David Painter Consulting [DPC] Ltd
PO Box 79196, Avonhead, Christchurch 8446, New Zealand
Telephone [NZ]: 03 964 6518; [International]: 64 3 964 6518
Facsimile [NZ]: 03 964 6520; [International]: 64 3 964 6520
Email: david@dpconsulting.co.nz

Peer Review February 2016 of "Akaroa Wastewater - Concept Design Report for Alternatives to Harbour Outfall" CH2M Beca, 29 January 2016

Client Consultancy Report for
Te Rūnanga o Ngāi Tahu
Report Number CP5R-16
March 2016

Document History				
Date	11 February 2016	16 February 2016	29 February 2016	7 March 2016
ID No.	CP5D1-16	CP5D2-16	CP5D2r-16*	CP5R-16
Author	DJP	DJP	DJP	DJP
Status	Draft for client	Draft for client	Draft for client	Final [Public]
* Re-issued as draft. Identical to CP5D2-16 except for a minor change to Frontispiece caption.				

Public Domain Document.

This report was until 7 March 2016 a confidential client report prepared by DPC Ltd for the client on the client's instructions and solely for the client's use for the purpose intended. With the agreement of the client, it has been re-classified on 7 March 2016 as a public domain document. Except for the changes on this page and the date and report number on the title page, related changes to the final paragraph of Section 1.0, references to "this draft report" and "draft peer review" elsewhere in the report and removal of the "DRAFT" watermark, the report is identical to the 29 February 2016 draft report.

Frontispiece. Akaroa [Long harbour].

[From NASA: http://eoimages.gsfc.nasa.gov/images/imagerecords/3000/3217/christchurch_etm_2001264_lrg.jpg]

EXECUTIVE SUMMARY

A brief overview of this report can be obtained by reading this Executive Summary and the Summary Conclusions of the Review in Section 6.

This report presents a peer review of the CH2M Beca draft report for Christchurch City Council: **Akaroa Wastewater – Concept Design Report for Alternatives to Harbour Outfall [29 January 2016]** (CH2M Beca 2016)**.** That report fulfils its purpose as it "describes all options considered by Council, presents concept designs for the scheme options shortlisted in consultation with the Ngāi Tahu parties in September 2015 and compares those options with the harbour outfall for which the Council sought consent."

The most important function of the peer review is to highlight any problems, errors, missing information, misjudgements, fitness for purpose and opportunities for improvement in the Concept Design Report. For that reason, very little space is devoted to aspects of the Concept Design Report which are judged to be without obvious such problems and opportunities. The draft Concept Design Report is fit for purpose and minor errors can be dealt with. So this review report concentrates on highlighting any problems, missing information, misjudgements and, especially, opportunities for improvement.

All of the options alternative to a mid-harbour outfall which are considered in the Concept Design Report, with the exception of all year round irrigation under trees, result in all [2 options] or some [1 option with 2 alternatives] of the effluent from the new wastewater treatment plant passing through additional system components before being discharged, mostly unchanged in measurable quality, to the harbour at a coastal infiltration gallery. Whether or not the additional treatment trains [with system components including storage pond, subsurface flow wetland or filtration basins, coastal gallery] qualify as culturally acceptable 'passage through land' has not yet been decided. The alternative under the 'all year round irrigation to land' option of irrigating pasture is an omission from the report. The alternative under the 'all year round irrigation to land' option of irrigating under trees has a number of advantages additional to cultural acceptability but has been downgraded in the Concept Design Report due to perceived "significant risks around land access and land procurement; … the dispersed nature of the irrigation fields, spread across five separate areas; … extended timelines for scheme implementation; … and the highest capital cost land treatment option." But these are all questioned in this review.

Stormwater inflows to the Akaroa sewer network have been reduced by Christchurch City Council efforts in recent years. They are still high and this is a burden on the proposed Wastewater Treatment Plant, the wet weather bypass and all of the final effluent disposal options, including the mid-harbour outfall. Rather than accept the improved stormwater exclusion, as the Concept Design Report does, it should call for further efforts to reduce stormwater inflows to be actively pursued as a priority.

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1.0 Introduction

Christchurch City Council [CCC] holds consents providing for Akaroa wastewater management which include a Coastal Permit: "To discharge treated effluent from the Akaroa wastewater treatment plant into coastal water" [CRC133179]. This Permit expires in October 2020[1]. In June 2014 CH2M Beca, on behalf of CCC, made application to Canterbury Regional Council [CRC] for resource consents to enable the construction and operation of an upgraded Akaroa Wastewater Scheme which included a new Wastewater Treatment Plant [WWTP] in a new location, a new outfall to the harbour in a new location and associated infrastructure including pumping stations and pipelines. Following a Hearing in May 2015, Commissioners decided in July 2015 that consents should be granted for the WWTP, a terminal pump station and drainage network changes. They did not grant consent for an effluent outfall to the harbour. They pointed out that there had been "inadequate consideration of alternatives" and that, in their assessment, "efficient use of resources as promoted by section 7(b) of the Act[2] requires an investigation of whether land disposal, possibly involving some sort of wetland, is technically feasible and how the cost would compare to the likely cost of the proposed outfall."

CCC appealed the CRC and CCC ['Hearing Commissioners'] decision to the Environment Court in August 2015 and Ngāi Tahu, which had long advocated land disposal of the final effluent, joined the appeal the same month. The parties to the appeal, at a mediation in September 2015, agreed to a timetable of activity while the appeal was put on hold by the Environment Court, "pending the outcome of investigations and decisions by Christchurch City Council (as applicant) on alternative options for the discharge of treated sewage at Akaroa"; and "The applicant is to fully involve Ngāi Tahu (and keep Canterbury Regional Council informed) in the development and selection of options for disposal."

An Akaroa Wastewater Working Party previously in place had undertaken "extensive work on alternatives" but this had been "not comprehensively documented" (CH2M Beca, 2015). CH2M Beca, as consultants to CCC, provided a report in September 2015: "Akaroa Wastewater Project – Review of Disposal Alternatives for Ngāi Tahu – First Stage" (CH2M Beca, 2015). This report was a "draft for discussion" and it "renewed and updated investigation into alternative disposal options." In addition to the harbour outfall option as in the June 2014 consent application, the report considered eleven other options for the WWTP effluent:

- irrigation to, or passage through, land [2 options];
- flow via a wetland or overland flow to coastal waters [2 options];
- flow via a wetland or overland flow to a harbour outfall [2 options];
- discharge via a "Rakahore chamber"[3] [1 option];
- pumping or tankering wastewater to Christchurch [2 options];
- or reticulating for potable or non-potable reuse [2 options].

A comparison of the options, **excluding "evaluation of cultural acceptability, which will be confirmed during consultation"**, concluded that the four options in the first two bullet points above were favoured for their use of land rather than any harbour outfall, but less favoured due to: "higher costs, longer time, land requirements, lower community acceptance and potential public health risks." Most favoured, "based on overall scoring", were the discharge via a "Rakahore chamber" [if it was culturally acceptable] and the harbour outfall option as in the June 2014 consent application.

[1] This consent had been due to expire in 2013, but was extended on appeal to 2020 by the Environment Court to allow for consideration of alternatives.

[2] I.e. the Resource Management Act(1991).

[3] Rakahore is a grandson of Ranginui and Papatuanuku and is Atua [god] of rocks. A "Rakahore chamber" is a channel or chamber where effluent runs over rocks, either intended or claimed to provide a final 'cleansing' of effluent before discharge (Barber 2012).

CH2M Beca and Pattle Delamore Partners [PDP] gave a presentation on 27 January 2016 to the Ngāi Tahu parties[4], CCC Councillors and staff, ECan staff, Te Rūnanga o Ngāi Tahu [TRoNT] staff and myself, as consultant to TRoNT for the purpose of a peer review of the foreshadowed Concept Design Report (CH2M Beca 2016). This presentation: "Akaroa Wastewater Project Presentation of Concept Design Report on Outfall Alternatives Working Draft Stage" considered five options:

1. Year-round irrigation under trees.
2. Summer irrigation to pasture or trees with passage through land and engineered pathway discharge.
3. Sub-surface flow wetland and engineered pathway discharge.
4. Infiltration basin and engineered pathway discharge.
5. Non-potable reuse.

All options were considered to be "consentable". Notably, all options had concept design capital costs less than the harbour outfall option as in the June 2014 consent application, except for the considerably more expensive non-potable reuse option.

CH2M Beca provided a draft report: "Akaroa Wastewater - Concept Design Report for Alternatives to Harbour Outfall" on 29 January 2016 (CH2M Beca 2016). It is that report which is the subject of this review and review report. The review has been prepared in accord with the IPENZ Practice Note on Peer Reviewing (IPENZ 2003)[5]. The *scope of the review report* is to review the CH2M Concept Design Report (CH2M Beca 2016). The *purpose of the draft review report* is to provide technical guidance to the Ngāi Tahu parties[5] on the content of the draft Concept Design Report. This *report was initially confidential* to the Ngāi Tahu parties[5] and others nominated by them and *intended for the purpose just stated* but was re-classified, with the agreement of Te Rūnanga o Ngāi Tahu, as a public domain document on 7 March 2016. The report *relies in part on information provided* by TRoNT, CCC, CH2M Beca and CRC. The author has not made on-site inspections of the locations referred to in the report, although they are mostly familiar to him.

The most important function of the peer review is to highlight any problems, errors, missing information, misjudgements, fitness for purpose and opportunities for improvement in the Concept Design Report. For that reason, very little space is devoted to aspects of the Concept Design Report which are judged to be without obvious such problems and opportunities; that should not be taken to imply that those aspects have not been considered.

[4] Representatives of Ōnuku Rūnanga, Wairewa Rūnanga, Te Rūnanga o Ngāi Tahu and the Akaroa Taiāpure Management Committee.
[5] This Practice Note is acknowledged by IPENZ to be outdated. Review is "underway but with the publication date not yet in sight". (Pers. comm. from IPENZ 11 January 2016).

2.0 The WWTP Effluent in Context

The options for management of the effluent from the proposed WWTP need to be seen in the context of the overall system for managing domestic sewage, and a few commercial/industrial sources, in Akaroa. The proposed Akaroa Wastewater Scheme Upgrade describes a system which includes (CH2M Beca 2014):

- A redeveloped sewerage network, including pipeline replacement and upgrading of existing pumping stations;
- A new Terminal Pumping Station, with primary screening, at the boat/trailer park in Jubilee Park;
- A new WWTP at Old Coach Road, with solids separation, biological nitrogen removal and disinfection by membrane filtration;
- A route for peak wet weather high flows to bypass the WWTP and receive UV disinfection before entering the discharge pipeline;
- A new discharge pipeline from the WWTP to a terminus at Childrens Bay;
- A 2.5 km long outfall pipe from Childrens Bay to a diffuser in mid-harbour, located on the harbour floor 9.5 m below Mean Sea Level.

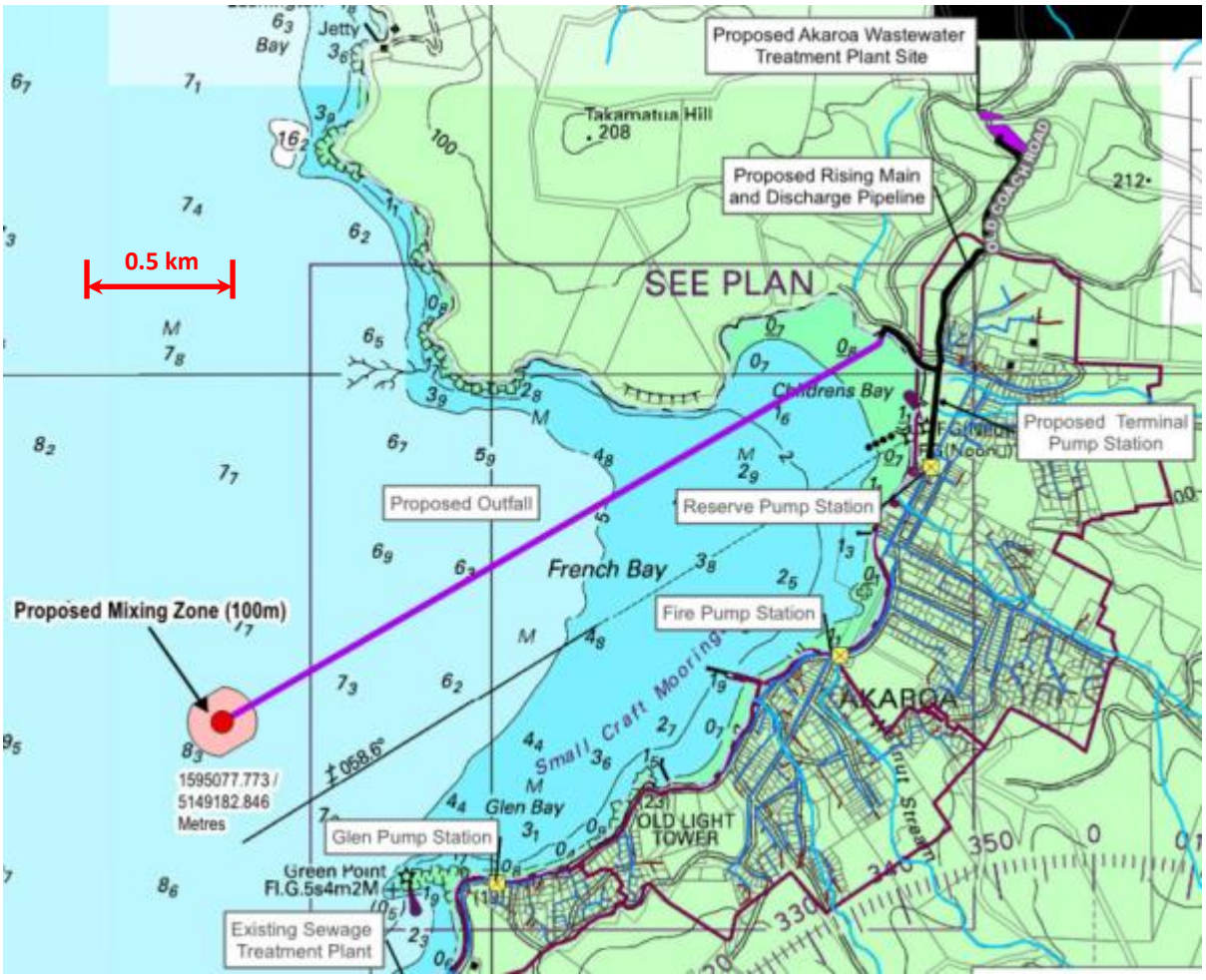

Figure 2.1 Akaroa Wastewater Scheme Map: from the CCC website 28 January 2016.

The options considered in the Concept Design Report are alternatives to the 'Proposed Discharge Pipeline' and 'Proposed Outfall' in Figure 2.1, and the discharge of effluent to the harbour. Other components of the overall system [the drainage network, the terminal pump station and the wastewater treatment plant] remain as proposed and indeed have been consented.

3.0 Layout of Report

Following the preliminary material in Sections 1 to 3, the sections in this report follow the pattern of the Concept Design Report, reviewing the Executive Summary and 11 of the 12 sections in Sections 4.0 to 4.11. Section 12 Conclusions and the appendices are not specifically commented on here, although they have been reviewed as required to comment on the sections which refer to them. There follow Discussion in Section 5 and Summary Conclusions in Section 6. The report is completed by References in Section 7, Acknowledgements, an Appendix of clarification questions and answers and an appended letter.

4.0 Review of Draft Concept Design Report [DCDR]

The 4-page Executive Summary has an overall finding: "that a land-based wastewater scheme is technically viable and a similar capital cost to the original scheme involving a 2.5km harbour outfall – except non-potable reuse which is significantly more expensive." Excluding Option 5: Non-potable reuse, alternatives to a harbour outfall [estimated capital cost M$6.7] have estimated capital costs in a range from M$3.5 to M$6.2, additional to the M$21 cost of the town network changes, new treatment plant and pumping station changes.

The 'traffic light' [green, orange, red matrix] display in the 'Summary Qualitative Evaluation of Options' has value in drawing attention to 'red light' aspects of options but does not clearly show that the 'Evaluation Criteria' are subjectively chosen and not of equal significance. There is also some subjectivity in assigning the colours. For example: The Social Acceptance criterion is based on "the degree of opposition that may be expected from directly impacted stakeholders." [DCDR s9.7] It is hard to understand from later sections of the DCDR report why the Social Acceptance of 'Irrigation to land year round' is shown in the matrix as red, while the Social Acceptance of the 'Harbour Outfall' is shown as green.

In the 'Projects risks and opportunities' summary on p. v, it is stated under Option 1 that "Year round irrigation is the highest capital cost option." In response to questions [Q&A 1, Appendix 1], this was corrected to read: "Year round irrigation is one of the highest capital cost options." It was further stated [Q&A 2, Appendix 1] that: "Further work is being done on land purchase costs that will likely increase the cost of irrigation." Based on content in the DCDR as it is, without reference to the "further work", 'Irrigation under trees at Location A' is one of the **lowest** capital cost options [M$4.1] and the statement on p.v needs further correction unless the "further work" is included.

Apart from these comments, the Executive Summary appropriately summarises the content and conclusions of the DCDR. Insofar as the content and conclusions of the DCDR might change in response to feedback, including this review, so would the Executive Summary need changing.

4.1 DCDR Section 1: Introduction

Section 1 [1.1 to 1.4] of the DCDR provides appropriate information on the Background, Purpose, Scope and Statutory Overview of the alternatives to Harbour disposal. In s1.4, the Canterbury Regional Policy **Statement** [missing word] and the Land and Water Regional Plan should be included [Q&A 3, Appendix 1].

4.2 DCDR Section 2: Design Flows and Loads

Section 2.1 Design Wastewater Flows provides crucial information for all components of the overall wastewater management system. Sections 2.1.1 Dry Weather Flows and 2.1.2 Wet Weather Bypass Flows could usefully be clearer about average and peak volumes and flows in 'dry' and 'wet' weather. In particular, peak flows and peak volumes should be made clear for 'wet' and 'dry' weather in comparable units.

It will be helpful from this part of my review forward to present my own simplified diagram, Figure 4.1, of the overall wastewater management system, with the options included in the DCDR. It is important to note that the 'Future Design Influent Flows' in Table 2.1, added to in the text of s2.1.1 and s2.1.2, and illustrated as 'SW' and 'WW' in Figure 4.1, are also the 'Future Design Effluent Flows' which reach the receiving environments. A slight exception is the volume evaporated from the subsurface flow wetland in the 'Winter' alternative of Option

2 and in Option 3. The receiving environments are land under trees in Option 1, land in pasture or under trees in Option 2/Summer and the Harbour in all four other options [D2, 2/Winter, 3 and 4].

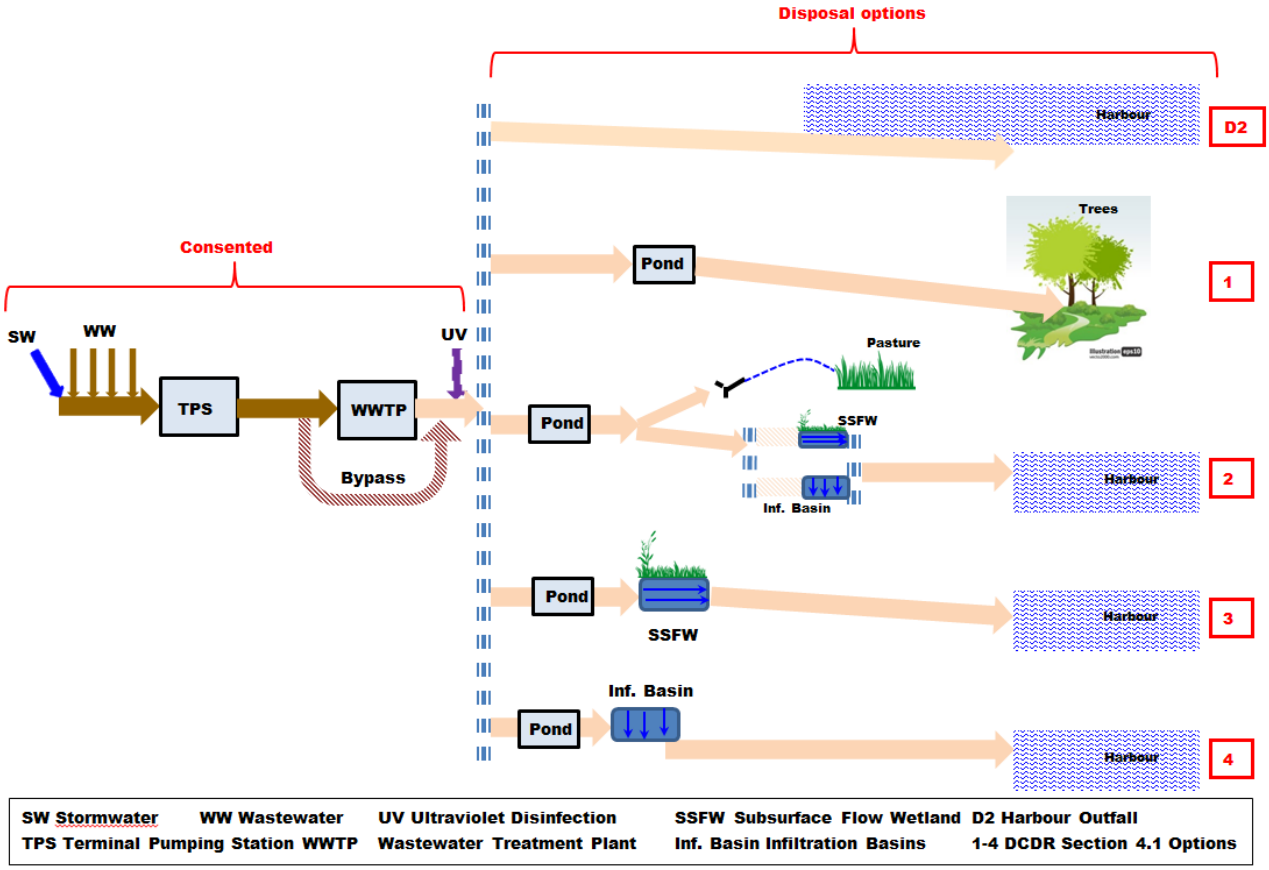

Figure 4.1. Simplified diagrammatic representation of the overall wastewater management system, with DCDR options.

The influent [and effluent] flows and volumes in s2.1.1 and s2.1.2 are based on population estimates, historic inflows to the existing WWTP and a relationship between rainfall and wet weather flows. This is all well presented in the DCDR, but I see two problems:

1. No allowance has been made for climate change [Q&A 4, Appendix 1]. In related aspects of CCC forward planning, such as stormwater infrastructure, the current recommendation is to allow for a "Ministry for Environment recommended climate change adjustment of +16% for year 2100 over year 2008." (CCC 2011)
2. It is noted in s2.1.1 "that through a programme of pipe renewals it had been able to reduce infiltration and inflow to the network. As a result peak wet weather flows have reduced from around 3,000 m³/day to 1,800 m^3/day and further reductions may be possible as the Council continues its programme of work." In light of the influence of the 'SW' component on all downstream components, this should not be a passive acceptance of incidental improvements to date but a signal to actively seek further improvement. Peak wet weather volumes of 1800 m^3/day compared to Summer Average 386 m^3/day [ratio 4.7 times] are still too high.

The 'Design Treated Wastewater Values' in DCDR Table 2.2 are "what can reasonably be expected of a biological nitrogen removal plant with membrane solids removal and disinfection." This WWTP was specified when the expectation was that final effluent disposal would be to a harbour outfall; it has since been consented. The DCDR does not address the question: What WWTP would be appropriate for each of the other disposal options now being considered? That is understandable, given [Section 1.0 Introduction herein] the Hearing Commissioner decisions, the Environment Court direction and the CCC's need for urgency. But it risks the overall eventual Akaroa wastewater management system having an inappropriate and cost-ineffective combination of

components. For example: “If all-year round irrigation is chosen as the preferred option there is potential for the treatment plant design to be simplified considering that further and final treatment will be provided by irrigating the treated wastewater to land.” [Q&A 22, Appendix 1]

The ‘Design Land Irrigation Rates’ in DCDR s2.4 are provided in the context of polythene dripper-line [purple pipe] irrigation under trees, DCDR Option 1. At concept design stage they could also apply for pasture irrigation. The first paragraph in DCDR s2.5 is acknowledged to need re-wording to more clearly describe flows considered when sizing the subsurface flow wetland and its buffer storage: more volume in the wetland, less needed in the storage pond, and vice versa. The “peak summer flow of 561 m^3/day” is an error; according to Table 2.1: ‘Peak Summer Day’ flow is 1011 m^3/day; ‘Summer Average’ flow is 561 m^3/day. “The minimum contact time of 2 days” needs to be considered in the light of nutrient reduction, human health [e.g. virus reduction] requirements, **local** cultural requirements for contact with land and wetland cost. This matter is commented on further in Section 4.4 [DCDR Section 4].

It might seem a pedantic point, but I consider that DCDR s2.6 should use the terminology: ‘filtration basin’ and ‘filter’ instead of ‘infiltration basin’ and ‘infiltrate’. These components are much more akin to the filtration processes used in wastewater treatment plants than to the infiltration basins used in urban stormwater management and managed aquifer recharge; in the latter two the fluid passes **in** to the underlying medium. I have been reminded [Q&A 40, Appendix 1] that some stormwater basins [including in Christchurch] do have under-drainage similar to that proposed in the DCDR; I consider that these should also be called ‘filtration basins’.

4.3 DCDR Section 3: Development of Options

Figure 3.1 in DCDR s3.2 is intended to represent the preferred options of the Ngāi Tahu parties as conveyed in a letter dated 7 October 2015 [Appendix 2]. The figure was “was presented to and discussed with the Ngāi Tahu parties at the hui on 21 October 2015 and was agreed to represent the intention of the message they wished to convey.” [Q&A 11, Appendix 1]. My reading of the 7 October letter leads to a diagram and comments [Figure 3.1, revised DJP 2 February 2016] which are different. The two diagrams are shown in Figure 4.2. It has been confirmed on behalf of the Ngāi Tahu parties [email personal communication 3 February 2016] that my “interpretation is correct”. The further explanation is that ‘passage through land’ [as a proposed specific engineering solution, rather than the principle] was first put forward in a presentation on 8 September 2015 with “very little information about how it would work”. The 7 October 2015 letter intended to “keep it on the table requesting further information, but not explicitly supporting it.”

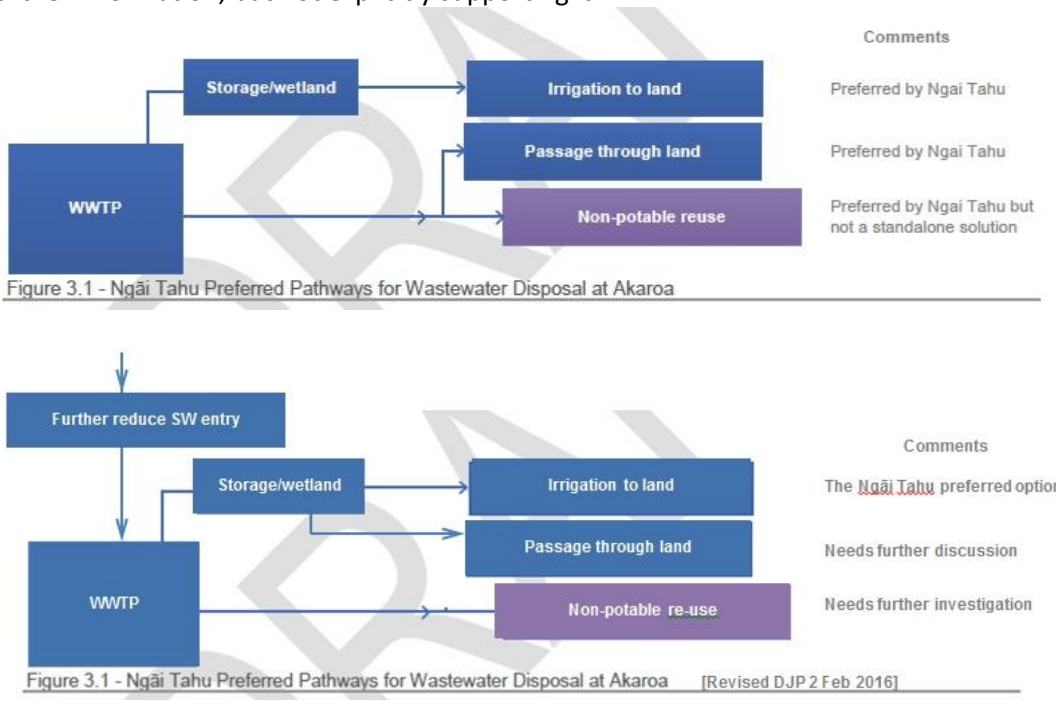

Figure 4.2. DCDR Figure 3.1 compared with a revised version based on a 7 October 2015 letter.

The two primary differences between the two different portrayals are:

1. The revised comments clarify that 'Irrigation to land' is the preferred option. 'Passage through land' was not 'preferred' at that time, in part because the Ngāi Tahu parties did not then know enough about it.
2. The revised diagram includes the need to "Further reduce SW entry". [See also Point 2, under Figure 4.1 in Section 4.2 above.]

DCDR s3.6 correctly notes that the bullet points are "initial findings presented at this[6] hui". The first bullet point states that "Irrigation to land for the year round option would likely be drip irrigation under trees as per Wainui". I have been unable to find where in the DCDR [including Appendix B] omission of consideration of irrigating pasture or similar is justified. I return to this point in Section 4.4 below. This section does not point out that some of these findings are revised later in the DCDR e.g. the "16-20 ha" land area requirement for summer only irrigation stated here [4th bullet point] is said to be "around 12 ha" in DCDR s4.5 and "11.2 ha" in Table 5.1. [See also Q&A13, Appendix 1]." Brief bullet points are sometimes so abbreviated as to be wrong! "Initially would not be able to use irrigation while trees are growing until the canopy had formed" [3rd bullet point] misses out that growing trees need to be irrigated, just not as much as when they have reached full canopy cover [Q&A12, Appendix 1].

4.4 DCDR Section 4: Description of Options

4.4.1 DCDR Section 4.1 Overview of Shortlisted Options

Notwithstanding the possible communication difficulty illustrated in Figure 4.2, Options 1 to 5 in DCDR s4.1 do appear to reflect development in preceding DCDR sections and 21 October 2015 agreement among CCC, CH2M Beca and the Ngāi Tahu parties. However, it becomes obvious in DCDR s4.4 Option 1 – All Year Round Irrigation that the only land option considered is plantation trees. I noted in Section 4.3 above that this omission is not explained in the DCDR and I have not found an explanation in the DCDR appendices. In response to my question, it appears the explanation is that: "A previous study by Harrison and Grierson (2010) identified that there was a risk to ground stability with all year round irrigation to pasture" [Q&A 15, Appendix 1]. It is also stated that "It may still be possible to irrigate year round on pasture at a much reduced application rate, but there would still be land stability risk involved and the amount of land that would be required would be large and the scheme would need to be spread over a very wide area. Therefore this option was not considered feasible for the area."

The Harrison and Grierson (2010) study Section 5 Land Based Effluent Irrigation Investigation relied on an appended report [Appendix 3] by ecoEng Ltd [Andrew Dakers]. For the "Northern site", the Takamatua Peninsula, access to properties to carry out site assessment was declined for about 127 ha in the North and West of the Peninsula and approved for about 88 ha in the Southeast. The Southern half, including the Southeast, has been excluded from consideration in the DCDR due to silent file and stability concerns. So the ecoEng and Harrison and Grierson reports focussed on their "Southern Site", i.e. a land area South of Akaroa township. In contrast to the impression given in the DCDR, the 'Land Stability Geotechnical Assessment' in the ecoEng report [Section 3.3, based on a 2009 report by geologist, Mark Yetton] includes the statement: "While the report found that the north facing slopes above Takamatua*....are the most suitable at the northern site* this area has been excluded as an option due to the land owner denying access (Refer Section 3.2)." The "north facing slopes above Takamatua" make up most of the land identified as Blocks A to E in the "Option 1: All Year Irrigation' map in Appendix E of the DCDR.

I have commented in some detail on this omission because:

1. All year round irrigation to land is the clear preference of Ngāi Tahu Parties. As such, it merits thorough investigation, including irrigation of pasture.
2. I am not convinced, without this thorough investigation, that the pasture option is "not … feasible for the area".
3. Reasons for the omission are not clearly stated in the DCDR.

[6] Hui 4 December 2015.

4.4.2 DCDR Section 4.2 Wastewater Treatment Plant Design Changes

References are made in the first paragraph of DCDR s4.2 to the assumption that the consented WWTP will be retained and that the wet weather flow bypass is required due to "high stormwater inflow and groundwater infiltration into the wastewater network during heavy rainfall." I have commented on these in Section 4.2 above.

Two aspects of Tables 4.1 and 4.2 need clarification: why the subsurface flow wetland is stated to achieve typical removal of [only] 0.5 log; and why the pond storage achieves typical removal of 1 log, prior to the subsurface flow wetland, or 0.7 log prior to the filtration basins. The 0.5 log figure is said to be [Q&A14, Appendix 1] "based on published literature (including Wetlands 2nd Edition (2009), Kadlec and Wallace). A summary of this literature is provided in Appendix I." Appendix I notes removals from 0.5 log [1 day Hydraulic Retention Time] up to 2.3 log and concludes that: "with an appropriately-designed subsurface wetland (ie well-mixed, vegetated, with HRT of at least 3 days), between 90 - >99% (ie 1- >2 log order) reduction in both viruses and bacteria could be achieved." Secondly, the "the pond, if nothing else, achieves 1 log reduction simply based on a reduction in flow between the inlet and outlet from 65 L/s to 6 L/s, taking the SSF wetland option as an example." [Q&A14, Appendix 1]. If I understand this correctly, it is not 'Removal Performance', as in the titles of Tables 4.1 and 4.2, but just a slowing down of the rate of arrival of the **same** amount of virus at the receiving environment.

I will comment further on 'contact time' [equivalent here to hydraulic retention time, HRT] in Section 4.4.6.

4.4.3 DCDR Section 4.3 Storage Pond Design

{Heading numbering placeholder only; no content}

4.4.4 DCDR Section 4.4 Option 1 – All Year Round Irrigation

I have commented at some length in Section 4.4.1 on the omission from consideration of All Year Round Irrigation to Pasture. Consideration of All Year Round Irrigation under trees should benefit from experience with the Wainui and Tikao Bay wastewater irrigation systems close by. Monitoring since 2011 of the Wainui scheme has not shown any compliance issues [Q&A 6 and 39, Appendix 1]. Mention is made in the DCDR Section 3.7 of Lincoln University trials on actual evapotranspiration and tolerance to/use of irrigated wastewater. But information from these sources is not explicitly included in the DCDR and possibly should be.

4.4.5 DCDR Section 4.5 Option 2 – Summer Only Irrigation Plus Wetland or Infiltration Basin

"Lack of discharge to wetland/infiltration basin over summer, when the majority of flow is used for irrigation, risking die off of plants if these are planted on the surface" in DCDR s4.5.8 is not a 'Disadvantage'. It would be a management error if it were allowed to happen as the flow division between irrigation and wetland is a management choice [Q&A 17, Appendix 1].

4.4.6 DCDR Section 4.6 Option 3 - Sub Surface Flow Wetland

In Section 4.4.2 above I commented on the DCDR Tables 4.1 and 4.2 and on information in DCDR Appendix I. A quotation from Appendix I includes reference to an "appropriately-designed subsurface wetland (ie well-mixed, vegetated, with HRT of at least 3 days)" for effective virus removal. Literature quoted in Appendix I mentions HRT [Hydraulic Retention Time] up to 5.5 days in that context. The reasons given for the 2 day [3 in Winter] contact time are:

- "The minimum contact time of 2 days is consistent with other subsurface flow wetlands that have been installed elsewhere in New Zealand to meet cultural requirements for contact with land (e.g. Outward Bound at Anikiwa)." [DCDR s2.5]
- Longer contact times require greater wetland volume and therefore greater cost [DCDR s4.6]
- Greater wetland volume requires more flat area, which is scarce [Q&A 19, Appendix 1].

While these are valid points, I consider that more weight should be given to appropriate design for human health requirements, including virus removal.

4.4.7 DCDR Section 4.7 Option 4 – Infiltration Basin

I have offered my view in Section 4.2 above that these are really 'filtration basins' as the filtrate leaving them does not go **in** to the underlying media. Although the DCDR s4.7.1 refers to "Excess wastewater collected at the base of the infiltration basin", this is to be re-worded, as the collected wastewater is not "excess" in any sense [Q&A 20, Appendix 1].

4.4.8 DCDR Section 4.8 Options for Discharge to the Receiving Environment

The "residual and localised public health risks associated with operation of the engineered pathway" have not yet been assessed [Q&A 21, Appendix 1]. As the "engineered pathway" is a crucial component of Options 2-4 [see Figure 4.1], this assessment is a high priority if any of these options are to be taken further. Discharge of final effluent to ground, a dry gully, a stream or other waterway are effectively dismissed from further consideration in the DCDR s4.8.1 and s4.8.2, for good reasons. It is more accurate and informative to thereafter refer to final effluent discharge to a 'Coastal Infiltration Gallery' [as in the DCDR heading for s4.8.4], rather than the vague 'Engineered Pathway'.

I make further comment on discharge via a Coastal Infiltration Gallery in Section 4.4.9 below.

4.4.9 DCDR Section 4.9 Treated Wastewater Quality

It is worth emphasising again that Option 1 Irrigation to Land Year Round is the only option taken to the present stage which has no measurable effect on harbour water quality, because there is no point source discharge to the harbour [DCDR s4.9.1]. Other options retained rely either part-year [Options 2, either wetland or filtration basins] or all year [Options 3 and 4] on a point source discharge to the harbour via a coastal infiltration gallery. Dilution of "treated wastewater" discharged via the coastal infiltration gallery "located at the shoreline will not be as effective as the dilution achieved by a 2.5 km harbour outfall pipe." [DCDR s4.9.5, corrected as in Q&A 25, Appendix 1]

The DCDR correctly describes, but does not emphasise in a simple clear manner, that Options 3 and 4 take the same WWTP effluent as for the harbour outfall, pass it through further system components at considerable cost and then discharge it at the harbour edge, very little changed in quality, in a manner which does not dilute the effluent as effectively as the harbour outfall. The alternatives in Option 2 do this for the lower flows in Winter, but not for the higher flows in Summer. The intended justification for these options is that they achieve 'passage through land' to overcome cultural objections to discharging human waste to water without the appropriate intervention of 'earth/Papatūānuku'. Whether they do that is yet to be advised.

4.4.10 DCDR Section 4.10 Non-Potable Reuse

The third paragraph in DCDR s4.10 states: "Additional treatment at the treatment plant would be required for wet weather bypass flows to reduce viruses to an acceptable level for non-potable use; or alternatively only take water for reuse during dry periods (this would be a simpler alternative)." It seems even simpler "to only take water for reuse that has passed through the WWTP". [Compare Q&A 26, Appendix 1]

4.5 DCDR Section 5: Land Requirements, Location and Layout

As foreshadowed in Section 4.4.1 above, DCDR s5 should include an Irrigation to Pasture All Year Round option. It should also take in to account the two 'problems' identified in Section 4.2 above.

DCDR Table 5.1 areas differ from those on the maps in Appendix E. The areas on the maps are the correct ones. They were revised because: "After a review with Council a decision was made to allow more land to be

considered for irrigation than was originally estimated." [Q&A 27, Appendix 1] Table 5.1 also shows numbers of 'Owners' which might not now be correct and does not show which blocks might have the same owner [Q&A 28, Appendix 1].

The third bullet point in DCDR s5.4.1.2 states: "Irrigation pump station – this pump station will be designed to be dual purpose and can pump out of the storage basin to either the subsurface flow wetland or the infiltration basins when not irrigating." It should also be able to provide a small flow as required to keep the wetland wet while the main flow is irrigating [Q&A 29, Appendix 1].

Reference to the non-potable water booster pumps "needed within the township to reticulate the treated wastewater to properties above the level of the wastewater treatment plant." [DCDR s4.10] should be added to DCDR s5.4.1.4 [DCDR Q&A 30, Appendix 1].

The first sentence of DCDR s5.4.2 should be reworded to clarify that there are options which require a storage basin, a pump station AND a wetland or filtration basins [DCDR Q&A31, Appendix 1].

The "Irrigable Areas" [DCDR s5.4.3] would need to be reconsidered if all year round irrigation of pasture is included as an alternative in DCDR Option 1 [See Section 4.4.1 above]. The 15 degree slope limitation would also be appropriate for irrigating pasture but I note that centre-pivot irrigators, for example, do operate on steeper slopes [possibly outside their warranty conditions] and that some land re-shaping has been carried out to enable their use in other parts of New Zealand.

4.6 DCDR Section 6: Geotechnical Land Suitability

There is no doubt that disposal of wastewater from such a coastal town as Akaroa, with its surrounding topography, geology, fresh and marine water environment, presents many challenges. DCDR s6 is appropriate at concept design stage. It also needs to be reconsidered if all year round irrigation of pasture is included as an alternative in DCDR Option 1 [See Section 4.4.1 above]. My caution in Section 4.4.1 about ensuring the relevant areas are being referred to should be noted. [See also Q&A 15 and 41, Appendix 1]

4.7 DCDR Section 7: Consenting Requirements and Risks

DCDR s7.4.1 on 'Positive Effects' is problematic. Only DCDR Option 1 All Year Round Irrigation results in the discharge of human wastewater being "removed" from the coastal marine area. Option 4 Filtration Basin does not result in it being "reduced"; Option 3 Subsurface Flow Wetland results in a slight reduction [due to evapotranspiration from wetland plants]; and Option 2 results in a reduction in Summer, not in Winter. So there are not "positive effects" from "all of the options" as a result of removal or reduction [Q&A 33, Appendix 1]. Whether or not Options involving the "Engineered Pathway" satisfy the "cultural objections to discharging human waste to water without the appropriate intervention of 'earth/Papatūānuku'" [Section 4.4.9 above] is yet to be advised [Q&A 34, Appendix 1].

The brief sentence fragment ending DCDR s7.4.3 about TSS being reduced by wetlands appears to contradict information in DCDR s4.9.2 and 4.9.3. The DCDR authors recommend removing it as not relevant here without a longer explanation [Q&A 35, Appendix 1].

Reference in DCDR s7.4.5 to a storage requirement for the wetland option of "1ha (7,500m^3)" should be corrected to "0.7 ha (12 000 m^3)" as in DCDR Table 5.1 [Q&A 36, Appendix 1].

4.8 DCDR Section 8: Cost Estimation

The Cost Estimations in DCDR s8 would need to be reconsidered if all year round irrigation of pasture is included as an alternative in DCDR Option 1 [See Section 4.4.1 above]. Even after noting the 30% risk contingency in DCDR s8.2, I am surprised at the low "provisional sum allowance" of $50 000 in DCDR s8.3.3 for the Coastal Infiltration Gallery ['Engineered Pathway']. Options A to D in DCDR s6.6 sound a lot more expensive to me, even before getting to the gallery itself!

4.9 DCDR Section 9: Evaluation of Options

In relation to the evaluation methodology, I repeat a paragraph from Section 4.0 above, as it applies also to DCDR Table 9.2.

"The 'traffic light' [green, orange, red matrix] display in the 'Summary Qualitative Evaluation of Options' has value in drawing attention to 'red light' aspects of options but does not clearly show that the 'Evaluation Criteria' are subjectively chosen and not of equal significance. There is also some subjectivity in assigning the colours. For example: The Social Acceptance criterion is based on "the degree of opposition that may be expected from directly impacted stakeholders." [DCDR s9.7] It is hard to understand from later sections of the DCDR report why the Social Acceptance of 'Irrigation to land year round' is shown in the matrix as red, while the Social Acceptance of the 'Harbour Outfall' is shown as green."

The All Year Round Irrigation [Option 1] is ranked poorly for Land Availability and Suitability in DCDR s9.4 and s9.11 [and by implication s9.5] "as to achieve the amount of land required numerous disparate parcels would need to be purchased." But see Q&A 27 and 28 in Appendix 1, and particularly the information related to ownership of Blocks A, E and B in the 'Option 1: All Year Irrigation' map in Appendix E of the DCDR, which suggest this might not be so.

There is a suggestion in DCDR s9.10 that: "The weightings of the criteria are yet to be determined, in consultation with the Ngāi Tahu parties." This form of Multiple Criteria Analysis is often used by engineers and others but probably shouldn't be. "Unfortunately it is very poorly supported by any evidence that it reflects real world decision making, and my feeling is that it is by and large not very good. It makes a whole lot of unjustified assumptions about the relationships between various decision making factors which I think are problematic." (Personal communication 25 January 2016 from Simon Harris, Agricultural Economist).

4.10 DCDR Section 10: Projects Risks and Opportunities

4.10.1 DCDR Section 10.1 Irrigation to Land Year Round

The alternative of pasture irrigation is not considered [Section 4.4.1 above]. The accepted positives of irrigation under trees are said to be balanced by: "significant risks around land access and land procurement; … the dispersed nature of the irrigation fields, spread across five separate areas; … extended timelines for scheme implementation; … and the highest capital cost land treatment option." The first three might not be so [Q&A 27 & 28, Appendix 1] and the fourth is incorrect [Q&A 1 and 2 and Section 4.0 above].

4.10.2 DCDR Section 10.2 Summer Only Irrigation + Wetland or Infiltration Basin
4.10.3 DCDR Section 10.3 Subsurface flow wetland
4.10.4 DCDR Section 10.4 Infiltration basin

As correctly stated in the DCDR, the viewpoint of the Ngāi Tahu parties is yet to be established.

4.10.5 DCDR Section 10.5 Use of Treated Wastewater by Local Farmers

As stated in the DCDR, providing the hardware for this option would not be difficult. Managing it to provide equitable distribution to farmers and appropriate maintenance of whatever downstream option is in place would be likely to incur some additional operational cost.

4.11 DCDR Section 11: Conclusions

The DCDR Conclusions follow from material earlier in the report. They might alter as a result of further consideration, this review and further discussion with the Ngāi Tahu parties. That being so, I will not comment on them here.

5.0 Discussion

The DCDR fulfils its purpose, as it "describes all options considered by Council, presents concept designs for the scheme options shortlisted in consultation with the Ngāi Tahu parties in September 2015 and compares those options with the harbour outfall for which the Council sought consent." [DCDR s1.2] It presents a considerable amount of technical information, appropriately referenced. As stated in the Introduction to this review report: "The most important function of the peer review is to highlight any problems, errors, missing information, misjudgements, fitness for purpose and opportunities for improvement in the Concept Design Report. For that reason, very little space is devoted to aspects of the Concept Design Report which are judged to be without obvious such problems and opportunities; that should not be taken to imply that those aspects have not been considered."

Authors of the DCDR have emphasised that it is 'concept' and 'high level'. I accept this. They have been frank and prompt in answering my questions of clarification, recorded in Appendix 1. Many of the comments included in this review report, and in the questions and answers to the authors recorded in Appendix 1, are simple clarifications or corrections needed [or not] in the DCDR and need no further comment. So the DCDR is fit for purpose and errors [many due to a tight timeline for preparation] will be corrected. That leaves [from the paragraph above]: problems; missing information; misjudgements and opportunities for improvement. My hope is that most of what I point out in this review report as problems, missing information or misjudgements can be taken as opportunities for improvement.

An aerial view of Akaroa township in the context of the harbour, the nature of the surrounding land and its waterways makes clear that CCC and advisers are not dealing with a simple problem to incorporate wastewater back in to the environment in a manner appropriate for human health and wellbeing. The history of wastewater management for Akaroa to date and the protracted efforts to upgrade wastewater management are not surprising. The DCDR does represent a genuine attempt to look more carefully than had previously been done at alternatives to a harbour outfall.

There are already positive outcomes from the continuing process to consider alternatives. Capital cost estimates [DCDR Table 8.1] from M$3.5 to M$6.2 for disposal options alternative to the M$6.7 harbour outfall encourage consideration of the alternatives one with another. All year round application to land has long been the preferred option for the Ngāi Tahu parties and there is now a clearer view of its advantages and disadvantages in this context – at least for the 'application under trees' alternative. And there is now a clearer view of what is meant by 'passage through land' and 'engineered pathway', so that issues associated with them can be discussed. All year round irrigation under trees at Location A has an estimated capital cost M$0.6 higher than the lowest capital cost option [a subsurface flow wetland at the same location] and M$2.6 lower than the mid-harbour outfall alternative. It is also the only option which already has an indication of cultural acceptability and the only one with which there is nearby experience [Wainui, Tikao Bay], albeit on a smaller scale. It is therefore important to clarify any confusion over area[s] of land required and likely degree of social acceptability.

It is against this background of positive progress that I present some "problems; missing information; misjudgements and opportunities for improvement" in this review report. I see this as part of a recursive process of continuing improvement.

6.0 Summary Conclusions of the Review

More substantive comments and suggestions made in the sections above are gathered here as Summary Conclusions of the Review. Those in **bold red** are considered to be the six most significant comments.

1. The 'traffic light' [green, orange, red matrix] display in the 'Summary Qualitative Evaluation of Options' has value in drawing attention to 'red light' aspects of options but does not clearly show that the 'Evaluation Criteria' are subjectively chosen and not of equal significance. There is also some subjectivity in assigning the colours. [Executive Summary]
2. Allowance should be made for climate change in forward planning wastewater inflows. [4.2 and 4.9]
3. It should be clarified that the future design inflows of wastewater and stormwater are also the future design outflows which reach the receiving environments: land under trees in Option 1, land in pasture or under trees in Option 2/Summer and the Harbour in all four other options [D2, 2/Winter, 3 and 4]. [4.2]
4. **Further improvement in excluding stormwater from inflow to the treatment plant [or bypass] should be actively sought. Peak wet weather volumes of 1800 m^3/day compared to Summer Average 386 m^3/day [ratio 4.7 times] are still too high. [4.2]**
5. **The wastewater treatment plant designed and consented with a harbour outfall expected would not necessarily be the most appropriate and cost-effective treatment plant if a different final effluent disposal is chosen. [4.2]**
6. Figure 3.1 in the Concept Design Report does not accurately represent the preferred options of the Ngāi Tahu parties as conveyed in a letter dated 7 October 2015. It should recognise that Irrigation to Land is the preferred option, stormwater entry should be further reduced, passage through land needs further discussion and non-potable reuse needs further investigation. [4.3]
7. **Option 1 Irrigation to Land should include the alternative of irrigation to pasture. [4.4.1 and 4.4.4]**
8. Whether or not appropriate use has been made of prior information about land suitability needs to be checked. [4.4.1 and 4.6]
9. If a wetland option is further developed, more weight should be given to designing for human health requirements, including virus removal. [4.4.6]
10. The 'Engineered Pathway' should be referred to as the more accurate and informative 'Coastal Infiltration Gallery'. [4.4.8]
11. **It should be emphasised in a simple, clear manner that Options 3 and 4 [and Option 2 alternatives in Winter] take the same WWTP effluent as for the harbour outfall, pass it through further system components at considerable cost and then discharge it at the harbour edge, very little changed in quality, in a manner which does not dilute the effluent as effectively as the harbour outfall. [4.4.9]**
12. **It should be made clear that whether or not Options 2[Winter], 3 and 4 satisfy cultural requirements for 'passage through land' is yet to be advised. [4.4.9]**
13. The areas of suitable and available land in Table 5.1 of the Concept Design Report should be corrected to match those in the maps in its Appendix E. The numbers of owners should also be checked and clarified, as some appear to be owners in common for different blocks. [4.5 and 4.10.1]
14. **Section 7.4.1 on 'Positive Effects" in the Concept Design report needs to be rewritten as some is incorrect [concerning removal or reduction of human wastewater from the coastal marine area] and some has yet to be advised [concerning 'passage through land']. [4.7]**
15. The poor ranking of Option 1 All Year Round Irrigation Under Trees for 'Land Availability and Suitability' needs re-examination in the light of 4, 8 and 13 above. [4.9]
16. The 'traffic light' matrix used in the Executive Summary and Section 9.10 of the Concept Design Report should not be used in a numerically weighted version as a Multiple Criteria Analysis decision aiding tool. [4.9]

7.0 References

CCC (2011) Waterways, Wetlands and Drainage Guide, Christchurch City Council, Appendix 10.

CH2M Beca (2015) Akaroa Wastewater Project – Review of Disposal Alternatives for Ngāi Tahu – First Stage.

CH2M Beca (2016) Akaroa Wastewater - Concept Design Report for Alternatives to Harbour Outfall, Client Report for Christchurch City Council 29 January 2016, 6517986 // NZ1-11926513-75 0.75 // i.

Harrison and Grierson (2010) Akaroa Wastewater Treatment and Disposal, Client Report for Christchurch City Council, *HG Document No. R001v4-AK128694-01.*

IPENZ (2003) Peer Review, Practice Note 02, Institution of Professional Engineers.

Acknowledgements

Kirsty Huxford of Te Runanga o Ngāi Tahu has been an effective, supportive client contact. Behind her has been an equally supportive Matthew Ross and other Te Runanga o Ngāi Tahu staff. Rae Stewart and her colleagues at CH2M Beca have been prompt and helpful in answering my questions of clarification. Mike Bourke and his colleagues at Christchurch City Council provided helpful comments about draft Sections 1 to 3 of this report.

Naku te rourou nau te rourou ka ora ai te iwi. With your basket and my basket the people will live.

Appendices

Appendix 1 Questions and Answers [Reviewer to authors]

Concept Design Report Q & A

Q1	1 Feb 2016	*Executive Summary, p. v, Option 1: "Year round irrigation is the highest capital cost option." Just an error?*
A1	1 Feb 2016	– We were asked to add costs in for Summer irrigation plus infiltration basin late on Friday (we had previously assumed only summer irrigation plus wetland due to the relative merits and costs of the two combinations). Obviously in doing this late in the day we have not picked up all the places reference to this should have changed. Exec summary should therefore read "Year round irrigation is one of the highest capital cost options".
Q2	2 Feb 2016	*Under trees at Location A it is one of the lowest capital cost options. So why still "one of the highest" in the Executive Summary?*
A2	3 Feb 2016	This comment is about the relative costs between types of option. Further work is being done on land purchase costs that will likely increase the cost of irrigation.
Q3	2 Feb 2016	*s1.4 para 1 line 3: Presumably the Canterbury Regional Policy Statement. Why no mention of the Land and Water Regional Plan?*
A3	3 Feb 2016	Yes the document referred to is the Canterbury Regional Policy Statement. The Land and Water Regional Plan has also been considered, this is covered in Section 7.
Q4	2 Feb 2016	*s2.1.1 Are the rainfall data for 2006-2015 appropriately representative? [Presumably they are from more than one site, as the NIWA EWS did not start until 2009.] Has climate change been taken in to account?*
A4	3 Feb 2016	The rainfall data is from a single station in Akaroa - Akaroa Ews (Stn 36593) Lat -43.80938 Long 172.96574 (NIWA) opened 12/11/08. The flow data dates back to 2006. The rainfall data is the most representative information we have for Akaroa. Climate change has not been taken into account.
Q5	2 Feb 2016	*s2.1.2 With 1-2 bypass events/yr, 1-2 days each, what flows and volumes of what quality end up in the engineered pathway, for those options?*
A5	3 Feb 2016	The quality of the discharged treated wastewater during bypass flow events is described in Section 4.2, Tables 4.2, 4.3 and 4.4. All bypassed flow is combined with flow that goes through the wastewater treatment plant before being transferred to the storage pond and then on to either the infiltration basins or the subsurface wetland. So the total flow (both bypassed and non-bypassed) will end up in the engineered pathway at some stage, the timing of this will depend on the volume of wastewater in the storage pond prior to the wet weather event. Discharge flow is fixed from the passage through land

		options regardless of the incoming flowrate. From the infiltration basins (2 assumed operational for wet weather event) this will be 10 l/s (refer note for Table 4.4); discharge flow from the sub-surface wetland will be 6 l/s (refer note for Table 4.3). Assuming a treatment capacity of 14 l/s, this equates to approximately 1,200 m3/day. In a wet weather event of 1,800 m3/day for 2 days, a maximum of 1,200 m3 of bypass flow would occur. The combined quality of wastewater is difficult to predict accurately during bypassing at this stage as there is uncertainty about the quality of stormwater flowing into the Akaroa sewage system, and this is likely to vary significantly between events. Assuming raw stormwater TSS and BOD of 100 g/m3 and 15 g/m3 respectively (from Hicks 1993 and NIWA 1991) and a flocculant-dosed disc filter removal rate of 60% (specified by the supplier) the combined quality of wastewater flow into the infiltration basin or wetland is estimated at TSS & BOD of 14 &5 g/m3.On this basis the expected discharge quality in the engineered pathway for a wetland is 10 g/m3 for both TSS and BOD. For an infiltration basin it is estimated at TSS & BOD of 14 &5 g/m3 (worst case). Virus removal rates are estimated in Tables 4.1 and 4.2 Further evaluation of treatment performance will be required to confirm the final discharge quality more accurately
Q6	2 Feb 2016	*s2.4 Are there quantitative or qualitative monitoring results available from the Wainui Irrigation Scheme?*
A6	3 Feb 2016	There is no monitoring of the Wainui treated wastewater irrigation scheme, and neither is there monitoring of the Tikao Bay irrigation scheme.
Q7	3 Feb 2016	*s2.4 Are the application rates consented for the Wainui scheme appropriate for Locations A and B?*
A7	3 Feb 2016	Locations A and B are currently farmed by the land owners and largely used for hay making. The preliminary geotechnical information indicates deep loess deposits and the pasture looks to be some of the better pasture in the area. It is therefore felt that the Wainui application rates are appropriate for these locations at this stage of design. More detailed investigations will be required to confirm application rates if irrigation is chosen as the preferred option.
Q8	3 Feb 2016	*s2.5 Paragraph 1 Line 4: Why is "1.5 times the future winter average dry weather flow" "typical of "low flow""?*
A8	3 Feb 2016	This could be reworded for clarity. A range of flows were considered, at the lower end of the flow range 1.5 times the future winter average dry weather flow was considered a reasonable flow rate to balance the difference between the low winter flow rates and the much higher summer rates.
Q9	3 Feb 2016	*s2.5 Paragraph 3 Line 1: Is "2 days contact time" based on plug flow, no short-circuiting? What means will there be to ensure this is achieved?*
A9	3 Feb 2016	The 2 days contact time is based on plug flow without short circuiting, and represents an average time in the wetland at the design flowrate of the wetland. While short circuiting is not such an issue with sub-surface flow wetlands compared with surface flow wetlands, short circuiting of a small proportion of treated effluent is always possible. The wetland geometry can be configured with the appropriate side slopes and length to width ratios to minimise this occurring. This is a matter for more detailed design work.
Q10	3 Feb 2016	s2.6 *Why 7 basins?*
A10	3 Feb 2016	As described in 4.7.2 seven basins were selected for ease of management (1 per day). As noted it could be less or more. We are aware of 6 being used at some locations and 8 at another location. Once again the final numbers will be confirmed during preliminary design work if this is the selected option.
Q11	3 Feb 2016	*Figure 3.1 is stated to be based on a response from the Ngāi Tahu parties "with their preferred options on 8th October 2015." My reading of a 7 October 2015 letter from Ngāi Tahu parties [Kirsty Huxford] to CCC [Jane Parfitt] leads to a different picture from Figure 3.1. Are we considering different documents?*
A11	3 Feb 2016	Figure 3.1 was based on the response presented by the Ngāi Tahu parties as recorded in the letter dated 7 October 2015. The letter states "The alternative options preferred by Ngāi Tahu involve discharge through land, utilising the natural ability of Papatūānuku to filter and cleanse contaminants from waste. Consequently, Ngāi Tahu would like the Council to undertake more detailed investigations that involve combining discharge through land options with use of wetlands." And "The preferred option is Irrigation to land (Option A1) with use of a wetland(s) for storage." Figure 3.1 is an interpretation of these comments. Figure 3.1 was presented to and discussed with the Ngāi Tahu parties at the hui on 21 October 2015 and was agreed to represent the intention of the message they wished to convey.
Q12	3 Feb 2016	*s3.6 Paragraph 3: "Initially would not be able to use irrigation while trees are growing until the canopy had formed" Why not? Growing trees need irrigation.*
A12	3 Feb 2016	This is a high level summary bullet point from presentation of the initial desk top review. Growing trees need irrigation but not at the full application rates for year round irrigation. The canopy is required,

		particularly during winter, to allow the scheme to irrigate at the desired rate. Without the canopy irrigation cannot be used as a standalone option for wastewater disposal.
Q13	3 Feb 2016	*s3.6 Paragraph 3: Why 16 – 20 ha? 561 m^3/d applied at 5 mm/d needs 11.2 ha nett.*
A13	3 Feb 2016	This is a high level summary bullet point from presentation of the initial desk top review. This land area requirement was refined by the further work as described in the report – refer Section 4.5 and Section 5.1 which states that 11.2 ha of land is required.
Q14	4 Feb 2016	*Tables 4.1 and 4.2: I understand virus removal to involve capture plus inactivation i.e. contact with a suitable surface plus time. Why then is the "0.5 log" for SSF wetland [not referenced until Table 4.3] less than the two pond storage estimates?*
A14	5 Feb 2016	The 0.5 log reduction for SSF wetland is an estimate based on published literature (including Wetlands 2nd Edition (2009), Kadlec and Wallace). A summary of this literature is provided in Appendix I. Virus reduction in the wetland may be as high as 1-2 logs, but this not proven for norovirus in New Zealand and will also be influenced by the design of the wetland. Hence a lower estimate of 0.5 log removal has been assumed at this early stage. This is less than the pond storage estimate because the pond, if nothing else, achieves 1log reduction simply based on a reduction in flow between the inlet and outlet from 65 L/s to 6 L/s, taking the SSF wetland option as an example. The NIWA Quantitative Microbial Risk Assessment (QMRA) model assumes a rate of discharge for norovirus (viruses/second) and is currently based on a peak flow of 65 L/s. If the revised flow at the point of discharge, via SSF and engineered pathway, is 6 L/s then the rate of viruses (viruses/second) will be 1/10 of, or 1 log less than, the current model basis
Q15	4 Feb 2016	*s4.4: Many WWTP in NZ irrigate final effluent on pasture all year round [Ashburton, Te Anau etc.] Why was an option of all year round irrigation to pasture [e.g. cut and carry on CCC purchased land] not covered?*
A15	5 Feb 2016	A previous study by Harrison and Grierson (2010) identified that there was a risk to ground stability with all year round irrigation to pasture. Our consideration of ground conditions in the area (predominantly loess and undulating with numerous historic slip faces and some steep slopes – refer Appendix F) supported this. It may still be possible to irrigate year round on pasture at a much reduced application rate, but there would still be land stability risk involved and the amount of land that would be required would be large and the scheme would need to be spread over a very wide area. Therefore this option was not considered feasible for the area. Schemes such as Ashburton are situated on much flatter land with less geotechnical risk.
Q16	4 Feb 2016	*s4.4.2 Para 5: 5 ha/d at 5 mm over 20 hours is 3.5 l/s. At 3 mm it is 2.1 l/s. Why is it stated that "These flows are based on irrigating approximately 5 ha per day over 20 hours." i.e. "These flows" being 14 l/s and 4.2 l/s.*
A16	5 Feb 2016	This was to explain that not all 25ha would be irrigated at one time. The amount of land and flows are based on irrigating parts of the total area and rotating between them. The peak summer flow is predicted to be 1,011 m^3/day. Based on an average application rate of 5mm/day this represents an area required of 20.2 hectares. Usually irrigation is rotated through blocks. Assuming 4 blocks irrigating one block of 5ha represents an application depth of 20 mm (not unreasonable in summer), and the flow rate based on irrigating over a period of 20 hours is14.04 L/s. A similar calculation gives a flow of 4.2 L/s with the average winter application depth of 1.5 mm/day.
Q17	4 Feb 2016	*s4.5.8: Why is there a "Lack of discharge to wetland/infiltration basin over summer, when the majority of flow is used for irrigation, risking die off of plants if these are planted on the surface" when the flow division [irrigation/wetland] is a management choice?*
A17	5 Feb 2016	Agree. This is a bullet point to highlight a possible risk if the scheme isn't managed correctly and to reiterate that the flow needs to be managed.
Q18	4 Feb 2016	*s4.6.2 Paragraph 3: Why is the maximum storage volume 12 000 m^3 in the text, 7000 m^3 in the bullet point?*
A18	5 Feb 2016	In the text a volume of storage required is quoted. The bullet points are on the amount of land area required. As mentioned in the text to get 12,000 m^3 storage volume a pond of approximately 2.5m deep and 0.7 ha is required. Refer also Table 5.1.
Q19	4 Feb 2016	*s4.6.3: "To a certain extent the wetland can be sized to achieve a specific contact time." Are there any disadvantages of having a longer contact time, other than marginal cost increase due to volume increase? [This is related to Q9 and Q14.]*
A19	5 Feb 2016	The main disadvantage is the cost increase. This may be more than marginal given the lack of suitable

		land in the vicinity. As noted in the discussions at huis held to date, the contact time of 2 days was based on previously consented requirements for SSF wetlands in similar circumstances. The final agreed contact time, if this option is selected, may be shorter or longer.
Q20	4 Feb 2016	*s4.7.1 Paragraph 2: In what sense is "wastewater collected at the base of the infiltration basin" "excess"?*
A20	5 Feb 2016	Poor choice of words, reword to "Wastewater that has infiltrated through the basin and has been collected at the base of the infiltration basin …."
Q21	4 Feb 2016	*s4.8.4 Figure 4.14: Would the top surface of the beach gravels – or the top surface of the Gabion basket if the gravels above it are removed by wave action – be accessible for foot traffic at less than high tide? Would warning signs be required?*
A21	5 Feb 2016	We have yet to assess the residual and localised public health risks associated with operation of the engineered pathway. A recommendation about access for foot traffic, and any warning signage, would be made when a full assessment of relevant aspects has been undertaken and a site confirmed. These aspects will include the microbiological quality at the point of discharge, wastewater infiltration and dispersion and dilution processes throughout the tidal cycle, and the location and potential accessibility to the public.
Q22	4 Feb 2016	*s4.9: Retaining the BNR WWTP "as an integral part of all scheme options" is in accord with granting of the consent for it in July 2015, with the Environment Court mediation agreement in September 2015 for further investigations of alternatives to a harbour outfall and, apparently, in accord with the views of most or all of the parties in mediation. To what extent does this risk sub-optimal design of an overall wastewater treatment system for Akaroa? For example, if an all year round irrigation option for final effluent were chosen, would the BNR WWTP be the most cost-effective?*
A22	5 Feb 2016	A BNR WWTP is a sophisticated and high cost treatment option that was originally conceived to meet the Council resolution of 8 December 2011 that "the new treatment plant be designed to produce wastewater that achieves the best quality available at the time, and that the design of the plant enable the potential future beneficial re-use of treated wastewater for domestic, commercial and agricultural purposes". If all-year round irrigation is chosen as the preferred option there is potential for the treatment plant design to be simplified considering that further and final treatment will be provided by irrigating the treated wastewater to land. It remains to be seen if the council would be able to pursue this path given the commitment made in the December 2011 resolution.
Q23	4 Feb 2016	*s4.9.2 Paragraph 1: "Summer time irrigation to land will have no measurable effects on harbour water quality during summer when there is no discharge to the harbour." Would there be a minor discharge due to keeping a wetland wet?*
A23	5 Feb 2016	The context in the paragraph relates to the impact of the irrigated wastewater. Yes there may need to be a minor discharge associated with keeping the wetland wet during summer.
Q24	4 Feb 2016	*Tables 4.3 and 4.4 appear to contain the same information as Tables 4.1 and 4.2, but with columns and rows transposed and addition of the Kadlec (2009) reference. Am I missing something?*
A24	5 Feb 2016	This is correct – to assist the reader to evaluate comparisons without having to turn back and forth between sections.
Q25	4 Feb 2016	*s4.9.5 Last bullet point: "Discharge of treated wastewater via the engineered pathway located at the shoreline will not be as effective as the dilution achieved by a 2.5 km harbour outfall pipe." Is the intended meaning: "Dilution of treated wastewater discharged via the engineered pathway located at the shoreline will not be as effective as the dilution achieved by a 2.5 km harbour outfall pipe."*
A25	5 Feb 2016	Yes
Q26	4 Feb 2016	*s4.10 Paragraph 3: "alternatively only take water for reuse during dry periods". Will the discharge from the WWTP [not the bypass] be the same in wet and dry periods and therefore suitable for reuse?*
A26	5 Feb 2016	For the majority of wet period rainfall events, all the flow will be fully treated including passing through the membranes, and so the quality will be the same as during dry periods. During infrequent bypassing there is a higher risk associated with water reuse. This risk can be further assessed during detailed design if water reuse is adopted as part of the scheme.
Q27	5 Feb 2016	*s5.3.3: Why are the areas for Blocks E and G in Table 5-1 different from those shown in the Appendix E map?*
A27	9 Feb 2016	After a review with Council a decision was made to allow more land to be considered for irrigation than was originally estimated. While the maps were updated the table wasn't. The table will be revised for

		the final report to be consistent with the maps.
Q28	5 Feb 2016	*s5.3.3: Table 5.1 shows 3 owners of Block E but LINZ data show it is nearly all one owner, who also owns Blocks A and B. Has this and other such cases been taken in to account?*
A28	9 Feb 2016	At this stage we have not tried to narrow options by minimising the number of land owners involved, we have simply shown land area that is "suitable". The number of landowners was identified to give Council and the Ngāi Tahu parties an indication of how many affected parties may need to be negotiated with and to enable a high level assessment of cost and timeliness to be made. If irrigation is chosen as the preferred option, at the next phase of design we could consider ways to simplify procurement of land that could take into account the number of landowners.
Q29	5 Feb 2016	*s5.4.1.2 3rd bullet point: Is it "when not irrigating" only? Might it be needed to keep the wetland wet when irrigating?*
A29	9 Feb 2016	Yes a very small proportion of the total flow will need to be pumped onto the wetland periodically to keep the wetland wet when irrigating. This is easily managed within the scope of the irrigation pump capacity.
Q30	5 Feb 2016	*S5.4.1.4: No need to mention the booster pumps, as in s4.10?*
A30	5 Feb 2016	Reference to the possible booster pumps should be added to S5.4.1.4.
Q31	5 Feb 2016	*S5.4.2 Line 1 "For each option there is a requirement to construct a storage basin and either pump station or wetland/infiltration basins adjacent to this." Is this intended to include the and-and options?*
A31	5 Feb 2016	We assume by "and-and" options you mean summer irrigation plus wetland or infiltration basin and Engineered Pathway. Yes the "and-and" options also require a storage basin and pump station. For summer irrigation the pump station will be dual purpose – irrigation and the ability to pump out of the storage pond and into the SSF wetland or infiltration basin.
Q32	5 Feb 2016	*s4.9.3 and s4.9.4 First paragraphs: Am I understanding correctly that your expectations of the quality of effluent from either a SSF wetland or the infiltration basins is that it will be little changed from their influent quality i.e. the predicted effluent water quality from the WWTP as in Table 2.2?*
A32	5 Feb 2016	Final wastewater quality for an infiltration basin scheme is assumed to be the same as Table 2.2 –i.e. no change. For a wetland scheme the final TSS is likely to be higher while BOD is likely to be similar.
Q33	5 Feb 2016	*s7.4.1: The first sentence applies to the all year round irrigation option. Is it also intended to apply to the options having an engineered pathway to submarine discharge at the harbour edge?*
A33	9 Feb 2016	All options are assumed to have a positive cultural outcome over the current operation or proposed outfall as the treated wastewater will pass through land. The first sentence regarding reduction of wastewater to the coastal marine environment also applies to summer irrigation plus passage through land and engineered pathway and to a lesser extent the SSF wetland plus engineered. The infiltration basin option will have little if any reduction in load to the harbour so this sentence will not apply to this option.
Q34	5 Feb 2016	*s7.4.1: Is the second sentence intended to reflect a conclusion from prior consultations with the Ngāi Tahu parties?*
A34	9 Feb 2016	The second sentence is intended to reflect feedback that was given at the hearing and at subsequent huis and also as recorded in the letter from the Ngāi Tahu parties to Jane Parfitt dated 7th October 2015 "The alternative options preferred by Ngāi Tahu involve discharge through land, utilising the natural ability of Papatūānuku to filter and cleanse contaminants from waste."
Q35	5 Feb 2016	*s7.4.3 Last paragraph: "subsurface wetlands are effective at reducing solids (TSS)."* *Is this sentence fragment [which directly contradicts s4.9.2 and s4.9.3] here in error?*
A35	9 Feb 2016	Literature research and experience shows that wetlands are effective at removing suspended solids. However, compared to a typical secondary clarifier-type treatment plant, the proposed Akaroa wastewater treatment plant will discharge negligible suspended solids. Hence during dry weather flow the TSS for the SSF wetland option will tend to increase rather than decrease through the wetland. During wet weather a small reduction in TSS will be achieved. This sentence can be deleted for consistency.
Q36	5 Feb 2016	*s7.4.5: "around 1ha (7,500m^3)" Is this intended to be as for A18, above?*
A36	5 Feb 2016	This sentence should be updated to reflect the storage and area requirements as shown in Table 5.1.
Q37	5 Feb 2016	*s7.4.8 3rd paragraph: "Depending on land area and nitrogen load, removal of biomass eg by cut and carry may not be necessary..." What is intended by the ellipsis … ?*
A37	5 Feb 2016	Typing error – should be a full stop only.
Q38	5 Feb 2016	*s7.4.10 2nd paragraph: What is intended by the ellipsis … ?*
A38	5 Feb 2016	Typing error – should be a full stop only.

Q39	5 Feb 2016	*s2.4 In relation to Q6 and A6 above: I have attached ECan consent conditions for the Wainui Wastewater Treatment Plant discharge permit CRC091580. If there is "no monitoring of this scheme" [A6], in the light of the conditions, do you know why this is so?*
A39	5 Feb 2016	Our previous response to Q6 assumed you meant monitoring of the receiving environment. Monitoring of the scheme as per the consent requirements is carried out. The most recent monitoring reports are attached for your information.
Q40	9 Feb 2016	Would the 'infiltration basins' be more accurately called 'filtration basins', as the filtrate does not go "in" to the underlying media?
A40	9 Feb 2016	The use of the term infiltration basin is generic. There are a number of "infiltration" basins operating for stormwater management in the Christchurch area which have under drainage systems similar in nature what is proposed here and the term "infiltration" basin has been retained.
Q41	9 Feb 2016	In relation to Q15 and A15 above: Harrison and Grierson (2010) did not consider land on the northern half of the Takamatua Peninsula due to land access refusal, except to point out that the Northern slopes were more stable than the Southern slopes. The South-Eastern 'quarter' of the Peninsula, which they did consider, is prone to erosion. So their consideration of land application of effluent was in the context of land South of Akaroa township. Were these factors taken in to account in considering the all year round and Summer-only land application options?
A41	9 Feb 2016	Yes – refer to Section 5.2 and Section 6.4 of the report. Geotechnical considerations around land stability (Geotech Consulting Ltd report) from the Harrison and Grierson report have been reviewed and taken into account. We have also conducted our own review of geotechnical and other factors to identify suitable land for irrigation (both year round and summer only). Land to the south of Akaroa township was not given further consideration due to feedback from the Ngāi Tahu parties and the Akaroa working party as described in Section 5.2.

Appendix 2 Letter referred to in Section 4.3

Te Rūnanga o NGĀI TAHU

7 October 2015

Jane Parfitt
Christchurch City Council
PO Box 73016
Christchurch

Tēnā koe Jane

RE: Akaroa wastewater – wastewater discharge options

Thank you for meeting with Ngāi Tahu representatives on 21 September 2015. The Ngāi Tahu representatives were heartened by your opening comments confirming the Christchurch City Council's commitment to finding an alternative wastewater discharge solution that would be acceptable to both Ngāi Tahu and the Council.

Thank you also to the representatives from the Council's Akaroa wastewater project team for presenting a summary of alternative wastewater discharge options for the new Akaroa wastewater treatment plant.

It was agreed at that hui that the Ngāi Tahu parties (being representatives of Ōnuku Rūnanga, Wairewa Rūnanga, Te Rūnanga o Ngāi Tahu and the Akaroa Taiāpure Management Committee) would provide the Council with details of the discharge options that we would like to see investigated further.

Ngāi Tahu preferred options

As outlined in the Ngāi Tahu submission and presentation at the consent hearing, the discharge of treated wastewater directly into Akaroa harbour is culturally offensive and incompatible with the harbour as mahinga kai. The alternative options preferred by Ngāi Tahu involve discharge through land, utilising the natural ability of Papatūānuku to filter and cleanse contaminants from waste.

Consequently, Ngāi Tahu would like the Council to undertake more detailed investigations that involve combining discharge through land options with use of wetlands.

Te Rūnanga o Ngāi Tahu
15 Show Place, Christchurch
PO Box 13-046, Christchurch, New Zealand
Phone + 64 3 366 4344, 0800 KAI TAHU
Email: info@ngaitahu.iwi.nz
Website: www.ngaitahu.iwi.nz

The preferred option is Irrigation to land (Option A1) with use of a wetland(s) for storage.

An option that combines passage through land (Option A2) with a wetland(s) would meet our primary objective of avoiding the direct discharge of wastewater the harbour. However the Ngāi Tahu parties are concerned about the requirement to collect the wastewater following passage through land, and discharge it to coastal waters via a creek or pipe. The Ngāi Tahu parties would like to discuss this option further with the Council before providing a more formal position.

For clarity, it is noted that the use of a wetland as the sole discharge to land option (Option B1 or B2) does not achieve the required passage through land to an extent that satisfies cultural concerns.

Ngāi Tahu also requests that non-potable reuse (Option A3) should be further investigated, particularly given the existing summer time water shortages that are likely to continue in Akaroa.

In addition, Ngāi Tahu would like the Council to continue to investigate options to reduce the volume of wastewater entering the system, in particular measures to prevent stormwater entering the wastewater system.

Next steps

As agreed at the hui on 21 September and the Environment Court mediation conference on 30 September, the Ngāi Tahu parties wish to be involved in the next stage - detailed investigation of options. This starts with the briefing of CCC consultants and we are liaising with Mike Bourke directly regarding a suitable date for this briefing.

Contact person

If you would like to discuss the information contained in this letter in further detail, don't hesitate to contact me. Please send all future correspondence to myself instead of Philippa Lynch. My contact details are Kirsty.huxford@ngaitahu.iwi.nz or 021 590 263.

Nāku noa, nā

Kirsty Huxford
Senior Environmental Advisor
Te Rūnanga o Ngāi Tahu

cc: Mike Bourke, Brent Pizzey

{Report ends}

Akaroa Wastewater - Response to Peer Review Comments

	Peer Review Comment	Beca Response
1.	The 'traffic light' [green, orange, red matrix] display in the 'Summary Qualitative Evaluation of Options' has value in drawing attention to 'red light' aspects of options but does not clearly show that the 'Evaluation Criteria' are subjectively chosen and not of equal significance. There is also some subjectivity in assigning the colours [Executive Summary].	The matrix has been removed.
2.	Allowance should be made for climate change in forward planning wastewater inflows [4.2 and 4.9].	No allowance has been made for climate change as it is estimated there will be little effect on future wastewater flows – see Section 2.1.1 for a full explanation.
3.	It should be clarified that the future design inflows of wastewater and stormwater are also the future design outflows which reach the receiving environments: land under trees in Option 1, land in pasture or under trees in Option 2/Summer and the Harbour in all four other options [D2, 2/Winter, 3 and 4] [4.2].	A sentence to this effect has been added to Section 4.2.
4.	Further improvement in excluding stormwater from inflow to the treatment plant [or bypass] should be actively sought. Peak wet weather volumes of 1800m^3/day compared to Summer Average 386m^3/day [ratio 4.7 times] are still too high [4.2].	The future design flows have assumed the peak wet weather flows will remain at 1,800 m3/day even though the peak summer day will increase from 386 m^3/day to 561 m^3/day – representing a reduction in ratio peak wet weather volume to summer average from 4.7 to 3.2. This has been described in Section 2.1.1 and emphasised in the Executive Summary.
5.	The wastewater treatment plant designed and consented with a harbour outfall expected would not necessarily be the most appropriate and cost-effective treatment plant if a different final effluent disposal is chosen [4.2].	The wastewater treatment plant design has been reviewed and commentary on this has been added to Section 4.2.
6.	Figure 3.1 in the Concept Design Report does not accurately represent the preferred options of the Ngāi Tahu parties as conveyed in a letter dated 7 October 2015. It should recognise that Irrigation to Land is the preferred option, stormwater entry should be further reduced, passage through land needs further discussion and non-potable reuse needs further investigation [4.3].	The figure has been updated.
7.	Option 1 Irrigation to Land should include the alternative of irrigation to pasture [4.4.1 and 4.4.4].	A new section has been added on an irrigation to pasture option.

	Peer Review Comment	Beca Response
8.	Whether or not appropriate use has been made of prior information about land suitability needs to be checked [4.4.1 and 4.6].	We understand this comment has been addressed by including an option on year round irrigation to pasture.
9.	If a wetland option is further developed, more weight should be given to designing for human health requirements, including virus removal [4.4.6].	If selected as the preferred option, design of the wetland would carefully consider requirements for human health including maximising virus removal.
10.	The 'Engineered Pathway' should be referred to as the more accurate and informative 'Coastal Infiltration Gallery' [4.4.8].	This terminology has been updated to refer to a Coastal Infiltration Gallery where applicable.
11.	It should be emphasised in a simple, clear manner that Options 3 and 4 [and Option 2 alternatives in Winter] take the same WWTP effluent as for the harbour outfall, pass it through further system components at considerable cost and then discharge it at the harbour edge, very little changed in quality, in a manner which does not dilute the effluent as effectively as the harbour outfall [4.4.9].	Sentences to this effect have been included in sections 10.3 and 10.4.
12.	It should be made clear that whether or not Options 2 [Winter], 3 and 4 satisfy cultural requirements for 'passage through land' is yet to be advised [4.4.9].	The Ngāi Tahu parties have now advised their assessments based on cultural requirements and these comments have been included in the report.
13.	The areas of suitable and available land in Table 5.1 of the Concept Design Report should be corrected to match those in the maps in its Appendix E. The numbers of owners should also be checked and clarified, as some appear to be owners in common for different blocks [4.5 and 4.10.1].	This table has been updated and commentary added about the number of landowners.
14.	Section 7.4.1 on 'Positive Effects' in the Concept Design Report needs to be rewritten as some is incorrect [concerning removal or reduction of human wastewater from the coastal marine area] and some has yet to be advised [concerning 'passage through land'] [4.7].	This section has been rewritten.
15.	The poor ranking of Option 1 A;; Year Round Irrigation Under Trees for 'Land Availability and Suitability' needs re-examination in the light of 4, 8 and 13 above [4.9].	The traffic light matrix has been removed and the evaluation/ranking sections reworded.
16.	The 'traffic light' matrix used in the Executive Summary and Section 9.10 of the Concept Design Report should not be used in a numerically weighted version as a Multiple Criteria Analysis decision aiding tool [4.9].	The traffic light matrix has been removed.