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Report

Akaroa Wastewater Investigation of Alternative Sites for Land Irrigation

Prepared for Christchurch City Council

Prepared by CH2M Beca Ltd

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Revision History

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Document Acceptance

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on behalf of	CH2M Beca Ltd		

Executive Summary

CH2M Beca Ltd (Beca) is assisting Christchurch City Council (Council) in developing alternative disposal options for treated wastewater from Akaroa. Earlier work involved a largely desktop study to identify all possible suitable treatment and disposal options and this is summarised in the draft report Akaroa Wastewater Project – Review of Disposal Alternative for Ngāi Tahu – First Stage (CH2M Beca September 2015). From the long list of options identified in this report, a short list was agreed for further investigation and development. The report Akaroa Wastewater Concept Design Report for Alternatives to Harbour Outfall (CH2M Beca, May 2016) summarises this further work on the short list which included options for irrigating treated wastewater to trees or pasture on areas within 2km of the proposed treatment plant on Old Coach Road. During public consultation on the options, concerns were raised about irrigation exacerbating instability in the Takamātua area. The Council asked Beca to undertake land investigations to better understand the instability risk and the area required for irrigation.

The Stage 1 ground investigations involved geotechnical testing and infiltration testing of land that had been identified in the desktop study as potentially suitable for irrigation, and was summarised in the Beca letter report Akaroa Wastewater Irrigation to Land Investigations dated 15 June 2016. This found risks of land instability in areas that had previously been assessed as potentially suitable for wastewater irrigation and recommended that land where the downhill slope was steeper than 15˚ should not be irrigated. Based on this advice Council decided to conduct a second stage of land investigations (Stage 2), extending the search area to the wider eastern extent of Banks Peninsula.

The Stage 2 investigation included alternative site selection, identification of key criteria for analysis, and development of basic design concepts. Firstly a high level screening process based only on slope and land area was undertaken. This identified twenty one possible sites.

The twenty one sites were subject to a revised set of criteria for analysis that included geotechnical considerations, and buffer zones to residential properties and waterways. From this a shortlist of four sites was identified – Robinsons Bay Valley, Takamātua Valley, Pompeys Pillar and Wainui. Very high level cost estimates ($18M - $20M) eliminated the Wainui scheme from further consideration due to the significant cost associated with running a 5km pipeline across Akaroa Harbour. Hence the shortlist was reduced to three sites.

A second round of ground testing was completed on the three remaining alternative sites. Geotechnical investigation and land infiltration testing was carried out. The results of the testing give sufficient geotechnical information for the Council to decide which, if any, general area to pursue for irrigation. However, further geotechnical investigations and infiltration testing is required before committing to irrigating particular land parcels. In addition there are some overall differences in the soil types, land gradients and groundwater levels at the different sites which have implications for land irrigation scheme design and operation at each site. Concept designs were developed for each of the three sites based on information obtained from the land investigations.

The amount of area required for irrigation and storage for all sites was only slightly changed from the Stage 1 investigations – an area of approximately 28ha would be required for year round irrigation to trees (including a 17,500m^3 storage pond) and 38ha for year round irrigation to pasture (including a 35,000m^3 storage pond). Using the concept designs and land area requirements, earlier capital cost estimates were refined for the shortlisted options.

Criteria were then used with GIS mapping to determine potential pond storage locations for the three shortlisted sites. In total ten possible pond storage sites were identified in and around Takamatua Valley and Robinsons Bay Valley, some of these separate from the irrigation areas that had been identified. Further survey was completed at Pompeys Pillar and from GIS analysis of this information and site walkover observations four possible pond sites were identified at Pompeys Pillar.

A treated wastewater storage pond across the road from the wastewater treatment plant site (Pond Site 10) is currently the preferred site out of the ten potential pond sites around Takamatua and Robinsons Bay. This is because it is near the treatment plant, has the lowest overall impact, is in the best position to provide reclaimed water for non-potable reuse in Akaroa, and could provide storage of water for irrigation at any of the locations being considered. There is potentially not enough room to store all the required volume at this site, so it may be that at least one other pond would be required.

A high level non-potable reuse scheme has been developed. Based on this scheme it would be possible to use approximately a quarter of the treated wastewater to irrigate public parks and flush public toilets in Akaroa.

Further GIS mapping of irrigable areas at the three shortlisted areas was also conducted. This found that the irrigable land available in Takamātua Valley is insufficient for dripper irrigation and also insufficient for spray irrigation. Hence any scheme involving irrigation in Takamātua Valley would need to be combined with another area. The remaining two shortlisted sites are considered feasible for land irrigation considering slope stability, soil type, land area available, and consenting factors, although there are some concerns around the visual and landscape effects associated with irrigating at Pompeys Pillar.

Pompeys Pillar has sufficient suitable land and is remote from residential areas and other infrastructure. However it has the highest capital cost of the three due to the need to construct a pump station and high pressure pipeline to transfer treated wastewater over a saddle 620m above sea level, from the treatment plant site to the irrigation area. Robinsons Bay Valley has sufficient suitable land including areas suitable for construction of the storage pond. For the Robinsons Bay scheme the storage pond construction is relatively simple and should be able to be fed by gravity from the treatment plant and so this option has the lowest capital cost.

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1 Introduction

1.1 Background

CH2M Beca Ltd (Beca) is assisting Christchurch City Council (Council) in developing alternative options and locations for wastewater management for Akaroa. This Background refers to two other reports which should be read in conjunction with this report. These are:

- Akaroa Wastewater Project – Review of Disposal Alternatives – First Stage (CH2M Beca, August 2015)
- Akaroa Wastewater – Concept Design Report for Alternatives to Harbour Outfall (CH2M Beca, May 2016)

The Council has obtained resource consents for building and operating a wastewater treatment plant on Old Coach Road, a new pump station in the boat park at Childrens Bay, for upgrading wastewater mains, and upgrading three existing pump stations. Council also applied for a consent to construct a new harbour outfall for discharge of treated wastewater. At the consent hearing the Commissioners concluded that the strong policy theme of statutory requirements was that disposal of even highly treated human effluent into the Coastal Marine Area was not a good option, and should only be considered necessary in some circumstances after all other options had been fully investigated.

In addition the Ngāi Tahu parties were strongly opposed to a direct discharge to harbour. The Commissioners considered that the Council had not undertaken sufficient investigation of alternative locations and options for disposal of treated wastewater as required under the Resource Management Act. Ultimately consents for the discharge and outfall pipe were declined on the grounds that consent for a direct discharge to the harbour was not consistent with the Council's obligations under the Resource Management Act as alternatives had not been adequately investigated.

Ngāi Tahu advises that "Ngāi Tahu rights and interests associated with Akaroa Harbour are strongly focused on mahinga kai (food gathering practices). Discharge of treated wastewater to the harbour is culturally offensive and incompatible with the harbour as mahinga kai. As tāngata whenua, Ngāi Tahu have kaitiaki rights and responsibilities to actively protect natural resources in Akaroa for future generations. Protecting and enhancing the mauri (life force) of the harbour requires the elimination of wastewater discharges to Akaroa Harbour. The Mahaanui Iwi Management Plan (2013) provides further detail on Ngāi Tahu objectives and policies for managing wastewater in Akaroa to protect customary fisheries."

The Council will be making a Local Government Act (LGA) decision on which wastewater discharge option it will pursue. The Council's decision-making under the LGA includes a requirement to consider all reasonably practicable options to achieve the objectives of the decision, and the advantages and disadvantages of those options. The chosen option needs to meet the current and future needs of communities for good-quality (efficient, effective and appropriate to present and anticipated future circumstances) local infrastructure in a way that is most cost-effective for households and businesses. The option must also be consentable as sustainable management under the Resource Management Act (RMA). While Council has lodged an appeal against the declining of the consents, Council has not yet concluded a reassessment of options but considers that there are some discharge to land options that are more efficient, effective, feasible and appropriate than originally thought. Discharge via a harbour outfall may not be sustainable management under the RMA, or a reasonably practicable option under the LGA, if land disposal is efficient, effective, feasible and appropriate.

The Council has been working with Ōnuku Rūnanga, Wairewa Rūnanga, the Akaroa Taiāpure Management Committee and Te Runanga o Ngāi Tahu (the Ngāi Tahu parties) to explore land based alternatives to the harbour outfall as they have joined as parties to the Council's appeal. The Council has been keeping the consent authorities – Environment Canterbury and the Christchurch City Council in its regulatory capacity –

involved in that process as they are respondents to the Environment Court appeal. The investigations to date are assessing whether there are some land based discharge options that are efficient, effective, and feasible and may be more appropriate than the discharge to the harbour.

The report *Akaroa Wastewater Project Review of Disposal Alternatives – First Stage* (CH2M Beca August 2015) summarised the long list of possible alternative options to a harbour outfall that were identified. The findings of this report were discussed with the Ngāi Tahu parties and Council and from the long list an agreed short list of options was established for further investigation. This short list comprised:

- Year round irrigation to trees;
- Year round irrigation to pasture;
- Summer only irrigation with a subsurface flow wetland or infiltration basin and discharge via a coastal infiltration gallery at other times;
- Subsurface flow wetland and discharge via a coastal infiltration gallery;
- Infiltration basin and discharge via a coastal infiltration gallery; and
- Outfall pipeline to mid-harbour.

The Council sought public feedback on the range of options to help inform a decision on which option to progress through the resource consent process. Consultation on the short list of options was undertaken between 26 April and 12 June 2016. The consultation found that the preferred options at that time were a harbour outfall or irrigation to land, although a significant number of respondents did not have a preference. During this consultation phase concerns were raised by the public about irrigation causing land instability.

The report *Akaroa Wastewater – Concept Design Report for Alternatives to Harbour Outfall* (Concept Design Report, CH2M Beca, May 2016) summarised the concept investigations on the shortlisted options. This report also highlighted some risks around the effect of irrigation to land on slope stability noting that the effect of applying treated wastewater to land will increase the risk of instability occurring, particularly during heavy rainfall events. The report recommended that it would be advisable not to introduce treated wastewater to areas that are currently, or have been historically, unstable and suggested targeting areas where no instability had previously been identified and where the slope was not greater than 15 degrees. The 15-degree slope criteria was adopted based on guidelines in the *Process Design Manual for Irrigation of Municipal Wastewater to Land* (USEPA, 2006).

After considering this information and feedback from consultation on the short list options, Council staff decided that prior to making a recommendation to Council as to the preferred disposal option, preliminary geotechnical and infiltration testing should be undertaken to better understand the slope stability risk.

The results of these ground investigations indicated that the land previously considered possibly suitable on the Takamātua peninsula was less suitable than first thought. These investigations and findings are outlined in Section 2 of this report and in the reports in Appendix A and Appendix B.

1.2 Summary of Consultation with Ngāi Tahu Parties

Engagement between the Council and the parties to the Council's appeal against the decline of resource consent for the discharge to the harbour – the Ngāi Tahu parties and the two councils in their regulatory capacity – began in 2015.

The Concept Design Report on shortlisted options was finalised after a hui with the Ngāi Tahu parties and other parties to the appeal at Ōnuku marae on 4 March 2016 to discuss the draft report, and to accurately capture the feedback.

All parties wanted the collaborative process developed during the initial phases of the project continued. As such a hui was held on 2 August 2016 on the preliminary findings from the ground investigations on the land identified in the Concept Design Report as potentially suitable for irrigation. This hui was held at the Christchurch City Council Civic offices and was attended by representatives from the Ngāi Tahu parties, Environment Canterbury (ECan), Christchurch City Council (including councillors), Beca and their sub-consultants Pattle Delamore Partners Ltd (PDP).

Since the preliminary findings of the investigations were that much of the land being investigated at Takamātua Peninsula was unsuitable for stability reasons, Beca had worked with Council staff to identify other possible locations for wastewater irrigation to land for consideration. These options were presented at the hui and the Council staff informed the attendees that alternative sites would be investigated further, with concept designs and cost estimates refined to assist in decision making.

Beca undertook a desktop assessment and filtering assessment of the possible alternative sites and developed a short list of four:

- Robinsons Bay Valley
- Takamātua Valley
- Pompeys Pillar
- Wainui.

Council staff decided that Wainui ought not to be further investigated as it would be significantly more expensive at $18M - $20M than the other options (primarily due to the cost of a pipeline across the harbour floor).

A second round of ground investigations was undertaken on the Robinsons Bay Valley, Takamātua Valley and Pompeys Pillar alternative sites in late September 2016. Again the preliminary findings from these investigations were presented at a hui with the Ngāi Tahu parties and Council, held at the Ngāi Tahu offices in Show Place, Christchurch on Wednesday 2 November 2016. At this hui discussions were also had around the next steps in the project and the forthcoming public meeting.

On Wednesday 9 November 2016 a public meeting was held at the Gaiety Hall in Akaroa. The purpose of this meeting was to advise the public of the process the Council was working through and work that had been undertaken since the last consultation round. Representatives from the Ngāi Tahu parties attended this public meeting.

1.3 The Akaroa Treated Wastewater Reuse Options Working Party

The Banks Peninsula Community Board established the Akaroa Treated Wastewater Reuse Options Working Party (the Working Party) in January 2017 to assist the Council in investigating and consulting on the options for the beneficial reuse of Akaroa's treated wastewater.

1.4 The Akaroa Wastewater Technical Experts Group

The Akaroa Wastewater Technical Experts Group (the Technical Experts Group) consist of experts working for the Council, the Friends of Banks Peninsula and the Ngāi Tahu parties. The Technical Experts Group has been tasked with answering specific technical questions about the irrigation scheme.

1.5 Scope of the Report

This report outlines the work that was undertaken on the further investigation of land disposal options from May 2016 – March 2017, after finalising the Concept Design Report. This includes a summary of:

- The initial land investigations;
- The process for identifying alternative sites (to the Takamātua Peninsula) that may be suitable for irrigation of treated wastewater to land;
- The physical investigations that have been undertaken on these alternative sites;
- The conclusions that have been drawn from the investigations;
- Subsequent development of scheme design concepts and costs for the alternative sites.

The purpose of this report is to clearly outline the process around possible site selection, identifying criteria analysis, and the basic design concepts that have been assumed to allow the sites to be compared.

2 Land Disposal Investigation – Stage 1

The initial investigation covered an assessment of potentially irrigable land for previously identified sites that were the subject of public consultation on April – June 2016. The work method and outcomes are set out below.

2.1 Criteria Around Suitable Land Used During Concept Design

As part of the short listing of options, areas of land potentially suitable for irrigation within 2km of the proposed treatment plant were identified by considering slope, geotechnical stability, ownership, proximity to the proposed wastewater treatment plant, proximity to residential dwellings and consentability. Once general areas were identified, the short listing also considered the practicality of constructing an irrigation scheme by better defining criteria and exclusions around land area (buffer zones to streams and residential areas).

The list of criteria used during concept design to identify the potentially suitable land at concept design stage is given in Table 2-1.

Table 2-1: Selection Criteria for Suitable Land at Concept Design (May 2016)

Selection Criteria	Constraint	Basis for Criteria Selection
Land Stability	Land to be less than 15 degrees slope	Based on USEPA design guideline for irrigation of wastewater to land. To prevent land instability and run-off.
Minimum land parcel	2ha	To exclude plots that are too small to contribute significant irrigable area.
Erosion zones	Land listed as an area of “slope hazard susceptibility” from the Tonkin & Taylor plan titled ‘Christchurch City Council – Slope Hazard Susceptibility Akaroa Harbour Settlements’ (attached in Appendix C) was excluded	To minimise the risk of accentuating land instability caused by irrigation.
Residential setback	Residentially zoned areas (as identified by a planning overlay) were excluded, including a 25m buffer around the boundary of these areas.	To minimise the risk of nuisance effects for the range of irrigation scenarios.
Stream setback	A buffer of 25 metres was applied to streams and these areas were excluded	To reduce the risk of migration of wastewater through shallow ground water to streams.
Distance to Wastewater Treatment Plant	Less than 2km	To minimise capital and operational cost of irrigation scheme

The details of this shortlisting process are described in the Concept Design Report and the maps that were produced based on these criteria are provided in Appendix D. The majority of the land identified was on the Takamātua Peninsula, extending to some areas in the lower Takamātua Valley. This overall area was the subject of the first round of land investigations to better understand the slope stability risk.

2.2 Land Investigations of Originally Identified Area

Infiltration and geotechnical testing was undertaken in May 2016 to better understand the ground conditions in areas that had been identified as possibly suitable for irrigation. Summary reports from these investigations are included in Appendix A (infiltration testing) and Appendix B (geotechnical testing). A high level summary is presented in the following sections.

2.2.1 **Akaroa Wastewater Disposal Soils Investigation Report (PDP, June 2016)**

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

Site investigations were carried out on 30 and 31 May 2016. These were carried out in conjunction with geotechnical investigations undertaken by Beca of the soil 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 Plant Available Water (PAW); and
- Measuring the infiltration rate at the ground surface and, if required, of low permeability layers.

Refer Appendix A for the full test report. Six test pits were excavated and eight infiltration tests were carried out. The locations of these test pits are shown in Figure 2-1:

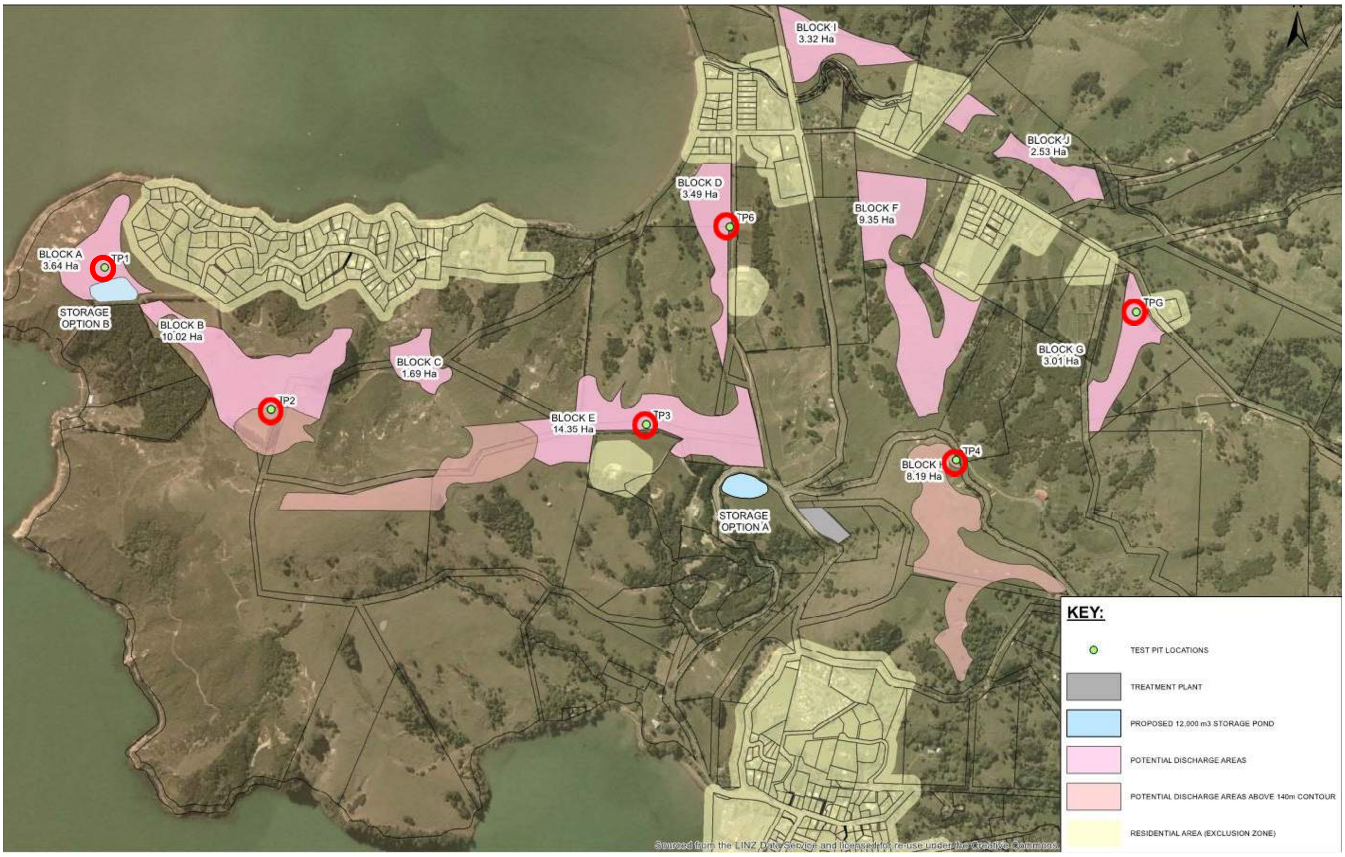

Figure 2-1: Test Pit Locations for Preliminary Ground Investigations

The testing at the sites indicated measured topsoil infiltration rates between 8 - 30mm/hr. Infiltration rates of the sub-surface soil ranged from 0 to 24mm/hr. It is considered that the bulk hydraulic conductivity of the loess in the area is of a similar magnitude. Typical infiltration rates are shown in Figure 2-2. Appropriate design infiltration rates would be somewhat less than these field measurements.

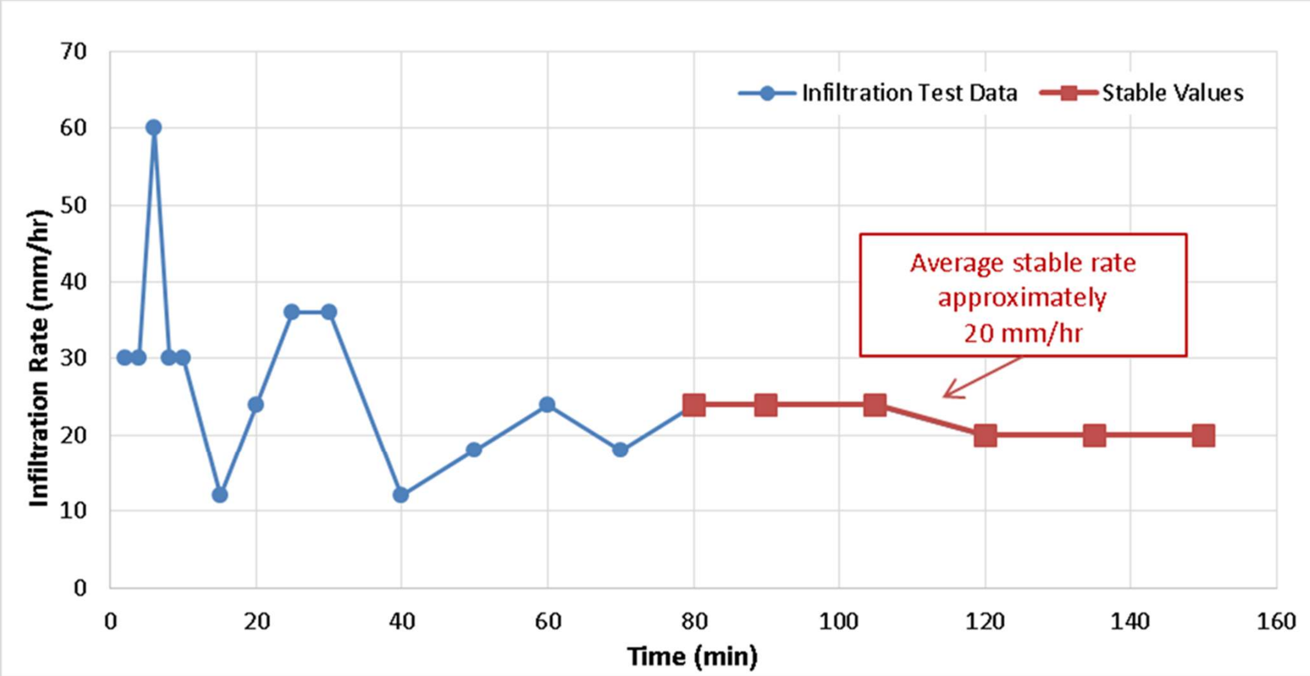

Figure 2-2: Typical Infiltration Test Results

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

The observations from the infiltration testing indicate that the soils are suitable for irrigation but the water available to plants (the plant available water (PAW)) at 48mm is lower than the 72mm estimated from literature research and used in the Concept Design Report. Plant Available Water is used to determine irrigation depth and drainage past root-zone to underlying strata. Figure 2-3 shows this pictorially. The decrease in PAW will impact on the detailed design of the irrigation system, with the main implication being a possible increase in the amount of storage required.

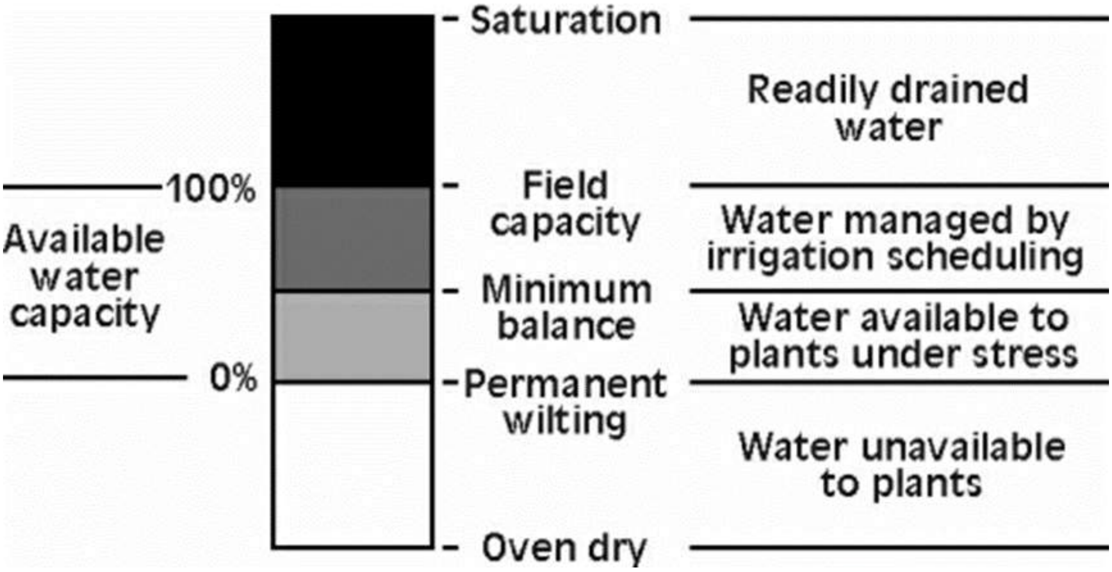

Figure 2-3: Plant Available Water

At two locations (Blocks A and D as shown on Figure 2-1) the subsoils had very low permeability. At these locations it was recommended that they should only be irrigated in summer, spring and autumn. However the low permeability layer is shallow and it may be able to be broken up by deep ripping of the soil. Such ripping should be completed prior to the installation of an irrigation system.

For detailed design (and subject to a preferred irrigation method) the following was recommended based on the June 2016 investigations:

- PAW = 48mm
- Application rates for irrigation to trees should not exceed 37.5mm/week in summer, and 17.5mm/week in winter
- Application rates for irrigation to pasture should not exceed 7mm/day in summer, and 1mm/day in winter
- Application to Block A and Block D should be limited to irrigation in summer, spring and autumn only.

More detailed investigations of the soils would be required prior to detailed design (and subject to a preferred irrigation method) for these sites to be taken further, to confirm the following:

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

These tests would have been 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.

2.2.2 **Akaroa Wastewater Irrigation Preliminary Geotechnical Assessment (CH2M Beca, June 2016)**

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

- All the exploratory holes encountered partially saturated Quaternary loess (wind deposited glacial silt) to the full 4m depth of excavation. Groundwater was not encountered in any of the test pits.
- The proposed irrigation rate was 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 would accumulate with time if the application of wastewater is ongoing and is not mitigated by vertical seepage effects.
- A preliminary assessment indicated 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 Figure 2-1) may have 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 would be likely to be reduced to the point of slope movement as a result of wastewater application.

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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.

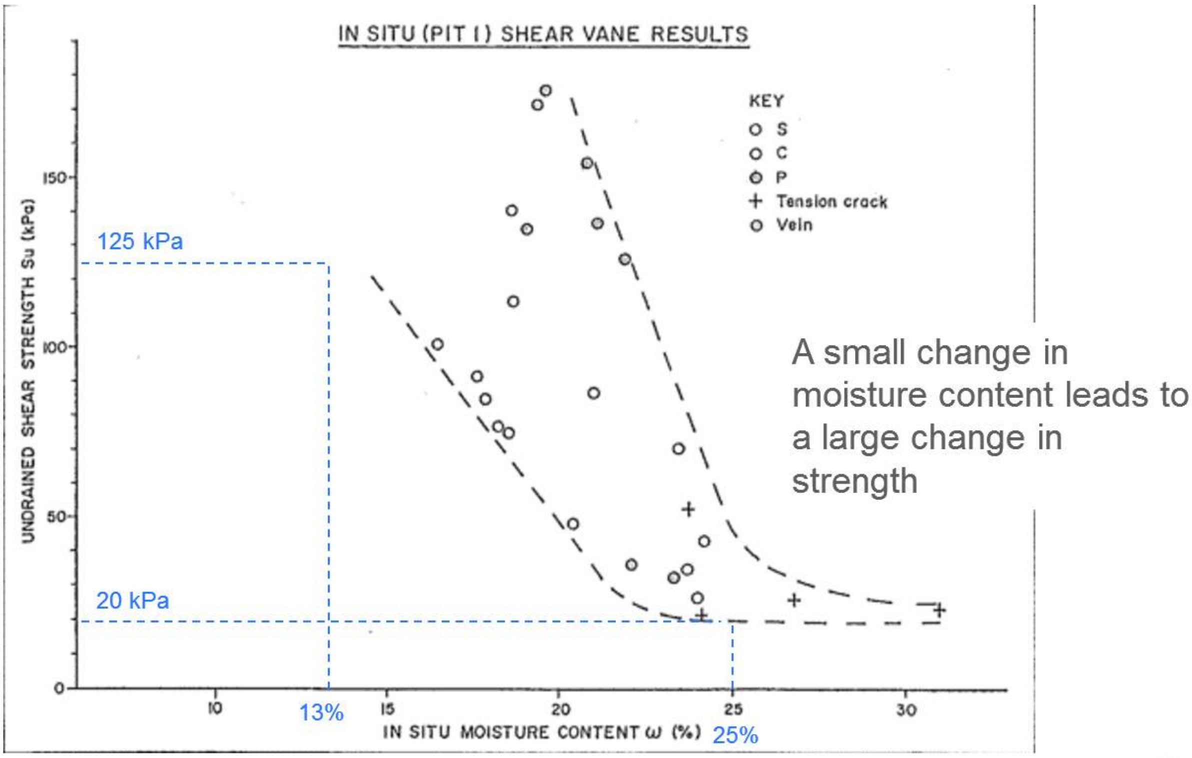

Figure 2-4: Findings of Preliminary Geotechnical Testing

- A factor contributing to the reduction in factor of safety with increase in groundwater level is the large change in strength of soil resulting from a small change in moisture content (decreasing strength with increasing moisture content) that occurs with the type of soil present within the potentially irrigable areas. This is exemplified in the graph shown in Figure 2-4.
- 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.
- The current stability of the slopes can be inferred from the previous studies by Tonkin and Taylor[2] and Geotech Consulting[3]. 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 Takamātua 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 Takamātua Peninsula land. At Wainui tunnel gullies were assessed as rare, there was 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 Takamātua Peninsula that was

[2] Tonkin and Taylor (2008), "Slope Hazard Susceptibility Assessment – Akaroa Harbour Settlements"

[3] Geotech Consulting (2010) "Preliminary Geotechnical Appraisal of Potential Slope Stability Issues in Relation to the Proposed Wastewater Irrigation Areas of Land Near Akaroa"

being considered 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 of a wastewater irrigation scheme at Takamātua compared to the existing wastewater irrigation scheme at Wainui.

- Figure 2-5 presents the height of groundwater mounding against duration of loading application for Blocks E and G based on the average net infiltration rates. The longer the wastewater was applied the higher the groundwater mounding.
- There is 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, which also acts as a dis-benefit once the trees are harvested or die.

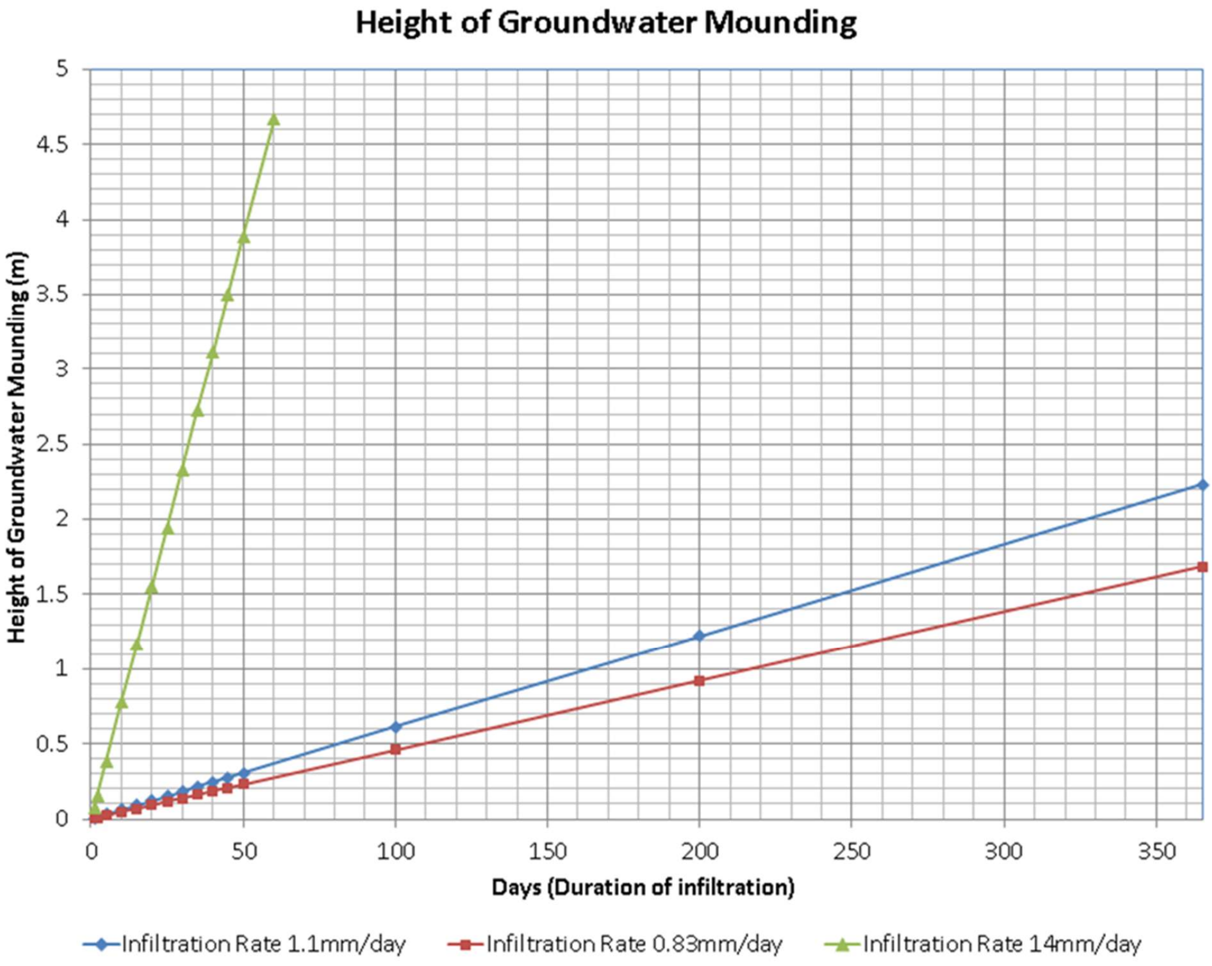

Figure 2-5: Groundwater Mounding Compared with Irrigation Duration (days)

- Comparing upper slope risks to lower slope risks, the stability analysis identified 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, where steeper slopes lie below. This criteria was considered an appropriate rule to apply for high level screening, noting the possibility of refining permissible slopes during detailed site specific investigations later in the design process.

The preliminary geotechnical assessment 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 the criteria of grades less than 15 degrees and no downslope greater than 15 degrees was considered appropriate for high level screening to find suitable sites. These criteria are 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 may be greater. Further geotechnical investigation and assessment would be required to classify those areas which are suitable and it is possible that these site specific investigations may identify suitable land at higher gradient. The full geotechnical report can be found in Appendix B.

Consequently, following the site investigations it was identified that there were appreciable risks of land instability associated with some of the sites identified in Figure 2-1 and it was recommended by Beca/PDP that irrigation only occurs on land where the slope is less than 15 degrees, and where the downhill slope is less than 15 degrees.

2.2.3 Peer Review of Documents Associated with Preliminary Land Testing

David Painter Consulting Ltd was engaged by the Ngāi Tahu parties and undertook a review of the summary letter and reports produced from the preliminary land testing. Mr Painter’s comments and the Beca/PDP responses are given in Appendix E. No changes were made to the outputs as a result of the review comments.

3 Revised Assessment Criteria

After the preliminary ground testing was completed, refined mapping was undertaken to exclude those areas on the Takamātua Peninsula and in Takamātua Valley where the downgradient slope was greater than 15 degrees. From this assessment it became apparent that some land previously identified was no longer considered suitable due to land stability risks. Based on the ground testing results and the need to widen the net and consider other land areas, a refined set of criteria was established. These took into account the information obtained from the ground testing but allowed for different criteria for the different types of irrigation. The refined criteria are summarised in Table 3-1 and Table 3-2.

Table 3-1: Revised Assessment Criteria for Land Suitable for Spray Irrigation (October 2016)

Selection Criteria	K-Line spray irrigation option	Basis for Criteria Selection
Land Stability	- Include land less than 15 degrees slope and downslope to coastline same grade or less - Include land with no identified instability within or downhill of area - Exclude land that, if it became unstable, could pose risks to downslope residences and infrastructure	To minimise risk of land instability resulting from irrigation
Minimum land parcel	2ha	To exclude plots that are too small to contribute significant irrigable area
Erosion zones	Tonkin & Taylor map erosion zones excluded + 20m buffer to edge of zone	To minimise risk of land instability resulting from irrigation
Residential setback	Exclude residentially zoned land (as defined by a planning overlay) Exclude land parcels ≤ 4ha that contain a house + 25 m buffer zone around the boundary of the parcel that contains a house For land parcels containing a house that are > 4ha include any land over and above the initial 4ha + 25m buffer zone	It is assumed that, initially at least, rural dwellings within the irrigation area will not be connected to the new treatment system. Hence the specified buffer around a rural house assumes that dwellings require a fully complying on-site wastewater system. Land and Water Regional Plan (LWRP) Rule 5.8 requires a 4 ha site for onsite wastewater disposal as a permitted activity. To meet this requirement a 4 ha land parcel has been specified plus 25 m boundary buffer.
Stream setback	25m to centreline of continuous flowing streams	To minimise the potential for nutrients in irrigated wastewater to migrate through shallow groundwater into surface water courses.
Coastline setback	25m	To minimise the potential for nutrients in irrigated wastewater to migrate through shallow groundwater into coastal waters.

Table 3-2: Revised Assessment Criteria for Land Suitable for Dripper Irrigation (October 2016)

Selection Criteria	Dripper irrigation option	Basis for Criteria Selection
Land Stability	- Include land that is less than 15 degrees slope and downslope to coastline same grade or less - Include land that has no identified instability within or downhill of area - Exclude land that, if it became unstable, could pose risk to downslope residences and infrastructure	- To minimise risk of land instability resulting from irrigation
Minimum land parcel	1ha	To exclude plots that are too small to contribute significant irrigable area
Erosion zones	T&T map erosion zones excluded + 20m buffer to edge of zone	To minimise risk of land instability resulting from irrigation
Residential setback	Exclude residentially zoned land (as defined by a planning overlay) Exclude land parcels ≤ 4ha that contain a house + 5m buffer zone around the boundary of the parcel that contains a house For land parcels containing a house that are > 4ha include any land over and above the initial 4ha + 5m buffer zone	It is assumed that, initially at least, rural dwellings within the irrigation area will not be connected to the new treatment system. Hence the specified buffer around a rural house assumes that dwellings require a fully complying on-site wastewater system. Land and Water Regional Plan (LWRP) Rule 5.8 requires a 4 ha site for onsite wastewater disposal as a permitted activity. To meet this requirement a 4 ha land parcel has been specified plus 5 m boundary buffer.
Stream setback	10m to centreline of continuous flowing streams	To minimise the potential for nutrients in irrigated wastewater to migrate through shallow groundwater into surface water courses.
Coastline setback	25m	To minimise the potential for nutrients in irrigated wastewater to migrate through shallow groundwater into coastal waters.

The differences between the refined criteria shown in Table 3-1 and Table 3-2 and the original mapping criteria shown in Table 2-1 are as follows:

- Reduced buffer zones have been introduced for dripper irrigation to recognise the reduced risks to nearby receptors for this application method. This is based on working knowledge of other dripper irrigation schemes and their operational consents.
- Land at a slope less than 15 degrees, but with associated downslope areas of greater than 15 degrees, is excluded and several other factors affecting land stability risk have been taken into account based on advice from geotechnical engineers. This is to minimise the risk of possible land instability down gradient from an irrigation site even if the site itself has a slope of less than 15 degrees.
- Land parcels up to 4ha that contain a residence are excluded to meet permitted activity conditions for Rule 5.8 in the LWRP, plus a 25m buffer zone around the boundary of the parcel that contains a house for spray irrigation (same as original criteria) or a 5m buffer for dripper irrigation (new revised buffer distance due to lower public health risk).
- For rural residential blocks greater than 4ha the balance of land (i.e. over and above the initial 4ha) is included in considerations. This is to include larger and potentially irrigable areas.
- The location of existing houses was based on LINZ 2000 digital data. This was followed by a manual check of aerial maps to identify dwellings and screen out non-residential farm buildings and other structures.
- Minimum parcel size for dripper irrigation reduced to 1ha rather than 2ha because the buffer zone for drippers is smaller. Hence a smaller unoccupied block will yield more irrigable area for drippers than for spray irrigation.

4 Land Disposal Investigation – Stage 2

As discussed in Sections 2 and 3, it became apparent after initial land investigations that the area of investigation needed to be extended to a wider radius around the consented treatment plant site. This section outlines the work method and outcomes of the second investigative stage which focused on alternative sites.

4.1 High Level Screening of Alternative Sites

Figure 4-1 shows the land eliminated by the revised assessment criteria described in Section 3. This included much of the land closest to the proposed wastewater treatment plant (WWTP). To achieve the necessary land area for an irrigation scheme it was necessary to increase the overall area being considered for irrigation.

Figure 4-1: Land Areas Eliminated by Revised Assessment Criteria

Community feedback during consultation in Stage 1 had asked that Hinewai Reserve be considered as a possible area for irrigation. The far edge of the Hinewai area is approximately 10km from the treatment plant site. Council staff decided to extend the search for suitable land beyond this to the eastern side of Banks Peninsula to make sure all reasonably practicable options had been identified.

Roads were chosen as preferred pipeline alignments due to several factors. Utilities are commonly installed along road corridors because the land belongs to the Council or NZTA, alignment along roads is often the more cost-effective than other options, and disruption to private landowners is avoided.

For site options on the western side of Akaroa harbour a cross harbour pipeline is required (approximately 5km in length) passing wastewater across the harbour from the treatment plant. Council has some experience with running cross harbour pipes as part of the Diamond Harbour water supply and proposed Lyttelton Harbour wastewater scheme.

4.2 Land Options Identified

An initial evaluation was conducted based on high level screening of potential sites on the eastern side of Banks Peninsula. The sites have pipeline routes of up to 24km from the proposed treatment plant site. The work commenced with a GIS analysis to identify large blocks of rural land with suitable slope that could potentially be irrigable. Figure 4-2 (full map in Appendix F) shows the areas identified as having potential for irrigation based purely on providing sufficient land area, and meeting slope and downslope criteria.

The initial version of this map adopted less than 15 degrees slope for potential irrigation areas, with less than 15 degree slopes downslope amongst other criteria. In the current version of this map the slope acceptance criteria has been increased to 19 degrees (15 – 19 degree slope areas are shown in purple in Figure 4.2) while maintaining the downslope acceptance criteria of 15 degrees. A criteria of 19 degrees has been used as it is possible to irrigate to steeper slopes when irrigating with drip irrigation under trees. This change has made no material difference to the screening shortlist of sites for the following reasons:

- For the most part the additional irrigable 15 – 19 degree (purple) areas are part of, or adjacent to, less than 15 degree (green) areas that were previously selected
- The remaining purple areas are generally small and occur where there are not continuous less than 15 degree (green) downslope zones to the coastline, hence they have not been shortlisted.

Furthermore, irrigation causes increases in soil moisture, which, for land with slope greater than 19 degrees, increases the risk of land instability. Therefore slopes greater than 19 degrees have been excluded.

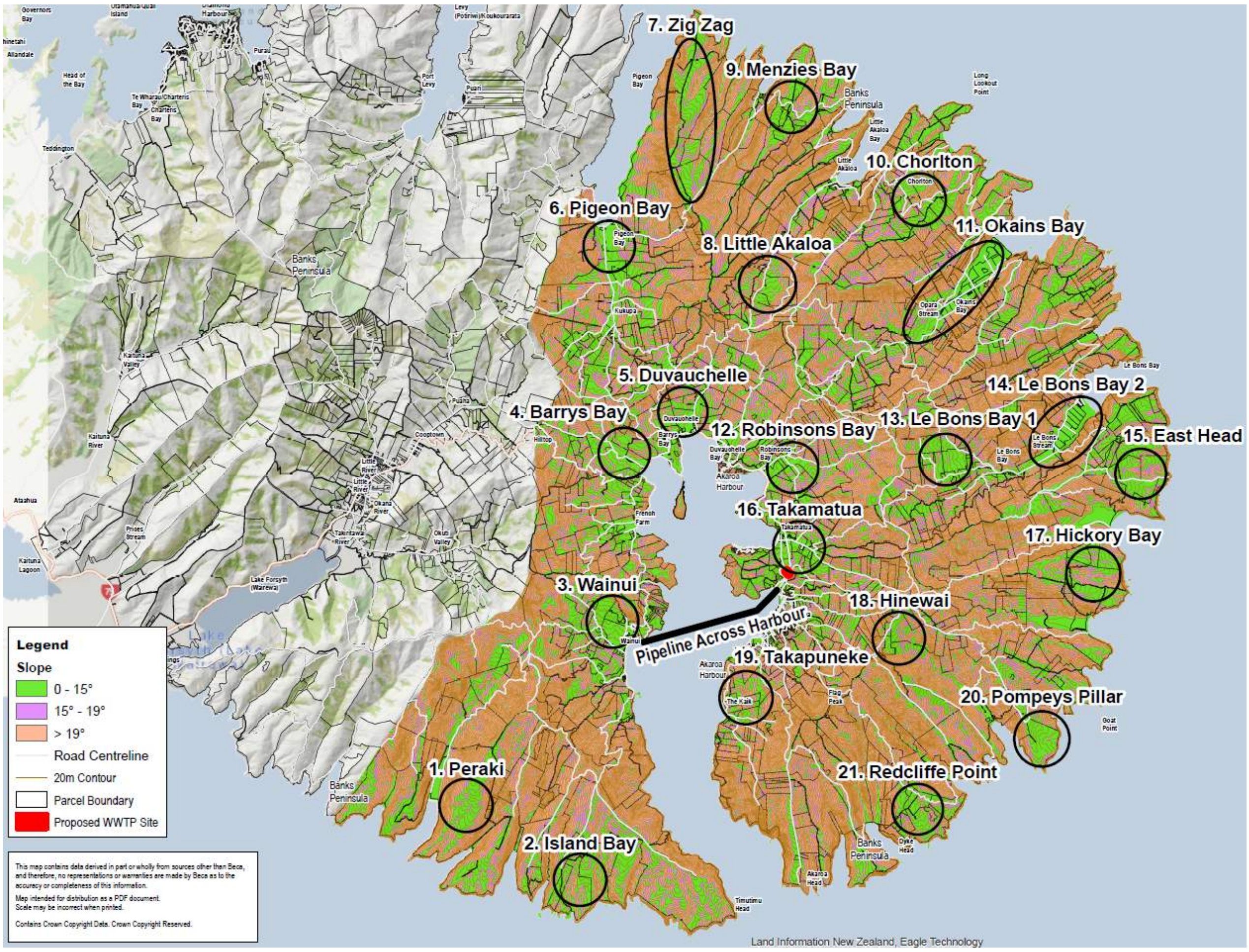

Figure 4-2: Potentially Irrigable Areas Identified by High Level Screening

Screening criteria were identified to allow the sites to be compared to each other. The screening criteria are primarily focused on land stability, but also consider distance from the treatment plant. Distance from the treatment plant has been applied as a criteria as higher distance translates to higher capital cost and higher operational costs. Increased distance to the irrigation area also translates to lower overall resilience as long conveyance pipelines are at risk from land slips and other natural hazards. The selected criteria are summarised in Table 4-1.

Table 4-1: Land Area and Slope Screening Criteria

Assessment Criteria	Comparative Performance Definitions		
	Favourable	Moderately favourable	Unfavourable
Land area and slope stability	Sufficient land, continuous irrigation area and slope less than 19 degrees	Land area sufficient but discontinuous. Site slope less than 19 degrees	N/A
Downgradient slope	Downgradient slopes less than 15 degrees, and low risk to infrastructure or property	Downgradient slopes greater than 15 degrees, and low risk to infrastructure or property	Downgradient slopes greater than 15 degrees, and significant risk to infrastructure or property (**SITE EXCLUDED**)
Distance from treatment plant	Less than 5km from WWTP by road (or cross harbour pipeline)	5 – 10km from WWTP by road (or cross harbour pipeline)	More than 10km from WWTP by road (or cross harbour pipeline)

Potential irrigable areas identified, and initial screening results (indicated by the ticks and crosses) based on the criteria set out in Table 4-1, are shown in Figure 4-3. The initial screening is high level. The primary purpose is to provide a shortlist of potential options for further investigation.

Based on the initial screening five sites have been excluded (Barrys Bay, Le Bons Bay 1, Little Akaloa, Hinewai and Takapuneke). While sixteen sites were found to be potentially suitable based on the specified criteria.

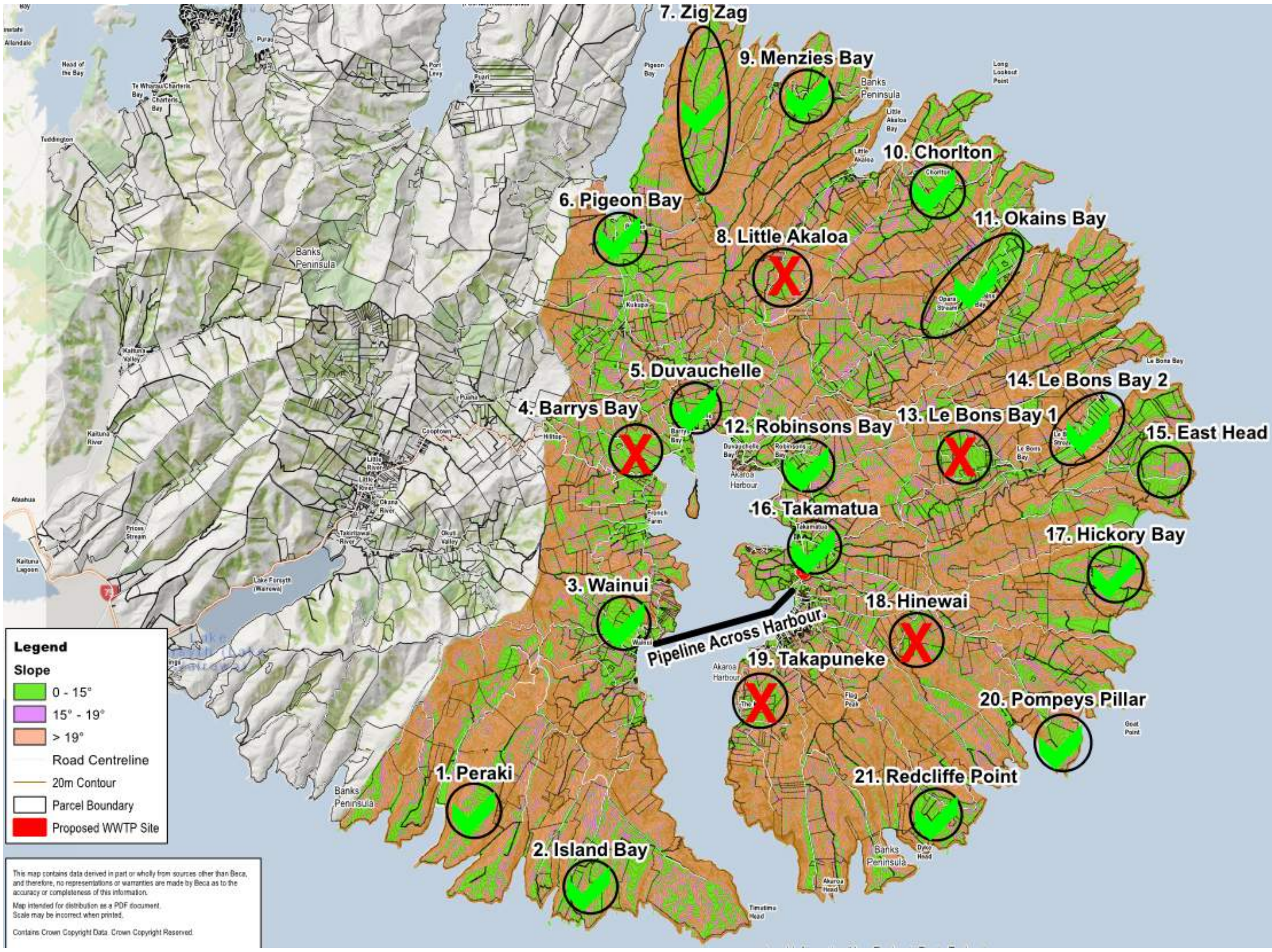

Figure 4-3: Results of Screening of Irrigation Sites on Eastern Side of Banks Peninsula

The criteria in Table 4-1 were applied to the 21 sites identified in Figure 4-3. The result of this evaluation is shown in Table 4-2.

Table 4-2: Initial Site Screen Assessment

No.	Site	Land Area and Slope	Downgradient slope and risk	Distance from treatment plant[1] (km)	Commentary
1	Peraki	Favourable	Moderately favourable	32	Not shortlisted initially due to long distance from treatment plant
2	Island bay	Favourable	Moderately favourable	32	Not shortlisted initially due to long distance from treatment plant
3	Wainui	Favourable	Favourable	22	Not shortlisted initially due to long distance from treatment plant
4	Barrys Bay	Moderately favourable	Unfavourable	10	Excluded due to downslope geotechnical risk
5	Duvauchelle	Favourable	Favourable	7	Not shortlisted initially as site earmarked for irrigation of Duvauchelle wastewater[2]
6	Pigeon Bay	Favourable	Favourable	16	Not shortlisted initially due to long distance from treatment plant
7	Zig Zag	Favourable	Moderately favourable	21	Not shortlisted initially due to long distance from treatment plant
8	Little Akaloa	Favourable	Unfavourable	13	Excluded due to downslope geotechnical risk
9	Menzies Bay	Favourable	Moderately favourable	24	Not shortlisted initially due to long distance from treatment plant
10	Chorlton	Favourable	Moderately favourable	21	Not shortlisted initially due to long distance from treatment plant
11	Okains Bay	Favourable	Favourable	16	Not shortlisted initially due to long distance from treatment plant
12	Robinsons Bay	Favourable	Favourable	4	Recommend further investigation due to sufficient and potentially suitable land area, low geotechnical risk and moderate distance to treatment plant
13	Le Bons Bay 1	Favourable	Unfavourable	10	Excluded due to downslope geotechnical risk
14	Le Bons Bay 2	Favourable	Favourable	16	Not shortlisted initially due to long distance from treatment plant
15	East Head	Favourable	Moderately favourable	21	Not shortlisted initially due to long distance from treatment plant
16	Takamātua	Moderately favourable	Favourable	1	Recommend further investigation due to sufficient and potentially suitable land area, low geotechnical risk and moderate distance to treatment plant
17	Hickory Bay	Favourable	Moderately favourable	11	Not shortlisted initially due to increased distance from treatment plant

No.	Site	Land Area and Slope	Downgradient slope and risk	Distance from treatment plant[1] (km)	Commentary
18	Hinewai	Favourable	Unfavourable	7	Excluded due to downslope geotechnical risk
19	Takapuneke	Favourable	Unfavourable	4	Excluded due to downslope geotechnical risk
20	Pompeys Pillar	Favourable	Moderately favourable	10	Recommend further investigation due to sufficient and potentially suitable land area, low geotechnical risk to infrastructure and property, and moderate distance to treatment plant
21	Redcliffe Point	Favourable	Moderately favourable	12	Not shortlisted initially due to long distance from treatment plant

Notes
1. Distance measured by public road as this is a practical and low cost route for construction of wastewater pipelines and avoids crossing private land. Cross harbour pipe length is actually 5km but is calculated as 20km as the marine pipeline cost is approximately four times the land pipeline cost per kilometre.
2. Duvauchelle Golf Course is under consideration by Christchurch City Council for application of Duvauchelle wastewater.

4.3 Summary

Based on the screening exercise conducted, sites shortlisted as reasonably practicable options for further investigation were:

- Site 12 - Robinsons Bay Valley
- Site 16 - Takamātua Valley
- Site 20 - Pompeys Pillar

Maps showing potentially suitable irrigation area for the three shortlisted sites based on the criteria given in Table 3-1 and Table 3-2 are attached in Appendix G.

5 Irrigation Concept Design for Alternative Sites

Initial design concepts have been developed for shortlisted options to enable high level and comparative cost estimates to be developed. This work brings together two lines of investigation:

- Identification and assessment of potentially irrigable land; and
- Identification of potential wastewater storage pond locations

It is important to note that, while there may be some efficiency in co-locating the storage ponds and the land irrigation in the same area, these features may also be physically separated. In may also be possible, and necessary, to divide the total required storage volume over multiple ponds e.g. having a small pond across from the treatment plant site and a larger pond nearer to the irrigation area. In the work conducted to date the selection of land for irrigation and for storage has proceeded separately and using distinct criteria. There is likely to be a range of options for "connecting up" the storage and the irrigation components of the scheme and these have not yet been fully explored. This concept design work is described in the following sections.

5.1 Land Area Requirements

The requirements for land area are slightly changed from those identified in the May 2016 Concept Design Report and are summarised in Table 5-1. Land requirements have been determined based on estimated application rates. The application rates, expressed as mm/day, depend on the soil moisture content for pasture and vary from less than 1mm/day to 7 mm/day. For trees the winter application rate is based on an average of 1.2 mm/day in winter and 2.5 mm/day in summer, with a maximum rate of 4.2 mm/day. Nutrient load is less than 70 kg/ha/year for trees and pasture based on the proposed nutrient removal of the treatment plant. In addition to irrigation area, the following factors will impact on the area of land needed:

- Land required for storage ponds;
- Buffer zones required to neighbouring properties, streams and other features;
- Allowance for non-irrigable areas such as springs, boggy areas, and localised areas that are too steep;
- Allowance for protection of features with specific heritage, cultural or natural or ecological values as recognised in relevant planning and other regulatory documents; and
- Detailed design may allow for mixed irrigation system of spray and drip systems.

A buffer zone is an area of land which is excluded from potential irrigable area based on selected criteria.

Table 5-1: Land Area Requirements

Option	Wastewater Storage Pond (m^3)	Minimum Area for Irrigation (ha)	Minimum Area for Storage (ha)
Irrigation to trees (drip)	17,500	25	0.9
Irrigation to pasture (spray)	35,000	27	2.5

Note that the total area required for irrigation to trees has changed slightly from the May 2016 Report. This is a result of discussions amongst the Technical Experts Group around winter drainage from the soil in January 2017. A preliminary review of winter drainage compared with the long term ability of the soil to accept wastewater (the Long Term Acceptance Rate or LTAR) suggested the use of a slightly lower winter application rate than originally used.

To mitigate this lower rate an increase in storage has been incorporated for the tree irrigation option - up to 17,500m^3 of storage as opposed to 12,000m^3 identified previously. Increasing the pond storage to 17,500m^3 provides a more conservative irrigation application rate, and includes a provision of 2,500m^3 to accommodate direct rainfall onto the ponds. The storage volume remains indicative at this stage and can only be confirmed accurately once the irrigation area has been identified in terms of specific land parcels and the infiltration characteristics of these areas has been fully investigated. Detailed soil moisture modelling will be carried out for selected sites and areas once known.

Assuming a pond water depth of 3.0m and a rainfall buffer of 0.5m then an active storage of 2.5m would be provided. A total water depth of 3m is considered well suited to meeting the storage requirement while also assisting to maintain the pond dissolved oxygen levels to full depth. Based on this depth, for an active storage volume of 17,500m^3, a roughly square pond would need to be around 90m in length and 90m in width at its wetted perimeter, with a water surface area of 8,100m^2. This pond may be separated into two ponds using an intermediate embankment, but within the same overall footprint. Detailed investigations and design will be required to better define these figures for specific sites.

5.2 Irrigation Area Selection Criteria

Some minor adjustments to the irrigation land selection criteria from October 2016 have been adopted. These changes are as follows:

- Potentially irrigable land within 5m of any adjacent land ownership area has been excluded for dripper irrigation to trees. A land ownership area refers to an area of land that may include multiple titles owned by a single party.
- For spray irrigation to pasture a 25m buffer zone from a land ownership area has been adopted.
- For any potentially irrigable property parcel containing a dwelling, 1 ha of land has also been subtracted from the irrigable area to allow for the dwelling, ancillary buildings and the land needed for onsite wastewater disposal in compliance with the New Zealand Standard for Onsite Domestic Wastewater Management AS/NZS1547:2012
- Stream setback has been adjusted to 25m for permanently flowing streams and 10m to ephemeral streams for both irrigation to trees and pasture. This is for consistency as the risks of nutrient migration to water courses are likely to be similar for both spray and dripper irrigation. The risks to stream ecology and water quality are less for an ephemeral stream than for a permanently flowing stream hence a lesser setback has been adopted
- A new criteria around excluding land with areas of High Natural Character or Outstanding Natural Landscape has been added to avoid adverse landscape effects
- All other criteria are the same as those specified in October 2016

Table 5-2: Revised Assessment Criteria for Land Suitable for Spray Irrigation (February 2017)

Selection Criteria	K-Line spray irrigation option	Basis for Criteria Selection
Land Stability	- Include land less than 15 degrees slope and downslope to coastline same grade or less - Include land with no identified instability within or downhill of area - Exclude land that, if it became unstable, could pose risk to downslope residences and infrastructure	To minimise risk of land instability resulting from irrigation
Minimum land parcel	2ha	To exclude plots that are too small to contribute significant irrigable area
Erosion zones	Tonkin & Taylor map erosion zones excluded + 20m buffer to edge of zone	To minimise risk of land instability resulting from irrigation
Residential setback	Exclude residential zone land parcels. In addition, potentially irrigable land within 25m of any adjacent land ownership area has been excluded For any potentially irrigable property parcel containing a dwelling, 1 ha of land has also been subtracted from the irrigable area to allow for the dwelling, ancillary buildings and the land needed for onsite wastewater disposal in compliance with the New Zealand Standard for Onsite Domestic Wastewater Management AS/NZS1547:2012	It is assumed that rural dwellings require a complying on-site wastewater system. LWRP Rule 5.8 requires a 4 ha site for onsite wastewater disposal as a permitted activity. However, subject to resource consent, this land area could be reduced to 1 ha providing the on-site wastewater system complies with AS/NZS1547:2012. The basis for this is as follows: the required irrigation field area for a rural residence is about 3,000 m^2. AS/NZS1547:2012 requires a reserve area of the same size to be provided, hence a minimum total area of 6000 m^2 is required. Allowing for the house site, driveway, and outbuildings the minimum site has been set at 10,000m^2 or 1 ha. A 25m buffer around the 1 ha is also provided
Stream setback	25m to centreline of continuous flowing streams 10m setback to ephemeral streams	To minimise the potential for nutrients in irrigated wastewater to migrate through shallow groundwater into surface water courses.
Coastline setback	25m	To minimise the potential for nutrients in irrigated wastewater to migrate through shallow groundwater into coastal waters.
Landscape effects setback	Exclude land identified as High Natural Character or Outstanding Natural Landscape in the District plan, plus a 50 metre buffer zone	To avoid possible negative landscape effects

Table 5-3: Revised Assessment Criteria for Land Suitable for Dripper Irrigation (February 2017)

Selection Criteria	Dripper Irrigation Option	Basis for Criteria Selection
Land Stability	- Include land less than 19 degrees slope for dripper irrigation to trees - Include land with less than 15 degrees downslope to coastline from irrigation site - Include land with no identified instability within or downhill of area - Exclude land that, if it became unstable, could pose risk to downslope residences and infrastructure	- To minimise risk of land instability resulting from irrigation
Minimum land parcel	1ha	To exclude plots that are too small to contribute significant irrigable area
Erosion zones	T&T map erosion zones excluded + 20m buffer to edge of zone	To minimise risk of land instability resulting from irrigation
Residential	Exclude residential zone land parcels	It is assumed that rural dwellings require a complying on-site

Selection Criteria	Dripper Irrigation Option	Basis for Criteria Selection
setback	In addition, potentially irrigable land within 5m of any adjacent land ownership area has been excluded For any potentially irrigable property parcel containing a dwelling, 1 ha of land has also been subtracted from the irrigable area to allow for the dwelling, ancillary buildings and the land needed for onsite wastewater disposal in compliance with the New Zealand Standard for Onsite Domestic Wastewater Management AS/NZS1547:2012	wastewater system. LWRP Rule 5.8 requires a 4 ha site for onsite wastewater disposal as a permitted activity. However, subject to resource consent, this land area could be reduced to 1 ha providing the on-site wastewater system complies with AS/NZS1547:2012. The basis for this is as follows: the required irrigation field area for a rural residence is about 3,000m^2. AS/NZS1547:2012 requires a reserve area of the same size to be provided, hence a minimum total area of 6000m^2 is required. Allowing for the house site, driveway, and outbuildings the minimum site has been set at 10,000m^2 or 1ha. A 5m buffer around the 1 ha is also provided
Stream setback	25m to centreline of continuous flowing streams 10m to centreline of ephemeral streams	To minimise the potential for nutrients in irrigated wastewater to migrate through shallow groundwater into surface water courses.
Coastline setback	25m	To minimise the potential for nutrients in irrigated wastewater to migrate through shallow groundwater into coastal waters.
Landscape effects setback	Exclude land identified as High Natural Character or Outstanding Natural Landscape in the District plan, plus a 50 metre buffer zone	To avoid possible negative landscape effects

Maps showing one possible high level scheme design for each of the shortlisted sites, based on the criteria in Table 5-2 and Table 5-3, are given in Appendix H. The amount of potentially suitable area identified for these areas after applying the criteria is given in Table 5-4. These are net areas after buffer zones, setbacks and buffer areas have been removed and so can be compared directly to the amount of land required for irrigation given in Table 5-1. The available areas for dripper irrigation will be higher than for spray as the buffer zones allowed around the irrigation areas are reduced.

Table 5-4: Land Area Identified as Potentially Suitable for Irrigation

Location	Maximum Available Area – Spray (ha)	Maximum Available Area – Dripper (ha)
Robinsons Bay Valley	40.9	63.8
Takamātua Valley	9.2	18.6
Pompeys Pillar	34.8	40.8

5.3 Storage Pond Site Considerations

5.3.1 Pond Site Selection

GIS mapping was employed to select potential storage pond sites based on criteria agreed with Council staff as shown in Table 5-5. Pond storage site selection criteria take into account a range of potential risk issues that are specific to wastewater storage, hence are different from irrigation area selection criteria. Storage pond odour considerations are separately assessed as part of Section 5.8.

Table 5-5: Pond Selection Criteria

Factor	Criteria	Basis for Criteria Selection
Waterways	Exclude 25m buffer on either side to centreline of waterway	To avoid impinging on stream floodplains and to reduce risks of storage pond embankment erosion due to flooding.
Road	Exclude 25m buffer on either side to centreline of road	To provide protection against visual impacts from a storage pond which may incorporate above ground embankments.
Residential Dwelling	Exclude 100m buffer around residential dwellings	Odour risks associated with the pond operation are considered to be low based on the assessment provided in this report (refer to Section 5.8). The 100m buffer is proposed to manage other potential nuisance effects from the pond including noise from an aeration bubble curtain compressor and midge populations.
Plot size	Exclude all land plots 1 ha or less including a 100m buffer around the plot	Plots of less than 1ha are assumed to contain a residential dwelling.
Groundwater and seal level rise	Exclude land less than 2m above Mean High Water Spring (MHWS)	Shallow groundwater within this area poses significant risks for pond design and construction. Accounts for future sea level rise.
Elevation	Exclude consideration of land above 200m (with specific exceptions shown)	Pumping treated wastewater to a pond located above 200m would be comparatively costly. Pond construction costs above 200m are also likely to be higher due to the limited depth of loess and higher risk of encountering rock at shallow excavation depth.
Planning	Included all planning overlays including Silent File Areas	To take into account land planning status and other protections in the selection of potential pond sites
Property boundaries	Include property boundaries	To understand where pond sites cross property boundaries and how many land parcels would be involved in a given scheme configuration.
T&T Geotechnical Assessment	Exclude areas identified as unstable by T&T geotechnical assessment	Geotechnically unstable areas are unsuitable for pond construction and carry high risk.
Land slope	Exclude land greater than 4 degrees slope	Land greater than 4 degrees slope requires more extensive ground works resulting in higher costs

A map of potential pond storage sites in and around Takamātua Valley and Robinsons Bay Valley, as selected by GIS using the criteria outlined above is provided in Appendix I. A total of 10 potential storage sites have been identified in this area. A brief description of each site is set out in Table 5-6.

Table 5-6: GIS Selected Pond Storage Sites in and around Takamātua and Robinsons Bay

No.	Approximate Area (m^2)	Location
1	7,000	North slope of Robinsons Bay Valley at 200m height ASL
2	17,000	Lower Robinsons Bay Valley
3	6,000	Lower Robinsons Bay Valley
4	4,000	Mid-Robinsons Bay Valley
5	6,000	Mid-Robinsons Bay Valley
6	2.000	South slope of Robinsons Bay Valley at 200m height ASL
7	23,000	Lower Takamātua Valley
8	9,000	Takamātua Peninsula
9	13,000	Takamātua - near proposed treatment plant site on Old Coach Road
10	4,000	Takamātua - near proposed treatment plant site on Old Coach Road

The area of each site can be used as a starting point for a calculation of the potential volume that may be stored at each site. However, storage volume potential for each site is affected by a number of variables that have not been explored at this initial stage. These variables include land slope, down gradient slope, risk to infrastructure, depth to bedrock, landscape, visual impact and other factors.

It should also be noted that sites with land slope greater than 4 degrees may be used for wastewater storage albeit at significantly higher costs. Conversely, land near to flat with deep on site soils may provide for the cheapest development option.

The initial pond screening excluded Pompeys Pillar as the survey data available for this site was not accurate enough to be analysed using GIS. Now that more detailed survey information has been gathered, potential pond site options at Pompeys Pillar have been identified using GIS and site based observations. These potential pond sites are shown on the scheme design for Pompeys Pillar in Appendix H and described briefly in Table 5-7. No specific flat land pond sites were directly inspected while on site since the sites were many and varied. Sites P1, P2 and P3 are on potentially suitable flat areas as identified by GIS.

The same points around using the area for the starting point of a potential volume calculation apply, however it was noted that in several areas rock was exposed at the land surface, which may mean a shallow soil profile and the need to build the ponds on flat land on top of the landform. For this reason Pond site P4 is the currently preferred site for a valley pond as there is a relatively wide valley in which the valley floor is flatter than most others on the property. This valley also has a limited upstream catchment.

Table 5-7 - Pompeys Pillar Potential Pond Sites

No.	Approximate Area (m^2)	Location
P1	1,000	Northern end of site on flat land identified by GIS
P2	7,000	North-western side of site on flat land identified by GIS
P3	17,000	Southern end off site on flat land identified by GIS
P4	18,000	Y-shaped valley in the central part of the site, identified by land walkover

5.4 Pond Naturalisation

Based on feedback from the Working Party there is a preference to have storage of treated wastewater at Site 10 across the road from the new WWTP as it is near the treatment plant, has the lowest overall impact, is in the best position to provide reclaimed water for non-potable reuse in Akaroa and could provide storage of water for irrigation at any of the other locations being considered. Storage pond volumes and locations are therefore based on having 10,000 m^3 adjacent to the treatment plant, with the balance of volume located elsewhere. A volume of 10,000 m^3 at Site 10 is considered a conservative estimate for the size of pond that could be readily constructed at this site, meeting the requirements for setbacks, landscaping and still allowing space for other possible ancillaries such as small pump huts, access roads etc. The scheme designs and costings have been developed on the basis of a 10,000 m^3 pond at Site 10, this volume can be optimised during the next stage of works. Site 10 could also be used for the storage of raw wastewater if required.

A concept design has been developed for this site where the pond is cut into the hill to minimise visual effects. Geometric modelling of a pond of between 10,000 and 19,000 m^3 (depending on depth) is shown in this location in Figure 5-1 for an indication of how the pond might be positioned.

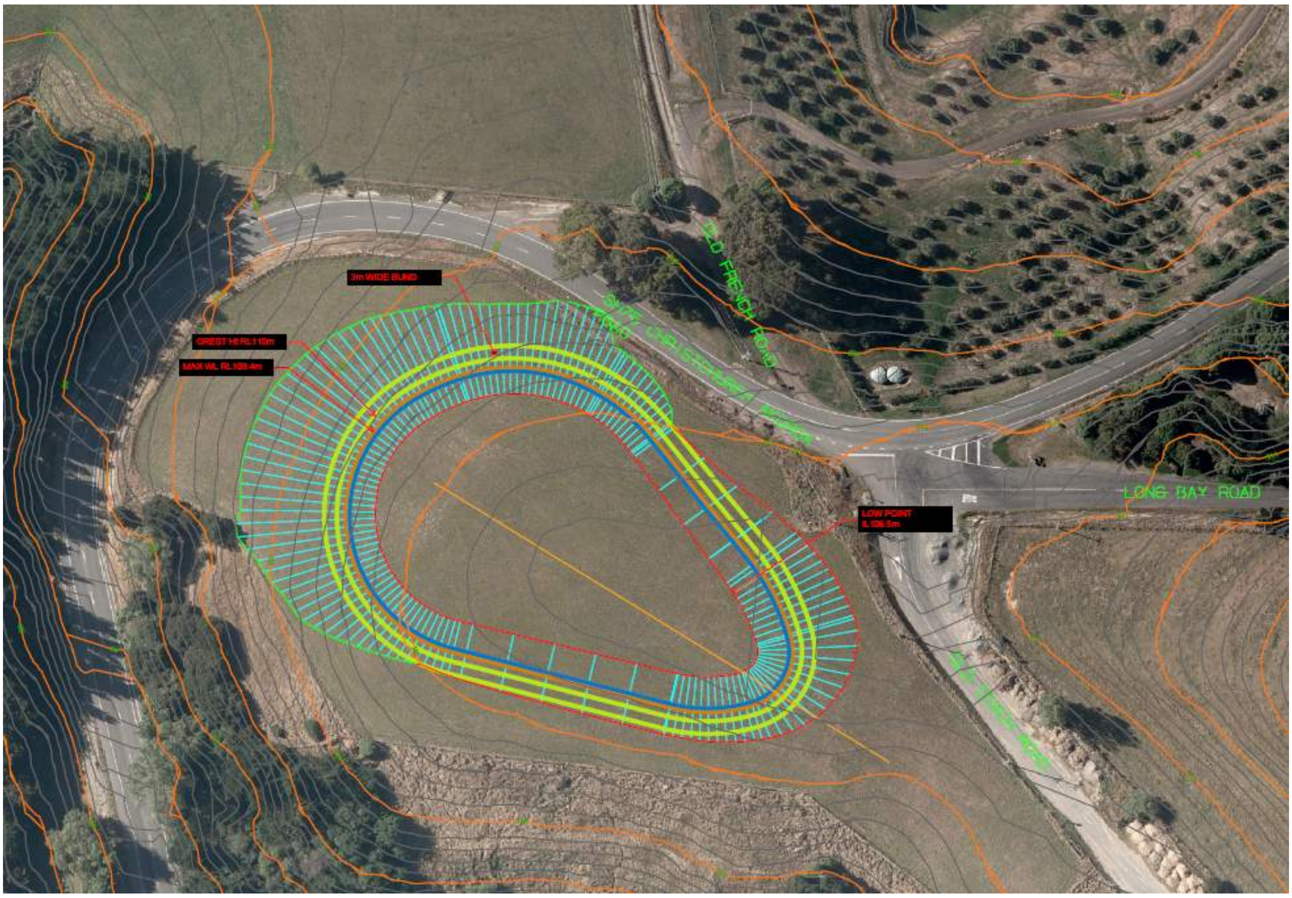

Figure 5-1: Geometric Design of Possible Storage Pond Opposite WWTP (Site 10)

The pond concept designs vary from site to site depending on land slope. Factors that could be taken into account with the design and location of storage ponds are as follows:

- Siting the ponds with regard to view paths to vantage points, dwellings, public roads and other sensitive receptors; and
- Consideration of whether they are constructed into the ground or on top of the ground to minimise the visual prominence (this depends on site geotechnical conditions, i.e. depth of rock)

Secondary design aspects to be considered are as follows:

- Contouring the pond embankments into a natural shape, which would result in longer, and hence more costly, embankments; and
- Landscaping of embankments and the area surrounding the pond. It is noted that trees are problematic when planted near to ponds, as their roots tend to seek out such water sources. This in time can be detrimental to the integrity of the pond embankment and can allow for an erosion path from the pond. Furthermore, tall tree barriers directly adjacent to the pond will reduce the wind on the pond surface and necessitate a higher degree of mechanical aeration to the pond.

We note that planting the internal pond embankments with species such as flax that will grow to the water's edge is not possible in this case as it is intended that the pond be lined with a HDPE liner, or similar. It may be possible to plant some shallow rooting shrubs only. Landscaping directly on the external embankment slope should also be minimised so that the integrity of the embankment system can be directly observed. The preference is for landscaping to be set back from the pond system.

Furthermore, it is not recommended to install wetland plants within the ponds. Wetlands may be viable in some form but there are potential risks as the water level in the ponds will vary over a wide range. Most wetland plants can survive within a limited water depth range – up to 300mm typically. With a typical working depth range of 3m wetland plants would, for most of the time, tend be out of the water completely or totally inundated. Floating wetlands will not likely provide any treatment benefit over the expected water level range of the pond.

An initial review of potential visual impacts associated with the potential storage sites has been completed. Landscaping concepts will be developed further once a preferred pond site is selected, an indication of the type of landscaping that may be employed at Site 10 is given in Figure 5-2. This is indicative only and has not been prepared in accordance with the NZ Institute of Landscape Architects Best Practice Guide, Visual Simulations. A summary of findings from the landscape and visual effects review is given in Section 7.8.2. Further artists impressions and the full visual effects review report are given in Appendix J.

Figure 5-2 Artists Impression of Landscaping of Pond at Site 10

5.5 Robinsons Bay Valley Design Concepts

A map of one potential scheme design in Robinsons Bay Valley, based on the selection criteria stated in Table 5-2 and Table 5-3, is provided in Appendix H.

The basic engineering requirements for the land irrigation scheme, at any location, include the following:

- Storage pond volume totalling 17,500m^3 for tree irrigation and 35,000m^3 for pasture irrigation. This is made up of approximately 10,000 m^3 in a pond located opposite the WWTP, with the balance of the volume in a pond in the Robinsons Bay valley;

- A minimum land irrigation area of 25ha for tree irrigation or 27 ha for pasture irrigation excluding buffer zones;
- Pipelines to connect from the treatment plant to the storage pond(s) and from the storage pond(s) to the irrigation area(s); and
- A final filtration system and pump station to convey the wastewater to the irrigation area(s). The final filtration system is required to filter out wind-blown debris that has entered the pond and that has been generated by fauna (bird feathers, etc.).

As stated in the introduction to Section 5 the storage ponds may be positioned at any of ten potential sites shown in Appendix I and the total storage may be divided over multiple pond locations. (This excludes storage at Pompeys Pillar as storage at this location is unlikely to be a viable component of a scheme based on irrigation to land at Takamātua or Robinsons Bay). A range of considerations will need to be taken into account in selecting preferred pond sites as follows:

- Locating storage ponds and irrigation areas closer together will be more efficient in terms of capital and operating costs than distributed storage and irrigation systems;
- A single pond will be more cost effective than multiple ponds;
- Construction and operational risks for specific storage sites will need to be considered; and
- Whether there will be visual effects, nuisance effects, and other potential impacts for specific storage sites will also need to be addressed.

The requirements for a final pump station will depend on the height of the storage ponds in relation to the irrigation fields. This issue will be resolved once preferred pond sites have been confirmed.

5.5.1 **Thacker Land in Robinsons Bay**

The owner of the Thacker Property in Robinsons Bay has instigated discussions with the Council regarding possible purchase of that land for use as a wastewater irrigation area. Beca has conducted an initial investigation into the feasibility of using this land for irrigation of trees using drip irrigation at the request of the Council. A summary report on the initial walkover is provided in Appendix K.

The criteria selected to identify potentially suitable land are specific to the circumstances of the Thacker site (nature of the land and requirements to consider only drip irrigation to trees) and for this reason are more refined than the same as the initial site screening criteria which apply to a range of different site types and irrigation methods, and to both tree and pasture options.

The initial walkover identified a preferred area for irrigation with slope less than 19 degrees. The use of 19 degrees is based on the USEPA Guideline recommendation that afforested slopes may be irrigated up to 19 degrees rather than the more conservative 15 degrees previously assumed. There is a total of 62 ha of land with slope less than 19 degrees. Of this the preferred area for irrigation amounts to 30.7ha, which is more than the minimum area required for irrigation to trees of 25ha. Seven potential pond storage sites were also identified. Three of these are located below the 200m contour which offers benefits in terms of reduced pumping and lower cost construction costs.

Physical investigations of the Thacker land involving test pits and infiltration tests have been completed. Results from physical investigations are being used to develop a specific concept design scheme for this site.

A visual impact and landscaping assessment has also been completed for all potential storage sites (Refer to Appendix J).

5.6 Takamātua Valley Design Concepts

As stated in Section 5.3, the basic engineering requirements for the land irrigation scheme, includes the following:

- Storage pond volume totalling 17,500m^3 for tree irrigation and 35,000m^3 for pasture irrigation. This is made up of approximately 10,000 m^3 in a pond located opposite the treatment plant, with the balance of the volume in a pond in the Takamātua Valley. The only possible pond location identified by the pond screening exercise in the Takamātua Valley is on land that is identified as a liquefaction management zone and in areas of high groundwater. Therefore the pond at this site is assumed to be constructed of entirely imported material, above ground, and ground investigations are required to categorise the liquefaction risk;
- A minimum land irrigation area of 25 ha for tree irrigation or 27 ha for pasture irrigation excluding buffer zones and storage allowance;
- Pipelines to connect from the treatment plant to the storage pond(s) and from the storage pond(s) to the irrigation area(s); and
- A final filter and pump station to convey the wastewater to the irrigation area(s). Two (or more) pump stations may be required since there is insufficient land in Takamātua Valley for a standalone system. If land in Robinsons Bay (or another site) is used in addition to Takamātua Valley to create a hybrid scheme, an irrigation pump station would be required at each location.

In Takamātua Valley the maximum available area for spray irrigation (9 ha) is significantly less than the minimum required (refer to layout plan Appendix H). There is the possibility that a spray irrigation scheme could be developed that utilises some suitable land in Takamātua Valley, with the balance of land required located elsewhere. This is considered less practicable than an option based on a single irrigation area due to the cost and complexity of having multiple, isolated irrigation fields.

Furthermore, the most recent GIS layout map for Takamātua (refer to Appendix H) shows that the potentially irrigable area, based on dripper irrigation, is also insufficient (18.6 ha) for the total flow and load so to achieve a dripper irrigation scheme to trees this would also need to be a hybrid option. A range of buffer zones that have been specified have contributed to the reduction in area. These include:

- 25m buffer zone to permanently flowing streams
- 10m buffer zone to ephemeral streams
- Residentially zoned land is excluded
- Potentially irrigable land within 5m of any adjacent land ownership area has been excluded for irrigation to trees. For spray irrigation to pasture a 25m buffer zone has been adopted. A land ownership area may include multiple titles owned by a single party.
- For any potentially irrigable property containing a dwelling, 1 ha of land has also been subtracted from the irrigable area to allow for the dwelling, ancillary buildings and the land needed for onsite wastewater disposal in compliance with the New Zealand Standard for Onsite Domestic Wastewater Management AS/NZS1547:2012
- Exclusion of land based on geotechnical risks including areas identified in the T&T hazard maps (2009) and other areas

Overall, it is considered that land in Takamātua Valley is not viable for irrigating 100% of the wastewater flow using dripper or spray methods. This is an important conclusion and implies that, if Takamātua Valley is to be irrigated, it would need to be in conjunction with another area.

5.7 Pompeys Pillar Design Concepts

For the Pompeys Pillar scheme option treated wastewater would need to be pumped over a hill 620m above sea level and a total distance of 10km to reach the Pompeys Pillar land. The key components of this scheme would include:

- Pond of approximately 10,000m^3 across the road from the wastewater treatment plant site to buffer peak wet weather flows and allow steady pumping of flow from the treatment plant site to the irrigation area;
- An additional pump station building (approximately 15m long by 5m wide) adjacent to the pond with two (duty/standby) 75kW pumps. The land directly across the road from the wastewater treatment plant site appears to be suitable in size, slope and features for construction of the pond and pump station;
- 10km pipeline, 5km of this would be fabricated in stainless steel due to very high pumping pressures, with the final 5km fabricated in polyethylene (PE) with down slope pressure break tanks every 1km;
- Treated wastewater storage pond for the balance of storage volume (approximately 25,000m^3 for pasture or 7,500m^3 for irrigation to trees) at Pompeys Pillar. The concept at Pompeys Pillar is based on forming a pond by damming an existing ephemeral waterway at location P4 (this pond site is hidden from view from all terrestrial viewing points surrounding the farm) and
- Irrigation pump station and distribution pipelines and irrigation system at Pompeys Pillar.

Initial indications are that this site is exposed to higher wind velocities than the other sites and this may influence irrigation scheme design and selection and growth of vegetation, however these high winds are not a barrier to use of this site.

5.8 Storage Pond Odour Considerations

During recent public consultation on the scheme some members of the community have expressed concern about the likelihood and potential effects of pond odours on nearby properties. Potential odour effects associated with the pond are related to their operation, the risk that odours will be produced, and “FIDOL” factors[4] (the odour Frequency, Intensity, Duration, Offensiveness and Location).

5.8.1 Overview of Pond Odour Risks

The potential for emission of odours from wastewater storage ponds is related to the pond surface organic loading (measured as kg of Biological Oxygen Demand (BOD) per hectare of pond surface area per day, or kg BOD/ha/day)[5]. Organic load is represented by the organic substances present in the wastewater flowing into the pond. The organic load provides food for biological activity and encourages growth of biomass and algae in the pond water. Some of biomass (bacterial) respires aerobically, using up the dissolved oxygen in the pond. Other biomass near the surface (algae), uses photosynthesis to release oxygen into the pond.

If the organic loadings are high enough, the biomass will consume the dissolved oxygen faster than it can be replaced by surface diffusion from the atmosphere and by algal activity. In this scenario the dissolved oxygen concentration tends towards zero. Initially the pond will become “anoxic” which means that the biomass survives by scavenging oxygen from any nitrate-nitrogen present. Ultimately, if the BOD loading is high enough, the pond may go anaerobic and start to produce odours.

A contributory factor in pond anaerobic conditions is layering, or stratification, in the pond water. In calm or light wind conditions the pond water may become stratified and the solids in the incoming wastewater will settle onto the pond base. In addition, while the daily loading of solids is very low, over an extended period of

[4] Ministry for the Environment Good Practice Guide for Assessing and Managing Odour, 2016, p18.

[5] Pond Treatment Technology, IWA, 2005, p.373.

time solids may accumulate and any dead algal mass will settle on the base of the pond. The base layer of solids is more likely to go anaerobic because the effects of oxygen diffusion and algal oxygen production have less effect at greater depth especially if the pond becomes stratified. Under stratified conditions the odours emitted from the anaerobic layer on the pond base are treated by the overlying aerobic liquid. However, such odours can escape the stratified system, especially when mixing resumes.

5.8.2 Assessment of Pond Level and BOD Concentrations

Flows and storage volume for the proposed Akaroa pond have been calculated based on the Akaroa wastewater monitoring dataset from December 2008 to October 2015. The irrigation field loadings have been analysed using the combined rainfall and evapotranspiration data measured from 2008 to 2015 at the Akaroa EWS and forecasted data from NIWA's virtual climate station network (Stn 20249, NIWA VCNS) from 1972 to 2016 to determine how much wastewater can be applied and also when wastewater cannot be applied. These two datasets have been combined to provide a model for pond operation that identifies daily flow and pond level over a 7 year period.

The modelled storage pond volume, for a scheme based on dripper irrigation to trees, is shown in Figure 5-3. This graph effectively shows how the pond would have operated from December 2008 to October 2015 if the land irrigation scheme had been operating at that time.

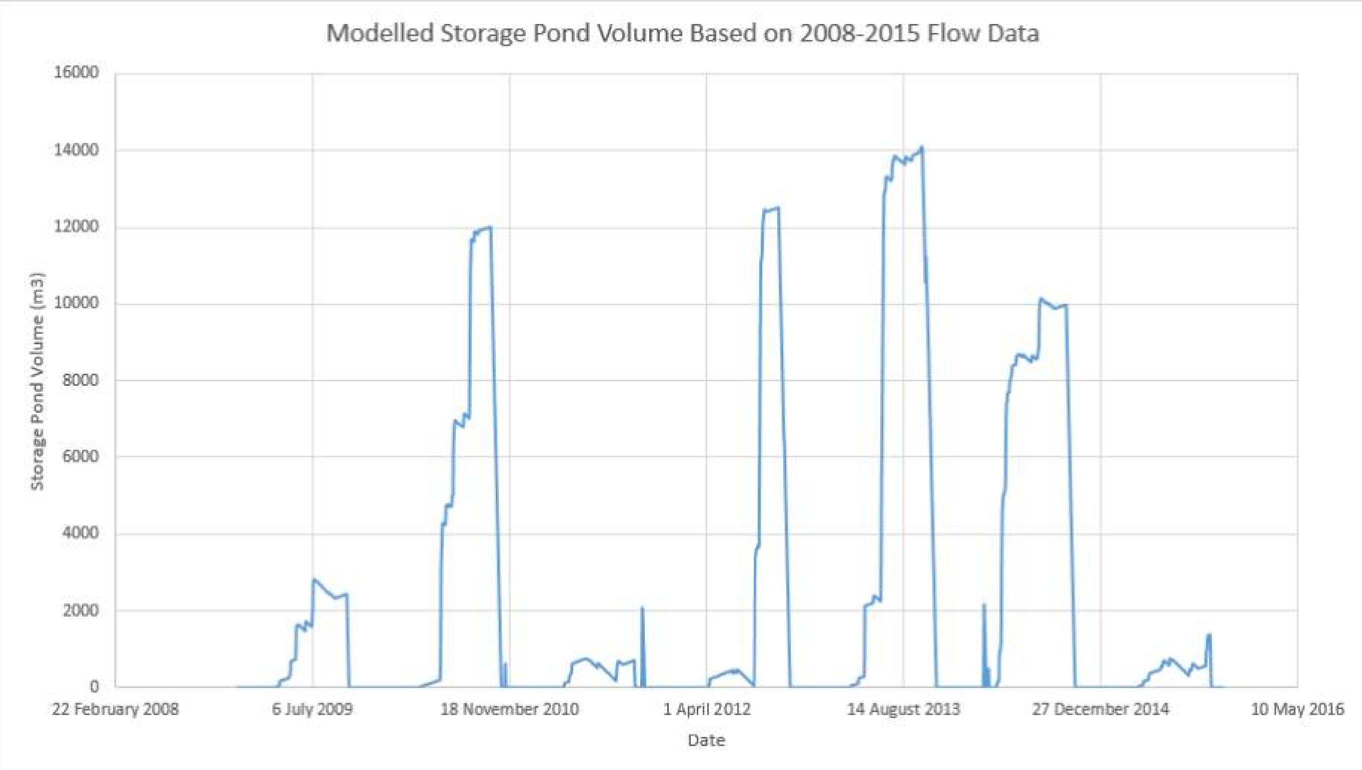

Figure 5-3: Model of Storage Pond Operation

Several operational features can be seen in Figure 5-3 as follows:

- The pond contained elevated water levels every winter for a period of 5 to 6 months;
- The pond was not used for storage during the summer (evaporation has not been accounted for, but it is intended for all flow go through the pond);

- The pond maximum level varied considerably from year to year, with a maximum of about 5,500m^3 in 2009 and 4,500m^3 in 2011. The peak year was 2013 when the pond storage volume reached 16,500m^3; and
- The pond empties rapidly during October every year.

The modelled performance is a snapshot of performance for the given 7 years of rainfall and wastewater flow. It is possible that the pond will fill up during the summer under some circumstances but this is less likely than in winter. In the summer the groundwater is lower and this means that infiltration into the wastewater network will be less, even during heavy rainfall (albeit Council is looking to reduce infiltration).

The other main factor is the reduced ability of the soil to absorb water during the winter and the much lower application rates that will need to be used during the winter months. The combination of these two factors mean that the pond will generally fill up in winter rather than in summer.

The Ministry for the Environment's Climate Change Predictions for NZ (2016) indicates that the annual precipitation for the Canterbury region may not vary significantly, but it is expected that the rainfall intensity of extreme events could increase. It is difficult to determine how detrimental the change in magnitude of extreme events will affect the Banks Peninsula region, but it appears the change in magnitude will not materially impact the estimated storage requirements and annual drainage. The working volume of the storage pond used for sizing and location purposes includes 0.5m or approximately 2,500m^3 as a buffer to account for unknowns such as rainfall. The pond also has an additional freeboard of approximately 0.6m.

Rainfall data from two sources for the 3-month period between July and September each year when the pond is likely to be most full has been considered. In the Akaroa Electronic Weather Station (EWS) data from 2009 to 2015 the maximum rainfall in this period was 572mm. In the Akaroa Armstrong Crescent data (from NIWA Cliflo) the maximum rainfall in the three month period recorded between 1900 and 1994 was 806mm. Conservatively considering the scenario where no discharge is allowed to occur at all during the July to September winter months and negating the contribution of evaporation, this data demonstrates that there is a 79% chance that rainfall will be accommodated within the 500mm allowance provided for rainfall. At no point during 102 years on record did the rainfall depth over these months exceeded 1,100mm (the combined rainfall and freeboard depth).

MfE Tools for Estimating the Effects of Climate Change on Flood Flow: A Guidance Manual for Local Government in New Zealand. Ministry for the Environment, May 2010 estimates that the change in rainfall until 2040 attributed to climate change is not statistically significant. Therefore this high level review indicates that the pond configuration is adequate for the likely worst-case rainfall during periods where discharge is not permitted. Once the location of the pond(s) is confirmed, more detailed modelling will be undertaken to confirm the rainfall allowance appropriate to the specific site.

BOD concentrations for the proposed Akaroa pond have been calculated based on the pond flow data shown in Figure 5-8. Pond wastewater quality (BOD specifically) has been determined by calculating the flow split between the membrane treatment plant and the bypass as shown in Figure 5-4.

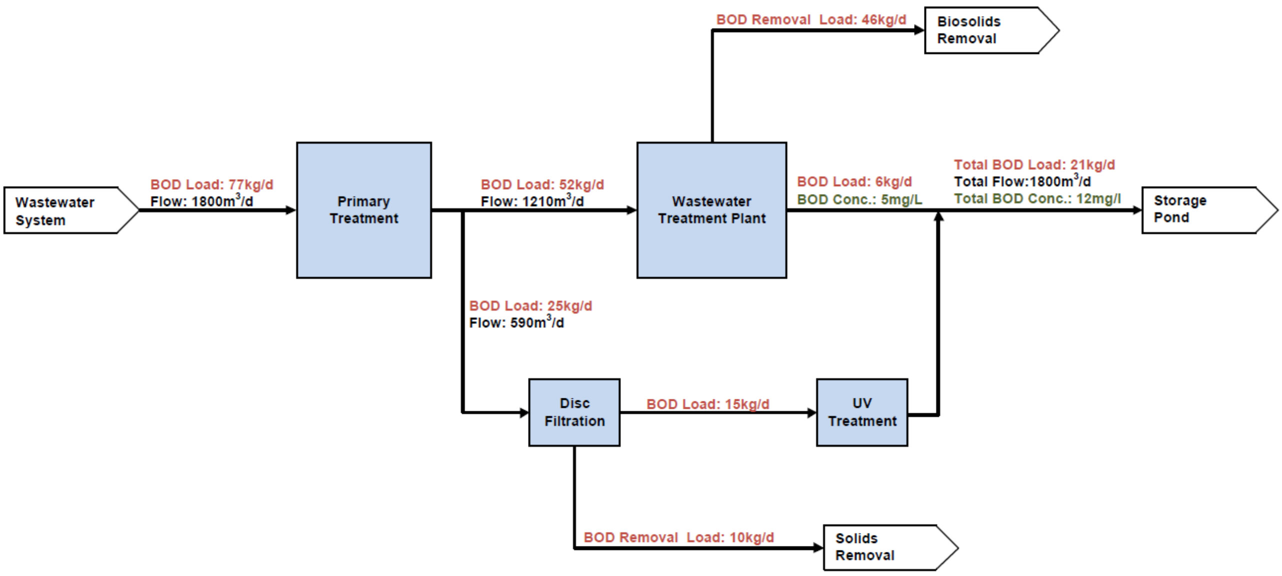

Figure 5-4: Treatment Plant Mass Balance for BOD

Total BOD influent load has been calculated based on the design population and per capita BOD production rates. The BOD level in the treatment plant discharge has been set at 5 mg/l, based on performance parameters set down for the design of the new wastewater treatment plant in the CH2M Beca report Akaroa Wastewater Preliminary Design Report dated April 2014. This is the design average BOD concentration in winter, when the pond is most likely to be in use. This assessment is very conservative as the typical BOD level in treated wastewater is more likely to be 2 mg/l during normal operation. The assumed 5 mg/l is the design standard and represents the worst case scenario.

The bypass flow BOD calculation takes into account the removal of BOD by the disc filter. This filter contains a very fine screen that will remove solids down to small particle sizes. The monitoring of Akaroa wastewater flows over Christmas 2013 found that 55% of the BOD present is in soluble form. The remaining 45% of the BOD is present in solid form and it is assumed that 90% of this BOD will be removed by the disc filter.

Comparison of BOD concentration in the storage pond for a range of storage events is shown in Figure 5-5 and Figure 5-6. This analysis is “simplistic” as it does not allow for BOD reduction through consumption by biomass in the pond. Nor does it allow for avian introduced BOD directly into the pond and potential algal bloom within the pond, both of which could greatly increase the non-human BOD concentrations within the pond. The depletion of oxygen in the pond is associated with the BOD being consumed, hence if the dissolved oxygen drops over time then the BOD concentrations may also reduce. However, the biomass in the pond will include algae that release oxygen by photosynthesis into the pond. This factor has also been ignored even though it will provide a benefit in oxygenating the pond water.

Overall, the graphs as shown represent a worst case under normal operating conditions. Further modelling of the biological performance of the pond may be conducted in due course as appropriate to refine the assessment of BOD concentrations and BOD attenuation in the pond.

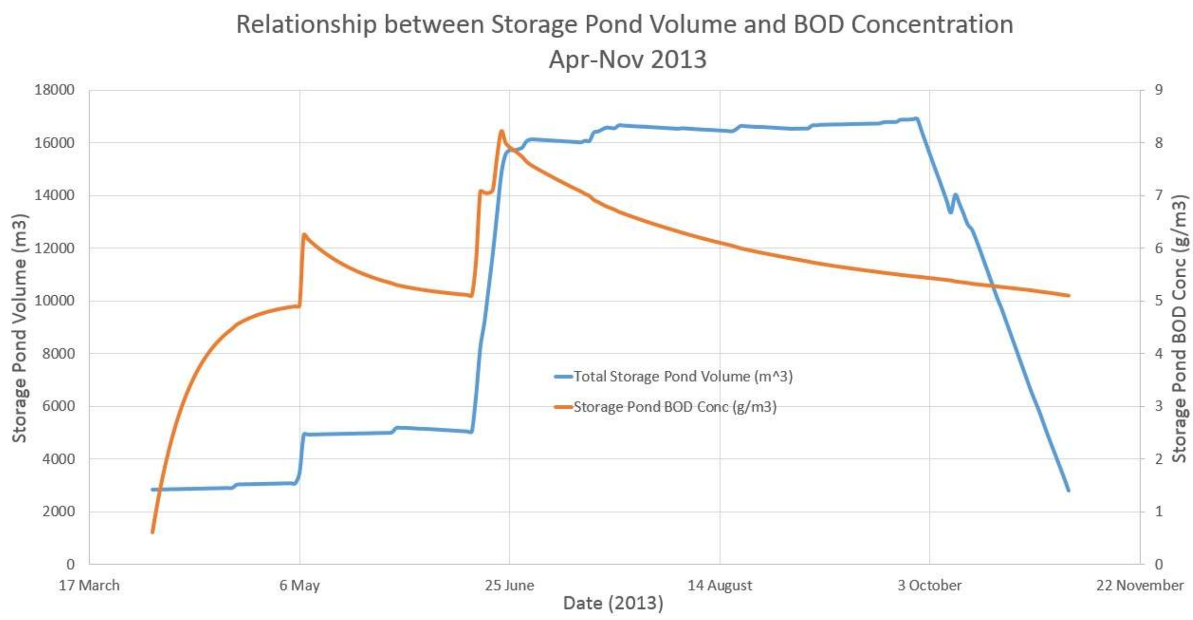

Figure 5-5: Simplistic BOD Concentration in Storage Pond for 2013 Event

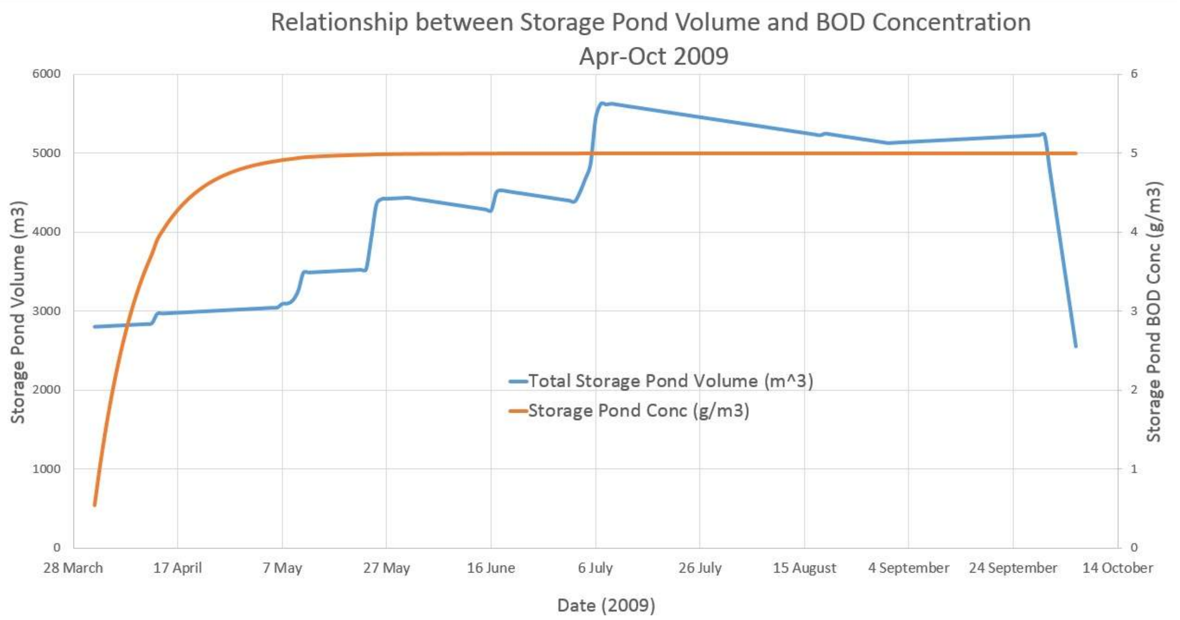

Figure 5-6: Simplistic BOD Concentration in Storage Pond for 2009 Event

Figures 5-5 and Figure 5-6 show that the BOD concentration in the storage pond will be low and generally similar to the BOD concentration in the discharge from the membrane plant. As a comparison, the Christchurch Wastewater Treatment Plant Oxidation Ponds receive wastewater from the Christchurch Treatment Plant at a typical BOD value of 10 mg/l, which is similar to the concentration proposed for the Akaroa Storage Pond. The CWTP oxidation ponds have a high avian BOD load direct to the pond system.

5.8.3 Pond Surface Loading Assessment

Design loading rates have been developed to guide wastewater storage pond design so that odour risks can be managed. A design guideline for wastewater storage ponds contained in Pond Treatment Technology published by IWA, 2005, provides useful design references. These are summarised as follows:

- Israeli engineers have used an average surface organic loading rate of 50 kg BOD/ha/day as a maximum allowable loading[2].
- A value between 30 to 40 kg BOD/ha/day would be a safer upper limit when the non-emission of offensive odour is imperative[2].

Based on this design guideline an upper daily limit of 40 kg BOD/ha/day has been selected as a recommended maximum loading for the Akaroa storage pond. Operation of the pond at loading rates less than 40kg BOD/ha/day will minimise the risk of pond odour emissions.

To determine surface organic loading rate it is necessary to assume a pond surface area. For this analysis we have assumed irrigation to trees and a pond with a volume of 17,500m^3, a working depth of 3m, a buffer volume of 2,500m^3, and pond internal embankments at 1V:3H (Vertical:Horizontal) slope. Based on this pond design the surface area has been calculated at 0.68ha when the pond is half full. Since the BOD loading is highest when the pond is filling up it is reasonable to assume the pond surface area for this condition. Irrigation to pasture will require up to 35,000m^3 of pond storage[6] but the pond geometry will be similar hence the surface loading rate would also be similar.

Surface organic (BOD) loading rates for the 2013 inflow event at the proposed Akaroa storage pond are shown in Figure 5-7. This event represents the worst case over the 7 year data set, as the pond inflows were the highest for this event and the pond storage volume was also highest. Further modelling over a longer time period to account for a more extensive range of weather and rainfall events will be conducted in the next phase of work.

As the surface loading rate is based on daily BOD load into the pond, the figure only covers the time period when the pond is filling up. For the remainder of the event the pond is subject to small daily inflows and outflows and the organic loading rate will be much lower and hence is not shown on the graph.

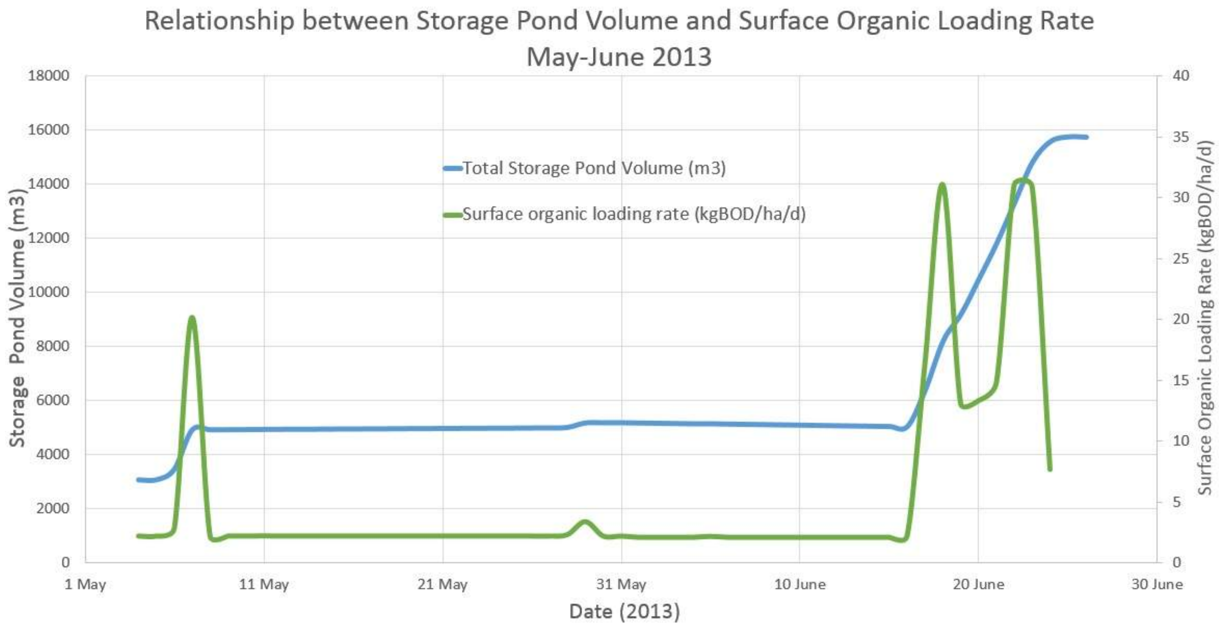

Figure 5-7: Surface Organic Loading Rates in the Storage Pond

[6] CH2M Beca Concept Design Report and Andrew Brough, PDP, pers.comm.

Figure 5-7 shows that the surface loadings on the Akaroa pond are below the recommended maximum of 40 kg BOD/ha/day. On this basis it is considered that the risk of pond odours from operation of the Akaroa wastewater pond is low.

Additional steps may also be taken to further reduce pond odour risk, including adjustments to the pond geometry to reduce water depth and addition of aeration systems such as bubble curtains or similar, to mix the pond contents, transfer oxygen and to minimise the risk of an anaerobic conditions in the pond.

5.8.4 Operational Philosophy for Storage Pond

Several factors have been considered when deciding how the storage pond should be operated – these are BOD loading and potential odour risks, algal growth, midge concerns. The preferred approach is to keep the pond as empty as much as possible, only filling up when treated wastewater volume exceeds allowable irrigation volume, to minimise the risk of midge populations during summer.

5.8.5 Storage Pond Midge Risks

Midges (Chironomus Zealandicus) are a seasonal pest, endemic to bodies of quiescent water such as wastewater treatment or storage ponds. Midges lay eggs on water within the pond. As part of the life cycle the eggs sink into sediment on the bottom of the pond and from this sediment layer larvae hatch and undergo four stages of development, prior to emergence as adults two to seven weeks later (depending on water temperature). Although not identified as a disease vector, and hence posing no specific health risk, midges have the potential to become a nuisance by forming mating swarms. These swarms may be blown by the wind to neighbouring locations, or become attracted to the outdoor lighting used in these areas.

An initial literature review has identified a range of factors that may influence midge populations around wastewater treatment or storage ponds. These factors, and associated mitigation measures as outlined below.

- Pond sediment layer. In order to support larvae, the sediment layer on the pond base must be at least 3 – 5cm thick. To disrupt the midge life cycle this sludge layer can be controlled through the use of polyethylene lining, and routine emptying and cleaning of the pond. Allowing the pond to dry out in summer will kill the larvae cycle, significantly hindering reproduction.
- Pond BOD loading; chironomid generally exhibits good resistance to pollutants found in the wastewater treatment environment. Pond organic loading rates above 40 kg BOD ha^{-1} d^{-1} have been shown to be sufficient in controlling midge breeding. In the case of the proposed Akaroa wastewater storage ponds the BOD loadings will be less than 40 kg BOD ha^{-1} d^{-1} hence there is limited opportunity to control midges by controlling BOD loadings
- Strategic vegetation planting; appropriately placed shrubbery can serve to concentrate midges as they shade before mating. This mechanism can be used to concentrate midge populations close to the ponds and also reduce their wider movement in conjunction with the effect of vegetation in reducing wind speeds

Within the New Zealand context, no initial conclusions can be drawn regarding whether or not midges will becoming a nuisance around a treatment pond. For example, the wastewater treatment ponds operated in Tasman District Council, Marlborough District Council and Blenheim do not generate midge related complaints from nearby residents. Conversely, the Christchurch Wastewater Treatment Plant oxidation ponds and Mangere discharge flow channel have been known to cause midge issues on occasions.

The KawaKawa Wastewater Scheme is very similar to the proposed Akaroa scheme, incorporating an MBR treatment plant, treated wastewater storage ponds, and irrigation to land. Further information is being sought about the operation of the Kawakawa scheme as may be relevant to Akaroa especially in regard to the operation of the storage ponds and any associated midge management issues.

5.9 Further Information on Treatment Plant Performance

Monitoring of the existing Akaroa wastewater treatment plant influent virus concentrations in December 2013 and January 2014 shows median concentrations of 10,000 genome copies per litre, which is typical of a small community with seasonal tourist peaks. The proposed treatment plant membrane filtration system would be operated to provide a 3 log reduction in viruses (i.e. 99.9% removal to concentrations of less than 10-100 genome copies per litre). When there are bypass flows the combination of disc filter and UV disinfection on the bypass will achieve a 1.5 log reduction in viruses (equivalent to 96.1% removal).

The proposed membrane filtration system has high reliability and will effectively remove all larger organisms (i.e. bacteria and protozoa) under a normal flow scenario, including peak summer holiday flows. An additional 1- 2 log reduction in microorganisms could also be achieved during passage through soils. As the treated wastewater quality meets public health guidelines for recreational use (Public Health Guidelines for the Safe Use of Sewage Effluent and Sewage Sludge on Land (New Zealand Department of Health, 1992)), the likely effects of a land discharge on public health would be minimal.

Table 5-8 summarises the proposed quality of the treated wastewater. The proposed treatment plant will produce wastewater containing low levels of BOD, suspended solids (TSS), nitrogen, and microbiological contaminants.

Table 5-8: Proposed Wastewater quality for Fully Treated and Bypass Operating Conditions

Parameter		Treated Wastewater Quality - fully treated[1]	Units	Treated Wastewater Quality Maximum bypass flow[2]	Units[3]
TSS	mg/L	5	annual median	10	median
		10	annual 95 percentile		
$CBOD_5$	mg/L	5	annual median	12	annual median
		10	annual 95 percentile		
TN	mg/L	20	annual median	25	annual median
		30	annual 95 percentile		
Faecal Coliforms	cfu/100mL	5	annual median	150	annual median
		50	annual 95 percentile		
Norovirus	Virus units/100mL	3 log reduction (99.9% removal)	Log removal of genome copies per litre	1.5 log reduction (96.1% removal)	Log removal of genome copies per litre

Note 1. Fully treated with no bypass

2. Maximum bypass of 590 m^3/d with total flow of 1800 m^3/d

3. 95th percentile not calculated as only 2 events per year typical

The treated wastewater quality parameters provided in Table 5-8 are slightly different to those specified in the Preliminary Design Report from 2014. The data in Table 5-8 reflects recent tender negotiations with membrane suppliers for the Pukekohe Wastewater Treatment Plant which is currently in design.

The design standard will be used as a basis for specification and purchasing of the plant including the membrane modules. It represents a conservative assessment of treated wastewater quality over the full life of the plant and taking into account a range of operating conditions, including:

- A range of influent flows and loads
- Impacts of influent and load changes on biological treatment performance
- Changes in the performance of the membranes over their lifetime
- Operational aspects including membrane cleaning and maintenance requirements

The Working Party questioned why treated wastewater quality data from the operational Turangi WWTP is different from the design values specified for the Akaroa WWTP. For most of the time the plant is expected to produce wastewater that is significantly better than the contaminant concentrations stated in Table 5-8, but this improved quality cannot be guaranteed to occur every day over the life of the plant due to the range of operating conditions and operating performance. This explains the difference between Turangi WWTP data and the Akaroa data – one represents typical operating performance, and the other represents the design standard which is effectively a “worst case”.

An example of this difference can be found in the performance of the Motueka WWTP Membrane Plant operated by Tasman District Council that was commissioned in October 2016. This data is presented in Table 5-9.

Table 5-9: Motueka Membrane Plant Performance

Parameter	Unit		Design Value	**Performance Value**
TSS	mg/L	annual median[1]	3	<3
		90th percentile[1]	6	<3
$CBOD_5$	mg/L	annual median[1]	5	2
		90th percentile[1]	10	5
TN	mg/L	annual median[1]	20	24[2]
		90th percentile[1]	30	30[2]
Faecal Coliforms	cfu/100mL	annual median[1]	5	1
		90th percentile[1]	10	3
Norovirus	Log removal of genome copies/litre[1]		3 log reduction	Not yet determined[3]

Note 1. Statistical evaluation is based on a dataset of 14 data values as this is the total available to date

2. Total nitrogen is primarily driven by the biological treatment process and not the membrane as TN includes soluble forms that pass through the membrane

3. For the tests to date there have been insufficient genomes in the influent to prove 3 log reduction

The treatment plant can be configured to reduce nitrogen to an average concentration as low as 5mg/l if this is necessary to meet the nitrogen assimilation capacity of the irrigation scheme. Achieving this level of denitrification will involve increasing the reactor sizing, increasing the sludge recycle rate, and also adding ethanol dosing to provide additional carbon. These design features will impose additional costs and the intention is to optimise the design, and associated costs, once the assimilative capacity of the irrigation scheme has been confirmed.

Subsequent passage of wastewater through underlying soils will further reduce the concentrations of micro-organisms such as viruses and bacteria through filtration and die off. The effects of a land discharge on public health would be minimal and the proposed wastewater quality will easily meet current public health guidelines (i.e. Department of Health, 1992) for irrigation of pasture and trees.

5.10 Treatment Options for Peak Flows

Figure 5-8 shows how often the bypass would have been used based on the wastewater flow monitoring dataset for flows from Akaroa from 2009 to 2015, noting that this data was largely collected before works on reducing inflow and infiltration into the wastewater network.

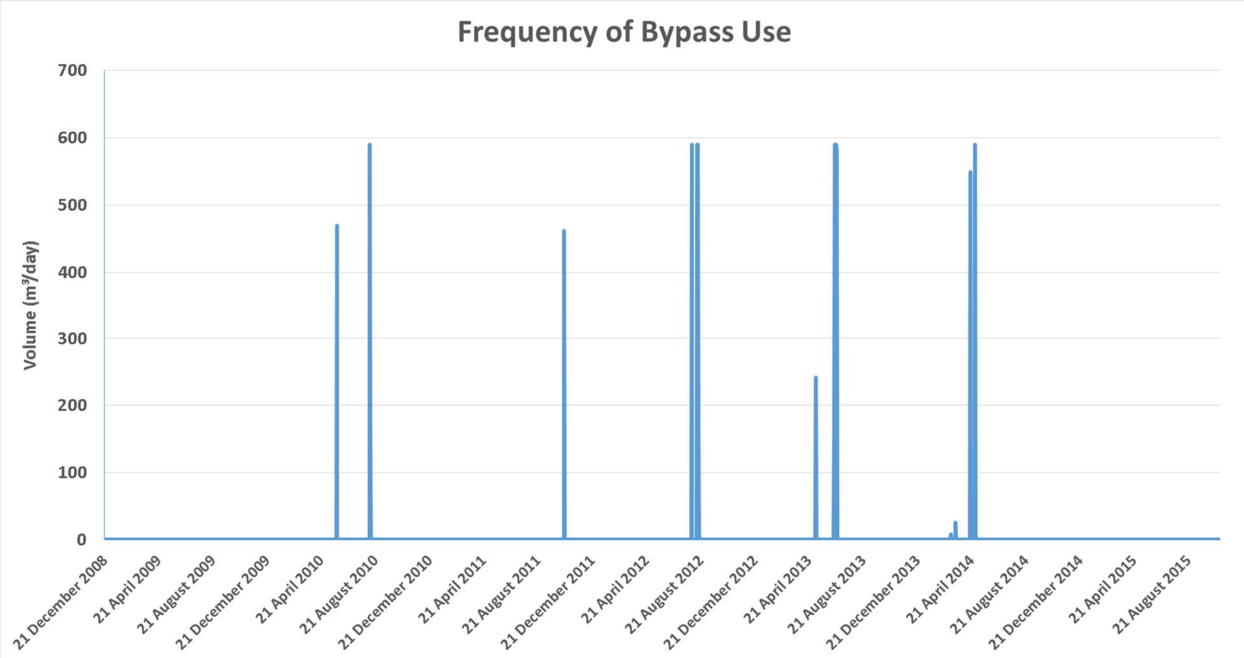

Figure 5-8: Frequency of WWTP Bypass using Historical Flow Data

The wastewater flow for all significant wet weather events from 2010 to 2012 was modelled as part of the preliminary design for the project. The results show that for the 250m³ balance tank proposed there would be an average of two events per year when some wastewater bypasses the treatment plant and receives primary treatment plus disc filtration and disinfection only. The typical duration of these events is 1 – 2 days.

The Working Party has questioned whether a covered storage pond could be constructed on the site across the road from the new wastewater treatment plant that would capture all bypass flows and eliminate irrigation of bypass flows to land. The collected bypass would be returned from the covered storage pond to the treatment plant when the extreme wet weather event had passed and there was sufficient capacity again to treat all the flow. Two possible treatment options have been considered to prevent any bypass of the treatment plant:

- Peak flow storage pond
- Short term peak flow storage pond and additional membrane filtration capacity.

5.10.1 Use of a Peak Flow Storage Pond

Peak flows have been modelled to determine that a pond of approximately 5,000 m^3 would be sufficient to capture the volume of wastewater pumped to the treatment that is over and above the treatment plant capacity. As shown in Figure 5-9 the peak flow storage pond would have disc filtration upstream (to prevent build-up of solids in the pond) but no UV treatment. The buffer tank prior to the treatment plant would no longer be needed. The peak flow storage pond would need to be covered due to the risk of odour. The air would be extracted and passed through an odour treatment device. Whitianga Wastewater Treatment Plant uses a covered storage pond in a similar manner.

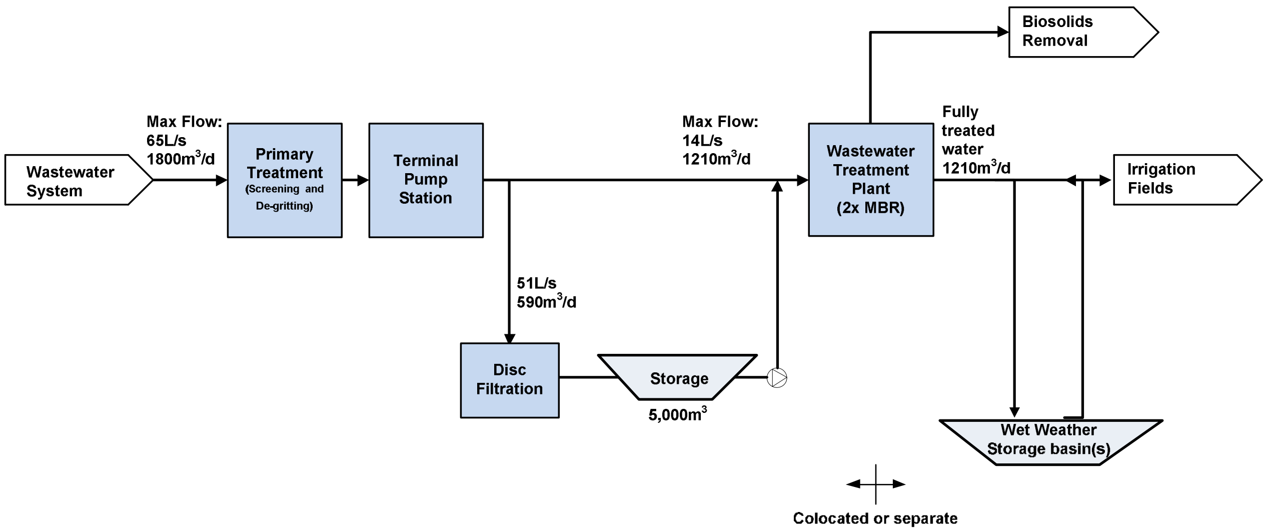

Figure 5-9: Operation with a Peak Flow Storage Pond

5.10.2 Short Term Peak Flow Storage Pond and Additional Membrane Area

As an alternative to a peak flow storage pond, the capacity of the treatment plant membranes could be extended to allow peak wet weather flows to be directly treated. To do this a third membrane module with capacity of 600m^3/d could be added to the two x 600m^3/day modules already specified. This is shown in Figure 5-10.

The biological reactors would be not be changed. This means that at flows above 1,210m^3/day some loss of nitrogen removal performance would occur but this has little consequence as the nitrogen load is measured as an annual total and the peak flow events will occur very infrequently. The upstream 250m^3 buffer tank will not be sufficient for short term peak storage requirements under this scenario and the simplest option is to replace it with a 600 – 1,000m^3 lined buffer pond located across the road (this assumes that the adjacent storage pond site (site 10) can be accessed for installation of the pond). A 600 – 1,000 m^3 buffer pond is specified for this option because inflows are always balanced with outflows over a 24 hour period, and so the buffer pond is only required to store short term peak flows.

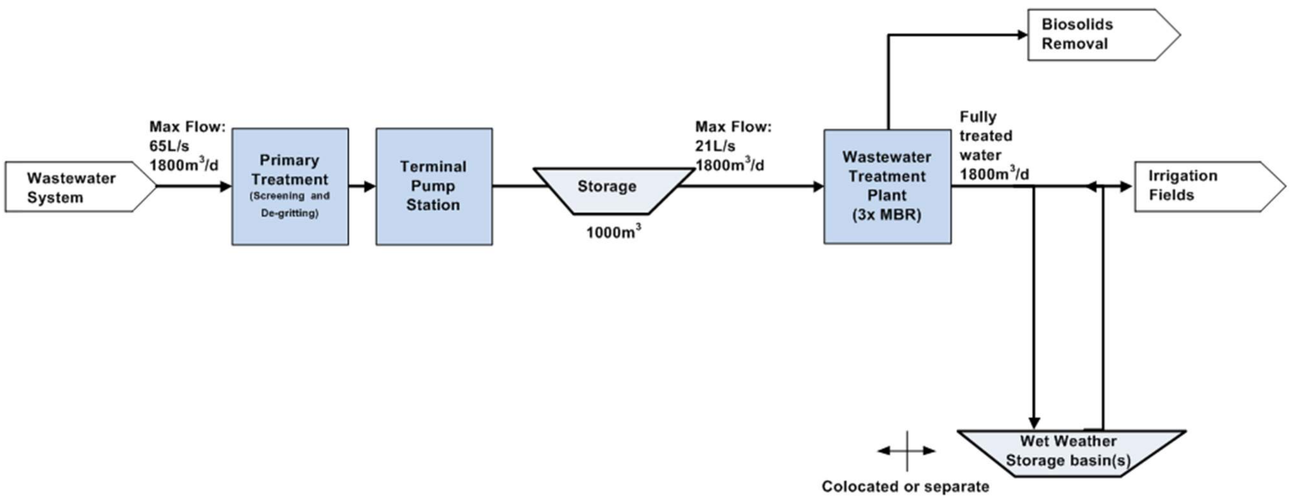

Figure 5-10: Additional Membrane Capacity for Peak Flow Treatment

5.10.2.1 Summary of Peak Flow Treatment Options

A summary of the equipment required for each option for dealing with peak flows is shown in Table 5-10.

Table 5-10: Summary of Peak Flow Treatment Options

Ref	Description	Base Case	Peak Flow Storage Pond	Additional Membrane
	Items in preliminary WWTP estimate:			
A	UV treatment	✓	✗	✗
B	250m³ buffer tank	✓	✗	✗
	Items in Land Disposal estimates to date:			
C	Disc Filter	✓	✓	✗
	Additional Items:			
D	5,000 m³ covered pond	✗	✓	✗
E	1,000 m³ pond	✗	✗	✓
F	Additional Membrane Cassette	✗	✗	✓
G	Additional building / civil works	✗	✗	✓
Note:				
Additional Membrane cassette option requires additional building modifications				

High level cost estimates (refer Section 8) have shown that it is less expensive to add a 1,000 m³ storage pond and extra membrane filtration cassette to fully treat peak flows than to include peak storage and treatment. Inclusion of additional membrane filtration is now the preferred option rather than bypass treatment and assessment of potential public health effects, costs and treatment performance are now based on this option. Additional land near the treatment plant (Site 10 or similar) would need to be obtained for the storage pond as there is insufficient flat land available at the treatment plant site. It is likely that a peak flow storage pond and treated wastewater storage pond could be co-located at Site 10.

5.11 Reverse Osmosis of Treated Wastewater

The Working Party requested that a reverse osmosis plant be considered as an additional means of treating the wastewater. The reverse osmosis (RO) plant would be an add-on to the existing treatment plant process. The permeate from the reverse osmosis plant would presumably be irrigated to land .The retentate would also need to be disposed of in some manner. As the retentate will represent a significant percentage of the incoming wastewater flow, and will also contain almost all of the contaminants present in the influent wastewater, this stream will not be easy to dispose of. It is unlikely to be economically viable to tanker the retentate back to Christchurch Wastewater Treatment Plant.

Other options for disposal of the retentate could include local disposal to land or to sea. Retentate disposal to Akaroa Harbour is unlikely to be acceptable to range of stakeholders. Retentate disposal to land may be viable, but negates the benefit of the RO system as the contaminants separated by the RO system end up back on the land along with the permeate. Under this scenario the RO system provides no obvious benefit. Further investigation of retentate disposal pathways would be an essential next step in the development of a RO scheme option. The equipment configuration involved in adding reverse osmosis of the treated wastewater is shown in Table 5-11.

Table 5-11: Configuration Reverse Osmosis

Ref	Description	Base Case	Reverse Osmosis
	Items in preliminary design WWTP estimate:		
A	UV treatment	✓	✓
B	250m³ buffer tank	✓	✗
	Items in Land Disposal estimates to date:		
C	Disc Filter	✓	✗
	Additional Items:		
D	5ML uncovered pond	✗	✓
F	Additional Membrane Cassette	✗	✓
G	Reverse Osmosis plant	✗	✓
H	Additional building / civil works	✗	✓
Note:			
Reverse Osmosis option also includes for additional Membrane cassette			
Reverse Osmosis and additional Membrane cassette options require additional building modifications			

5.12 Non-Potable Reuse Options

Treated wastewater from the membrane treatment plant can be beneficially reused within the Akaroa township for flushing of public toilets and for irrigation of public parks as indicated in Figure 5-11. As the treatment plant is located at the top of Old Coach Road the reuse scheme can operate by gravity with no additional pumping. Reuse water can be taken from the storage pond located at Pond Site 10 and conveyed in a purple pipe network down Old Coach Road and along Rue Lavaud. Purple pipes can be laid alongside new raw wastewater pipelines when the Akaroa reticulation work associated with the overall wastewater scheme upgrade is constructed in order to minimise costs.

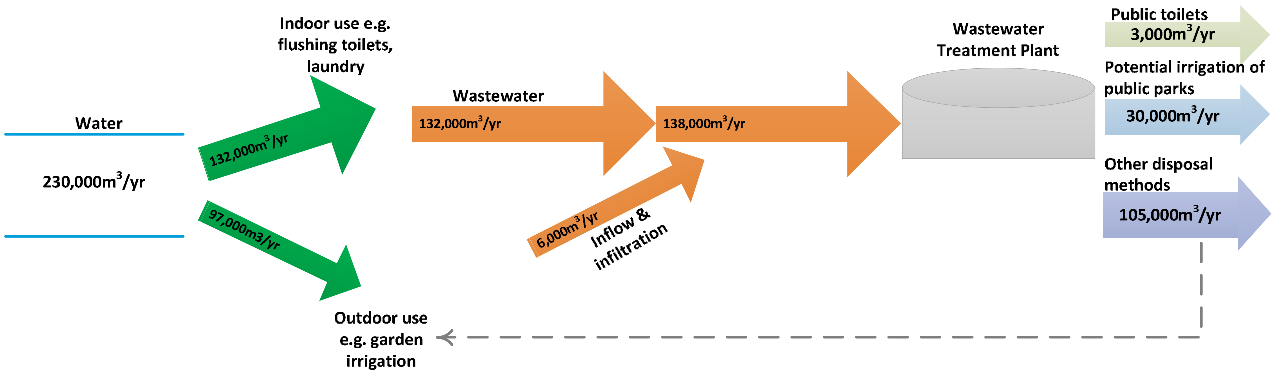

Figure 5-11: Non-potable Reuse Scheme

The purple pipe main has been sized to convey 100% of the average wastewater flow to year 2041, as this allows for unlimited reuse in Akaroa in future. Initially up to 30,000 m³/yr may be irrigated in Jubilee Park, L'Aube Hill Reserve and Stanley Park (based on irrigating 3mm/day for 3 months over summer) and up to 3,000m³/yr for public toilet flushing. This is approximately a quarter of the total annual treated wastewater volume. Each irrigation area will be provided with soil moisture monitoring and equipment to control the application of reuse water by subsurface dripper irrigation.

6 Preliminary Ground Investigations of Alternative Sites

At the hui held with the Ngāi Tahu parties, Beca, PDP, David Painter, Council staff, ECan staff and councillors on Tuesday 2 August 2016 to present the findings of the first round of ground investigations and the possible alternative sites. Council staff informed the other parties of the alternative sites being investigated further, with the exception of Wainui due to the significant cost ($18M - $20M) due to the pipeline across the harbour required for the scheme.

Council commissioned preliminary ground investigations for the three other sites (Takamātua Valley, Robinsons Bay Valley and Pompeys Pillar) to identify if there were any critical issues associated with ground conditions that might exclude an option from proceeding further. The works are summarised in the following sections, with the full reports attached in Appendix L (Infiltration Testing) and Appendix M (Geotechnical Investigations).

6.1 Infiltration Testing Results for Akaroa Treated Wastewater Disposal via Irrigation – Robinsons Bay and Pompeys Pillar (PDP, November 2016)

To assess the soil at the alternative sites, eight test pits were formed and six groundwater monitoring bores were installed. Site investigations were carried out from 26 – 29 September 2016 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 Plant Available Water (PAW);
- Measuring the infiltration rate; and
- Estimating the land area required for irrigation and the amount of storage that would be needed at each location.

No infiltration testing was completed in Takamātua Valley.

6.1.1 Robinsons Bay Infiltration Test Results

The locations of the investigations in Robinsons Bay are shown in Figure 6-1. These consist of four infiltration test locations, four boreholes and one test pit.

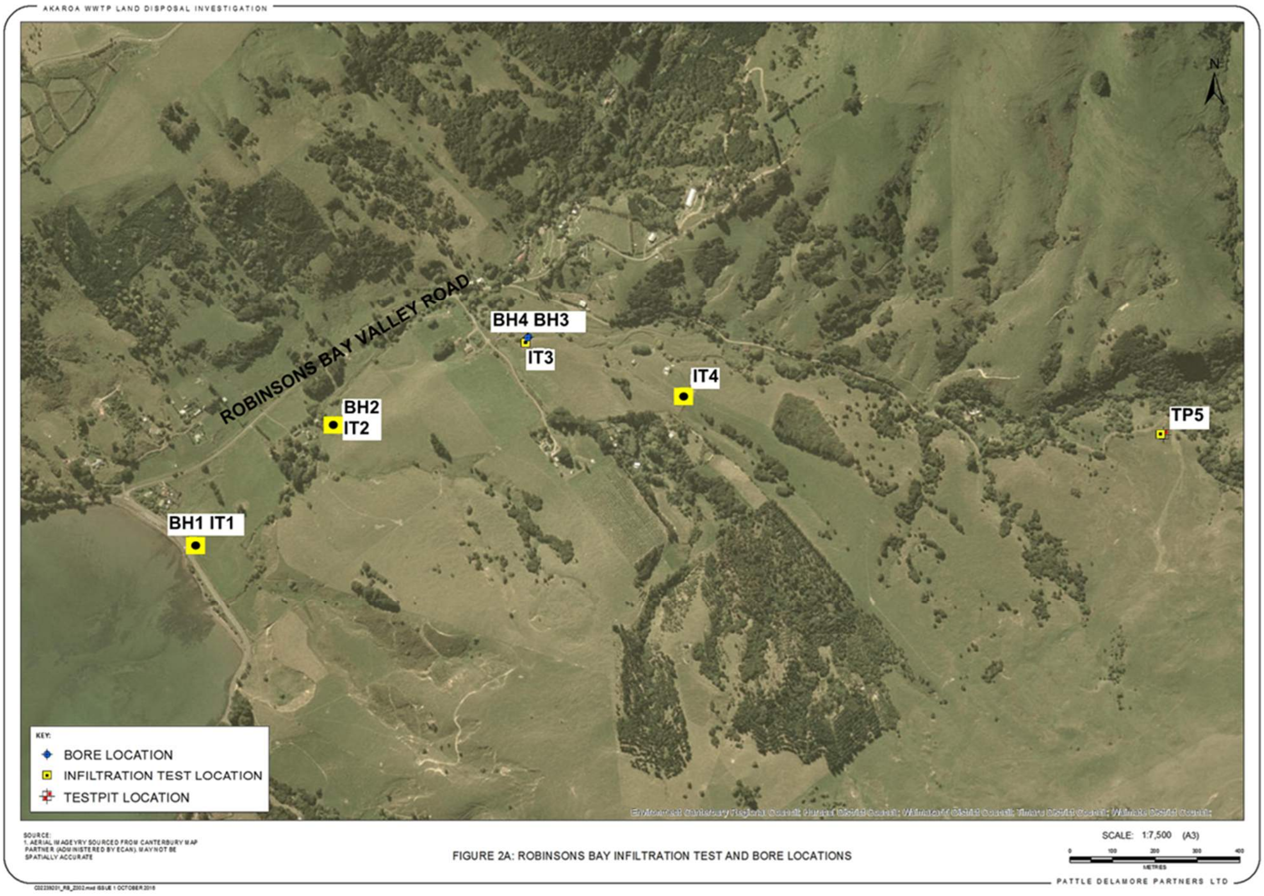

Figure 6-1: Robinsons Bay Valley Test Pit and Borehole Locations

Figure 6-2 shows the groundwater levels measured in the Robinsons Bay Valley bores after approximately one month of monitoring.

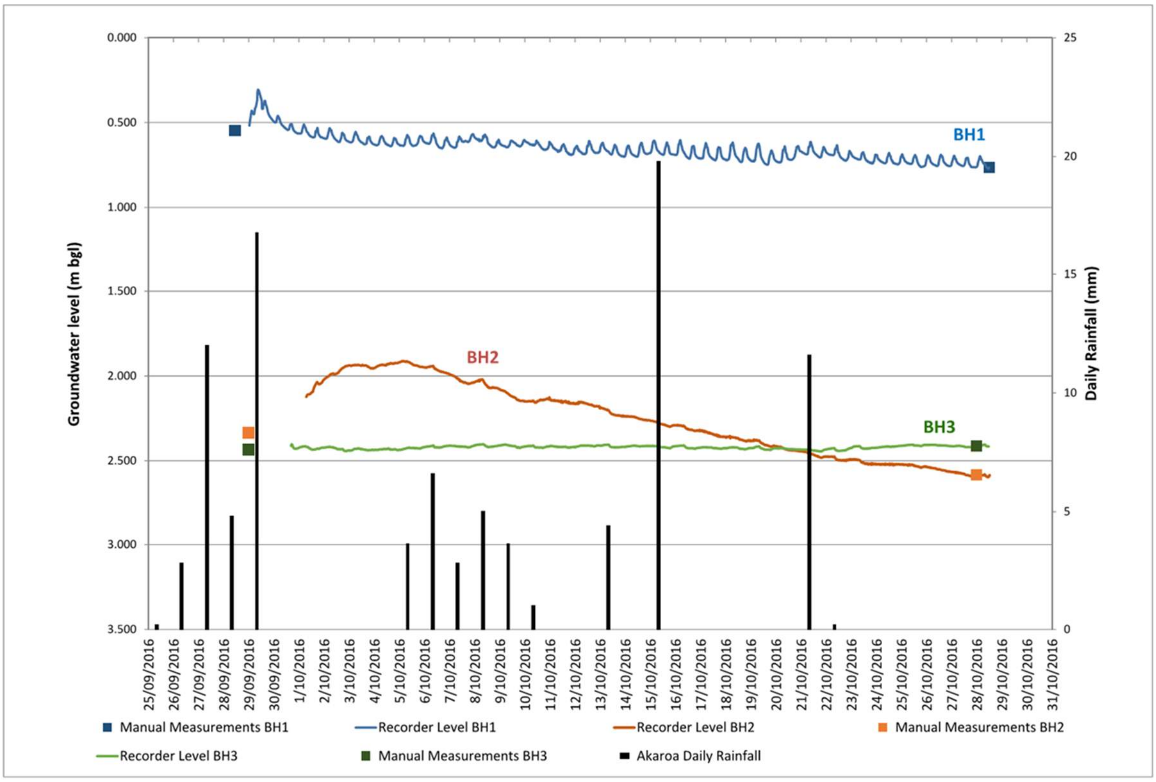

Figure 6-2: Groundwater Levels in Robinsons Bay Valley

The findings from the infiltration testing in Robinsons Bay Valley are as follows:

- The ground conditions observed within the potentially irrigable zone within Robinsons Bay are generally similar to existing Wainui irrigation sites and hence PDP consider them suitable overall for application of wastewater to land;
- Infiltration rates, soil PAW and depth to groundwater vary from the lower through mid-to-upper valley areas;
- Site 1 at the bottom of the valley has high groundwater and this may constrain irrigation (and pond construction) especially during winter;
- Sites 2 and 3 in mid valley have higher PAW and 2-3m depth to groundwater. These areas are considered favourable for irrigation year round but only represent 20% of total area required;
- Sites 4 and 5 in the upper valley are more extensive, with lower PAW, lower soil permeability and greater depth to groundwater observed. Soil ripping may improve the land permeability to allow wastewater to be applied during winter and therefore decrease storage requirements; and
- Robinsons Bay is the most suitable site of the three areas under investigation due to more favourable PAW and infiltration characteristics overall compared with Takamātua Valley and Pompeys Pillar.

6.1.2 **Takamātua Valley Results**

No infiltration tests were undertaken in Takamātua Valley as access to land could not be obtained and some work in this area had been completed as part of the first round of ground investigations undertaken in May 2016. Two monitoring bores were installed in the road reserve; the locations of these bores is shown in Figure 6-3.

Figure 6-3: Takamātua Valley Borehole Locations

Results from one month of groundwater monitoring data are shown in Figure 6-4.

Figure 6-4: Takamātua Valley Groundwater Levels

Initial results indicate that the groundwater is close to ground level in lower valley (i.e. very shallow). This could restrict irrigation and pose higher risks (such as ground water mounding and nutrient leaching) in Takamātua Valley compared to other sites.

6.1.3 **Pompeys Pillar Infiltration Test Results**

No groundwater monitoring bores were installed at Pompeys Pillar as, given the relative height of the site above sea level, groundwater is unlikely to be an issue. Three infiltration test sites were completed, these are shown in Figure 6-5.

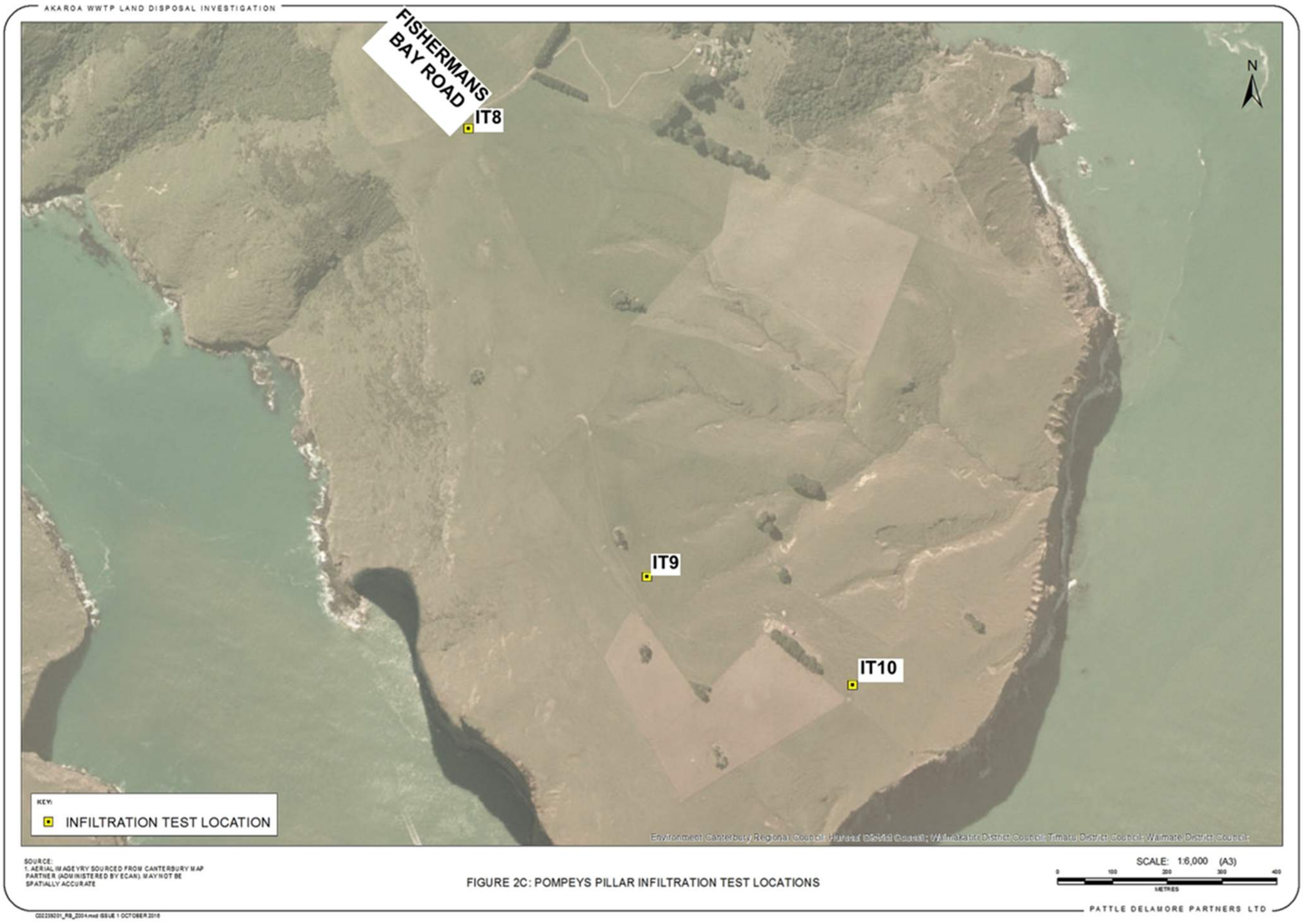

Figure 6-5: Infiltration Test Locations on Pompeys Pillar

The findings from the infiltration testing at Pompeys Pillar are:

- The ground conditions observed within the potentially irrigable zone at Pompeys Pillar are considered suitable overall for application of wastewater to land, although they exhibit consistently lower permeability than Robinsons Bay and Takamātua Valley; and
- The presence of low permeability soils may limit the application rate. However, the available area is extensive, and the wastewater application area can be increased to meet the loading requirements to counter lower permeability.

6.2 Akaroa Wastewater Disposal Alternative Sites Stage 2 - Geotechnical Report (CH2M Beca, November 2016)

A Beca engineering geologist attended each site to observe the test pits excavated, install piezometers in the boreholes that were drilled, and log the soil and rock from the excavations. The scope of work undertaken provides preliminary information to make a first order assessment for the three alternative areas being considered in Takamātua Valley, Robinsons Bay Valley and Pompeys Pillar. The Beca report (Appendix M) presents the results of preliminary geotechnical investigations to inform the option of applying treated wastewater to the three potential land areas.

The general conclusions from the Beca report are that all three sites are suitable, and as follows:

6.2.1 Takamātua and Robinsons Bay

- Soils in these valleys are more free draining being composed of silts and sandy silts overlying gravel, with the depth to groundwater increasing from 0.5m at the coast to 3.0m inland;
- Central lower-gradient areas have comparatively low risk of ground movement; and
- However, there is potential for localised erosion at points where groundwater exits the ground such as banks of water courses and other slopes.

6.2.2 Pompeys Pillar

- Soils at Pompeys Pillar are less free draining, being composed of loess with groundwater at depth (likely within the bedrock); and
- Irrigation may cause localised instability around cliff tops and steeper zones around incised gullies.

6.3 Overall Findings of November 2016 Land Testing

The overall findings from the land testing of the alternative sites completed in November 2016 were:

- None of the sites were considered to have critical issues based on the investigative work and information obtained at that time;
- There are some overall differences in the soil types, land gradients and groundwater levels at the different sites which have implications for land irrigation scheme (and pond) design and operation at each site; and
- The amount of area required for irrigation and storage for all sites based on the second round of land investigations was unchanged from the first round of land investigations.

6.4 Land Testing of Thacker Land, 11 Sawmill Road, Robinsons Bay Valley

The Thacker property, at 11 Sawmill Road, which is located on farmland located between Robinsons Bay Valley Road and the valley summit to the east, and by Sawmill Road to the south, covers around 114 hectares and is being considered as an option for drip irrigation beneath trees. The farmland comprises predominately sloping land, being relatively flat in the valley floor, increasing to steep slopes higher in the valley. There are no occupied dwellings on the property. Land testing of the Thacker land at 11 Sawmill Road in Robinsons Bay Valley was undertaken between 1st and 3rd February 2017. The testing consisted of twelve test pits and seven infiltration tests.

6.5 Infiltration Testing Results for Akaroa Treated Wastewater Disposal Via Irrigation – Thacker Land (PDP February 2017)

Field investigations were undertaken to assess the soil suitability and characteristics of the Thacker land at 11 Sawmill Road to enable the development of a site-specific concept and to confirm the overall suitability of the land. Twelve test pits were excavated to characterise the soil and sub-soil conditions on the property (particularly on the land below the 200m contour). Seven infiltration tests were carried out to confirm the suitability of the land for the irrigation of treated wastewater. The results of the field work indicated that the field parameters of the soils are consistent with previous observations and results within Robinsons Bay.

Overall, the February 2017 results indicate a slightly higher infiltration rate than that recorded in September 2016. The surface and sub-surface materials were significantly drier than what was encountered during the previous round of investigations. Sites located close to the stream that runs through Robinsons Bay Valley and sub-surface soils were indicative of loess colluvium. There is some variance of infiltration rates between the sites below the 100m contour and the lower slopes between 100m and 200m above sea level. This may be a reflection of the higher moisture content of the materials at Sites 101 and 109 rather than any differences of the makeup of the sub-soils.

For the assessment of the suitability of the site for irrigation the most critical infiltration rates are those from the sub-surface tests ranging from 4 to 55mm/hr. Given the potential variability of infiltration across the site the assessment of the irrigation requirements for the land at this stage should be based on the lower rate.

The infiltration rate used to calculate the required irrigation area is the lowest measured rate from both the earlier and latest round of tests. This was recorded when PDP did the first round of testing in Robinsons Bay. The latest measured infiltration rates have not changed the area requirements, however the Technical Experts Group has agreed that the Long Term Acceptance Rate ((LTAR) which is the amount of wastewater that can be applied each day over an indefinite period of time to an area of soil) should be considered and a soil moisture balance be developed for the tree irrigation option.

In addition, there is some debate around the nutrient uptake by trees and, while a lower nutrient uptake than used initially has been factored in, further information is required to confirm this. The nutrient concentrations in the treated wastewater can be controlled by the process at the treatment plant and this may assist in reducing the nitrogen loading further. A preliminary assessment of the soil drainage from pasture compared with LTAR indicates that this is unlikely to influence the area required for this option. The soil moisture balance for the trees and any changes to nutrient loading requirements could influence the area required for trees but is unlikely to make a significant change. For instance on the Thacker land investigations have identified approximately 32 hectares potentially available for tree irrigation compared with the current estimate required area of 25 hectares so there is room to expand the irrigation area if required.

The full report is given in Appendix N.

6.6 Akaroa Wastewater Alternatives – Thacker Site Robinsons Bay – Geotechnical Report (CH2M Beca February 2017)

Geotechnical investigation comprising; a walkover of the land, the excavation and logging of soils from twelve test pits, the preparation of engineering logs, consideration of storage pond locations and a qualitative assessment of the effect of the proposed irrigation on the ground conditions, including identifying any major geotechnical risks, was carried out.

The ground conditions encountered in the test pits was broadly consistent with the published geological information either being derived from, or comprising, Quaternary alluvium and loess overlying the Akaroa Volcanic Group. Loess soils can contain low permeability fragipan zones near to the surface that are problematic for the vertical drainage of the soil (i.e. they become a controlling feature for the design of irrigation systems). However, no continuous horizontal zones that may interfere with vertical permeability of the soil mass were observed in the test pits.

In the November 2016 investigation groundwater was measured at approximately 2.5m to 3.5m depth belowground level in the valley floor. However, groundwater was not encountered in any of the February 2017 exploratory holes higher up the valley sides.

The risk of inducing instability in the alluvial soils underlying the valley floor is comparatively low, with the exception of local river banks. On the higher elevation slopes underlain by loess and loess colluvium, the risk of instability is greater than on the valley floor. Slopes inclined at less than 19° have been used as one of the criteria in selecting the irrigation areas for trees. The dispersive nature of the loess may result in some localised erosion and potential instability in these higher areas as a result of irrigating wastewater to land. It is of note that reworked loess, such as loess colluvium, is more susceptible to erosion and instability than in situ loess. Localised movement of such silt slopes may be expected to occur following periods of heavy rainfall, or during seismic activity. Shallow surface instability can be mitigated to a degree by planting trees in irrigation areas.

Water flow is expected to be predominantly vertical through the loess. If the applied water reaches the bedrock, flow is expected to be controlled by the lithology, fractures and interconnected pore spaces within the Akaroa Volcanic Group. The layered silt and gravel will have anisotropic permeability, with dominant groundwater flow being horizontally through the gravel.

The full report is attached in Appendix O.

6.7 Further Land Investigations

Initial geotechnical and infiltration rate investigations have been completed at all three potential irrigation areas. Geotechnical investigations and land infiltration testing carried out to date have provided sufficient information for the Council to decide which, if any, general area to pursue for irrigation. However, further geotechnical investigations and infiltration testing at a level similar to that conducted on the Thacker land is required before committing to irrigating particular land parcels.

The following land investigations would be required to achieve an equivalent density of investigation to that undertaken for the Thacker land at 11 Sawmill Road:

Takamātua (approximately 23 ha based on current GIS maps)

- 12 Test Pits (large number due to the very disjointed nature of the available land in Takamātua)
- 4 Infiltration Tests
- 1 Borehole
- 1 Piezometer
- Hand augers between test pits to confirm sub-soil conditions.

Robinson's Bay Valley (excluding Thacker Land approximately 48 ha based on current GIS maps)

- 17 Test Pits
- 8 Infiltration Tests
- Hand augers between test pits to confirm sub-soil conditions.

Pompeys Pillar (approximate area 35 ha based on current GIS maps)

- 14 Test Pits
- 4 Infiltration Tests
- 2 Hand Augers (Note it may be possible to increase the number of hand augers and decrease the number of infiltration tests depending on the finding of the hand augers. Initial testing has shown the land at Pompeys Pillar to be similar across the site).
- 2 Boreholes (including defining depth to rock at the pond site(s))
- 2 Piezometers

These lists could be refined, subject to locating the exploratory holes to give an appropriate distribution based on the topography and anticipated ground conditions.

6.8 Groundwater Data Download February 2017

As shown in Figures 6-6 and 6-7, continued monitoring of the groundwater piezometers in Takamātua Valley and Robinsons Bay Valley up to February 2017 indicates an overall slight to moderate fall in groundwater level typical for this summer period. Significant rainfall events have resulted in short term rises in groundwater, with this rainfall effect being moderated in the deeper piezometers. The fall in groundwater levels and the short term rises in groundwater resulting from rainfall were expected. Therefore these observations do not change the conclusions reached from other investigations about the suitability of land for irrigation, or the calculations for the size of the irrigation area required.

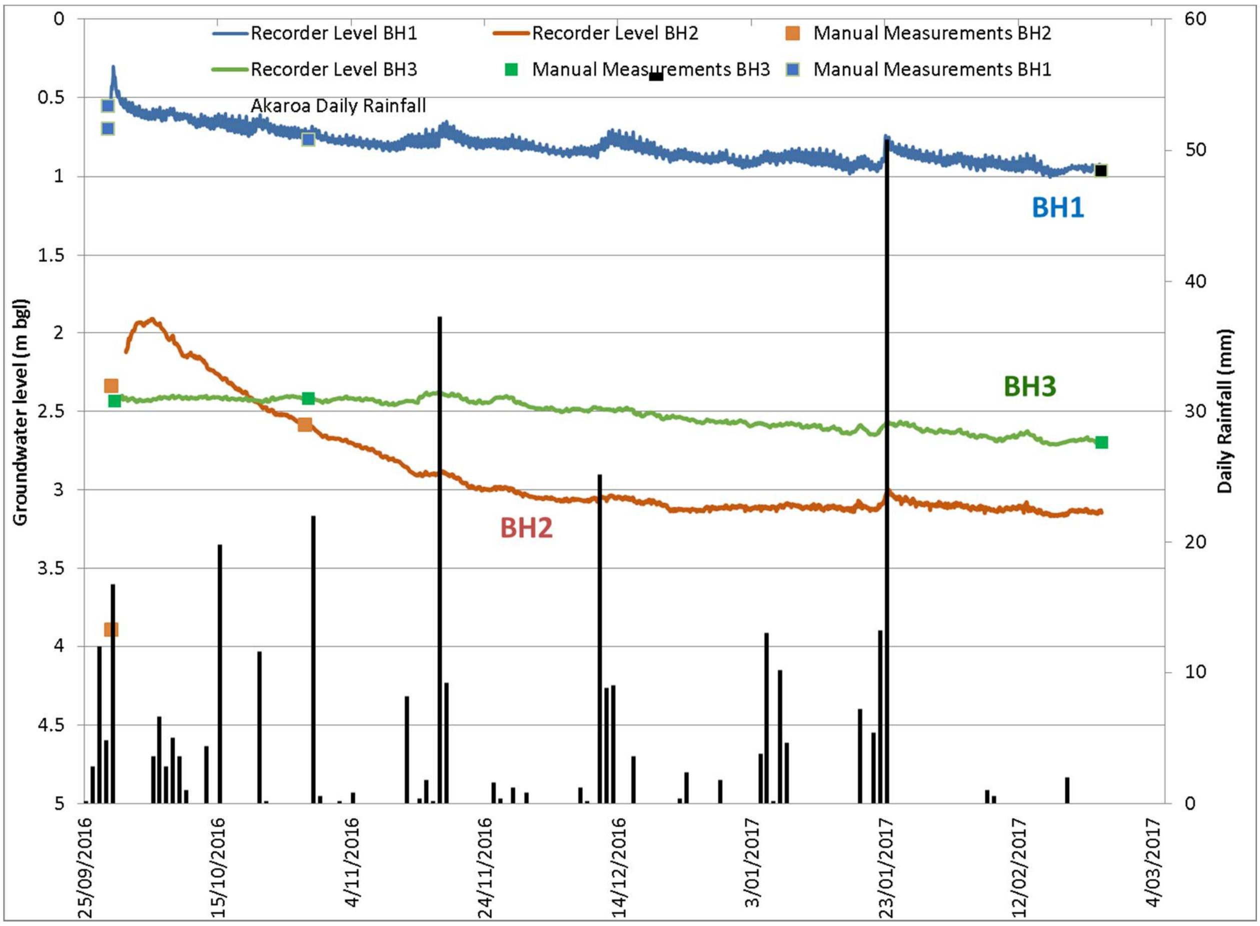

Figure 6-6 - Groundwater Information for Robinsons Bay Valley Piezometers

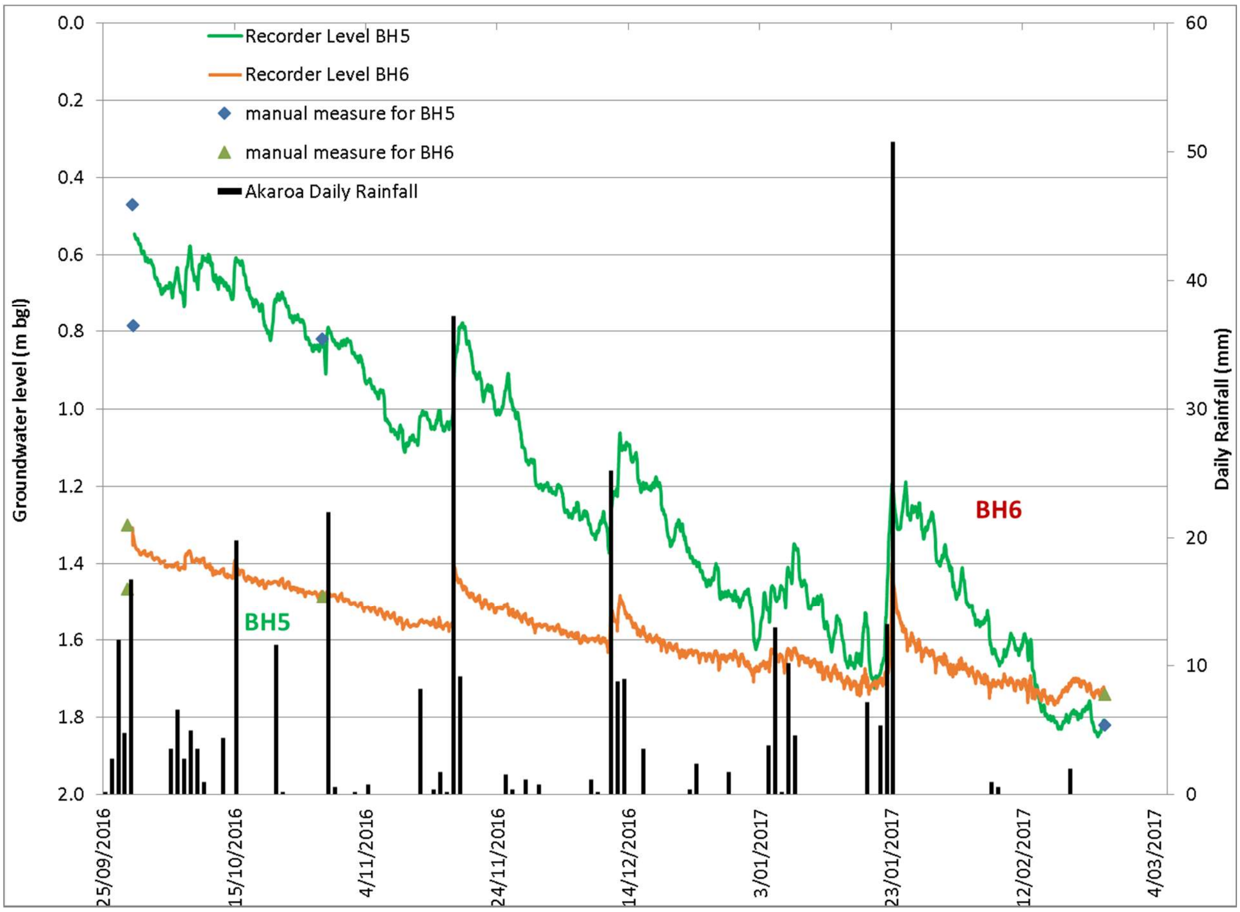

Figure 6-7 - Groundwater Information from Takamātua Valley Piezometers

7 Resource Consents/Authorisations

7.1 Overview

- This section considers the following matters in relation to wastewater disposal at three general sites located at Takamātua Valley, Robinsons Bay Valley, and Pompeys PillarResource consents that may be required from the Christchurch City Council in respect of the partly operative Christchurch Replacement District Plan (RDP)[7] and from Environment Canterbury in respect of the various regional plans.
- Other consents/authorisations that may be required and the identification of private covenanted areas.

It is noted that within Takamatua Valley and Robinsons Bay Valley there are a number of smaller sites identified as able to accommodate the storage pond and irrigation.

7.2 District Plan Requirements

7.2.1 Zoning and Overlays

In terms of the RDP the following identifies the zoning, hazard overlays, landscape overlays and coastal overlays and other items that apply to the three sites. This is also shown on the maps in Appendix P.

7.2.1.1 Takamātua Valley

- The zoning of site area is Rural Banks Peninsula.
- An area of the site located on the flat has a Liquefaction Management Area overlay (LMA).
- The remaining area of the site has a 'Remainder of Port Hills and Banks Peninsula Instability Management Area' Overlay.
- The coastal part of the site is located within the Coastal Environment in which the northern headland of Takamātua Bay at Te Umu Te Rehua/Hammond Point is an Area of high (and very high) natural character area (HNC 19.0) and the remaining part of the Coastal Environment "Other Area of Natural Character in Coastal Environment" (NCCE 1.0).The upper slopes of the area are an Outstanding Natural Landscape (ONL 19.0) with the remainder of the area having a "Rural Amenity Landscape"(RAL) overlay.
- 'Main Ridge Protection" lines run from the summit of the Banks Peninsula hills to Takamātua Headland and Te Umu te Rehua/Hammond Point respectively.
- A Heritage Item and Setting 1185 and 151 Former Takamātua School is located adjacent to SH 75.
- There are four Significant Trees T23-T26) (2 walnuts, a totara and a kahikatea) located at Bells Road.
- The southern area of the site is located within Silent File Area 14a (notated as Number 27 on Planning Map 76).

7.2.1.2 Robinsons Bay Valley

- The zoning of the site area is Rural Banks Peninsula.
- A 'Remainder of Port Hills and Banks Peninsula Instability Management Area' Overlay is located over the site.

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[7] The following is based on the pRDP as it is assumed that the Operative Banks Peninsula Plan will no longer apply when the works commence. The provisions referred to are those in the decisions of the Christchurch Replacement District Plan Hearings Panel.

- The coastal part of the site is located within the Coastal Environment and is an "Other Area of Natural Character in Coastal Environment" (NCCE 1.0).
- Rural Amenity Landscape (RAL) Overlay located over the balance of the site.
- A 'Main Ridge Protection" line runs from the summit of the Banks Peninsula hills to Te Umu te Rehua/Hammond Point.
- Heritage Item and Setting 1171 and 145 Dwelling is located at 5 Sawmill Road and; Heritage Item Dwelling and Setting 1173 and 539, Former School Master's House is located at 99 Robinsons Valley Road.
- There is a Heritage NZ signboard at Sawmill Road that indicates the presence of a former historic sawmill site (Robinsons Bay Sawmills), but this site is not identified in the RDP.

7.2.1.3 Pompeys Pillar Headland

- The zoning of the site area is Rural Banks Peninsula.
- A 'Remainder of Port Hills and Banks Peninsula Instability Management Area' Overlay is located over the site.
- The coastal part of the site is located within the Coastal Environment in which the coastal cliffs and lower slopes are an Area of High (and very high) Natural Character (HNC 16.1) and the remaining part of the Coastal Environment an "Other Area of Natural Character in Coastal Environment" (NCCE 1.0) and
- An Outstanding Natural Landscape (ONL 16.2) is located along the coastline.
- A Rural Amenity Landscape (RAL) Overlay located over the balance of the site.

7.2.2 **RDP Provisions**

The proposed activities associated with the wastewater disposal area are a "utility" under the RDP.

Rule 11.3a of Chapter 11 Utilities and Energy states that the rules that apply to utilities are set out in Rules 11.4-11.8.

Rule 11.8.1 P2 states that the *"Construction or operation of structures for the conveyance, treatment, storage or retention/detention of water, wastewater and stormwater by the Council or a network utility operator"* are permitted provided the activity complies with the built form standards for the Rural Banks Peninsula Zone.

It is considered that the storage pond and irrigation pipes and equipment are permitted by the above rule given that the structures are used for the conveyance, treatment and storage of wastewater. It is noted that the definition of a "utility[8]" under the RDP is somewhat narrower than Rule 11.8.1 P2 but given the nature of the rule it is assumed the definition includes the activities in the rule.

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[8] The definition in the RDP for "Utility" includes:

…

d Reticulated water for supply or irrigation, stormwater management basins, swales or reticulated drainage, and reticulated sewerage provided by network utility operators or requiring authorities, including:

i. Private stormwater facilities connecting to such utilities; and

ii. Necessary incidental equipment including pumping stations provided by network utility operators or requiring authorities and private connections to such utilities;

…

However, the use of the land for irrigation of wastewater to pasture or trees, is not considered to be permitted in terms of Rule 11.8.1 P2 as the rule refers to structures only. The use of land for irrigation is considered to be a utility given that it meets the definition of "Utility" in the RDP (see Footnote 8) as it is "reticulated sewerage" in which irrigation is part of that activity. In this regard, while irrigation is not specifically referred to in the definition, the term "including" is non-exclusive and enables other activities such as irrigation to be considered. As the irrigation is a utility that is not specifically referred to in the Utility rules, the activity is considered to be a discretionary activity in terms of Rule 11.4.3 Discretionary Activities – General.

In terms of the Built Form Standards for the Rural Banks Peninsula Zone referred to in Rule 11.8.1P2 for utilities, the standards in large part refer to bulk and location of buildings.

The definition of building in the RDP is as follows:

a. any structure or part of a structure whether permanent, moveable or immoveable; and/or

b. any erection, reconstruction, placement, alteration or demolition of any structure or part of any structure within, on, under or over the land; and

…

in the case of Banks Peninsula only, excludes:

l. any dam that retains not more than 3m depth, and not more than 20,000m^3 volume of water, and any stopbank or culvert"

k. any tank or pool and any structural support thereof (excluding a swimming pool as defined in Section 2 of the Fencing of Swimming Pools Act 1987), including any tank or pool that is part of any other building for which building consent is required:

i. Not exceeding 25,000 litres capacity and supported directly by the ground; or

ii. Not exceeding 2,000 litres capacity and supported not more than 2m above the supporting ground

The storage pond meets the definition of a "building"[9]. While there is an exclusion for dams in Banks Peninsula from the definition, Council have advised that the dam must be for the retention of "water", and as such is deemed to not include "wastewater". There is also an exclusion for a "pool" if certain volumes are not exceeded which the proposed storage pond will not meet.

The storage pond as a building will be required to meet the above Built Form Standards. These include a minimum set back of 30m from SH 75 or 15m from another road (Rule 17.2.3.8) and 10m from internal boundaries (Rule 17.2.3.8). In addition, trees shall be planted so that SH75 is not shaded between 10:00 and 14:00 on the shortest day (Rule 17.2.3.7); site coverage of buildings shall not be greater than 10% of the site area or 2,000m^2 whichever is the lesser (Rule 17.2.3.10); and the maximum building footprint shall be 300m^2 (Rule 17.2.3.11). Given that the standards relating to matters such as site coverage and building footprint for the pond are unlikely to be met, resource consent as a restricted discretionary activity under Rule 17.2.2.3 would be required.

[9] Section 2 of the RMA defines a *"structure"* as *"any building, equipment, device, or other facility made by people and which is fixed to land; and includes any raft."* and as such appears to include a storage pond.

However, dams that retain water (as opposed to wastewater) and which have a depth of not more than 3m and a volume of not more than 20,000m^3 are not subject to these standards and as such form a permitted baseline.[10]

Rule 11.3b states that the rules in the Zone chapters do not apply unless specified (in this case only the Built Form Standards of the Rural Banks Peninsula Zone apply).

Rule 11.3c states that the activity status tables and standards in a number of chapters apply including Chapter 5 Natural Hazards, Chapter 8 Subdivision, Development and Earthworks and Chapter 9 Natural and Cultural Heritage.

In terms of Chapter 5 Natural Hazards the relevant rules do not affect the proposal, and in particular the Liquefaction Management Area located at Takamātua Valley, given the relevant rules only apply to subdivision and residential development.

The most relevant standard in Chapter 8 Subdivision, Development and Earthworks is that relating to earthworks, which will be required for the construction of the storage ponds and associated works. Table 9 in Rule 8.5A.2.1 sets out the various thresholds for earthworks which for the Rural Zones is 100m^3/ha. However Rule 8.5A.3 Exemptions (6a) states that utilities are exempt from the earthworks rules and accordingly earthwork rules do not apply.

In respect of Chapter 9 Natural and Cultural Heritage, sub chapters include

- 9.1 Indigenous Biodiversity and Ecosystems
- 9.2 Landscapes and Natural Character
- 9.3 Historic Heritage
- 9.4 Significant Trees
- 9.5 Ngai Tahu Values and Natural Environment
- 9.6 Coastal Environment.

In terms of 9.1 none of the sites are affected by this sub chapter.

The activity status tables and standards of 9.2 Landscapes and Natural Character do not apply to utilities and accordingly resource consent at the three sites is not required in terms of this sub chapter (Refer Rule 11.3(c) and Rule 9.2.3 9(g)).In terms of 9.3 Historic Heritage and 9.4 Significant Trees, heritage items and significant trees are identified at Takamātua Valley and Robinsons Bay Valley. At this stage it does not appear these items will be affected. In terms of 9.5 Ngai Tahu Values and the Natural Environment, Silent File Area 14a is included in Schedule 9.5.6.2 but does not have any rules applying to it. In terms of 9.6 Coastal Environment, which applies to the areas identified as Coastal Environment, no rules apply but objectives, policies and matters of discretion apply to any activities in these areas.

As indicated above the use of the land for irrigation of wastewater to pasture or trees is considered a utility which requires resource consent under Rule 11.4.3 as a discretionary activity. The other RDP chapters referred to above are applicable to the activity, although it is noted that the activity status tables and standards

[10] Section 104 (2) that the consent authority may disregard an adverse effect of the activity on the environment if the plan permits an activity with that effect (Section 104(2)).

of Chapter 9.2 Landscapes and Natural Character are not applicable. Rather than applying for a resource consent, the Council has the option of issuing a Notice of Requirement under Section 168A of the RMA designating the land for wastewater disposal purposes or similar to provide for the land use on the site.

The potential adverse effects to be assessed under the District Plan in terms of the irrigation of wastewater are likely to include public health and amenity values (which are assessed elsewhere in this report) and landscape and visual effects in respect of the ponds and the greening of pasture or the planting of trees. In terms of a permitted baseline, planting of "green "crops such as lucerne or the irrigation of pasture, is part of farming which is a permitted activity. Conservation and farming activities, which are defined to include tree planting, are permitted activities in the Rural Banks Peninsula Zone, provided it is not "plantation forestry".

Plantation forestry means *"use of land for planting, maintenance and harvesting of timber tree species for commercial wood production*" and the proposed planting of indigenous trees for the irrigation of the wastewater does not meet this definition as it is not "commercial wood production". Other resource consents for the discharge to land and air are required from Environment Canterbury for the irrigation of land (see Section 7.3).

7.2.3 **Summary**

The storage pond and irrigation pipes and equipment are considered a "utility" which is a permitted activity in terms of Rule 11.8.1 P2 subject to compliance with various bulk and location controls of the Rural Banks Peninsula Zone including setbacks, building footprint and site coverage. If these standards are not met resource consent is required as a restricted discretion activity.

There are provisions of other chapters that apply to utilities, including any works that affect heritage items or significant trees, requiring resource consent. Provisions relating to earthworks in Chapter 8 Subdivision, Development and Earthworks and provisions in Chapter 9.2 Landscapes and Natural Character do not apply to utilities.

However, the use of the land for irrigation of wastewater to pasture or trees is not considered to be permitted in terms of Rule 11.8.1 P2 as the rule refers to structures only. The use of land for the irrigation of wastewater is considered a utility that requires resource consent as a discretionary activity in terms of Rule 11.4.3. While the activity is discretionary, many of the effects are similar to those allowed by permitted activities in the zone.

Council also has the option of issuing a Notice of Requirement to designate the site for wastewater disposal purposes or similar under Section 168A of the RMA to provide for the land use on the site.

7.3 Regional Plans

7.3.1 **Overview**

In terms of regional plans, the following plans are of relevance:

- Canterbury Land and Water Regional Plan (LWRP)
- Proposed Canterbury Air Regional Plan (pCARP) – Environment Canterbury have adopted the decisions of the Commissioners and this plan is relied upon rather than the operative Canterbury Natural Resources Regional Plan (NRRP) – Chapter 3 Air Quality.

7.3.2 **Regional Plan Provisions**

Resource consents are required for the two disposal options as follows:

- The use of land for a community wastewater treatment system and discharge of treated sewage effluent from a community wastewater treatment system is a discretionary activity under Rule 5.84 of the LWRP and includes the irrigation of wastewater to land or trees.
- If the storage pond is to be located in a water way (such as suggested at Pompeys Pillar), a resource consent is required under Rules 5.155 of the LWRP as a discretionary activity as it is unlikely that the volume limits and other matters (including the damming of a mainstem of a river) would be complied with. If the mainstem is dammed resource consent as a non-complying activity is required under Rule 5.156[11]. Any associated diversion of a river requires resource consent under Rule 5.141B of the LWRP as a discretionary activity.
- Areas of Takamātua Valley and Robinsons Bay Valley are identified as "High Soil Erosion Risk". Earthworks associated with any storage pond in these areas are likely to require resource consent as a restricted discretionary activity under Rule 5.171 given the earthworks will exceed the specified limits in the LWRP.
- The flat areas of Takamātua Valley and Robinsons Bay Valley are also identified as over an unconfined or semi-confined aquifer in which Rule 1.75 of the LWRP requires any excavation to maintain 1m between any excavation and the aquifer and 50m separation from a waterbody. Storage ponds in these area therefore may require resource consent under Rule176 as a restricted discretionary activity.
- The discharge of contaminants to air from the disposal of human sewage effluent including the storage pond is a discretionary activity under Rule 7.63b of the pCARP[12].

The Regional Coastal Environment Plan for the Canterbury Region (RCEP) identifies "Pompeys Pillar" (without further defining it) as an "Identified Area of High Natural, Physical, Heritage or Cultural Value". Resource consent is not required under the RCEP (as the activities are above mean high water springs) but the above provision may have some relevance as Section 104 of RMA states that in considering an application regard must be had to provisions of other plans (such as the RCEP).

7.4 Summary of Resource Consent Requirements

A summary of the main resource consents that may be required in terms of the RDP, LWRP and pCARP for the three sites are set out in Table 7-1.

[11] Plan Change 4 to LWRP was made operative in March 2017 and removed the previous provisions relating to impoundment of water outside the bed of a river.

[12]

Table 7-1: Summary of Resource Consent Requirements

Activity	Plan	Activity Status		
		Takamātua Valley	Robinsons Bay	Pompeys Pillar
Irrigation piping and equipment	RDP	Permitted	Permitted	Permitted
Irrigation of wastewater (land use)	RDP	Discretionary – requires consent	Discretionary – requires consent	Discretionary – requires consent
Storage pond	RDP	Restricted discretionary – requires consent	Restricted discretionary – requires consent	Restricted discretionary – requires consent
Storage pond – if located in a waterway	LWRP	Not applicable	Not applicable	P4 pond site may require consent
Storage pond – if involves excavation to within 1m of semi-confined or unconfined aquifer	LWRP	Could require consent for pond site 7	Could require consent for pond site 2	No aquifer zone so not applicable
Use and Discharge of treated sewage effluent	LWRP	Discretionary – requires consent	Discretionary – requires consent	Discretionary – requires consent
Soil erosion risk	LWRP	May be discretionary if located in soil erosion risk zone	May be discretionary if located in soil erosion risk zone	No soil erosion risk zone so not applicable
Discharge of contaminants to air	pCARP	Discretionary – requires consent	Discretionary – requires consent	Discretionary – requires consent

7.5 Archaeological Sites

Section 42 of the Heritage New Zealand Pouhere Taonga Act (2014) states that unless an Archaeological Authority is granted from Heritage New Zealand, no person may modify or destroy an archaeological site.

An “archaeological site” is defined as “a place that was associated with human activity that occurred before 1900”. Potentially, earthworks associated with the storage ponds within all the proposed study sites could result in a requirement to apply for an Archaeological Authority.

It is noted that part of the Takamātua Valley site is located in a Silent File Area and there is also a registered Archaeological Site (N36/105) comprising ovens/middens located in the vicinity of SH 75 at Robinsons Bay.

7.6 Covenanted Sites

A search of the certificates of title show that a Conservation Covenant is located within the investigation area for Robinsons Bay Valley. The extent of this Covenant is 1.4ha and is close to the intersection of the State Highway and Robinsons Bay Valley Road at the base of the valley so is unlikely to affect the ability to implement an irrigation scheme in this location. There is also a Conservation Covenant above Takamātua Valley but this is outside the area being considered for irrigation at this stage.

7.7 Planning Considerations for Specific Pond Sites

7.7.1 Storage Pond Opposite Proposed Wastewater Treatment Plant

In terms of issues in respect of locating a storage pond opposite the WWTP the following is noted:

In terms of the RDP the site is Zoned Rural Banks Peninsula. The site is located within Silent file Area 14a but does not have any rules applying to it. Consultation should be undertaken with the appropriate rūnanga to identify any issues of concern.

No other RDP overlays apply and although the site is located in close proximity to a Main Ridge Protection the ridge does not encroach on the site.

The storage pond is considered as a utility under the RDP and subject to various standards including, setbacks from SH75 (30m), Old Coach Road (15m) and internal boundaries (10m) and compliance with site coverage and building footprint controls. As the storage pond will not meet the building footprint requirements at least resource consent is required.

A resource consent for the discharge of odour is required in respect of the pCARP.

In terms of effects the site is relatively well separated from sensitive uses with the nearest dwelling approximately 100m from the site. The Landscape and Visual Effects Review noted that the site is not visible from SH75 and views are limited from other vantage points and compared with other sites it is a preferred option. The site is relatively level which will reduce the amount of potential earthworks and its location in proximity to the WWTP is a logical one concentrating utility type developments in one locality. Potential odour from the pond is not considered to be a significant issue given the treatment and operation regime and the distance to sensitive users.

Overall, subject to final design which can incorporate appropriate mitigation such as landscaping to naturalise the pond, adverse effects can be managed in an acceptable manner.

7.7.2 Multiple Ponds and Amenity Effects

In terms of amenity effects having multiple ponds, as opposed to a single pond, offers the following advantages and disadvantages.

At a broad level multiple ponds will tend to disperse adverse effects rather than concentrate them at one location. Due to the smaller scale of the pond adverse effects are likely to be less at each individual site but with the potential to affect larger numbers of people because of the increased number of sites.

Multiple ponds will reduce the footprint of each pond thereby reducing its visual impact and potentially enabling them to be located more discretely with a wider variety of sites available. The smaller area may allow greater setbacks from sensitive uses such as dwellings and waterways. A number of ponds may however mean larger numbers of people are potentially affected.

The management of a number of ponds may be more difficult than a single larger pond. However, a number of ponds offer the opportunity to establish a network of ponds which along with associated plantings may have ecological and recreation benefits.

A disadvantage of distributed smaller ponds is that each pond would need its own infrastructure and consequently a greater combined gross area would be needed for the development due to additional pond access roads, additional filtration and pumping systems.

The size of pond storage required relates mostly to the number, frequency and intensity of wet weather days rather than the contributing population. Consequently the opportunity to stage the development of the ponds if a multiple pond system is preferred is limited since the majority of pond capacity would be needed straight away.

7.8 Preliminary Assessment of Actual and Potential Effects on Environment

This section provides a preliminary assessment of the likely effects on the environment of land-based disposal at the alternative sites. The assessment is only preliminary at this is stage because no detailed baseline studies or investigations (other than geotechnical) have occurred.

7.8.1 **Positive Effects**

Positive effects will accrue from passing the wastewater through land by avoiding the discharge to the harbour. The Ngāi Tahu parties have advised that year-round irrigation to pasture or trees are the only options that are acceptable to them.

7.8.2 **Landscape/Visual Effects**

A high level landscape and visual review has been undertaken to assist in the comparison of alternative sites by considering the effects of:

- Irrigation to pasture or trees at either Takamātua Valley, Robinsons Bay Valley or Pompeys Pillar
- The construction of a storage pond of either 35,000m³ for pasture or 17,500m³ for trees at the locations indicated on the map in Appendix I for Takamātua and Robinsons Bay, or the locations indicated on the map in Appendix H for Pompeys Pillar.

The following is a summary of the high-level review of potential landscape and visual effects prepared by Align Ltd and as part of the wider consideration of alternative locations for land irrigation as part of the Akaroa Wastewater Project. The full review is attached in Appendix J.

The review is not intended to provide a detailed assessment of landscape and visual effects for each (or a combination) of the potential sites as further design and assessment work will need to be carried out to provide such detail. See the review report in Appendix J for methodology and scope details.

The key landscape and visual characteristics of those local landscapes are described in a sufficient level of detail to indicate their capacity to accommodate one or both of the main project components (i.e. co-location of the irrigation area and storage pond *or* the potential for them to be separate to one another).

The review determined that all of the sites identified within the wider Robinsons Bay and Takamātua Valley landscapes have the potential to accommodate the proposed irrigation area (pasture or planted) with low to moderate impacts on the existing character or general amenity of the area. This is because both landscapes already consist of a patchwork of various land cover and land uses and the introduction of a new land use would be easily absorbed within the context. The review determined that the sites within Pompeys Pillar could present challenges given the unmodified nature of the area and lack of existing features to absorb the changes, particularly tree planting. Refer to Appendix J, Section 3.0.

Table 7.2 summarises the high level review of the potential landscape and visual effects of each of the identified sites that have been considered for their potential to accommodate a storage pond and/or irrigation. The sites have been ranked in terms of potential rural character, visual and wider rural amenity effects. An overall "on balance" rating has also been provided in summary.

Of the identified sites there is a recommendation that areas within Robinsons Bay Valley and Takamatua Valley have the greatest capacity to absorb development, will generate a lower degree of effect, and subsequently represent a comparatively lower consenting risk in landscape and visual terms. Pompeys Pillar is considered to have high potential for adverse character and landscape effects. It is accepted that other drivers for the project may make Pompeys Pillar an attractive/ suitable option for development, however the review identifies that development could present a significant risk in regards to landscape effects.

For the remainder of the pond sites a ranking has been applied in terms of potential rural character, visual and wider rural amenity effects. An overall 'on balance' rating has also been provided.

Table 7-2: Summary of High Level Visual and Landscape Effects Review

No.	Site	Activity	Description of Site Factors for Scoring	Potential Landscape and Visual Effects
1	Robinsons Bay - northern hill site	Pasture Tree Planting Storage	▪ Rural character effects are likely to be minimal given the mixed-use modified landscape and possibility for absorption. Amenity effects are likely to be minor but would be dependent on accommodation outlook etc.	Moderate
2	Robinsons Bay - mid lower valley	Pasture Tree Planting Storage	▪ Residential properties looking down onto area, including BnB establishments are likely to be visually affected. However distance may be a mitigating factor given the detachment from the flat pond site. ▪ Existing pasture lands and surrounding area are modified already, with surrounding vegetation pockets that could act to absorb the landscape change. Hence landscape effects are likely to be minor.	Moderate
3	Robinsons Bay - south lower valley	Pasture Tree Planting Storage	▪ Visible from SH75 and residential properties looking down onto area. BnB establishments may be visually affected. However distance may be a mitigating factor given the detachment from the flat pond site. ▪ Existing pasture lands and surrounding area are modified already, with surrounding vegetation pockets that could act to absorb the landscape change. Hence landscape effects are likely to be minor.	Moderate to high
4	Robinsons Bay - west of Sawmill Road	Pasture Tree Planting Storage	▪ The site is in proximity to Pavitt Cottage and old sawmill site (i.e. historic and cultural significance), but the pond site may be more discrete than others due to vegetation ▪ Landscape effects are the primary concern given the historic, cultural, stream environment setting etc.	Low to moderate
5	Thacker property – lower site	Pasture Tree Planting Storage	▪ Proximity to intersecting roads and Pavitt Cottage and old sawmill site (i.e. historic and cultural significance), could be an issue ▪ Landscape effects are the primary concern given historic and cultural features, and rural character.	Moderate
6	Thacker property – upper site	Pasture Tree Planting Storage	▪ Given the elevated position the visual nature of the area may change and the pond may be quite apparent. However the distance from viewing position counterbalances this effect.	Moderate
7	Takamātua – lower valley	Pasture Tree Planting Storage	▪ The pond site may need to be "built-up" above ground level, hence may be more visible from SH75 and surroundings. This will reduce the potential for a naturalised appearance (i.e. ancillary features, less streamlined appearance).	Moderate to high
8	Takamātua - headland	Pasture Tree Planting Storage	▪ High exposure from a multitude of areas including surrounding land, road and harbour users.	High
9	Takamātua – top of hill north of SH75	Pasture Tree Planting Storage	▪ High exposure from SH75 coming north around road bend and key views from southern approaches on SH and adjacent intersection.	High
10	Takamātua –	Pasture	▪ Mostly protected from visual exposure from SH75 due to terrain, which	Low to moderate

	top of hill south of SH75	Tree Planting Storage	lessens the impact on road users. ▪ Viewed on approach from Long Bay Road, but visual impact is transient.	
11	Pompeys Pillar	Pasture Tree Planting Storage	▪ High scenic values and relatively unmodified compared to other sites. ▪ High potential for landscape effects due to natural character and landscape	High

Legend	Low to moderate effects		Moderate effects		Moderate to high effects		High to very high effects

The review essentially removes three pond sites as they are situated on highly visual locations, or within unmodified landscapes. This leaves eight pond sites for consideration. If landscape and visual matters are recognised as an important consideration then further refinement should be limited to the remaining eight sites. This does not mean that the remaining sites cannot or should not be considered but the design of the facilities should respond to the site and its surroundings by providing adequate mitigation by having regard to available contours, extent of earthworks and planting for naturalisation and screening purposes.

Design recommendations are outlined within the review report. It is important to note that the ratings provided in Table 7-2 have been made under the proviso that design in regards to landscape treatments and mitigation is undertaken regardless of the final (engineering) requirements of the pond(s).

As indicated above, the review does not include a detailed policy analysis as this will be undertaken in the full Landscape and Visual Assessment, which will be completed at a later stage. The following is noted which will be assessed within the Landscape and Visual Assessment:

- A permitted baseline exists in respect of the “greening” of landscapes, the planting of trees and dams for the storage of water.
- Most of the sites do not encroach on the demarcated overlays relating to the coastal environment and all of the sites avoid demarcated outstanding natural landscapes and areas of high natural character in the coastal environment in the RDP.
- RDP policies recognise the need to provide for strategic infrastructure (which includes wastewater networks and associated facilities) that have a functional need to locate in the coastal environment.
- The sites are likely to be consistent with a number of the RDP landscape objectives and policies by:
  - avoiding development that breaks skylines and is not visually prominent
  - separating development from prominent ridgelines
  - not resulting in “over domestication “of the landscape
  - avoiding the use of substantial structures
  - integrating with the landscape by use of existing contours, appropriate earthworks and planting

7.8.3 Earthworks

Visual effects of earthworks associated with storage facilities could potentially be mitigated by integrating a pond with existing contours, minimising batter slopes, and implementing appropriate landscaping. The design of other earthworks such as those for access roads could also be undertaken sensitively utilising the above measures. A pond could be construed as consistent with the rural character of the area (given such a facility could be used for on-farm storage). It is not anticipated that a pond cover is required to control odour or exclude birds. Areas of High Natural Character in the Coastal Environment (HNC) in the Coastal Environment and Outstanding Natural Landscape (ONL) are able to be avoided given their location and size.

7.8.4 **Planting of Trees**

Any planting should be carried out as sensitively as possible with mitigation measures including planting along contours, avoidance of straight edges and ridgelines and use of native vegetation where possible, particularly if sites are located in the following demarcated areas - Coastal Environment, Outstanding Natural Landscape (ONL), or High Natural Character in the Coastal Environment (HNC).

7.8.5 **Natural Hazard Effects**

Beca's assessment is that geotechnical risks are low for all shortlisted sites since geotechnically unstable land has been excluded from further consideration. Appropriate engineering design will minimise any risks of such matters as bund failure of storage facilities (e.g. from seismic activity). The preference will be to locate storage facilities on, or within, relatively flat land so that these risks can be readily mitigated.

7.8.6 **Effects on Soils, Groundwater and Surface Waters**

The treated wastewater quality from the normal operation of the treatment plant will be suitable for land application and none of the individual contaminants are likely to affect soil structure. The wastewater is from domestic/commercial sources and will be treated to a relatively high level (i.e. very low concentrations of solids, organic matter, fats, oils and grease and trace metals; relatively low nutrients and micro-organisms). The wastewater would meet New Zealand guidelines for land application of wastewater (e.g. Category 1, Department of Health, 1992, NZ Land Treatment Collective, 2000).

Treated wastewater would be applied to land at rates that meets the assimilative capacity of site vegetation and soils. Generally, sustainable land application systems are operated on a soil moisture deficit basis so that no ponding or runoff to surface waters occurs. The provision of an appropriate volume of storage would be essential when soil conditions are unsuitable for irrigation.

Site vegetation will utilise nutrients contained in the wastewater and the land application system would need to be sized for both hydraulic and nitrogen loads.

The lower permeability soils at the Pompeys Pillar site will restrict drainage to groundwater. However drainage to groundwater at other sites is likely to be higher. Groundwater depth is relatively shallow in lower parts of Robinsons Bay and Takamātua Valley and irrigation rates would need to be managed to mitigate any adverse effects. Storage ponds would be lined (using High Density Polyethylene (HDPE) or similar) to minimise seepage that may lead to tunnel gullies or under-runners forming in the loess soil. It is also understood that some residential properties at Takamātua Valley rely on a reticulated system or rainwater for potable water supply rather than groundwater bores.

An initial search of the ECan groundwater well database has shown three wells located in or near the proposed irrigation areas (two in Robinsons Bay Valley, and one in Takamātua Valley (none at Pompeys Pillar)). However it is possible that further properties at all three sites may rely on groundwater bores and springs that are not recorded in this database. These would need to be located by site walkovers and landowner advice. An assessment on the effects on these water supplies would be required where any spring or groundwater source used for a drinking water supply could be adversely impacted and an alternative water supply or treatment may need to be provided. This assessment would be undertaken once the irrigation area has been confirmed.

The condition of existing waterways at the sites has not been assessed. Any discharge into streams that then enter coastal areas would require assessment of the potential to cause adverse effects, particularly if used for swimming (with their waters having a classification in the Canterbury Regional Coastal Plan of "Contact Recreation"). The possible locations for storage ponds and irrigations areas have been determined using setback distances selected to minimise the risk of discharge into waterways. In addition, low pressure type irrigators or drip lines that do not produce aerosols and/or planting of vegetation in the buffer areas will provide effective mitigation. The location and impact of storage ponds on floodways will need to be specifically addressed in the design to avoid any changes to naturally occurring surface flooding events. Council ecologist Greg Burrell has advised that an irrigation scheme involving trees, which includes riparian planting, could improve the ecology of an adjacent stream.

7.8.7 Effects on Cultural/Historic/Tree Values

The southern part of Takamātua Valley site is included within Silent File 14a/27 (although no actual rules apply to the area) with an indication that the area of the silent file is larger than those shown in the District Plan.[14] Early engagement with Ōnuku Rūnanga has identified that there are no sensitive areas that may affect disposal options in the Takamātua Valley.

Te Rūnanga o Koukourārata has advised that the eastern bays of Banks Peninsula contain a number of significant sites and cultural values of importance to Te Rūnanga o Koukourārata. The rūnanga therefore wishes to make sure that an appropriate assessment of cultural values is undertaken (such as a Cultural Impact Assessment) should the Pompey's Pillar option be considered further. The Council will liaise with Te Rūnanga o Koukourārata and Te Rūnanga o Ngāi Tahu directly to progress this.

Heritage Item and Setting 1171 and 145 Dwelling is located at 5 Sawmill Road and; Heritage Item Dwelling and Setting 11713 and 539, Former School Master's House is located at 99 Robinsons Valley Road. The locations of these heritage sites are shown on the planning maps in Appendix P. If these areas are avoided (which given their relatively small areas is possible) potential adverse effects will not arise. The Robinsons Bay Sawmill site, which is not detailed in the RDP, will be investigated further if development is proposed in proximity to this site.

Archaeological site N36/105 is located in proximity to SH 75 at Robinsons Bay and investigation will be required if works are proposed in proximity to the site.

As indicated, an Archaeological Authority may be also required from Heritage New Zealand if a site that is to be modified is associated with human activity pre-1900.

There are four Significant Trees T23-T26) (2 walnuts, a totara and a kahikatea) located at Bells Road in Takamātua Valley and if possible works affecting the trees should be avoided to minimise adverse effects..

7.8.8 Effects on Recreation

The wastewater disposal activities are unlikely to result in adverse effects on recreation activities (such as walking tracks, playing fields etc) given these activities are generally not in close proximity to the proposed sites. In particular, the Banks Peninsula Track is located over 1km from the Pompeys Pillar site on the opposite side of Otanerito Bay and is unlikely to be affected. In any event, from April 2017, this part of the track will no longer be available for use as the respective landowners have withdrawn their participation.

The storage ponds and irrigated areas, which will be managed by Council, may have the potential to be accessed by the public for recreational opportunities such as walking.

[14] Cultural Values Report: Takamātua to Takapuneke (Dyanna Jolly Consulting, July 2009)

In terms of public use and public health, the treated wastewater will be treated to a very high level. The use of land treatment areas by the public for recreation has been assessed against current New Zealand Guidelines.

The New Zealand Guidelines for Utilisation of Sewage Effluent on Land (NZ Land Treatment Collective, 2000) refers to the *Public Health Guidelines for the Safe Use of Sewage Effluent and Sewage Sludge on Land* (New Zealand Department of Health, 1992) for guidance on landuse (such as recreation) within land treatment areas. The 1992 guidelines provide for 5 categories of use to protect public health defined by the faecal coliform concentration of the applied wastewater. From Appendix 4 of these Guidelines, it can be concluded that the public could reasonably access the irrigation area for recreational purposes without restrictions (i.e. as all wastewater will receive full treatment).

7.8.9 **Noise**

The general noise environment of the irrigation scheme is likely to be typical of rural areas. The construction of pipelines and the excavation of ponds would produce a temporary localised increase in noise levels but this would be mitigated by compliance with NZS Construction Noise Standards and expected separation distances. Of the proposed irrigation methods, drip irrigation produces no noticeable noise and low pressure spray irrigators are very low sources of noise. Ponds are largely passive systems in terms of noise if the storage pond is located high enough above the irrigation area to allow irrigation by gravity. If mechanical pond aeration is needed or a transfer pump is required to pump between the pond and the irrigation area, potential noise effects can be mitigated by insulation of equipment and provision for adequate separation distances. Overall, there would be minimal potential for noise nuisance from the disposal options.

7.8.10 **Effects on Terrestrial Ecology**

Any effects on terrestrial ecology from earthworks activities (e.g. from direct disturbance or from dust deposition) would need to be appropriately minimised/managed. However at this stage, no at-risk plant or animal species have been identified from available literature, which appears to reflect the modified nature of the sites.

7.8.11 **Effects on Public Health**

The operation of other similar land irrigation schemes has been reviewed in order to characterise public health risks. A summary of information provided by plant operators is set out below.

7.8.11.1 Rotorua Land Irrigation Scheme

Rotorua District Council has operated a land irrigation scheme for more than 30 years. The scheme includes the first biological nutrient removal (BNR) treatment process commissioned in New Zealand, in 1989, and an extensive land irrigation scheme located in the Whakarewarewa Forest irrigating 50,000m^3/day on average. Wastewater is applied to land in the forest using spray irrigators in, and near to, areas used for public recreation. Information provided to us by the scheme operator indicates relatively few problems with public access to irrigation areas. Management measures that are employed to reduce public health risks include the following:

- Warning signage is provided advising the public to stay out of areas while spraying occurs;
- Where mountain bike tracks run next to spray irrigators the spray nozzles are orientated to spray in a reduced arc;
- An “at your own risk” policy is applied. An orienteering group that requested access to a wide area of forest for an orienteering event was offered access with a proviso for a waiver about health risks. The group declined the waiver and the event did not go ahead;

- Limited public health incidents have been reported.

7.8.11.2 Kawakawa Wastewater Treatment Plant

The Kawakawa scheme involves a vacuum collection system and MBR treatment plant (there is no bypass). Treated wastewater flows to a wastewater lagoon with capacity of 1000m^3 (lined with HDPE). There is a seasonal effluent lagoon with capacity of 9,000m^3, although this has never been used. The typical flowrate of wastewater is 65m^3/d (600 residents currently, can serve up to 3,000 people), with a BOD content post treatment of 1-2 g/m^3. The average retention time of wastewater in the wastewater lagoon is 5 -10 days. Wastewater is irrigated to forestry daily. The storage pond is located 2.5km away from the nearest residents, and no issues with odour emission or midges have been reported.

The irrigation area is fenced off with a 1.8m high deer fence, making it difficult for the public to enter. There are warning signs at the boundary of the irrigation fields. No public health issues with the operation of the scheme have been recorded and the total exclusion of the public from the irrigation area is considered by the scheme operators to contribute to positive public health outcomes.

7.8.11.3 Whitianga Wastewater Treatment Plant

A new treatment scheme was developed as part of the Coromandel Eastern Seaboard Wastewater Treatment Plants Project, which began in 2009. The treatment plant employs a sequencing batch reactor (SBR) process. Treated wastewater flows to a covered disposal tank lined with heavy duty polyethylene. The pond is covered with a flexible membrane that is completely sealed to prevent emissions to air. The plant has an emergency storage pond that receives peak wet weather bypass flows. Wastewater is disposed to council-owned land via surface sprinklers. The irrigation area has limited access and no public health issues have been reported.

7.8.11.4 Pauanui

Pauanui implemented a new wastewater scheme including a new SBR plant and land disposal scheme in 2009. Up to 16,000m^3 of treated wastewater is irrigated onto playing fields and parks/roads/medians within the township, and the local air field using subsurface drippers. The township and irrigation areas are located above a shallow aquifer at 5-6m depth. The groundwater is naturally brackish and is not abstracted for public water supply or any other use. No public health issues have been reported with operation of the scheme.

7.8.11.5 Summary

A range of different measures are applied to manage public health risks associated with irrigation of treated wastewater to land around New Zealand. While an abundance of caution is taken by some authorities, in other cases such as Rotorua the treated wastewater is spray irrigated within forestry areas that are extensively used the public. In the case of the proposed Akaroa Wastewater Scheme the treated wastewater will meet very a high standard and will present very low risks to public health. Hence there may be options for the public to safely access irrigation areas. This will need further consideration taking into account the location of the irrigation area, the type of vegetation, and the activities conducted by the public within the area.

7.8.12 Effects of Odour and Possible Midge Presence

As outlined in Section 5.8.2 the potential pond odour risk has been assessed by modelling BOD concentration with pond storage volume. This modelling work has concluded that the risk of pond odours from the operation of the Akaroa wastewater pond is low. Commentary on the potential for midges is given in Section 5.8.5.

The proposed 100m buffer between the pond and any residence will also assist to manage potential nuisance effects such as odour and midge populations.

7.8.13 **Effects of Spray Drift (Aerosols)**

Aerosols are spray droplets, and treated wastewater aerosols can contain potentially pathogenic micro-organisms. Downwind transport of aerosols from irrigators is dependent on irrigator type, droplet size and wind strength. The concentration of micro-organisms in the wastewater will be very low as a result of disinfection at the treatment plant (median faecal coliforms concentration of 5cfu/100mL) and will meet the Public Health Guidelines referred to above in 7.8.8.

Irrigation of land is also likely to be by surface driplines (under trees) or low pressure spray to pasture. Low pressure spray systems generate large droplets, low to the ground which do not tend to be dispersed (Akaroa Wastewater Disposal – Public Health Risks Associated with the Generation of Aerosols from Spray-type Land Application, CH2M Beca June 2016). Accordingly neither of these systems is conducive to aerosol creation, especially irrigation via drip lines.

The Blenheim irrigation scheme has the option of turning off spray irrigation above a certain wind speed and/or direction, which further minimises risk and a similar regime could be implemented for Akaroa. However the storage pond capacity may need to be increased if this control strategy is adopted. Overall, adverse effects associated with spray drift are likely to be less than minor.

7.8.14 **Effects on Amenity**

The amenity values of the surrounding areas are not anticipated to be significantly affected by an irrigation scheme. These facilities are not out of place in a rural environment and factors affecting amenity such as noise, odour and spray drift are anticipated to be minimal (see discussion above).

The visual effects of the pond can be mitigated by the type of measures referred to in Section 5.3.2.

However, there may be a public perception that amenity would be adversely affected by the discharge of wastewater to land, particularly if nearby residents (such as in Takamātua Valley and Robinsons Bay), consider themselves affected in some way. Concern that there may be a negative effect of land discharge systems on adjacent property values is often cited in opposition to such schemes.

The effects can be mitigated by a robust consultation and information sharing process with stakeholders and the public, and through appropriate design. The addition of new native plantings into a valley could be seen by many as a benefit to the community.

7.8.15 **Wastewater Disposal Alternatives**

A number of wastewater alternatives are considered in this report. Consideration of alternatives is critical given the provisions of the Resource Management Act including Section 105 (which relates to discharges) and Section 168A (which relates to designations) as well as various policies in the New Zealand Coastal Policy Statement, the Canterbury Regional Policy Statement and the Canterbury Regional Coastal Environment Plan (RCEP) relating to alternatives for the discharge of wastewater into the coastal area. There is also case law on the necessity to give adequate consideration to alternatives including the discharge of wastewater, particularly having regard to Maori matters set out in Section 6(e), Section 7(a) and (e) and Section 8 of the Act.

Council has considered a large number of possible disposal and reuse options and after analysis and consultation with the community and the Ngāi Tahu parties has narrowed these options to the shortlisted options described in this report and the discharge to harbour for which resource consent was sought. There is to be further consultation on those options.

7.9 Effects Assessment of Consenting Process

This is a high level assessment of effects. As noted above, the assessment is preliminary only and has been undertaken without the benefit of detailed investigations.

Resource consents are likely to be of discretionary and restricted discretionary status. Designation of the sites should also be considered.

The likely consenting risks have been assessed below in Table 7-3 based on the following: high (red), medium (orange) or low (green).

Table 7-3: Likely Consenting Risks

Adverse Effect	Site	Risk	Comment
Landscape /Visual – storage pond/access/trees	All Sites except Pompeys Pillar	Low	The landscape and visual assessment identified a number of sites that have low to moderate risk. Effects can be mitigated by careful design in respect of such matters as contours and landscaping and in respect of trees, the use of native species. While the overall risk is deemed to be low the Pompeys Pillar site is high risk in terms of the landscape and visual review undertaken. .
Natural Hazards	All Sites	Low	Unstable soil areas avoided and facilities engineered to avoid bund failure.
Soils, Groundwater and Surface Waters	All Sites	Low	High quality wastewater, storage systems, setbacks from waterways, uptake by plants and lining of facilities reduces risk.
Noise	All Sites	Low	Little noise generated.
Recreation	All Sites	Low	Limited recreation activities occur at present in the vicinity of the sites. Public access to the sites results in a positive recreation effect.
Cultural/Historic Values	All Sites	Medium	Takamātua Valley is located in a silent File Area. Ōnuku Rūnanga have advised Council that they support investigations to determine the feasibility of discharge of treated wastewater to land within the Silent File area. The Council will continue to work closely with Ōnuku Rūnanga to address concerns if they arise. Te Rūnanga o Koukourārata has advised that there may be significant sites and cultural values of importance to Te Rūnanga o Koukourārata at the Pompeys Pillar site that need to be investigated further. A cultural impact assessment is underway. Other sites are considered a low risk.
Terrestrial Ecology	All Sites	Low	No at-risk species identified at present.
Public Health – land and water	All Sites	Low	Discharges are likely to comply with relevant public health guidelines. The treated wastewater quality will be of a very high standard and suitable for use in public parks, so presents a very low public health risk. Implementation of setbacks from water bodies

Adverse Effect	Site	Risk	Comment
			and minimising aerosol creation will also assist in mitigation.
Odour and Spray Drift	All Sites	Low	Odour modelling (refer section 5.6) has shown that the risk of odour is low. No aerosols would be generated by drip irrigation (for irrigation under trees), and the use of low pressure spray irrigation systems with buffer areas around the irrigation areas would mitigate any risk from aerosols from spray irrigation of pasture. Furthermore spray irrigation to pasture can be turned off if wind speeds are too high.
Amenity	All Sites	Low	While the actual or potential effects appear to be minor or minimal some people may perceive that amenity will be adversely affected if the location of facilities is at Robinsons Bay or Takamātua Valley. Conversely the public may perceive the establishment of additional native forest as a benefit to region. We do not consider that perception, in the absence of an actual effect, poses a risk to the consenting process.

The preliminary assessment suggests that adverse effects of the land-based treatment and disposal options are likely to be low or medium at most sites. The reduction of medium risks to a low status will require ongoing stakeholder engagement and undertaking site-specific investigations.

Based on the investigations completed to date no high or significant risks are identified except for the Pompeys Pillar site in terms of landscape and visual appearance.

8 Cost Estimates

Using the design concepts described in Section 5, high level cost estimates were developed for the alternative sites. These cost estimates are summarised in Table 8-1. A more detailed breakdown is given in Appendix Q.

8.1 General Assumptions

The estimates have assumed current market rates and sums based on a traditional procurement route i.e. fully designed with competitive tendering from at least three suitable selected tenderers for the work as a lump sum tender. The estimates assume economy of working and procurement based on continuity of work.

The estimates assume the proposed work can be consented – allowances have been made for consenting costs.

The estimates are based on rates and prices current as of the 1st quarter 2017 and no allowance has been included for increases in costs of labour, materials or plant beyond this date.

8.2 On Costs

On Costs cover project costs that are in addition to the physical construction, supply and installation of the works.

- The estimates allow 12% for Preliminary and General and Contractor's margin.
- Risk contingency has been allowed at 30%. This reflects the stage of the design and the potential for scope change.
- The estimates allow 13% for professional fees.
- The estimates include a lump sum allowance of $200,000 for costs associated with the resource consent process.

8.3 Specific Assumptions

8.3.1 Storage Ponds

Based on the concepts presented in the report "Akaroa Wastewater – Concept Design Report for Alternatives to Harbour Outfall" and updates from recent modelling work, for trees 17,500m³ of storage is required. The preliminary infiltration testing increased the storage estimate for year round irrigation to pasture from 30,000m³ to 35,000m³. The basic concepts for the size and design of the storage ponds are described in Section 5 but are generally based on 10,000 m³ of storage near the treatment plant with the balance of storage located elsewhere.

It is assumed that the storage ponds will be fully lined with HDPE liner as this is cheaper than the Geosynthetic Clay Liner (GCL) option, and that 50% imported fill will be required to form the pond embankment (with the exception of the Takamātua pond which is assumed to be constructed entirely from imported materials since it needs to be built above ground).

Other allowances for a 25,000m³ pond at Pompeys Pillar (if required), which is likely to be classed as a large dam based on current design, include:

- Dam leak detection system and instrumentation;

- Emergency spillway, dissipater and formed discharge channel;
- Leachate return pump station;
- Perimeter stormwater cut off drain; and
- Earthworks to divert stormwater flows from existing stream.

We have assumed the ponds at Robinsons Bay Valley can be constructed from 100% locally won soil (loess). There is a risk that imported fill could be required, which would push the costs up.

8.3.2 Provisional Sums

The estimates include provisional sum allowances for the following items:

- Additional membrane unit added to treatment plant to accommodate peak flows (instead of bypass treatment system);
- Irrigation – reconfigure site fencing $12,000 and reconfigure site access $10,000 each;
- Power supply to the pump station sites $100,000; and
- Shelter belt planting for year round irrigation to pasture - $50,000.

8.3.3 Land Purchase Costs

Land purchase costs are based on approximate areas required for irrigation and use weighted average rateable values applied to the land area required in that location. Actual areas purchased may be larger as treatment sites may only cover a portion of a parcel/lot of land – the current cost estimates are based on only purchasing the amount of land required for irrigation and construction of a pond. No costs have been allowed for purchasing larger blocks of land and sub-dividing and reselling sections of the land, however a land acquisition factor of 25% has been added to the purchase costs.

8.3.4 Year Round Irrigation to Trees

Year round irrigation to trees is assumed to take the form of drip line irrigation laid on the ground beneath the trees. Drip line irrigation has been allowed at $2,000/ha and assumes small diameter polyethylene pipe or similar laid on the ground at 1 – 1.5m spacing.

The estimate makes a total allowance of $1,000/ha to establish the trees, including supply and planting of seedlings, fertilising and post plant weed control spraying. The estimate excludes further planting management post-planting (pruning, thinning etc.).

8.3.5 Year Round Irrigation to Pasture

The estimates assume year round irrigation to pasture will take the form of K-line, or similar, spray irrigation onto existing pasture land. The estimate allows for a rate of $3,000/ha to establish the spray system, as it is assumed the design will call for more pods than for a typical agricultural application to reduce the need for moving the pods on a regular basis. The estimate assumes pasture on site is suitable for use and excludes pasture renewal costs.

A provisional sum has been added for the establishment of shelter belts that may be needed close to residential properties.

8.3.6 Non-potable Reuse

A very high level estimate based on highly conceptual design information has been produced for the non-potable reuse option. The estimate assumes a DN110 PE pipe from the treatment plant to Akaroa township, mostly laid in a shared trench with proposed wastewater infrastructure upgrades. It allows for connections to

3 No. public toilet blocks and 3 No. irrigation sites at Jubilee Park, L'Aube Hill Reserve, and Stanley Park. It assumes Jubilee Park will have a subsurface drip irrigation system, L'Aube Hill a surface-laid drip system, and Stanley Park a mixture of both.

The NPV estimate non-potable reuse allows some maintenance of valving etc. and some additional mowing to Jubilee Park and Stanley Park. It assumes no balage income will be realised from either of these areas. The estimates do not allow for pasture renewal or management, nor tree establishment/management.

8.4 Cost Estimate Summary

The capital costs estimates for irrigation to the alternative sites identified range from $6.6M to $20.3M as shown in Table 8-1. Also included in this table for reference is the cost of the option of the harbour outfall, which has been escalated from the 2014 Preliminary Design estimate to the end of 2017 based on CGPI information, and the cost of a non-potable reuse system. The costs include allowances for land purchase, construction costs, equipment costs and allowances for fees, consents and Preliminary and General costs. The probable accuracy range of the estimates is -20% to +30%. The estimates do not include the cost of the new treatment plant and trunk main and pump station changes in Akaroa.

The cost estimates have been updated to account for a larger storage pond for irrigation to tree options, and are based on the outline schemes shown in Appendix H. The cost of the Takamātua Valley irrigation options have been increased to reflect there is insufficient land in Takamātua Valley to accept all the flow so further reticulation pipework would be required to send the remaining flow to another site (assumed to be Robinsons Bay for the purposes of costing). There may be potential to reduce the Wainui scheme costs by optimising the position, and therefore minimising the length, of the cross harbour pipeline.

Net present value figures have been produced for the three shortlisted options for comparison purposes, these are also shown in Table 8-1. The figures for Takamātua Valley and Robinsons Bay Valley assume a similar operating cost for each scheme. For Pompeys Pillar operating costs are dominated by pumping costs. Irrigation to pasture schemes have significant expenses associated with pasture maintenance tasks such as moving irrigators and fertilising – but these are partially offset by income from cut and carry operations.

Table 8-1: Capital Cost Estimates

Option	Description	Capital Cost Estimate	NPV
Takamātua Valley – pasture	Hybrid scheme – combined with some land from Robinsons Bay Valley. Year-round irrigation to pasture in Takamātua Valley and Robinsons Bay Valley.	**$11.8**	**$12.9M**
Takamātua Valley - trees	Hybrid scheme – combined with some land from Robinsons Bay Valley. Year-round irrigation under trees in Takamātua Valley and Robinsons Bay Valley.	**$8.4M**	**$8.9M**
Robinsons Bay Valley - pasture	Year-round irrigation to pasture in Robinsons Bay Valley	**$7.7M**	**$8.6M**
Robinsons Bay Valley - trees	Year-round irrigation under trees in Robinsons Bay Valley	**$6.6M**	**$7.1M**
Pompeys Pillar – pasture	Year-round irrigation to pasture on Pompeys Pillar	**$13.7M**	**$15.7M**

Option	Description	Capital Cost Estimate	NPV
Pompeys Pillar - trees	Year-round irrigation under trees on Pompeys Pillar	**$11.9M**	**$13.3M**
Wainui – pasture	Year-round irrigation to pasture in Wainui	**$20.3M**	
Wainui - trees	Year-round irrigation under trees in Wainui	**$18.1M**	
Non-potable reuse of treated wastewater via purple pipe (note this is not a standalone option since it would use only a portion of the treated wastewater so this cost would be in addition to one of the above options)		**$1.7M**	**$2.1M**
Disposal via harbour outfall (updated to 2017 values)		**$7.4M**	**$7.6M**

8.5 Costs for Peak Flow Treatment Options

As discussed in Section 5.10 there are two options that have been considered for treating peak flows that would effectively eliminate discharge of partially treated bypass flows to land. Very high level cost estimates have been established for these two options based on the equipment configuration summarised in Table 5-9.

The high level cost changes associated with the different peak flow treatment options are shown in Table 8-2. Note that these cost differences must be added to or deducted from the overall cost of the scheme (not just the cost of the irrigation component) since some items were part of the original treatment plant cost and some are part of the irrigation scheme proposed. All costs in Table 8-2 are rounded. As discussed in Section 5.10 the preferred option is to included additional membrane treatment so all flows are fully treated through the treatment plant.

Table 8-2: Peak Flow Treatment Options Cost Summary

Ref	Description	Base Case	Peak Flow Storage Pond	Additional Membrane
	TOTAL ESTIMATE		**-$210,000**	**-$430,000**

8.6 Reverse Osmosis Plant

The addition of a reverse osmosis plant has been investigated as described in Section 5.11. The cost shown in Table 8-3 is an extra-over cost to the existing wastewater treatment plant that would need to be added to the overall cost for the scheme. The costs associated with disposing of the retentate have not been quantified or allowed for at this time. Operating costs for a reverse osmosis plant are made up of considerable power costs for running the plant, plus renewals costs for replacing membranes, and considerable maintenance costs associated with daily operator attendance.

Table 8-3: Reverse Osmosis Cost Summary

Ref	Description		Reverse Osmosis
	TOTAL ESTIMATE		**$4,260,000**
	NPV Estimate		**$8,990,000**

8.7 Additional Costs for Upgrade to Treatment Plant to Reduce Total Nitrogen

As described in Section 5.9, changes can be made to the proposed treatment plant design to reduce the Total Nitrogen (TN) in the treated wastewater to 5 g/m^3. Allowances have been made for increased reactor capacity, increased blower capacity, increased pumping capacity and additional piping, valves, diffusers etc. The cost also includes allowance for a new ethanol dosing system. The capital cost estimate for these upgrades is an additional $1.8 million.

Sufficient design has not been completed to allow NPV estimates to be calculated, however as there will be additional power requirements, additional labour and attendance and costs for ethanol dosing, the NPV costs will be increased over that of the proposed treatment plant design.

9 Evaluation of Sites and Conclusions

9.1 Overview

Potential sites for irrigation of Akaroa wastewater to land have been evaluated over several phases of work. Stage 1 considered a range of disposal options and, which irrigation to land favoured by the Ngāi Tahu parties, assessed irrigation to land options within 2km of the wastewater treatment plant and as a result focused on land on Takamātua peninsula and valley. The land on the peninsula was found to be unsuitable due to land instability risks during the Stage 1 investigation. The Stage 2 investigation expanded the area to the eastern part of Banks Peninsula.

The Stage 2 investigation included alternative site selection, identification of key criteria for analysis, and development of basic design concepts. Firstly a high level screening process based only on slope and land area was undertaken. This identified twenty one possible sites.

The twenty one sites were subject to a revised set of assessment criteria that included geotechnical considerations, and buffer zones to residential properties and waterways. From this a shortlist of four reasonably practicable sites was identified – Robinsons Bay Valley, Takamātua Valley, Pompeys Pillar and Wainui. Very high level cost estimates eliminated the Wainui scheme from further consideration due to the significant cost associated with running a 5 km pipeline across Akaroa harbour ($18M - $20M for the pipeline plus irrigation scheme). Hence the shortlist was reduced to three sites.

The three sites have been further developed by more detailed GIS mapping, establishing potential pond sites, undertaking a high level landscape and visual effects assessment and producing scheme overviews for each site. A summary evaluation for each site is set out below.

9.2 Robinsons Bay Valley

Robinsons Bay Valley is more favourable on technical grounds than other sites due to more contiguous suitable land, soil type and ground water conditions. The Robinsons Bay Valley has the potential to accommodate the proposed irrigation area with little or no impact on existing character. There are a number of locations where wastewater storage ponds could be constructed that are technically feasible and are able to be designed to minimise potential landscape and visual effects. The ponds would be able to be fed by gravity from the proposed wastewater treatment plant. There are no silent file areas over Robinsons Bay valley, although there are some heritage sites and protected trees to be considered. Compared with Takamātua Valley there would be fewer landowners involved in acquiring sufficient land for an irrigation scheme, and there is sufficient potentially irrigable land available in Robinsons Bay Valley for a scheme to be located within the valley.

An irrigation scheme to trees in Robinsons Bay Valley has the lowest estimated capital cost of the alternative sites.

9.3 Takamātua Valley

A Takamātua Valley irrigation scheme would be problematic due to land constraints and areas of high groundwater. The topography of the valley dictates that suitably sloping and potentially irrigable land in the valley floor is a long and thin zone close to the stream path. By the time buffer zones to waterways and adjacent properties are accounted for, the residual irrigable areas are insufficient for both dripper and spray irrigation solely in Takamātua Valley. In addition the path to groundwater is likely to be shortest for this location, with the highest risk of nutrient migration to groundwater.

These same issues contribute to making the large storage pond difficult to site and construct. Only one possible pond site has been located for the Takamātua Valley and this is in a "Liquefaction Management Zone" and an area of high groundwater. For this reason it has been assumed that the pond is constructed above ground with all imported materials. Takamātua Valley has the highest number of landowners that would need to be negotiated with to obtain the areas identified as suitable for irrigation.

There is a silent file area located over some parts of the valley, although Onuku Runanga have indicated there are no sensitive areas that would affect disposal options. The capital cost of this scheme is moderate, made higher than the Robinsons Bay Valley costs due to the estimated pond construction costs and the need to utilise land in Robinsons Bay Valley (or elsewhere) to have sufficient irrigable area for a viable scheme.

9.4 Pompeys Pillar

Pompeys Pillar land is geotechnically suitable in terms of land stability and there is adequate land available for an irrigation scheme. The scheme has a significantly higher cost than the two other sites due to the requirements for a long, high pressure pipeline from Akaroa, and potentially more expensive storage due to higher land slopes at the identified storage sites.

This location has the benefit of no residential properties on the site and very few neighbouring properties. This may assist with consenting a large storage pond. Te Rūnanga o Koukourārata has advised that the eastern bays of Banks Peninsula contain a number of significant sites and cultural values of importance. Additionally the high level landscape and visual assessment has identified that development at this site would present a significant risk in landscape and visual terms. Both these aspects will need to be fully investigated if this site is selected and may restrict some of the irrigation area.

9.5 Next Steps

The next phases of work to be undertaken include:

- Completion of any further land investigations necessary to refine overall scheme designs or to develop more detailed design for a preferred area
- Completion of Overseer analysis of potential nitrogen leaching for each scheme option
- Completion of the soil water balance for irrigation to trees as recommended by the Technical Experts Group.

10 References

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Appendix A

Infiltration Testing Results for Akaroa Wastewater Disposal Via Irrigation (PDP, June 2016)

Appendix B

Akaroa Wastewater Upgrade Irrigation – Preliminary Geotechnical Assessment

Appendix C

Tonkin and Taylor Slope Hazard Maps

Appendix D

Map of Potentially Suitable Irrigation Areas from Akaroa Treated Wastewater Concept Design Report for Alternatives to Harbour Outfall (CH2M Beca, May 2016)

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David Painter Review of Preliminary Land Investigation Reports and Response to Peer Review

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High Level Land Screening Map

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Akaroa Wastewater GIS Screening of Pond Storage Locations

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Landscape and Visual Review

Appendix K

Preliminary Assessment of Thacker Land

Click here and
then click
'insert picture'

Appendix L

Infiltration Testing Results for Akaroa Treated Wastewater Disposal Via Irrigation – Robinsons Bay and Pompeys Pillar (PDP, November 2016)

Appendix M

Akaroa Wastewater Disposal Alternative Sites Stage 2 – Geotechnical Report (CH2M Beca, November 2016)

Appendix N

Infiltration Testing Results for Akaroa Treated Wastewater Disposal Via Irrigation – Thacker Land (PDP, February 2017)

Appendix O

Akaroa Wastewater Alternatives – Thacker Site Robinsons Bay – Geotechnical Report (CH2M Beca, February 2017)

Appendix P

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Appendix Q

Cost Estimates