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Christchurch City Council
53 Hereford Street
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15 June 2016

Attention: Bridget O'Brien

Dear Bridget

Akaroa Wastewater Irrigation to Land Investigations

Please find attached 2 copies each of the following reports on investigations into proposed application of treated wastewater to land at Takamatua:

- Infiltration Testing Results for Akaroa Wastewater Disposal Via Irrigation", PDP, 14th June 2016
- Akaroa Wastewater Upgrade Irrigation – Preliminary Geotechnical Assessment. CH2M Beca Ltd 13th June 2016

Our executive summary of the findings of the two investigations is set out below.

Akaroa Wastewater Disposal Soils Investigation Report (Pattle Delamore Partners Ltd)

Pattle Delamore Partners Ltd (PDP) have been engaged by Beca to carry out site investigations to better determine the suitability of the soils of proposed sites at Akaroa for the irrigation of effluent from a proposed wastewater treatment plant. PDP had previously carried out a desktop analysis to identify suitable land for this purpose.

Site investigations were carried out on 30 & 31 May 2016. These were carried out in conjunction with geotechnical investigations of the loess material at each site. The PDP investigations involved:-

- Assessing the soil type at each location (including the depth of the topsoil, presence and depth of any low permeability layer)
- Measuring the depth of root penetration to assist in estimating the Profile Available Water (PAW).
- Measuring the infiltration rate at the ground surface and, if required, of low permeability layers.

Six test pits were excavated and eight infiltration tests were carried out. The testing at the sites indicated topsoil infiltration rates between 8 - 30 mm/hr. Infiltration rates of the sub-surface soil ranged from 0 to 24 mm/hr. It is considered that the bulk hydraulic conductivity of the loess in the area is of a similar magnitude.

A layer with low permeability (poor drainage) was encountered at a depth of around 150 mm to 270 mm below the ground surface. There was no significant penetration of grass roots below this layer.

The observations indicate that the soils are suitable for irrigation but the water available to plants (the profile available water (PAW)) at 48 mm is lower than the 72 mm estimated previously. This will impact on the detailed design of the irrigation system.

At two locations (blocks A & D) the subsoils had very low permeability. At these locations it is recommended at present that they are only irrigated in summer. However the low permeability layer is shallow and it may be able to be broken up by deep ripping of the soil.

For detailed design (and subject to a preferred irrigation method) the following is recommended:-

- PAW = 48 mm;

- Application Rates for irrigation to trees should not exceed 37.5 mm/week in summer, and 17.5 mm/week in winter;
- Application Rates for irrigation to pasture should not exceed 7 mm/day in summer, and 1 mm/day in winter; and
- Application to Block A and Block D should be limited to irrigation in summer, spring and autumn only.

More detailed investigations of the soils will be required prior to detailed design (and subject to a preferred irrigation method) to confirm the following:

- Application Rates (mm/hr) by measuring the hydrophobicity[1] of the soil;
- Application depths (mm) and return periods; and
- Extent of low permeability layers over selected irrigation areas and potential to modify the permeability (e.g. by ripping).

These tests are in addition to general agricultural soil tests to determine the current nutrient state of the soils and appropriate measures to maximise growth of trees or pasture to maximise nutrient and water uptake from the applied treated wastewater.

Akaroa Wastewater Irrigation Preliminary Geotechnical Assessment (CH2M Beca Ltd)

A ground investigation of land at Takamatua that has been identified as potentially suitable for irrigation of treated wastewater was conducted. The physical investigation comprised six test pits and ten laboratory moisture content tests and was conducted in May 2016. From the results of physical testing infiltration rates for specific sites were established and a preliminary assessment of groundwater mounding and slope stability risks was conducted. Key findings of the work are as follows:

- All the exploratory holes encountered partially saturated Quaternary loess to the full 4m depth of excavation. Groundwater was not encountered in any of the test pits.
- The proposed irrigation rate is expected to result in an increased moisture content and groundwater mounding in the loess for both irrigation under trees and irrigation to pasture? Groundwater mounding will accumulate with time if the application of wastewater is ongoing and is not mitigated by vertical seepage effects.
- A preliminary assessment indicates that the global stability of the steeper areas downslope of the proposed irrigation Block B (the land area directly uphill from Kingfisher Point Subdivision - refer to the map in Appendix A to the Beca Report) may become approximately 10% to 20% less stable in the long term with an increase in groundwater level as a result of wastewater application to the land. This means that if the slopes are currently marginally stable (factor of safety of 1.1 to 1.3), the margin of stability in the longer term is likely to be reduced to the point of slope movement as a result of wastewater application.
- Previous slope stability reports by other consultants have indicated that the higher elevation conceptual irrigation blocks are adjacent to pre-existing land instability features such as tunnel gullies, surface erosion and historic deep seated failures on the loess/rock contact. The impact of irrigation on the existing slope movement features has not been quantified, but is likely to result in an increased frequency of movement compared to that which has occurred in the recent past.

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[1] NZ soils tend to repel water when dry. Soils of this nature are described as being hydrophobic. The rate at which water infiltrates can be measured as the hydrophobicity of the soil.

- With regard to the overall change in stability associated with application of wastewater to land, the change in the slope's Factor of Safety (FoS) is reported rather than an absolute FoS, as the analysis is based on a single cross section and a number of simplifying assumptions. It is not advisable to report an absolute FoS from this analysis as it would not be representative of all of the conditions and slopes in the study area.
- The current stability of the slopes can be inferred from the previous studies by Tonkin and Taylor (T&T) and Geotech Consulting[1]. T&T reported that one third of the mapped area contains active gullies which are subject to ongoing episodic movements and debris run out, in particular triggered by rainstorm events. For both the south facing and north facing slopes of Takamatua Peninsula both studies report that a series of wet winters leading to steady building of groundwater levels is a pre-requisite for widespread movement on a range of scales.
- It is useful to compare the relative stability issues at the Wainui wastewater land irrigation scheme and the proposed Akaroa scheme. At Wainui tunnel gullies were assessed as rare, there wás localised relatively shallow instability along gully margins, and the whole area is underlain by an ancient, deep-seated landslide. The application of treated wastewater in re-activating movement on the deep-seated landslide was considered unlikely by Geotech Consulting. On the land on Takamatua Peninsula proposed for Akaroa wastewater disposal tunnel gullies have been identified, slope inclinations are locally steeper, and active gullies including surface erosion and small to medium scale landslides have been identified. These factors suggest an elevated instability risk profile at Takamatua compared to Wainui.
- The difference in stability risk between irrigation to trees and irrigation to pasture options is shown in the time versus groundwater height graph in Figure 5-1 of the Beca Report. This indicates an approximate 25% reduction in the average groundwater mounding for irrigation beneath trees compared to irrigation to pasture. Hence, on average, there is a lesser risk of instability with irrigation to trees based on the change in groundwater mounding. Trees also improve the stability of the ground due to their ability to abstract greater volumes of water than pasture and the mechanical 'reinforcing' effect of their roots.
- Comparing upper slope risks to lower slope risks, the stability analysis identifies that the greatest instability risk occurs on the steep slopes below the upper slopes. Irrigating the land at the bottom of the hill on grades of less than 15 degrees, where there is no steep land below, will significantly reduce the risk of instability occurring compared to irrigating the upper slopes.
- In conclusion, the preliminary geotechnical assessment has found that the effects of wastewater irrigation to land are influenced by the location of the land (upper vs lower slopes), and also by ground cover (trees vs pasture). Irrigating land at the bottom of the hill on grades of less than 15 degrees, where there are no slopes steeper than 15 degrees below and where the irrigation areas are planted with trees will have a lower risk than irrigating higher and/or pasture slopes. Adopting this approach is expected to reduce the amount (and rate) of tunnel erosion, surface erosion and small to medium scale landslide instability compared to other irrigation options.
- Higher elevation areas could be considered further but the risks would be greater. As recommended by Geotech Consulting, further geotechnical investigation and assessment would be required to classify those areas which are suitable. Also as recommended by Geotech Consulting, careful monitoring of wastewater land irrigation on the upper and high risk slopes including groundwater level increases and slope instability, especially on upper slopes, would allow the effects of irrigation to be assessed and risks appropriately managed.
- Should shallow ground movement occur, the resulting damage is expected to be able to be dealt with by carrying out slope re-profiling and stabilising earthworks, installing drainage and possibly constructing retaining walls. Whether these measures are needed will be a function of the nature and location of the

instability in relation to the slope and any infrastructure or other structures. Installing drainage to improve stability may be considered a "double edged sword" in the sense that, while it assists in reducing instability risk, it diverts the water out of the land and directly towards the harbour via a drainage feature of some sort.

- The risks around ground movement, which are higher on the upper steeper slopes, pose an ongoing concern. If instability is observed after irrigation? the Council will need to take remedial action which may include improving drainage (which is counter to the scheme intentions), procurement of other land for wastewater application, or use of other means of disposal for a proportion of the wastewater.

We look forward to discussing the enclosed reports with you at the earliest opportunity.

Yours sincerely
Rae Stewart
Project Manager

on behalf of
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Encl:

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