surveys where replicate samples have been collected.

Donald Creek

Sampling of Donald Creek during late summer of 2010 and 2013 found that the discharge caused a significant reduction of all macroinvertebrate metrics (Coffey 2010, 2013). In April 2010 the QMCI scores were 4.3 and 2.9 for the upstream and downstream sites respectively i.e. a 33% lower (worse) at the downstream site. In March 2013 the average QMCI score was 3.7 (4.6 and 2.8) and 2.25 (2 and 2.5) for the average of the two upstream and downstream sites respectively, i.e. 39% lower for the average of the downstream sites.

The ecological surveys undertaken during spring (October and November 2016) found the effect of the discharge to be relatively mild compared to those observed during late summer (2010 and 2013). The macroinvertebrate community had slightly lower MCI scores at the two downstream sites (up to 7% lower), but no consistent upstream to downstream difference in QMCI scores.

In October 2016 the average QMCI was 3.8 and 3.7 for the two upstream sites and two downstream sites respectively – 3% lower downstream. There was no significant difference in the QMCI scores between the combined upstream and downstream sites. The lowest QMCI score was at the 100m upstream site (Figure 1).

In November 2016 the average QMCI was 4.3 and 3.9 for the two upstream sites and two downstream sites respectively – 9% lower downstream. There was not a consistent upstream downstream difference in QMCI scores. The site 60m downstream had a QMCI score of 3.2, which was 25% lower the upstream sites; and the site 650m downstream had a QMCI score of 4.5, which was 5% higher than the upstream sites. Despite a decline in QMCI at the 60m downstream site, the abundance of sensitive mayfly taxa was similar to the most upstream site (see also discussion in Hamill 2017).

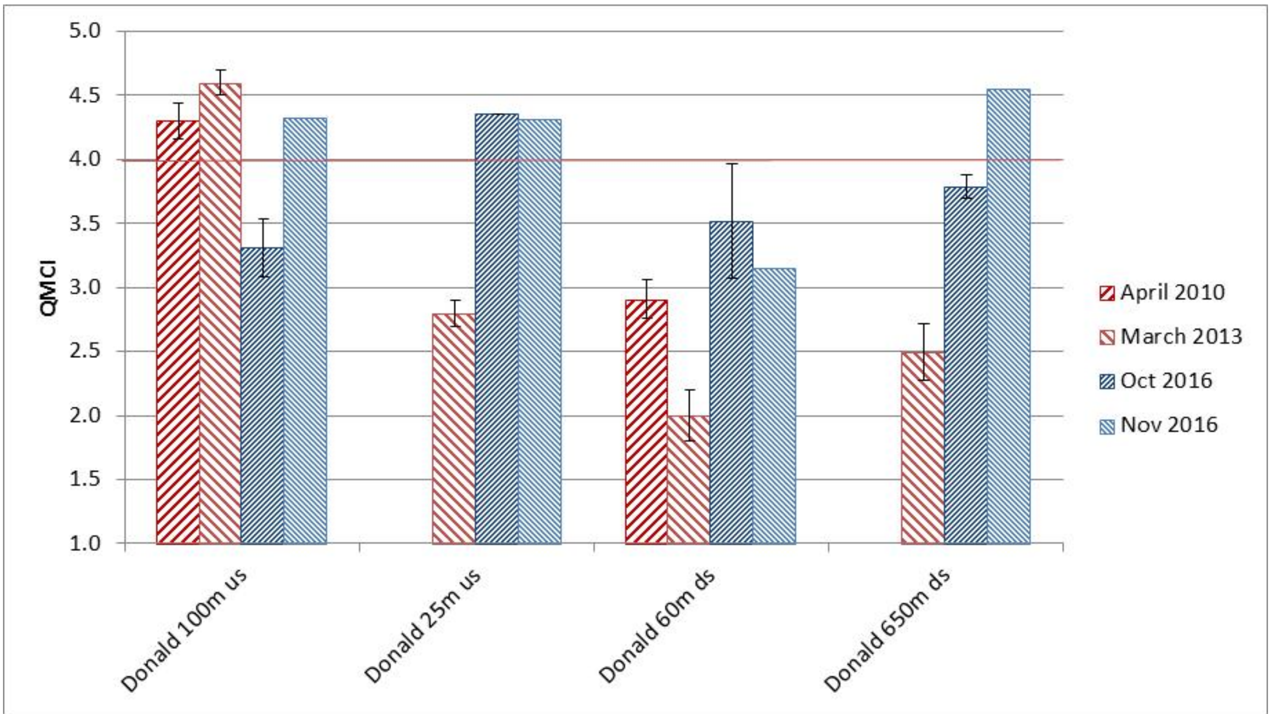

Figure 1: Median MCI and QMCI scores for Donald Creek for surveys in April 2010, March 201, October 2016 and November 2016 (Coffey 2010, 2013). The error bars show one standard deviation of replicate samples. No replicates were collected in November 2016. The red horizontal line indicates scores indicative of 'poor' water quality /habitat.

Otauira Stream spring surveys 2016

The macroinvertebrate survey of Otauira Stream during October 2016 found that the site downstream of the confluence with Donald Creek had a lower MCI scores but higher total abundance, higher % EPT abundance and higher QMCI scores. The QMCI score upstream and downstream of the confluence was 2.1 and 3.1 respectively, i.e. the QMCI at the downstream site was 41% higher (better) than the upstream site. This difference was statistically significant (Table 3.7 and 3.8 of Hamill 2017).

The November 2016 survey of Otauira Stream found that the MCI score was still a little lower downstream (7% lower) but all other indices were very similar between the two sites. The QMCI score upstream and downstream of the confluence was 3.0 and 2.9 respectively, i.e. 3% lower at the downstream site (Figure 3.2 in Hamill 2017).

Percent change in QMCI is one of multiple metrics to assess effects

Assessing effects based on a change in QMCI score is intuitively attractive but it can be fickle and like all metrics should be interpreted in conjunction with other information. A greater than 20% change in QMCI was measured between the two upstream sites in the summer of 2013 and spring 2016. In March 2013 the Donald Creek sites 100m upstream and 25m upstream had QMCI scores of 4.6 and 2.8 respectively – a 39% to 64% difference. In October 2016 the sites 100m upstream and 25m upstream had QMCI scores of 3.3 and 4.4 respectively – a 25% to 33% difference. Also in some of the surveys the downstream sites had higher QMCI scores than the upstream sites (e.g. Otauira Stream during October 2016).

There are likely to be multiple reasons for differences in QMCI scores between upstream sites. It may be particularly apparent in Donald Creek because the meso-habitat is quite heterogeneous. Choosing sites with similar habitat helps reduce this natural variability, but >20% differences in QMCI can still occur. For example in 2013 the 25m upstream site had a lower QMCI value than the 100m upstream site, while in 2016 it was lower.

These features of the QMCI (i.e. a greater than 20% change between upstream sites and occasionally a higher QMCI score occurring at sites downstream of a discharge) have also been observed in other rivers. It has a number of implications; firstly a percent change in QMCI should be interpreted in a wider context before deciding if it corresponds to a significant adverse effect on aquatic life (e.g. absolute value of the QMCI, other metrics, frequency and duration of the occurrence). From an ecological perspective it is just one of several useful metrics. Secondly, even in a situation where there is no discharge occurring and no impact on a stream it is possible for a 'downstream' monitoring site to have a greater than 20% lower QMCI score compared to an 'upstream' site. An overall picture requires multiple measurements.

Effects of the staged upgrade

Existing

Ecological surveys have found that the Featherston WWTP discharge has significant impacts on Donald Creek during the summer/autumn but relatively minor impacts during the spring (and presumably winter). This largely reflects seasonal differences in stream flow.

The October and November surveys found the effect of the discharge to be detectable, but relatively mild compared to those observed during late summer. The macroinvertebrate community had slightly lower MCI scores at the two downstream sites, and no consistent upstream to downstream difference in QMCI scores. The site 60m downstream had a QMCI score 25% lower than upstream sites while the site 650m downstream had a QMCI score 5% higher.

Stage 1A

Stage 1A is likely to have similar effects on the stream as the current discharge.

Stage 1B

Stage 1B will result in a substantial reduction in summer discharges. It is during summer that the worst effects on the stream occur. After implementation of this stage the discharge will cause either no effect or only minor effects on the stream during most of the summer. These relatively short periods of discharge are likely to cause changes in the aquatic macroinvertebrate community composition, but the effect will be small compared to effects of the current discharge during summer because there will be insufficient time for significant deposition of material on the stream bed. In my opinion the QMCI at the downstream sites will usually be within 20% of the upstream sites and if there are any occasional exceedance these will be short term (e.g. less than two weeks).

Implementation of Stage 1B will also reduce winter discharges. When winter discharges are occurring then the effects during base flow conditions are likely to be similar or better to the effects found during ecological surveys in October and November 2016. The macroinvertebrate community is likely to show a small decline in MCI. The change in QMCI between upstream and downstream will mostly be within 20% but it is possible that on occasions the some downstream sites may have a >20% change in QMCI compared to upstream as found in November 2016 when one downstream site had a lower QMCI compared to upstream and the other downstream site had a higher QMCI compared to upstream.

Stage 2A

Implementation of Stage 2A will reduce the frequency of discharge, and therefore effects, to a maximum of 4% of the time in summer and 76% of the time in winter. This will almost eliminate summer impacts on ecology. In my opinion the QMCI at the downstream sites will be within 20% of the upstream sites almost all the time. Variability in QMCI between sites will be very similar to natural variability.

Winter discharges will occur about two thirds of the time. The effects on aquatic life will be marginally less than Stage 1B. The change in QMCI between upstream and downstream will mostly be within 20% and probably similar to what was found during the October survey.

Stage 2B

Implementation of Stage 2B will eliminate summer discharges. Discharges during winter will also substantially reduce so that they occur only 7% of the time. The QMCI at the downstream sites will be within 20% of the upstream sites almost all the time. However, as discussed, even under a situation where there is no discharge to the stream it is possible that there sampling will occasionally find a greater than 20% change in QMCI scores due to the natural variability.