Hearings Panel
Akaroa Treated Wastewater Options
AGENDA

Notice of Meeting:
A Hearings Panel meeting will be held on:

Date:	**Monday 12 October 2020**
Time:	**9am**
Venue:	**The Gaiety Hall, Rue Jolie, Akaroa**

Panel

Members	Councillor Pauline Cotter Councillor Mike Davidson Councillor Aaron Keown Councillor Sara Templeton Community Board Member Nigel Harrison Community Board Member Tori Peden

2 October 2020

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Ōtautahi–Christchurch is a city of opportunity for all

Open to new ideas, new people and new ways of doing things – a city where anything is possible

Principles

- Being open, transparent and democratically accountable
- Promoting equity, valuing diversity and fostering inclusion
- Taking an inter-generational approach to sustainable development, prioritising the social, economic and cultural wellbeing of people and communities and the quality of the environment, now and into the future
- Building on the relationship with Te Rūnanga o Ngāi Tahu and the Te Hononga–Council Papatipu Rūnanga partnership, reflecting mutual understanding and respect
- Ensuring the diversity and interests of our communities across the city and the district are reflected in decision-making
- Actively collaborating and co-operating with other local, regional and national organisations

Community Outcomes

Resilient communities

- Strong sense of community
- Active participation in civic life
- Safe and healthy communities
- Celebration of our identity through arts, culture, heritage, sport and recreation
- Valuing the voices of all cultures and ages (including children)

Liveable city

- Vibrant and thriving city centre
- Sustainable suburban and rural centres
- A well connected and accessible city promoting active and public transport
- Sufficient supply of, and access to, a range of housing
- 21st century garden city we are proud to live in

Healthy environment

- Healthy water bodies
- High quality drinking water
- Unique landscapes and indigenous biodiversity are valued and stewardship exercised
- Sustainable use of resources and minimising waste

Prosperous economy

- Great place for people, business and investment
- An inclusive, equitable economy with broad-based prosperity for all
- A productive, adaptive and resilient economic base
- Modern and robust city infrastructure and community facilities

Strategic Priorities

- **Enabling active and connected communities to own their future**
- **Meeting the challenge of climate change through every means available**
- **Ensuring a high quality drinking water supply that is safe and sustainable**
- **Accelerating the momentum the city needs**
- **Ensuring rates are affordable and sustainable**

Ensuring we get core business done while delivering on our Strategic Priorities and achieving our Community Outcomes

- Engagement with the community and partners
- Strategies, Plans and Partnerships
- Long Term Plan and Annual Plan
- Our service delivery approach
- Monitoring and reporting on our progress

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The dates of the hearings are as follows:

- Monday 12 October 2020, 9am, The Gaiety Hall, Rue Jolie, Akaroa
- Tuesday 13 October, 12.30pm, The Gaiety Hall, Rue Jolie, Akaroa
- Friday 16 October, 2pm, Civic Offices, 53 Hereford Street, Christchurch
- Wednesday 28 October, 2pm, Civic Offices, 53 Hereford Street, Christchurch *(for considerations and deliberations)*

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1. Apologies / Ngā Whakapāha

At the close of the agenda no apologies had been received.

2. Election of a Chairperson / Te Whakatū Poumua

At the start of the meeting a Chairperson will be elected.

3. Declarations of Interest / Ngā Whakapuaki Aronga

Members are reminded of the need to be vigilant and to stand aside from decision making when a conflict arises between their role as an elected representative and any private or other external interest they might have.

4. Akaroa Treated Wastewater Options

Reference / Te Tohutoro:	20/1196094
Report of / Te Pou Matua:	Kylie Hills, Senior Project Manager, Kylie.Hills@ccc.govt.nz Bridget O'Brien, Programme Manager Water Supply, Bridget.Obrien@ccc.govt.nz Mike Bourke, Senior Technician Water and Waste Planning, Mike.Bourke@ccc.govt.nz Tara King, Senior Engagement Advisor, Tara.King@ccc.govt.nz
General Manager / Pouwhakarae:	David Adamson, General Manager City Services, david.adamson@ccc.govt.nz

1. Purpose of the Report / Te Pūtake Pūrongo

1.1 The purpose of this report is to provide the Hearings Panel with information on the Akaroa treated wastewater project and community views following public consultation on this project.

1.2 The decisions in this report are of high significance in relation to the Christchurch City Council's Significance and Engagement Policy. The level of significance was determined by the high level of community interest and involvement in this project, the high level of impact on Māori culture and traditions and the significant financial cost.

2. Proposed Officer Recommendations / Ngā Tūtohu

2.1 In response to the five questions asked in the consultation booklet, please refer to **Attachment A** for the Officers' recommendations.

3. Background / Te Horopaki

3.1 On 8 December 2011, the Council resolved:

(a) The Akaroa Wastewater Working Party be thanked for its valuable work over the last three years.

(b) A replacement wastewater treatment plant for Akaroa be located away from Takapuneke Reserve, and that staff discuss siting options with the Ōnuku Rūnanga and community, and report back to the Council within six months on suitable potential sites.

(c) The outfall for the treatment plant be re-located to the middle of the Akaroa Harbour and that consideration be given to measures to address cultural concerns, in consultation with Ngāi Tahu.

(d) The new treatment plant be designed to produce wastewater that achieves the best quality wastewater available at the time, and that the design of the plant enable the potential future beneficial re-use of treated wastewater for domestic, commercial or agricultural purposes.

(e) Should suitable land become available, a land irrigation trial be costed and presented to the Council for consideration.

(f) Environment Canterbury be advised of the working party outcomes adopted by the Christchurch City Council.

3.2 The Council applied for consents in 2014 for a new wastewater treatment plant, a new terminal pump station in the Childrens Bay boat park, upgrades to the wastewater network and a new outfall to discharge treated wastewater into the middle of Akaroa Harbour.

3.3 Consents for the treatment plant, terminal pump station and network upgrades were granted, but those for the new harbour outfall and the wastewater discharge to the harbour were declined.

3.4 This was due to the cultural effects of a direct discharge of treated wastewater to the harbour and an assessment that the application had not sufficiently investigated alternative locations and options for disposal of treated wastewater.

3.5 With respect to the harbour disposal option, 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."

3.6 Since the outfall consent application was declined in 2015, we have explored many alternatives to discharging treated wastewater directly to the harbour. Three land-based options have been shortlisted, all of which involve irrigation of treated wastewater to new areas of native trees. The land-based options are the Inner Bays (Robinsons Bay, Takamātua and Hammond Point), or pump it over the hill to the Eastern Bays (Goughs Bay or Pompeys Pillar). The new harbour outfall remains an option.

3.7 Investigations considered a non-potable reuse network (purple pipe) in Akaroa so residents could use the highly treated water for garden watering or other non-potable uses such as toilet flushing. Currently this is not supported by the Ministry of Health due to a lack of New Zealand regulations and would require considerable effort from staff to pursue. However, using treated wastewater to irrigate public parks and flush public toilets is still an option, though this would only use about 4% of the wastewater.

3.8 A detailed record of these investigations, including site visits and meetings with the Ngāi Tahu parties and the Akaroa Treated Wastewater Reuse Options Working Party can be found in the Akaroa Wastewater Summary of Disposal and Reuse Options report (Beca, 2020).

3.9 Public consultation in July – August 2020 asked submitters:

a. If they prefer irrigation to land or a harbour outfall

b. Their order of preference for the land based options

c. If they support the irrigation of Council parks and reserves with treated wastewater

d. If they support Council exploring the feasibility of non-potable reuse for residential properties

3.10 The Hearings Panel must now consider the written and public oral submissions received, the information in the Akaroa Wastewater Summary of Disposal and Reuse Options report (https://www.ccc.govt.nz/assets/Documents/Consultation/2020/07-July/Akaroa-Wastewater/Akaroa-Wastewater-Summary-of-Disposal-and-Reuse-Options-Rev-3.pdf and https://drive.google.com/drive/folders/16U3jSPguKcumEZ_KKr0y8u1rLU6p-tnu), the joint statement of the Akaroa Treated Wastewater Reuse Options Working Party, (https://www.ccc.govt.nz/assets/Documents/Consultation/2020/07-July/Akaroa-Wastewater/Akaroa-

WWWP-Joint-Statement-final-Redacted-web-version.pdf) and the Ngāi Tahu statement (https://www.ccc.govt.nz/assets/Documents/Consultation/2020/07-July/Akaroa-Wastewater/Ngai-Tahu-Statement.pdf) to determine the most appropriate course of action for Council in these matters.

3.11 Following the hearings process and a Council resolution on the preferred solution for each question in paragraph 3.9, the chosen option will be subject to the Resource Management Act process, as the Council will need to apply for resource consents for whichever option is chosen. This will provide further opportunity for members of the community to provide further comments on the selected scheme will impact them. The environmental effects of the chosen option, including effects on the community, must be considered and appropriately addressed as part of the Resource Management Act process.

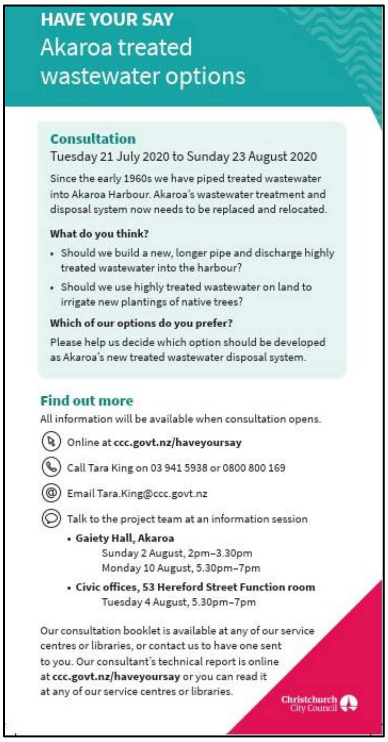
Community Views and Preferences / Ngā mariu ā-Hāpori

4. Public Consultation / Te Tukanga Kōrerorero

4.1 Community consultation on the Akaroa treated wastewater options project, was undertaken from Tuesday 21 July to Sunday 23 August 2020. It was then extended to 11.59 pm on Monday 24 August 2020. This was due to a system update un-expectantly closing the consultation a day early as it reverted the closing time to the default time of 12.00 noon on 23 August 2020.

4.2 The amended closing date and time for the consultation was communicated to the community via the Akaroa wastewater e-newsletter and with assistance from the Friends of Banks Peninsula group and with a message on the Council 'Have your Say" website on Monday 24 August. Emailed submissions were accepted over the entire weekend and up to the new closing date.

4.3 Approximately 2700 flyers were delivered to property owners in and around Akaroa Harbour. The flyer advertised the upcoming consultation, where people could view the full booklet and listed the public information sessions *(small flyer below)*.



4.4 The full consultation booklet (PDF)[1] and a link to the Council 'Have Your Say' website[2] was emailed to 776 key stakeholders when the consultation opened.

4.5 Hard copies of the booklet (refer to **Attachment B**) were made available at all Council libraries, service centres and at Civic offices.

4.6 The supporting technical report Akaroa Wastewater Summary of Disposal and Reuse Options (CH2M Beca, July 2020)[3] including all appendices[4] were made available on the 'Have Your Say' page. Also provided on that page were the joint statement of the Akaroa Treated Wastewater Reuse Options Working Party[5], the Ngāi Tahu statement[6] and the stream ecology report[7]. These are all important documents underpinning the consultation document.

4.7 The community were asked to respond to five questions:

- Should we discharge highly treated wastewater to land or the harbour?
- If the decision is made to irrigate to land, to rank from 1-3 their preference (1 being most preferred and 3 being least preferred). The choices being; Inner Bays (Robinsons Bay, Hammond Point, Takamātua) or Goughs Bay or Pompeys Pillar.
- Would they support us irrigating highly treated wastewater on public parks?
- Would they support us exploring further a purple pipe option for Akaroa?
- Is there anything else they would like us to consider?

4.8 At the request of the Friends of Banks Peninsula community group, 100 hard copy booklets were also left at the old post office in Robinsons Bay for locals to pick up. Booklets were also made available at the information sessions held during the consultation period.

4.9 Newsline articles were published to provide information on this project and encourage submissions on 17 July[8] and 18 August 2020[9].

4.10 The Newsline stories were also then posted on the Council social media channels. These posts could then be shared by the community.

4.11 A pre-engagement meeting was held with the Goughs Bay and Hickory Bay community on 19 December 2019, at their request, to provide specific information and answer questions about the Goughs Bay option to the community.

4.12 Pre-engagement meetings with the Robinsons Bay community were held, to provide specific information to the group on the Inner Bays option. These were held:

- Tuesday 7 July 2020 from 5.30 pm to 7 pm in the supper room at the Gaiety Hall in Akaroa.
- Monday 13 July from 5.30 pm to 7 pm in the supper room at the Gaiety Hall in Akaroa.

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[1] https://www.ccc.govt.nz/assets/Documents/Consultation/2020/07-July/Akaroa-Wastewater/WEB-Akaroa-treated-wastewater-options.pdf
[2] https://ccc.govt.nz/the-council/consultations-and-submissions/haveyoursay/show/316
[3] https://www.ccc.govt.nz/assets/Documents/Consultation/2020/07-July/Akaroa-Wastewater/Akaroa-Wastewater-Summary-of-Disposal-and-Reuse-Options-Rev-3.pdf
[4] https://drive.google.com/drive/folders/16U3jSPguKcumEZ_KKr0y8u1rLU6p-tnu
[5] https://www.ccc.govt.nz/assets/Documents/Consultation/2020/07-July/Akaroa-Wastewater/Akaroa-WWWP-Joint-Statement-final-Redacted-web-version.pdf
[6] https://www.ccc.govt.nz/assets/Documents/Consultation/2020/07-July/Akaroa-Wastewater/Ngai-Tahu-Statement.pdf
[7] https://drive.google.com/drive/u/0/folders/1vBF1w8-iOX7Vk7-N6YcSfU-QNhJ0vQkI
[8] https://newsline.ccc.govt.nz/news/story/four-options-for-akaroas-treated-wastewater
[9] https://newsline.ccc.govt.nz/news/story/feedback-on-akaroa-options-due-this-week

- Tuesday 14 July from 5 pm to 6.30 pm in the function room at Civic offices in Christchurch.

4.13 A community request was made for a specific meeting to also be held for the Takamātua community, to focus on the inner bays option. This was held on:

- Tuesday 21 July from 5.30 pm to 7 pm at the Gaiety Hall in Akaroa.

4.14 During the consultation period we held information sessions that covered all of the options being considered for the project. These were held:

- Sunday 2 August from 2 pm to 3.30 pm in the Gaiety Hall in Akaroa.
- Tuesday 4 August from 5.30 pm to 7 pm in the first floor meeting room in Civic Offices in Christchurch.
- Monday 10 August from 5.30 pm to 7 pm in the Gaiety Hall in Akaroa.

4.15 All of the information meetings offered to the community were very well attended with up to 85 attendees and the community appreciated having an opportunity to understand more about the project and ask questions. An independent facilitator was used to manage the meeting and to ensure that the community had both an opportunity to ask questions and also make comments about the project.

4.16 Any questions that were raised at the community information meetings were noted and many of these questions were then added to our 'commonly asked questions' information, which is available on the Council 'Have Your Say' page. http://www.ccc.govt.nz/assets/Documents/Consultation/2020/07-July/Microsoft-Word-Akaroa-Questions-Answers-10-August-2020.pdf

Community information meeting in the Gaiety Hall in Akaroa - 10 August 2020

5. Summary of Submissions / Ngā Tāpaetanga

5.1 At the close of consultation 341 submissions were received. This included submissions from these businesses and organisations:

- Fishermans Bay Co. Ltd (34150)
- Akaroa Health Hub (34148)
- Eyrie Trust, Takamātua (34138)
- Te Rūnanga o Ngāi Tahu (34134)

- Ōnuku Rūnanga (33961, 33691, 33917, 33904, 33693, 33694, 33695)
- Matapopore Charitable Trust (33860)
- Friends of Banks Peninsula (34115)
- Akaroa Harbour Recreational Fishing Club (Inc) (34070)
- Akaroa Civic Trust (34066)
- Robinsons Bay Bach Trust (34031)
- Robinson's Bay Ratepayers and Residents Association (33989)
- Heritage New Zealand Pouhere Taonga (33963)
- Takamatua Ratepayers Association (33936, 33733, 33593)
- Kingfisher Smoke House (33926)
- Akaroa On The Beach (34006)
- Pavitt Family Trust (33902)
- Department of Conservation (33883)
- Kingan Transport Ltd (33838)
- Canterbury District Health Board (33709)
- Mt Pleasant International Trust (33698)
- Cataliotti Wines (33632)
- Burrowes Holdings Limited (33560)
- Tresta Holdings Ltd (33545)
- Akaroa Salmon NZ Limited (33531)
- University of Otago and NZ Whale and Dolphin Trust (34366)
- Akaroa Ratepayers & Residents Association (34050)
- Tree Crop Farm (34151)
- Another Time Antiques (34000)
- Children’s Bay Farm (34105)
- Hickory Bay Farm Ltd (33611)
- Kimberley Farm Trading Trust (34086)

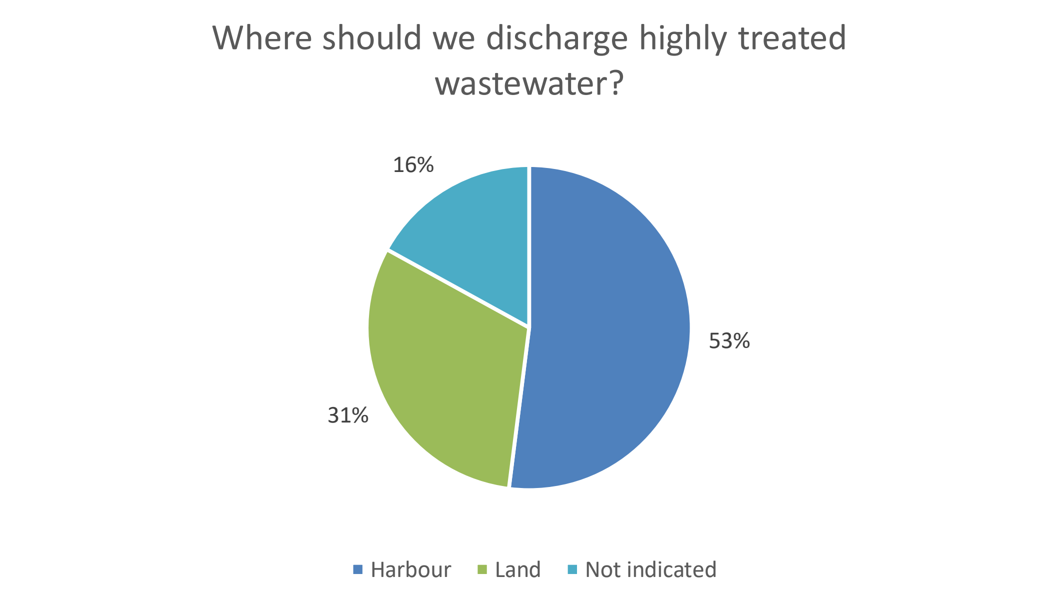
5.2 There were 22 submitters who in their own submission, also endorsed or mentioned supporting the Friends of Banks Peninsula submission (submission #34115).

5.3 The Friends of Banks Peninsula submission itself (pages 67-75), also lists 324 people who endorse their submission, not all of these made formal submissions.

Question 1 – Should we discharge highly treated wastewater from our new treatment plant to land or should we continue to discharge into Akaroa Harbour?

- At the close of consultation there were 179 submissions in support of discharging the highly treated wastewater to the harbour. There were 107 in support of discharging the highly treated wastewater to land and 55 who did not indicate an option.

Discharge to harbour	Discharge to land	Did not indicate	Total
179 (53%)	107 (31%)	55 (16%)	341 (100%)



6. Themes from those supporting discharge to the harbour

6.1 For those submitters who supported the discharge of highly treated wastewater to the harbour, the most frequent comments related to:

Comments	No. of comments	Submitter ID #
Need to reduce inflow and infiltration in the existing network (leaking and damaged pipes carrying wastewater)	27	33521, 33540, 33547, 33627, 33628, 33652, 33754, 33775, 33805, 33856, 33882, 33894, 33895, 33911, 33925, 33926, 33927, 33955, 33966, 34029, 34034, 34068, 34082, 34113, 34131, 34151, 34152
The harbour outfall is the only safe and feasible option	24	33554, 33555, 33664, 33754, 33783, 33843, 33856, 33873, 33898, 33926, 34017, 34021, 34050, 34053, 34076, 34084, 34091, 34106, 34113, 34143, 34148, 34163, 34166, 34169

Comments	No. of comments	Submitter ID #
The outfall should be extended out even further (beyond the heads)	23	34282, 33537, 33576, 33591, 33621, 33625, 33664, 33699, 33733, 33880, 33894, 33895, 33925, 33934, 33935, 33937, 34003, 34006, 34091, 34113, 34148, 34151, 34169
The wastewater should be treated to an even higher standard and discharged to the harbour	22	33521, 33615, 33652, 33699, 33702, 33744, 33805, 33882, 33886, 33894, 33895, 33911, 33925, 33926, 34003, 34017, 34021, 34029, 34050, 34068, 34091, 34152
The harbour outfall is the cheapest/most economical to ratepayers	14	34283, 33591, 33664, 33666, 33698, 33770, 33843, 33898, 34017, 34050, 34076, 34082, 34151, 34169,

6.2 Project team comments in relation to these are as follows (where relevant).

6.3 **Reduce inflow and infiltration issues** - We received feedback from the community about the importance of repairing the existing pipework, to ensure that there is less wastewater requiring treatment.

"We would suggest that the Council investigates further and targets substantial repairs and renewal of the existing wastewater network system to minimise the over capitalisation of the treatment plant." - Submitter #34082

Project team comments:

6.3.1 We agree that inflow and infiltration (I&I) in the wastewater network should be reduced as much as possible. Otherwise we are building an overly large and expensive scheme to pump, treat and dispose of large amounts of groundwater and stormwater.

6.3.2 We have undertaken a distributed temperature sensing survey of the Akaroa wastewater network. This pinpoints to the nearest metre any sources of stormwater inflow and groundwater infiltration, by measuring changes in temperature (groundwater and stormwater are colder than wastewater so a drop in temperature indicates cold water getting into the network via a fault). We therefore have a very good understanding of the faults in our network and those private laterals which have problems.

6.3.3 This is relatively new technology for identifying inflow and infiltration and provides much better information than traditional approaches. Traditionally it has been very difficult to get significant reductions in I&I without lining every pipe and every lateral in the network, which is very expensive.

6.3.4 To err on the side of caution, we have assumed that the work we plan to undertake to fix faults will result in a 20% reduction in I&I. This is based on the traditional approach. However, we are hopeful that with the much improved information we have from the distributed temperature sensing survey will mean that our targeted approach will be much more successful than the traditional approach, and that we will see much greater reductions in I&I than 20%.

6.3.5 It is important to note that a significant portion of I&I is from private properties and our assumed reduction in I&I of 20% does not rely on private property owners fixing their faults. However, we will be actively engaging with property owners with faulty laterals and requiring them to resolve their issues.

6.3.6 We will be able to measure the effectiveness of the work using the flow meters that we have at each pump station and at the treatment plant. We will then use these revised flows for the design of the new wastewater scheme.

6.3.7 The work to reduce I&I in Akaroa is being funded from the Government's 3 Waters Stimulus Funding, with a budget of $3.1 million. This is currently included in the cost estimates for each of the land based options (see Appendix AD Cost Estimates of the Beca report). Now this work is being funded by the Government it can be deducted from these cost estimates. The revised cost estimate range for each option is shown in Table 1.

Table 1 - *Comparison of Proposed Wastewater Treatment Plant and Reverse Osmosis*

Option	1	2	3	4
	Inner Bays Irrigation Scheme	Goughs Bay Irrigation Scheme	Pompeys Pillar Irrigation Scheme	Mid-Harbour Outfall
Low end cost estimate	$51 million	$58 million	$63 million	$45 million
High end cost estimate	$59 million	$67 million	$73 million	$52 million

6.4 **<u>Extension of the harbour outfall</u>** - Requests were made by some of the community to extend the harbour outfall even further, to lessen the risk of polluting the harbour.

"I understand the reluctance of having a harbour outfall pipe in the inner harbour. So ask why a longer outfall pipe that reaches beyond the heads is not considered. Wastewater from Christchurch City is piped out into the sea of the New Brighton shore." -Submitter #34091.

Project team comments:

6.4.1 The proposed outfall option has a 1.2 km marine pipeline to discharge in the mid-harbour to ensure dilution of discharged water and adequate flushing of discharged water out of the harbour. The cost estimate for this pipeline is $14.5 million.

6.4.2 The option of an outfall past the heads of Akaroa Harbour was considered in the report Akaroa Wastewater Selected Options 2008 (MWH, 2008)10.

6.4.3 This report advised that an outfall length of approximately 11 km would be required to ensure the outlet diffusers were located beyond the proposed (now existing) marine reserve. The report noted:

- *A major uncertainty is the nature of the sea bed and its suitability for construction of an outfall and securing it to the seabed. The Akaroa Harbour marine chart notes that the Harbour entrance has "generally heavy ground swell" and "Loose seabed, bad*

[10] https://ccc.govt.nz/assets/Documents/Services/Wastewater/Akaroa-Wastewater-Selected-Options-2008-MWH-October-2008.PDF

holding ground". The heads of Akaroa Harbour face southward and are expected to experience significant water currents and swells, particularly during bad weather.

6.4.4 A pipeline extending down the harbour terminating beyond the harbour heads would also be in significantly deeper water (greater than 40m deep) and in an area of strong current. This introduces significant cost, technical and construction safety risks. As a comparison the Christchurch ocean outfall is 18m deep.

6.4.5 The cost estimate in the MWH 2008 report for the ocean outfall pipeline was $28 million to $47 million.

6.4.6 The MWH report concluded that while an ocean outfall would remove the discharge from the harbour, the capital costs for an ocean outfall were significantly higher than other disposal options, with land disposal being the most technically and economically feasible option for removing the discharge from the harbour. The report recommended land disposal be investigated further, which the Council then did.

6.4.7 The Council's senior cost engineer has reviewed the cost estimate for an outfall beyond the Akaroa Heads and advised that it would be $63 million to $73 million in 2020 dollars, with the overall scheme cost estimate ranging from $91 million to $104 million. This is $18 million to $46 million more than any of the options consulted on, and $56 million to $69 million more than the Long Term Plan budget of $35 million.

6.4.8 In addition to the high cost and technical risks, this would still constitute a direct discharge of wastewater to marine water. The adverse effect on the Ngāi Tahu parties' cultural values would be high. The New Zealand Coastal Policy Statement and the Regional Coastal Environment Plan aim to avoid the discharge of treated human waste into water in the coastal environment, unless there has been adequate consideration of alternative methods. An ocean outfall may not be sustainable management under the Resource Management Act.

6.4.9 Therefore, because of the technical, cultural, cost and consenting risks, staff recommend that an ocean outfall beyond the Akaroa Heads is not considered any further.

6.5 **Higher standard of treated wastewater** - There were a number of submitters who would support the highly treated wastewater being even more highly treated before it is discharged to Akaroa harbour.

"This should involve a high level of treatment (eg. reverse osmosis) which would eventually allow various levels of reuse and/or release to streams or the harbour via a wetland." - Submitter #34068.

Project team comments:

6.5.1 The proposed treatment process for all options is of an extremely high standard and staff are not aware of any wastewater schemes in New Zealand that deliver a greater level of treatment, except for nutrient (nitrogen and phosphorus) removal.

6.5.2 A number of submissions have promoted reverse osmosis which would be in addition to the ultra-filtration treatment process already proposed. To our knowledge, reverse osmosis is only used in areas that are extremely short of fresh water for drinking-water and need to use seawater or stormwater as a source of drinking-water (e.g. cruise ships, Perth, Singapore). The waste stream from the treatment process is discharged to the sea.

6.5.3 Table 2 compares the treated wastewater standard of the proposed treatment plant with reverse osmosis. It can be seen that the pore size for reverse osmosis is 10 – 100 times smaller than for ultrafiltration. Both processes would remove protozoa, bacteria and larger viruses. Reverse osmosis would remove smaller viruses and salt. Ultrafiltration may also remove small viruses depending on the unit chosen, but it would not remove salt. Neither process would remove ammonia.

Table 2 *- Comparison of Proposed Wastewater Treatment Plant and Reverse Osmosis*

	Proposed Ultrafiltration Plant Removes	Reverse Osmosis Removes	Millionths of a mm (µm or micron)	Number of Water Molecules in a Row
Pore size – ultrafiltration			10	35
Pore size – reverse osmosis			0.1 – 1	0 – 4
One millimetre particle	✓	✓	1,000,000	3,508,772
Protozoa (large)	✓	✓	500,000	1,754,386
Human hair	✓	✓	17,000	59,649
Protozoa (small)	✓	✓	5,000	17,544
E.coli	✓	✓	1,000	3,509
Wavelength of green light	✓	✓	550	1,930
Virus Cell (Big)	✓	✓	400	1,404
Virus Cell (Covid 19)	✓	✓	65	228
Virus Cell (Small)	Dependent on filter unit chosen	✓	10	35
Salt (NaCl)	X	✓	0.700	2.5
Alcohol molecule	X	Dependent on filter unit chosen	0.440	1.5
Water molecule	X	X	0.285	1.0
Ammonia	X	X	0.260	1.0
Volume of concentrated waste stream (m^3/year)	1,040	62,400	-	-

6.5.4 Reverse osmosis treatment would introduce a number of significant problems. Key issues would be:

- The reverse osmosis process is highly energy intensive, requiring a similar amount of energy to pumping over the 670 m high hill to the Eastern Bays. It would require an additional \$80,000 - \$120,000 of electricity per year compared to ultra-filtration. This would significantly increase the operational cost and carbon footprint of the wastewater treatment plant. It would also increase the capital expenditure by around \$4 million.
- Approximately 20% - 40% of the water treated by reverse osmosis must be discharged as a waste stream and will carry all of the contaminants removed from the cleaned portion of flow. This waste stream would need to be discharged to land or harbour.
- For Akaroa, the waste stream from the proposed treatment plant would be 1,040 cubic metres per year and it is proposed to transport this by tanker to the Christchurch wastewater treatment plant for processing into biosolids, which is

about one tanker per week. For reverse osmosis the waste volume would increase to 62,400 cubic metres per year. This would require 60 tanker trips per week, which would be expensive and have negative impacts on the road and increase our carbon footprint. We do not support this option.

- Alternatively the waste stream would need to be disposed of locally to land or to the harbour. This would require resource consent and would be more problematic than disposing of the treated wastewater to land or harbour, because the environmental effects would be greater.
- The Council would also need to decide what could be done with the remaining 60% - 80% of clean water from the reverse osmosis process. This water would be no more culturally acceptable to discharge directly to water (to the harbour, a stream or groundwater) than that of the proposed process.

6.5.5 There is therefore no obvious benefit in using reverse osmosis and several disadvantages. The proposed treatment process is appropriate for the receiving environment (land or harbour) and we do not support a higher standard of treatment.

7. Themes from those supporting discharge to land

7.1 For those submitters who supported the discharge of highly treated wastewater to land, the most frequent comments related to:

Comments	No. of comments	Submitter ID #
Importance of protecting the harbour	22	33557, 33558, 33626, 33692, 33693, 33697, 33768, 33844, 33845, 33853, 33854, 33859, 33833, 33916, 33917, 33919, 33929, 33931, 33988, 34095, 34134, 34336
Biodiversity	13	33559, 33578, 33590, 33665, 33672, 33692, 33729, 33768, 33810, 33845, 33883, 34089, 34134
Community education	7	33578, 33665, 33729, 33810, 33869, 34089, 34134
Climate change	6	33578, 33590, 33672, 33729, 33982, 34134

7.2 Project team comments in relation to these are as follows (where relevant).

7.3 **<u>Protecting the harbour</u>** - The most common reason for submitters selecting the land option, related to a desire to protect the harbour.

"Clean water and a harbour rich in mahinga kai is surely an aspiration we all share."- Submitter #33988.

Project team comments:

7.3.1 We recognise this as a fundamental principal for all options and have proposed an extremely high level of treatment to support this for all of the consultation options.

7.3.2 We agree that it is preferable to discharge the treated wastewater to land as it protects the harbour and supports the cultural needs and aspirations of Ngāi Tahu, including mahinga kai.

7.4 **Biodiversity** - There were also a number of comments relating to biodiversity being a benefit of a land based option.

"Enhancement of indigenous biodiversity by establishment of new habitats in wetland and irrigated areas." - Submitter #34134

Project team comments:

7.4.1 We agree that increased biodiversity is an advantage of the land based options, as the planted areas of native trees will create habitat for birds and insects.

7.5 **Community education** - Other positives of a land based option recognised by submitters, relates to opportunities for more education of the area.

"The inner harbour option provides unique opportunities for connecting with the landscape. It creates new environments and ecosystems in the development. It allows visitors and residents to Akaroa better understand the resource of water, our relationship with it, and a platform to educate on these." - Submitter #34089

Project team comments:

7.5.1 We agree that this is an advantage of the land based options.

7.6 **Climate change** - There were other submitters who believed there was a benefit of a land based option in relation to climate change.

"Of all the benefits/issues raised locally, the one that seems to have had the least 'airtime' is also the most important to me – namely the long term environmental benefits of a land based solution, particularly the uptake of carbon by irrigated trees and the development of a wetland as part of the land based solutions." - Submitter #33672.

Project team comments:

7.6.1 We agree that the native trees storing carbon dioxide and reducing our greenhouse gas emissions is an advantage of all three land based options.

7.6.2 In the context of the Council goal of being carbon neutral by 2030 and the district being carbon neutral by 2045, the land based options present a significant opportunity in achieving carbon offsets as a part of that goal.

8. Themes from those who did not indicate a preference

8.1 For those submitters who did not tick either of these boxes to indicate whether they supported a discharge to land or to the harbour, the most frequent comments related to:

Comments	No. of comments	Submitter ID #
Support for reduce, recycle and re-use of the wastewater	22	33857, 33862, 33877, 33957, 33971, 34005, 34031, 34039, 34041, 34046, 34066, 34081, 34086, 34093, 34094, 34100, 34103, 34104, 34105, 34107, 34111, 34115
Need to reduce inflow and infiltration in the existing network (leaking and damaged pipes carrying wastewater)	21	33732, 33738, 33781, 33852, 33862, 33902, 33920, 33957, 33989, 33993, 33994, 34005, 34041, 34042, 34045, 34047, 34048, 34103, 34104, 34116, 34136
All of the options are too expensive	19	33732, 33738, 33781, 33877, 33957, 33989, 34039, 34041, 34042, 34047, 34086, 34103, 34104, 34114, 34115, 34116, 34132, 34136, 34171
Support re-use with water treated at a potable standard	18	33730, 33738, 33781, 33920, 33957, 33989, 33933, 33994, 34005, 34031, 34039, 34047, 34066, 34081, 34101, 34104, 34166, 34138

8.2 Project team comments in relation to these are as follows (where relevant).

8.3 **Reduce, recycle and re-use of the wastewater** - Many submitters did not support any of the options being considered and instead supported the ‘Friends of Banks Peninsula’ submission, which was based on reducing, recycling and re-use of the wastewater.

“We support Friends of Banks Peninsula submission and implementing action steps.” -Submitter #33932

8.4 The friends of Banks Peninsula (FOBP) submission suggested an integrated solution with four stages:

- Stage 1: Reduce I&I, get consents for additional new components of the wastewater system, retain plant at Takapūneke and outfall until stage 3.
- Stage 2: Build new treatment plant at Old Coach Road, with small buffer pond, larger wetland and purple pipe. Takapūneke treatment plant closes, but existing outfall still functions (interim solution). Decision made on stage 3 and consents sought.
- Stage 3: Harbour outfall ceases, either through development of recycling or extended re-use.

- Stage 3 Option A: (preferred option) Treatment upgraded to potable, provides opportunities for managed aquifer recharge (MAR) stream recharge or disposal of potable water to the harbour via coastal infiltration.
- Stage 3 Option B: If treatment not to potable standard, then purple pipe is extended to more of Akaroa, and harbour discharge is replaced by coastal infiltration.
- Stage 4: Potable supply recharge upstream from water intake.

Project team comments:

8.4.2 The intention of the submission appears to be to suggest combining a range of opportunities that reduce the demand on a harbour outfall. It does not support irrigation to land. We respond to the various aspects of the proposal in the submission as below.

- *Stage 1: Reduce I&I, get consents for additional new components of the wastewater system, retain plant at Takapūneke and outfall until stage 3.*

8.4.3 We agree that I&I should be reduced and have a project underway to achieve this using Government funding, as described in paragraphs 6.3.1 - 6.3.7. We have already applied for consents to continue using the existing wastewater treatment plant Takapūneke while the new wastewater scheme is consented, designed and built, with a requested consent term of eight years.

- *Stage 2: Build new treatment plant at Old Coach Road, with small buffer pond, larger wetland and purple pipe. Takapūneke treatment plant closes, but existing outfall still functions (interim solution). Decision made on stage 3 and consents sought.*

8.4.4 The buffer pond has been sized to allow peak flows from storm events to be contained and provide time for the new wastewater treatment plant to process the high flows. This means the wastewater treatment capacity and scheme cost is optimised, as it would be much more expensive to build a wastewater treatment plant to treat peak flows.

8.4.5 The buffer pond will have a volume of 1,000 cubic metres and will be lined, covered and have odour treatment. It will take up approximately 10% of the available flat land on the land that the Council owns on Old Coach Road opposite the proposed treatment plant.

8.4.6 Reducing the size of the buffer pond would mean there is less ability to store peak flows. This would increase the frequency of screened wastewater overflows from the Akaroa network. We therefore do not support building a smaller buffer pond than is proposed.

8.4.7 This problem could be minimised by increasing the processing capacity of the treatment plant to compensate for the lost buffer storage; a 500% increase in capacity would, for instance, remove the need for approximately 90% of the buffer capacity. However the saving in storage pond costs would be $100,000 - $150,000 whilst the increased capital cost of processing capacity would be in excess of $500,000.

8.4.8 The wetland with a 2-3 day retention time proposed in this submission is very similar to the subsurface wetland option that was consulted on in 2016, although the discharge in that case was via a coastal infiltration gallery rather than a harbour outfall. Of the 81 submissions received, only one person supported the wetland. It was not supported by the Ngāi Tahu parties as it didn't provide sufficient meet their cultural needs and aspirations, as it didn't provide additional treatment and restore the mauri of the water.

8.4.9 The wetland proposed in Option 1 Inner Bays would normally have a retention time of around two weeks for the occasional discharge proposed. If all treated wastewater was to pass through a wetland before being discharged, a retention time of two weeks would require the wetland to have an area of 16 hectares. This would need to be built on relatively flat land to avoid excessive earthworks. Based on previous investigations for storage pond sites, suitable flat land is very limited and it is unlikely that there is enough suitable land within the Inner Bays to accommodate such a wetland.

8.4.10 Increasing the size and scope of a purple pipe “reuse” network could use up to 10% of the annual volume of treated wastewater. Most of this would be used in summer for watering gardens. The volume would be much less in winter, as there is no need for garden irrigation and the population is much lower.

8.4.11 To continue using the existing harbour outfall, the purple pipe reuse pipeline would need to be extended a further 4.5 km than currently planned. This would be at an additional cost of $6.4 million to $8.4 million.

- *Stage 3A: Treatment upgraded to potable, provides opportunities for managed aquifer recharge (MAR) stream recharge or disposal of potable water to the harbour via coastal infiltration.*

8.4.12 For the reasons explained in 6.5.1 to 6.5.5, a higher standard of treatment such as reverse osmosis would significantly increase the capital and operating cost of the wastewater scheme. It also comes with other problems, such as what to do with the large volume of concentrated waste stream.

8.4.13 Additionally, reverse osmosis may not be a sufficient level of treatment for the water to be considered potable. Contaminants smaller than a water molecule (e.g. some pesticides) still remain in the water. Additional treatment steps may be required to remove these.

8.4.14 For the reasons explained in section 3.9 of the Beca options report (with supporting documents in Appendix F), managed aquifer recharge is not a viable option for Akaroa.

8.4.15 Also, it’s highly unlikely that the short retention wetland proposed would alleviate the cultural concerns of the Ngāi Tahu parties of a direct discharge of treated wastewater to water (either to the stream or to groundwater via managed aquifer recharge).

8.4.16 Discharge via a coastal infiltration gallery from at the end of Takamātua Peninsula after passing through a short retention land based system (subsurface wetland or infiltration basins) were put forward as options in the public consultation undertaken in 2016. Out of 81 submissions, only one person supported the wetland option and nobody supported the infiltration basin option. Neither option was supported by the Ngāi Tahu parties as the options didn’t meet their cultural needs and aspirations, as they didn’t provide additional treatment and restore the mauri of the water. Therefore these options were discounted due to lack of support from the community and the Ngāi Tahu parties.

8.4.17 We therefore do not view this as a feasible option.

- *Stage 3 Option B: If treatment not to potable standard, then purple pipe is extended to more of Akaroa, and harbour discharge is replaced by coastal infiltration.*

8.4.18 As explained in the consultation document and in section 9.5 of the Beca options report, there is no regulatory framework in New Zealand for non-potable reuse. CDHB provided feedback advising that it and the Ministry of Health did not support non-potable reuse (Appendix G of the Beca report). The Canterbury District Health Board says in its submission (33709) that it “supports the concept of non-potable reuse of treated wastewater however due to the current lack of regulatory framework around the public health risks we do not support this proposal at this stage, particularly in respect of private household use in Akaroa." Without New Zealand regulations, it would therefore be very difficult to obtain approval to implement a non-potable reuse scheme in Akaroa. Therefore, there is no certainty that the suggestion to extend the purple pipe to more of Akaroa is achievable.

8.4.19 As discussed in paragraph 8.4.16, discharge via a coastal infiltration gallery was consulted on in 2016 and was not supported. We therefore do not view this as a feasible option.

- *Stage 4: Potable supply recharge upstream from water intake*

8.4.20 The Havelock North Drinking Water Inquiry Stage 2 report[11] describes six fundamental principles for safe drinking water and these have been incorporated into the Guideline for Drinking-water Quality Management for New Zealand (Ministry of Health, 2017) and our revised water safety plans, including the Akaroa/Takamatua water safety plan.

8.4.21 Principle 2 is that protection of source water is of paramount importance. Protection of the source of drinking water provides the first, and most significant, barrier against drinking water contamination and illness. It is of paramount importance that risks to sources of drinking water are understood, managed and addressed appropriately.

8.4.22 Adding treated wastewater to the source water for Akaroa's water supply goes against this fundamental principle for ensuring safe drinking-water. The direct discharge of treated wastewater to source water for drinking-water would also have adverse cultural effects.

8.4.23 It would also contrary to Goal 2 of the Council's Te Wai Ora o Tāne Integrated Water Strategy, that water quality and ecosystems are protected and enhanced, which includes protecting groundwater sources from contamination.

8.4.24 We therefore do not view this as a feasible option.

8.5 **Reduce inflow and infiltration issues** - This was the next topic most commented on, to support the repair of existing pipes and other infrastructure to reduce the flows entering the system and then requiring treatment.

"The Akaroa wastewater network is in extremely poor condition, with excessive levels of inflow and infiltration (I&I). This increases costs and reduces resilience; this should be dealt with before developing a new treatment plant and disposal."- Submitter #34104

Project team comments:

8.5.1 We agree with the suggestions to reduce inflow and infiltration as explained in paragraphs 6.3.1 to 6.3.7.

[11] https://www.dia.govt.nz/diawebsite.nsf/Files/Report-Havelock-North-Water-Inquiry-Stage-2/$file/Report-Havelock-North-Water-Inquiry-Stage-2.pdf

8.6 **All of the options are too expensive** - There were submitters who had concerns about how expensive all of the options were, which made it challenging for them to choose any of the options.

"I do not support any of the options. They are all extremely expensive. For that sort of expenditure the Council should be aspiring to a truly sustainable and future-focussed system." - Submitter #34132

Project team comments:

8.6.1 We acknowledge that all of the options are more expensive than the $35 million budget allocated for this project in the Long Term Plan. Additional budget will need to be provided in the 2021 – 2031 Long Term Plan for whichever option the Council chooses.

8.6.2 In making its decision, the hearings panel needs to consider the economic, cultural, social and environmental well-beings of communities both in the present and for the future, as set out in the purpose of the local government in section 10 of the Local Government Act (and also referenced in the principles section 14).

8.7 **Support re-use to a potable (drinking water) standard** - Having the wastewater treated to an even higher standard so that it was potable, was requested by a number of submitters.

"Reverse osmosis was considered for this purpose but discounted on cost, however the actual costs have never been presented, and experiences elsewhere suggest it carries a similar cost to ultrafiltration. Similarly, the disposal of retentate has been sited as an issue, but has not been adequately explored, and there are solutions available."- Submitter #34104

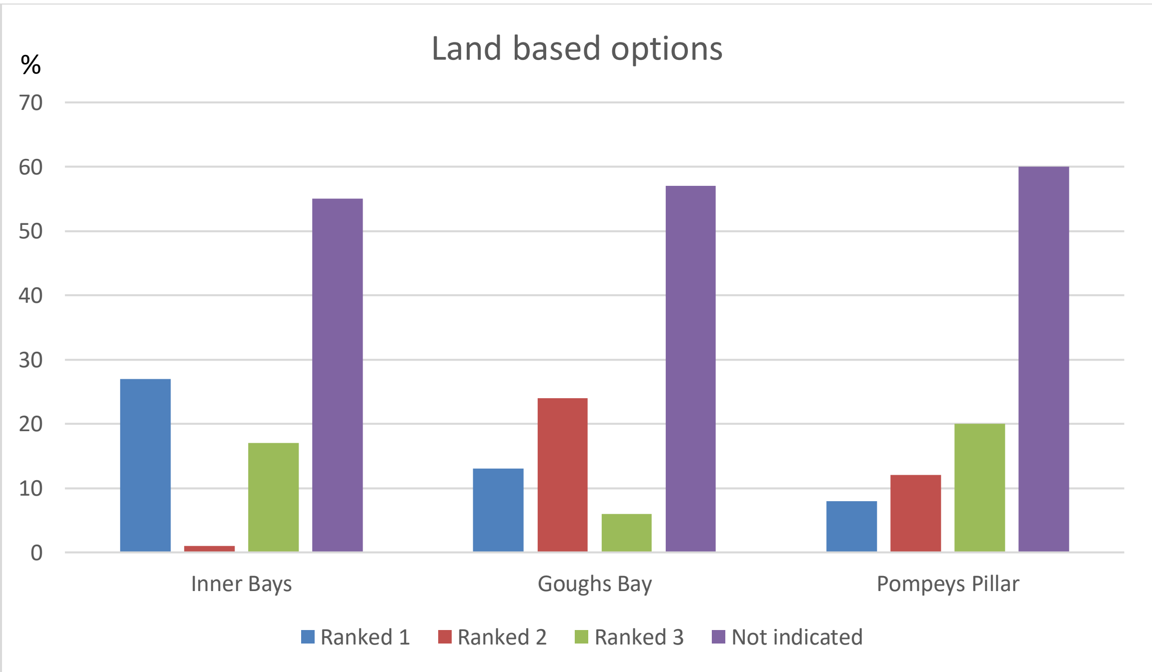
Project team comments:

8.7.1 Please refer to paragraphs 6.5.1 to 6.5.5 for our comments on this.

Question 2 – If the Mayor and Councillors decide to develop a scheme where highly treated wastewater is used on land for irrigation, where would you prefer we irrigated? Please rank your preference from 1 being your preferred and 3 being your least preferred.
- Inner Bays (Robinsons Bay, Hammond Point, Takamātua)
- Goughs Bay
- Pompeys Pillar

- At the close of consultation there were 92 submitters who ranked the Inner Bays option as their most preferred land-based option, 46 submitters who ranked Goughs Bay as their most preferred option and 29 submitters who ranked Pompeys Pillar as their most preferred option. There were 166 submitters who did not tick any of these boxes.

Option	Ranked 1	Ranked 2	Ranked 3	Not indicated	Total
Inner Bays	92 (27%)	3 (1%)	59 (17%)	187 (55%)	341 (100%)
Goughs Bay	46 (13%)	82 (24%)	19 (6%)	194 (57%)	341 (100%)
Pompeys Pillar	29 (8%)	40 (12%)	67 (20%)	205 (60%)	341 (100%)



9. Themes from the Inner Bays irrigation scheme option

9.1 The most common reasons that submitters supported the Inner Bays irrigation scheme option included:

Comments	No. of comments	Submitter ID #
This option protects the harbour	24	33531, 33558, 33626, 33692, 33693, 33696, 33697, 33711, 33768, 33844, 33845, 33859, 33883, 33904, 33916, 33917, 33919, 33929, 33931, 33982, 33988, 34108, 34127, 34170
This option has positive amenity and ecological enhancement	18	33939, 34136, 34137, 33559, 33578, 33588, 33665, 33692, 33729, 33751, 33810, 33853, 33883, 33982, 34035, 34089, 34108, 34134
This option creates recreational opportunities	10	33939, 33963, 34136, 34137, 34138, 33578, 33588, 33751, 33810, 34035
This option has good carbon capture	7	34005, 33578, 33590, 33672, 33729, 33982, 34134
This option is the best long term option	6	33672, 33729, 33844, 33853, 33931, 33982
This option is the most resilient	5	33590, 33729, 33853, 33982, 34134
This option creates good educational opportunities	5	33963, 33578, 33665, 33810, 34089

9.2 Project team comments in relation to these are as follows (where relevant).

9.2.1 The project team agree that these are all relevant benefits for the Inner Bays option.

9.3 The most common reasons that submitters did not support the Inner Bays irrigation scheme option included:

Comments	No. of comments	Submitter ID #
Too risky with soil conditions and risk of landslides or flooding	34	33521, 33652, 33782, 33783, 33873, 33955, 34016, 34283, 33537, 33621, 33698, 33702, 33754, 33882, 33928, 34024, 34053, 34076, 34083, 34091, 34099, 34118, 34163, 33781, 34039, 34041, 34046, 34093, 34103, 34104, 34124, 34138, 33930, 34095
This option will devalue properties and make them difficult to sell	34	33521, 33652, 33666, 33783, 33838, 33955, 34016, 34283, 33699, 33762, 33770, 33882, 33999, 34008, 34024, 34026, 34033, 34034, 34068, 34091, 34099, 34141, 34163, 34169, 33932, 34039, 34045, 33857, 33989, 34081, 34086, 34093, 34166, 34080,
Risk of contamination (streams, water bores and existing streams)	32	33652, 33777, 33782, 33838, 33873, 33955, 34283, 33537, 33621, 33699, 33744, 33882, 33937, 34011, 34033, 34034, 34068, 34074, 34099, 34113, 34141, 34143, 33932, 34039, 33857, 33862, 33960, 33989, 34046, 34093, 34166, 34115
Ponds will create insect and midge issues	27	33666, 33843, 33873, 33955, 34016, 34283, 33537, 33651, 33754, 33928, 34008, 34011, 34024, 34034, 34099, 33932, 34039, 34045, 33857, 34081, 34086, 34093, 34166, 34122, 34124, 33705, 34080
Risk with the pond leaking or bursting and flooding	26	33777, 33783, 33843, 33873, 33955, 34283, 33762, 33822, 34024, 34026, 34141, 34169, 34039, 34045, 33857, 33862, 33902, 34081, 34086, 34101, 34103, 34115, 34112, 34124, 34138, 34080
Option too expensive	23	33777, 34283, 33651, 33690, 33698, 33841, 33882, 33894, 33926, 34034, 34076, 34099, 34169, 33781, 33732, 33738,

Comments	No. of comments	Submitter ID #
		33989, 34046, 34086, 34104, 34114, 34122, 34132
Visual effects of looking at storage ponds, large native trees and treatment plant	22	33521, 33652, 33666, 33805, 33838, 33651, 33699, 33936, 34091, 33932, 34045, 33862, 33902, 34066, 34081, 34086, 34093, 34115, 34138, 34010, 34080, 34095
Storage ponds too large	21	33521, 33652, 33805, 34016, 33621, 33651, 33702, 33762, 33894, 33936, 34076, 34091, 34143, 34147, 33932, 34045, 33857, 34103, 34115, 34080, 34095
This option is not reuse, is dumping of wastewater	17	33521, 33652, 33782, 33805, 33936, 33781, 34045, 33738, 33989, 34086, 34103, 34104, 34114, 34115, 34132, 34080, 34095
Negative effects on historical sites – Pavitt Cottage and old sawmill site	17	33777, 33805, 34016, 34283, 33523, 33524, 33762, 33882, 34026, 34141, 33738, 33857, 33892, 33902, 34066, 34081, 34115
No option to at least offer a reticulated system to inner bays properties	11	33777, 34283, 34026, 34099, 34106, 34045, 33738, 33989, 34092, 34103, 34080

9.4 Project team comments in relation to these are as follows (where relevant).

9.5 **Risk of landslides and flooding with irrigation onto inner bays soils** – There were concerns from the community that existing land would be at risk of landslides and flooding if it was continually irrigated, due to the type of soils in the area.

9.6 *“The land in inner bays is unstable, prone to flooding, has poor drainage and is most unsuitable for irrigation schemes. Waterlogged soils would cause massive problems and many landowners would be affected.”- Submitter #34053*

Project team comments:

9.6.1 Section 4.1 of the Beca options report describes the selection criteria that were used to identify land that could be suitable for irrigation. This included a slope criteria of no more than 19 degrees for areas planted with trees, and no more than 15 degrees for areas downslope of the potential irrigation area. This is in accordance with the Process Design Manual for Land Treatment of Municipal Wastewater (USEPA, 2011).

9.6.2 Site visits and field investigations of the areas proposed for irrigation were undertaken by geotechnical engineers from Beca and environmental scientists from PDP, to confirm that the land was suitable for irrigation and that it would not create instability issues. These are described in section 5.3 of the Beca report, with supporting information in Appendix L (Inner Harbour Investigations) and Appendix M (Hammond Point Geotechnical Assessment).

9.6.3 The slope limit of 15 degrees for trees was endorsed in the third Joint Statement of Technical Experts12 (which included technical experts for the Council, the Ngāi Tahu parties and Friends of Banks Peninsula) dated 26 April 2017.

9.7 **Devaluing of properties** - There was concern from some of the community about losing value in their properties, due to the construction of the Inner Bays irrigation scheme option.

"It will/and already has effected our property value." - Submitter #34034

Project team comments:

9.7.1 Assertions of concern about diminution in property value is not evidence that it is going to happen. Valuation information would need to be provided by a submitter regarding a reduction in property value (not just a simple assertion) for the hearings panel to put any weight on the submission. The hearings panel should note that the Public Works Act 1981 provides for compensation to be made where substantial injuries affection to a person's land is caused by the construction of any public work.

9.7.2 Taking into account effects on property values in addition to the effects on amenity values is, as the Court has found in the Resource Management Act context, double counting of the impact on amenity values.

9.7.3 We note that some community members have suggested that large planting of native trees in the areas may have benefits and increase property values. These assertions would also need to be addressed in a valuation report.

9.8 **Risk of contamination** - There were comments relating to the risk that could be created from contaminating streams, private water bores and natural springs if the inner bays option were to go ahead.

"The effect on the land adjoining the proposed ponds in Robinsons Bay would be disastrous as the property is organic and any leakage/overflow/flooding would contaminate that land and all the land in its' path ruining any crops/buildings in its' way." - Submitter #34011

Project team comments:

9.8.1 As described in Section 9.2 of the Beca options report, the wastewater will be treated to a very high standard. Appropriate irrigation rates have been selected by PDP based on infiltration testing at the proposed sites, as described in Section 4.2 and Appendix L of the Beca options report.

9.8.2 Professor Brett Robinson from the University of Canterbury and his students have been undertaking a trail irrigating planted native trees with treated wastewater from the Duvauchelle wastewater treatment plant (which is of a lower quality than is proposed for Akaroa) at a rate of 1000 mm per year (compared with an average rate of 572 mm per year for the Inner Bays irrigation scheme) (see Attachment C for a copy of the report). The key conclusions from this report were:

[12] https://ccc.govt.nz/assets/Documents/Services/Wastewater/Akaroa-Wastewater-Irrigation-of-Treated-Wastewater-to-Land-Joint-Statement-of-Technical-Experts-No-3.pdf

- Nitrate-nitrogen leached at rates of 2 – 47 kilograms per hectare per year, which is similar to grazed pasture.
- There was no evidence of phosphorus accumulation in the soil, probably because the amount that was added from the wastewater was small compared to the amount of phosphorus already in the soil profile.
- Soil concentrations of heavy metals were not affected by wastewater irrigation and the concentrations of these elements were similar to background values reported for Canterbury soils.

9.8.3 Therefore adverse effects on streams and springs are not expected. If this option is chosen, potential effects on the environment will be investigated further as part of the Assessment of Environmental Effects for the resource consent applications. This will include an assessment of effects on any nearby private water supplies. We may need to provide additional water treatment for these households.

9.9 **Ponds will create insect/midge issues** - Submitters raised concerns about the risk of the ponds creating issues with insects or midges in the area.

"What right does council have to introduce a midge problem on our property boundary destroying our quality of outdoor living." - Submitter #34099

Project team comments:

9.9.1 As described in section 5.4.2 of the Beca options report, experience elsewhere suggests that if the wastewater is treated to a very high standard, then a natural balanced ecology system will establish, and midges are less likely to breed uninterrupted and become a nuisance to neighbours.

9.9.2 Midges used to be a problem in the maturation ponds at the Christchurch wastewater treatment plant at Bromley where conditions in those ponds are an ideal habitat for midges. The ponds receive wastewater that is treated to a much lower standard than is proposed for Akaroa. The ponds are not lined but have a sandy base. Suspended solids in the wastewater settle out as sludge on the base of the ponds and the midges breed in the sludge on the base of the ponds. In recent years, operational measures have been put in place (such as dragging chains along the base of the pond to disturb the midge larvae). This has significantly reduced complaints about midges by 73 per cent, with only two complaints received last year.

9.9.3 The storage ponds proposed at Robinsons Bay are unlikely to have problems with midges because:

- The ponds would have a polyethylene liner and the lack of suspended solids in the treated wastewater would mean that sludge would not build up in the base of the pond, which is much less suitable for midge larvae.
- The ponds would have a depth ranging from 3 metres in winter to empty in summer, which would significantly disrupt the larvae stage of the midge lifecycle
- Because there are two ponds, the ponds would be able to be regularly cycled to empty during summer which would disrupt the midge breeding cycle.

9.9.4 Therefore, we do not expect midges to be a nuisance to the neighbours. Potential effects on neighbours, including nuisance effects, will also be dealt with at the resource consent stage.

9.10 **Risk of storage ponds leaking or bursting** - A number of comments were made expressing concern about what could happen if the storage ponds leaked or burst.

"Vehemently opposed to the proposed sewage ponds in Takamatua and Robinsons Bay which will have a negative effect on our land value and will create an environmental disaster to historic Pavitts Cottage if the ponds are breached." - Submitter #33762

Project team comments:

9.10.1 Section 5.4 of the Beca options report describes the proposed storage ponds at Robinsons Bay. The ponds would be built to meet the dam requirements in the Building Code and taking into account the New Zealand Dam Safety Guidelines (NZ Society of Large Dams, 2015). The design will include a cement-stabilised core and a triple liner with leak detection system monitored 24/7 at the network control room at Bromley. Therefore, the likelihood of a dam failure would be very unlikely.

9.10.2 Section 5.4.1 of the Beca report describes the dam break analysis, with the detailed results provided in Appendix R. It should be noted that this analysis was for two ponds with a volume of 12,500 cubic metres each, whereas this has been reduced to two ponds with a volume of 9,000 cubic metres each due to the wetland on Old Coach Road now being part of the Inner Bays irrigation scheme. It also assumes that the ponds are full, which would only happen about once every four years. Therefore, the dam burst modelling results are very conservative.

9.10.3 This shows that if the dam failed on a sunny day (i.e. not during a large storm), the flooding extent would be greater than a 5 year flood in Robinsons Bay Stream, but less than a 10 year flood. This is the most likely scenario, as the catchment for the ponds is very small so it is very unlikely that a dam failure would coincide with a large storm.

9.10.4 The dam break assessment included looking at the flood levels at Pavitt Cottage and other houses downstream. Given suitable engineering controls the initial assessment of risks identified the following:

- In the event of a pond being full and failing in dry weather the resulting release of water would have no impact on the Pavitt Cottage or any other houses.
- If a pond failure coincided with a five year storm, there would be no impact on Pavitt Cottage or other nearby houses, but four houses further down the floodplain could have water up to 100 mm deep (i.e. underfloor flooding). Three of these houses are already in the floodplain for the five year storm.
- If a pond failure coincided with a 20 year storm, there would be some underfloor flooding at Pavitt Cottage and 100 – 200 mm flooding at five other houses downstream. Three of these houses are already in the floodplain for the 20 year storm.
- If a pond failure coincided with a 50 year storm, there would be some underfloor flooding at Pavitt Cottage and 100 – 200 mm flooding at five other houses downstream. Four of these houses are already in the floodplain for the 50 year storm.
- If a pond failure coincided with a one in 50 year rain event it is likely that the water would reach the edge of the Pavitt Cottage building footprint, however at that point the water depth would be less than 10 cm and not reach the building floor.

9.10.5 We consider that engineering a safe and secure pond to a high standard for all of the land based options is extremely important. This would mean that the likelihood of a pond failure would be very unlikely. The dam break modelling shows that the consequence of a dam break would be limited to six houses, and then only if it coincided with a large storm, and would most likely only result in underfloor flooding. Therefore the consequence of a dam burst is minor and the overall risk rating is low, as rated using the Council's risk management policy.

9.11 **Inner Bays option too expensive** - There were concerns about how expensive this option was in comparison to the harbour outfall option.

"The fact that CCC staff support the Inner Bays disposal option indicates that they are unconcerned about the impact of project costs on ratepayer invoices…" - Submitter #34050

Project team comments:

9.11.1 The Council is required under the section 130 of Local Government Act to continue to provide wastewater services to serviced communities such as Akaroa. The Council must undertake this activity in an efficient and cost effective manner. However, the Council must also meet the requirements of the Resource Management Act and ensure our activities do not have undue adverse effects.

9.11.2 As described on page 18 of the consultation document, discharging to the harbour undermines the relationship of tangata whenua and their culture and traditions with their ancestral land, water, sites, waahi tapu, valued flora and fauna, and other taonga. The New Zealand Coastal Policy Statement and the Regional Coastal Environment Plan aim to avoid the discharge of treated human waste into water in the coastal environment, unless there has been adequate consideration of alternative methods. A harbour outfall may not be sustainable management under the Resource Management Act and may not be considered a reasonably practicable option under the Local Government Act if there are other options for disposal to land that achieve the purpose of those acts. This is also covered in Section 1.4 Statutory Overview in the Beca options report.

9.11.3 As shown in Table 1 (6.3.7), now that the government is funding $3.1 million of inflow and infiltration reduction work that was included in the capex budgets for the land-based options, the cost of the Inner Bays irrigation scheme has reduced to $51 million to $59 million. The harbour outfall capex cost estimate remains at $45 million to $52 million, so the cost difference between the Inner Bays and the harbour outfall is reduced to $1 million to $11 million.

9.12 **Visual effects -** There were some concerns raised about the visual effects of looking at storage ponds, large native trees and the new treatment plant.

"The Akaroa Civic Trust has concerns regarding the visual impact of the new treatment plant, Pond Site 10 and the wetland area located in the vicinity of Old Coach Road as well as the already consented pumping station that will be built behind Akaroa Mini Golf on the recreation ground parking next to the designated two night freedom camping area." - Submitter #34066

Project team comments:

9.12.1 The planned treatment plant on Old Coach Road and pump station behind the Akaroa Recreation Ground already have consents and are not matters for consideration in this consultation.

9.12.2 The visual effects of Pond Site 10 are summarised in section 5.7.1.3 (Preliminary Assessment of Effects) of the Beca options report, and in the Landscape and Visual

Effects Review in Appendix V. This notes that the site is not visible from SH75 and views are limited from other vantage points. The site can be viewed from Long Bay Road, however this is predominantly of a transient nature for road users. Overall, subject to final design which can incorporate appropriate mitigation such as landscaping to naturalise the ponds and wetland, the report found that any adverse effects can be managed in an acceptable manner.

9.12.3 The visual effects of the native trees and storage ponds for the Inner Bays irrigation scheme are summarised in section 5.7.2.3 (Preliminary Assessment of Effects) of the Beca options report, and in the Landscape and Visual Effects Review in Appendix V. This found that all of the possible irrigation sites identified within the wider Robinsons Bay landscapes have the potential to accommodate the proposed irrigation area (pasture or trees) 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 this context.

9.12.4 Therefore, we do not expect the Inner Bays irrigation scheme would have adverse visual effects.

9.13 **Storage ponds too large** - Concern was raised about the size of the storage ponds being proposed.

"It places a large storage dam in the middle of our community on a heritage listed property, next to a heritage cottage, with the risk of a dam break flooding properties both nearby and downstream. The dam will be 2ha in size with a security fence and a road around the top."
- Submitter #34045

Project team comments:

9.13.1 Please refer to paragraphs 9.10.1 to 9.10.5 for our comments on the risk of dam break flooding downstream properties.

9.13.2 Section 5.6 (Heritage Features) of the Beca options report describes the heritage features on the Robinsons Bay site (11 Sawmill Road) and nearby. Appendix W contains an archaeological assessment of the Pavitt Cottage site and 11 Sawmill Road. Section 5.7.2.1 (District Plan Provisions) of the Beca options report notes that the proposed ponds do not appear to encroach on the former sawmill site and recommends that an Archaeological Authority from Heritage New Zealand Pouhere Taonga should be applied for in respect of works on the site.

9.13.3 The report also notes that the proposed ponds at 11 Sawmill Road are located more than 100 metres from Pavitt Cottage and its setting, and given this buffer distance it is anticipated there would be minimal effects on the cottage.

9.13.4 We note the top of the dam will be wide enough to drive a vehicle around for maintenance purposes. This will not be a public road.

9.13.5 Fencing to prevent livestock and members of the public accessing the dam is likely to be placed at the toe of the dam, not on top of the bund.

9.13.6 Therefore, we do not expect the ponds to have a negative effect on nearby properties.

9.14 **Option is not re-use** - There were some submitters who believed that this option should not be called re-use.

"The land options are dressed up as beneficial re-use, but are actually still just old-fashioned dumping of waste 'somewhere else', where it is not needed or wanted." - Submitter #34132

Project team comments:

9.14.1 Section 10 (Recommendations) of the Infiltration Testing Results for Akaroa Treated Wastewater Disposal via Irrigation – Robinsons Bay and Pompeys Pillar (PDP, November 2016, pages 141 to 142 in Appendix L of the Beca options report) recommends that application rates for irrigation to trees should not exceed 37.5 mm per week in summer and 17.5 mm per week in winter.

9.14.2 The proposed irrigation rate for irrigation to trees from the irrigation modelling report in Appendix B of the Beca options report is: Maximum Irrigation Application (mm/day): Dec–Feb: 2.75, Mar–May, Sep–Nov: 2.15, Jun–Aug: 1.5

9.14.3 This equates to a weekly application rate of 19.25 mm per week in summer (December to February) and 10.5 mm per week in winter (June to August).

9.14.4 The Process Design Manual – Land Treatment of Municipal Wastewater Effluents (US Environmental Protection Agency, 2006)[13] defines the term "reuse" of wastewater (page 8-1). The definition is:

9.14.5 Slow rate (SR) land treatment involves the controlled application of wastewater or to a vegetated land surface. There are two basic types of SR systems:

- Type 1 – maximum hydraulic loading, i.e.: apply the maximum amount of water to the least possible land area; a "treatment" system.
- Type 2 – optimum irrigation potential, i.e.: apply the least amount of water that will sustain the crop or vegetation; an irrigation or "water reuse" system with treatment capacity being of secondary importance.

9.14.6 We are not proposing to irrigate the maximum amount on the minimum area, so it more closely fits the Type 2 description than Type 1 in the USEPA guidelines.

9.14.7 We also consider the irrigation of new areas of native trees as having more long term benefits, such as increased biodiversity and recreation opportunities.

9.14.8 We therefore consider irrigating native trees to be beneficial re-use.

9.15 **Negative effects on historical sites -** There were concerns from submitters about the effect this option would have on nearby historical sites, such as Pavitt Cottage and the old sawmill site.

"The erection of two ponds above the cottage will be unsightly and ruin the ambiance and beauty of the valley, particularly as viewed from the cottage." - Submitter #33902

Project team comments:

9.15.1 Please refer to paragraphs 9.12.1 to 9.12.4 for our comments on visual effects. Please refer to paragraphs 9.13.2 to 9.13.6 for our comments on heritage features. As described in those sections, we do not expect the proposal would have adverse visual effects or adverse effects on heritage features.

[13] https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=2000ZYD5.TXT

9.15.2 Should the option be adopted there are opportunities in detailed design to carry out archaeological investigations and adjust the designs to accommodate any historical features that may be impacted.

9.15.3 We note that there is also a significant opportunity in the project to preserve and enhance the former sawmill site and make it available to the public, with educational information about the heritage features.

9.16 **No reticulation to unserviced areas with this option** - Questions were raised from submitters about why a reticulated system could not at least be offered to Inner Bays residents with this option. This would mean that septic tanks would no longer be required.

"The storage ponds and levels of irrigation are enormous; nobody would want this on their doorstep, least of all those who do not even receive the benefit of a reticulated sewer service."
- Submitter #34103

Project team comments:

9.16.1 We recognise that the irrigation options would be sited in areas without wastewater reticulation. While this could be added to the scope of the project, it would significantly increase the cost. We therefore do not recommend that this is added to the project.

9.16.2 We also recognise that people impacted by a discharge to harbour may also not have a reticulated wastewater connection.

Item 4

10. Themes from the Goughs Bay irrigation scheme option

10.1 The most common reasons that submitters supported the Goughs Bay irrigation scheme option included:

Comments	No. of comments	Submitter ID #
This option protects the harbour	12	33531, 33537, 33588, 33626, 33711, 33768, 33845, 33854, 33859, 33883, 33904, 33916
This option offers carbon benefits	3	33672, 33590, 34005
This option offers room for expansion of the system if required in the future	2	34115, 33898

10.2 Project team comments in relation to these are as follows (where relevant).

10.3 The project team agree that this option assists with keeping treated wastewater from directly discharging into the harbour and offers some carbon benefits.

10.4 **Option offers expansion of the scheme** - There were a couple of submissions that noted this option has the ability to be expanded into the future.

"It has room for expansion should it turn out to be undersized. Based on the land purchase costs, we presume the Council plans to purchase and retain the bulk of the farm for future expansion." - Submitter #34115

Project team comments:

10.4.1 We agree that the Goughs Bay option has opportunities for future expansion beyond the design flows which take into account growth until 2052. The Inner Bays irrigation scheme by comparison may require the purchase of additional land or additional inflow and infiltration reduction efforts to accommodate flows beyond 2052.

10.4.2 The Goughs Bay option has more land irrigation capacity than the Inner Bays option, and so does not use a wetland to accommodate peak flows. All treated wastewater can be directed to the irrigation scheme or storage at Goughs Bay.

10.5 The most common reasons that submitters did not support the Goughs Bay land based option included:

Comments	No. of comments	Submitter ID #
This option is too expensive	20	33843, 33939, 34050, 33651, 33690, 33698, 33841, 33895, 34006, 34083, 33932, 34039, 34103, 34104, 34116, 34132, 33588, 33881, 34134, 34108
This option is too difficult and risky engineering wise	18	33939, 34050, 33698, 33841, 33895, 34024, 34083, 34139, 34005, 34103, 34104, 34115, 34136, 34137, 33719, 34035, 34134, 34108
This option is not resilient	11	33939, 33591, 34076, 34039, 34041, 34104, 34136, 34137, 33588, 34035, 34134
This option has unwilling sellers	8	33939, 34139, 33877, 34136, 34137, 33881, 34035, 34134

10.6 Project team comments in relation to these are as follows (where relevant).

Item 4

10.7 **<u>This option is too expensive</u>** - There were concerns raised about how much more expensive this option is.

"The budgeted cost to install the high-pressure pumping station and pipe along Long Bay Road is a significant cost to the ratepayers; it is an unacceptable burden in the post-Covid economic environment." - Submitter #33939

Project team comments:

10.7.1 We agree that the Goughs Bay irrigation scheme option is more expensive to build than the Inner Bays irrigation scheme and harbour outfall options. This is due to the significantly longer pipeline for conveying treated wastewater and the pump station need to pump the wastewater over the hill.

10.7.2 The ongoing operational cost would also be high due to the significant power requirements to pump the wastewater over the hill.

10.8 **<u>This option is too difficult and risky</u>** - There were submitters who commented on the risk associated with this option as it was a difficult environment to be constructing in.

"Council staff describe this option as "technically challenging", which are code words for "warning – cost blow-out imminent". There is no comparable example anywhere in NZ of a pipeline operating at this length and pressure, through such difficult topography."- Submitter #34050

Project team comments:

10.8.1 All options have specific engineering challenges, but these can be addressed by existing techniques. The Goughs Bay irrigation scheme option does not require novel or untried technologies and it is not considered significantly risky or difficult from an engineering perspective.

10.9 **<u>This option is not resilient</u>** - Some of the submitters noted that this option does not offer adequate resilience.

"The options proposed by Council do not build or encourage a resilient community. An integrated approach to water and wastewater in Akaroa is required. Council needs to demonstrate leadership on ways and means to build and encourage resilience by using water resources wisely, and sustainably within the infrastructure." - Submitter #34041

Project team comments:

10.9.1 This option has an 11 kilometre pipeline for transferring treated wastewater whilst the Inner Bays option has a 5.6 kilometre pipeline. This means the option may be more likely to require a repair of damage or degradation and presents a future reliance risk by virtue of its greater length.

10.9.2 It would also be located on secondary rural roads and a paper road, which are more vulnerable to damage than the SH75 which is built to a much higher standard.

10.9.3 Therefore, we agree that the pipeline for this option is less resilient than the Inner Bays option.

10.9.4 We agree that the community should be encouraged to use water resources wisely.

10.10 **<u>This option has unwilling sellers</u>** - There were concerns raised about the land required for this option belonging to unwilling sellers.

"The fact there is an unwilling seller and a great cost of construction and running make this option unsuitable." - Submitter #33881

Project team comments:

10.10.1 We agree that the owner being unwilling to sell their property or use wastewater on it is a significant issue for this option. Whilst the Council could obtain the land by compulsory acquisition under the Public Works Act 1981, this would add additional time and cost. We would also need to demonstrate that we had considered and discounted other alternatives. We do not see compulsory acquisition as a desirable outcome.

11. Themes from the Pompeys Pillar irrigation scheme option

11.1 The most common reasons that submitters <u>supported the Pompeys Pillar irrigation scheme option</u> included:

Comments	No. of comments	Submitter ID #
This option protects the harbour	11	33531, 33558, 33626, 33711, 33768, 33845, 33854, 33859, 33883, 33904, 33916
This option offers carbon benefits	3	33672, 33590, 34005

11.2 Project team comments in relation to these are as follows (where relevant).

11.3 The project team agree that this option assists with keeping treated wastewater from directly discharging into the harbour and offers carbon sequestration benefits.

11.4 The most common reasons that submitters <u>did not support the Pompeys Pillar irrigation scheme option</u> included:

Comments	No. of comments	Submitter ID #
This option is too expensive	20	33843, 33846, 34050, 33651, 33690, 33698, 33841, 33895, 34083, 33781, 33932, 34039, 34103, 34104, 34114, 34116, 34132, 33588, 34134, 34108
This option is too difficult and risky engineering wise	13	33846, 34050, 33698, 33841, 33895, 34024, 34083, 33847, 34139, 34005, 34103, 34134, 34108
This option is not resilient	10	33846, 33591, 34076, 33847, 34039, 34041, 34103, 34104, 33588, 34134
Not good use of prime land	10	34050, 33549, 33555, 33699, 33775, 34150, 33847, 34104, 33869, 33881

The site is too windy for planting native trees	9	34050, 34096, 34148, 34150, 33847, 34115, 34136, 33869, 34035
This option has unwilling sellers	9	34150, 34139, 33877, 34136, 34137, 33869, 33881, 34035, 34134

11.5 Project team comments in relation to these are as follows (where relevant).

11.6 **<u>Option too expensive</u>** - There were concerns relating to this option being very expensive compared to the other options.

"The other options are too costly and prone to high maintenance due to pumping uphill and piping the wastewater for many kilometres." - Submitter #33588

Project team comments:

11.6.1 We agree that the Pompeys Pillar irrigation scheme option is most expensive option. This is due to the significantly longer pipeline for conveying treated wastewater and the pump station need to pump the wastewater over the hill. It is more expensive than the Goughs Bay irrigation scheme option because the pipeline is 2 kilometres longer.

11.6.2 The ongoing operational cost would also be high due to the significant power requirements to pump the wastewater over the hill.

11.7 **<u>This option is too difficult and risky</u>** - With this option there were also concerns that it was a difficult option to implement with too many risks.

"This option has several negative features: 1. The idea that the Waste Water be transported 13 kms to a height of over 600m to the farm…" - Submitter #33847

Project team comments:

11.7.1 All options have specific engineering challenges, but these can be addressed by existing techniques. The Pompeys Pillar irrigation scheme option does not require novel or untried technologies and it is not considered significantly risky or difficult from an engineering perspective.

11.8 **<u>This option is not resilient</u>** - As with the Goughs Bay irrigation scheme option, there were similar concerns that this option does not offer adequate resilience.

"Both of those options also require the acquisition of land from unwilling landowners and offer lower resilience, as a result of the risks associated with pumping over longer distances."
- Submitter #34134

Project team comments:

11.8.1 This option has a 13 kilometre pipeline for transferring treated wastewater whilst the Inner Bays option has a 5.6 kilometre pipeline. This means the option may be more likely to require a repair of damage or degradation and presents a future reliance risk by virtue of its greater length.

11.8.2 It would also be located on secondary rural roads, which are more vulnerable to damage than the SH75 which is built to a much higher standard.

11.9 **Not good use of prime land** - As the land for this option is used as a working farm, comments were made that this was not the best use of this land.

"This property has been farmed by Johns family for several generations. Locating the wastewater solution at Pompeys Pillar would have a devastating impact on the Johns family, and there are better options to consider."- Submitter #33869

Project team comments:

11.9.1 Staff recognise that all of the land based options propose the use of productive farmland. We acknowledge that the owners are unwilling to sell their land or use treated wastewater on it and this is a significant issue for this option.

11.9.2 The retirement of this land would have a short term negative impact on the local economy. There are however opportunities for public amenities such as walking, mountain biking and horse riding tracks that may present tourism opportunities which could offset some of this impact.

11.10 **Pompeys Pillar too windy for planting** - There were some submitters, who had concerns that the location in Pompeys Pillar for planting native trees would be unsuccessful, due to the harsh and windy location.

"I/we are most opposed to the pipelines to the Eastern Bays. The proposed native trees will not grow in these exposed areas." - Submitter #34148

Project team comments:

11.10.1 We do not consider the site to be too windy for tree planting. Prior to conversion to farmland the site was covered in native bush. We note that trees are currently growing on higher elevations in the area where land has been retired and allowed to regenerate to native bush.

11.10.2 It is useful to note that the project does not require a tall canopy to be established, just sufficient coverage to intercept the first few millimetres of rainfall.

11.11 **This option has unwilling sellers** - The issue of having unwilling sellers for this option and therefore using the Public Works Act to purchase land for this option was not supported.

"Group discussions have clearly identified that there are considerable impacts and any resolution is going to be appealed. Any compulsory purchase is not an acceptable outcome."
- Submitter #34139

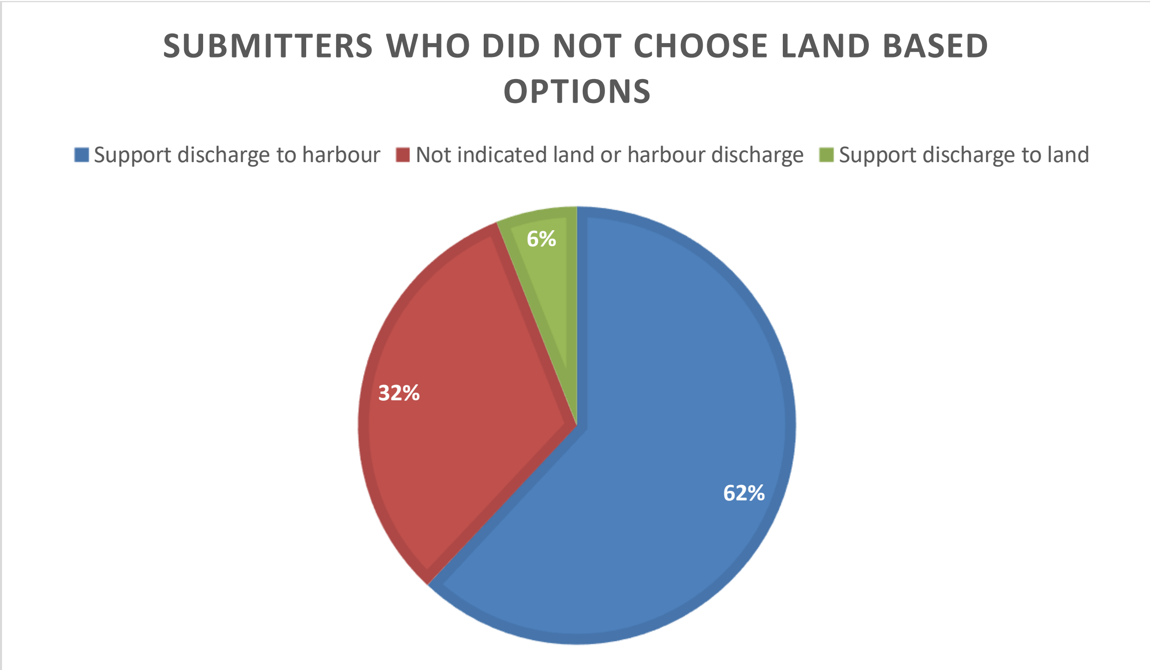
Project team comments:

11.11.1 We agree that the owner being unwilling to sell their property or use wastewater on it is a significant issue for this option. Whilst the Council could obtain the land by compulsory acquisition under the Public Works Act 1981, this would add additional time and cost. We would also need to demonstrate that we had considered and discounted other alternatives. We do not see compulsory acquisition as a desirable outcome.

12. Themes from those who did not rank any of the irrigation to land options

12.1 There were 165 submitters who did not rank any of the land based options. Of these there were 103 submitters who indicated they supported a discharge to harbour, 53 also did not indicate whether they supported a discharge to the harbour or land and 10 of these supported a land based discharge.

Question 1	No. of submitters
Supported discharge to harbour	103 (62%)
Did not indicate if supported discharge to land or harbour	52 (32%)
Supported discharge to land	10 (6%)
Total	165 (100%)



12.2 For those submitters who did not answer this question and did not rank any of the land based options, this appeared to be due to submitters:

12.2.1 Only supporting the harbour outfall option, and strongly disagreeing with any land based options.

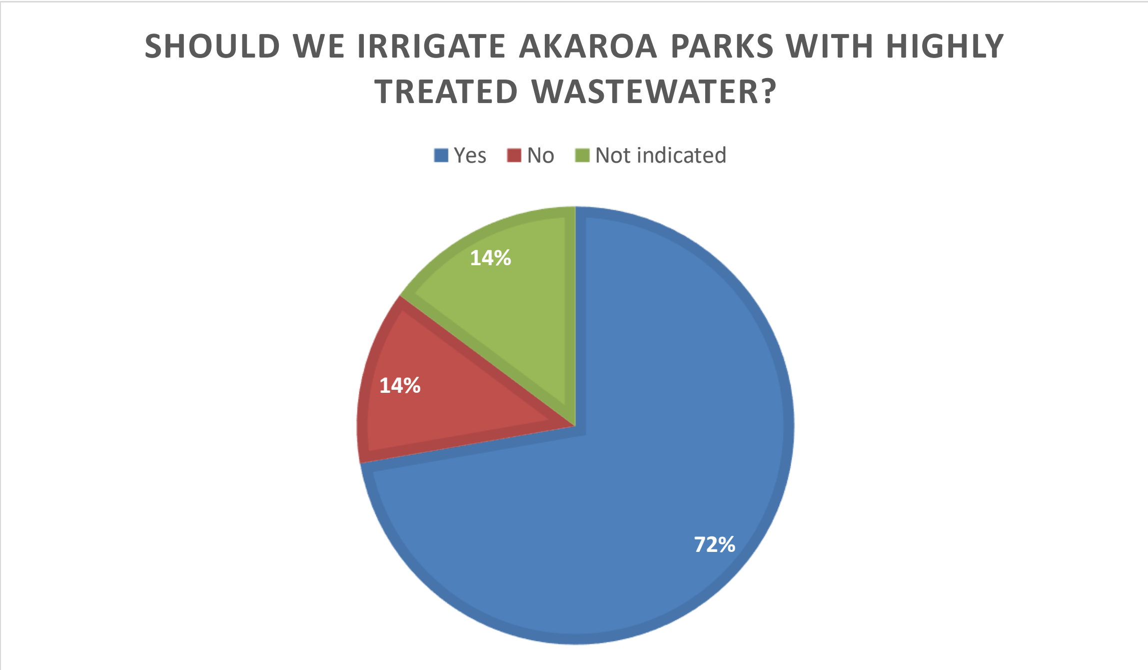
12.2.2 Supporting alternative land based options.

12.2.3 Supporting a different option that was not part of this consultation process.

13. Question 3 – Would you support us irrigating public parks in Akaroa with highly treated wastewater?

13.1 At the close of consultation there were 247 submitters who indicated that 'yes' they would support irrigating parks, 46 who indicated that 'no' they would not support irrigating parks and 48 who did not answer this question.

Yes – irrigate parks	No – do not support irrigating parks	Not indicated	Total
247 (72%)	46 (14%)	48 (14%)	341 (100%)



13.2 The main reason that submitters supported irrigating the parks, was that it was recognised that this was a positive step towards re-using a valuable water resource in the community.

Project team comments:

13.2.1 We agree with most comments on this matter. The option is however relatively expensive as a re-use option to minimise the burden on the land-based options, costing an extra $3.7 million and using approximately 4 per cent of the treated wastewater.

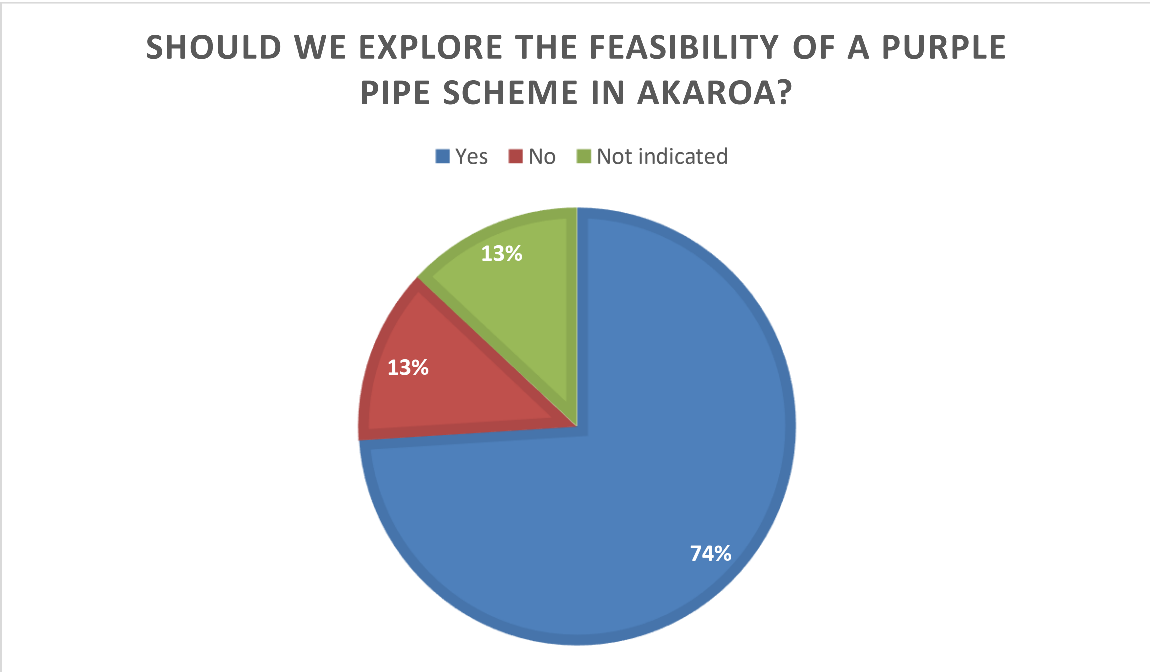
13.2.2 It is a much less expensive addition to the harbour outfall option, as the proposed route for the pipeline to the outfall is through town. The additional cost for the harbour outfall option is $270,000.

13.2.3 However, the proposed non-potable reuse scheme would form a significant portion of any future re-use schemes to private properties and would be advantageous if a wider non-potable reuse option were expected in the future.

14. Question 4 – Would you like us to explore the feasibility of a purple pipe scheme for Akaroa, so that residential property owners could use the water for garden watering and other non-drinking purposes?

14.1 At the close of consultation there were 253 submitters who indicated that 'yes' they would support us exploring the feasibility of a non-potable reuse for residential properties, 45 who indicated that 'no' they would not support us exploring this and 43 who did not answer this question.

Yes – explore purple pipe	No – do not support exploring purple pipe	Not indicated	Total
253 (74%)	45 (13%)	43 (13%)	341 (100%)



14.2 For those who were supportive of staff exploring the purple pipe option further, the main reasons were based on it being a good future proof option and it would make use of a valuable resource. Especially in the Akaroa area where there are water shortages each year and in light of climate change predictions.

Project team comments:

14.2.1 We agree with the comments on this matter. Akaroa is short of water and non-potable reuse would improve the resilience of the water supply for the town by reducing the reliance on drinking-water for irrigation and other non-potable uses.

15. Question 5 – Is there anything else you'd like us to consider?

15.1 For those submitters who provided comments, the remaining comments were about alternative options or suggested amendments to existing options. All other comments in this section have been captured in the earlier sections of this report, in the topics that they relate to.

15.2 **Harbour outfall option**

Suggested amendments to options or new options	No. of comments	Submitter ID #
With harbour outfall, it should be held in a pond and emptied mid harbour on the ebb tide.	1	33843
Use Algae water treatment before discharging into the harbour	1	34148

Project team comments:

15.2.1 The proposal to hold back flows and only discharge on the ebb tide is technically possible. It would introduce operational complexity and cost $250,000 - $500,000 to implement (Council would have to construct additional storage for treated wastewater). Modelling work performed by NIWA for the previous outfall consent application in 2014 indicated that there would be minimal adverse effects to the harbour by running a continuous discharge to harbour so it would not be necessary to hold back flows until the ebb tide. Given the increased cost and complexity for no significant environmental gain, we do not think this option is worth pursuing.

15.2.2 The proposal to include an algal stage to further cleanse the water before a harbour discharge may present an alternative solution for reducing dissolved nutrients in the treated wastewater compared to the proposed process. It would not affect the levels of pathogens in the treated water, as these are already proposed to be extremely low, and it would not reduce the scope of the proposed process. It would add additional cost, but it may be possible to grow specific species of algae that have an economic value.

15.2.3 Staff have not yet seen a business case that makes the algae process advantageous, however it can be considered further in detailed design.

15.3 **Future new builds**

Suggested amendments to options or new options	No. of comments	Submitter ID #
Smaller wastewater systems (e.g. Oasis) should be used be Akaroa township residents instead of a reticulated system	5	33652, 33521, 34113, 33744, 33530
New builds in Akaroa should have composting toilets and/or rainwater collection	4	33781, 34083, 33707, 33605

Project team comments:

15.3.1 The proposal to install on-site wastewater treatment at each property in Akaroa is not feasible for the following reasons:

- The Council is required under the section 130 of Local Government Act 2002 to continue to provide wastewater services to serviced communities such as Akaroa. Section 131 says that a local authority must not close down a water service that serves more than 200 normally resident people.
- There would be insufficient space on many properties in Akaroa to build an on-site wastewater treatment and disposal system.

15.3.2 Staff do not support this option.

15.3.3 Regarding composting toilets for new builds, this is something the Council could consider. However, the forecast growth in Akaroa is very low, so the impact this would have on the wastewater system would be negligible.

15.4 **Wetlands**

Suggested amendments to options or new options	No. of comments	Submitter ID #
Use a wetland with the new harbour outfall	8	34115, 34283, 33989, 34083, 34082, 34068, 33923, 34080
Use more wetlands to reduce storage	5	34139, 34115, 34041, 34005, 33877
Have a more frequent release into Children's Bay via a wetland into Pawsons Stream to reduce the size of the storage ponds.	2	34045, 33989

Project team comments:

15.4.1 A wetland could be incorporated into the harbour outfall option, however the wastewater is retained in the wetland for at least two to four weeks, it is unlikely that the Ngāi Tahu parties would be supportive of this proposal. Such a wetland would require approximately 16 to 32 hectares to construct. There is not enough flat land of this size close to Akaroa.

15.4.2 A more frequent discharge to harbour via a wetland, though not necessarily at Pawsons Stream (which is in Duvauchelle), would allow the storage volumes in the three land based options to be reduced. This may be preferred by residents near storage ponds and would reduce project costs. Staff therefore foresee a number of advantages from this proposal.

15.4.3 If a land based scheme is selected as the preferred option by Council, we would work with the Ngāi Tahu parties and the community to further investigate this option's viability.

15.5 **Irrigation**

Suggested amendments to options or new options	No. of comments	Submitter ID #
Use pasture based irrigation for the Goughs Bay option to reduce the impact on the farm	1	34115
Irrigate onto Stanley Park and Takapūneke Reserve	1	34006
Irrigate onto private land adjacent to Stanley Park (12 ha) in Akaroa township	1	34006
All treated wastewater should be irrigated onto the golf course land at Pawsons Valley/or Kaituna golf course near Birdlings Flat with storage ponds in Duvauchelle	1	33622
Irrigate treated wastewater onto Misty Peak land instead and areas of Takamatua peninsula between Takamatua and Akaroa	1	33881

Project team comments:

15.5.1 Pasture based irrigation on the farm at Goughs Bay was considered, and this was the original proposal. However, with the land owner now unwilling to sell or to use the wastewater, we would have to acquire the farm by compulsory acquisition under the Public Works Act.

15.5.2 Irrigation to trees is lower cost than irrigation to pasture, as less irrigation area is required due to the trees ability to intercept rainfall, which means wastewater can be irrigated for more of the year than for pasture. It also requires smaller storage ponds. Planting native trees also introduces benefits around biodiversity and carbon sequestration.

15.5.3 We therefore recommend irrigation to trees rather than irrigation to pasture.

15.5.4 We considered irrigation of Stanley Park, but due to the steep slopes on the downhill side of the park our geotechnical experts have advised us that irrigating this park would not be appropriate.

15.5.5 Parts of Takapūneke Reserve could be irrigated, however the irrigable area of sufficiently flat land was not considered sufficient to warrant investing in such an option. This would also require extending the non-potable reuse pipeline a further 4.5 km than currently planned. This would be at an additional cost of $6.4 million to $8.4 million.

15.5.6 The option of irrigating the Akaroa Golf Course at Duvauchelle with wastewater from both Akaroa and Duvuachelle was considered in Section 3.10 (Combined Duvauchelle – Akaroa Wastewater Scheme) of the Beca options report with supporting information in Appendix D (Assessment of Combined Akaroa Duvauchelle Scheme).

15.5.7 The work found that, for the Inner Bays scheme there was no useful reduction in storage or the required irrigation area for the Akaroa scheme. There were no clear synergies or efficiencies to be gained by combining Akaroa and Duvauchelle in a combined Inner Bays scheme.

15.5.8 For a combined scheme with Goughs Bay or Pompeys Pillar, the combined costs are likely to be significantly higher cost than for two separate schemes.

15.5.9 Irrigating Misty Peaks was suggested by the working party in 2017. Beca staff visited the site and reported back to the working party at its meeting on 15 March 2017[14]. An extract from the minutes of that meeting states:

- *There were two aspects to instability risk – drainage causing deeper instability in subsoil or bedrock, and increased soil moisture which causes increased risk of shallow instability. When large rainfall events occur the risk of instability increases. Irrigation always increases soil moisture content and this leads to increased risk of shallow instability on steep slopes. If irrigating pasture/crops, the soil moisture content must be at least 50% or the pasture/crops will not grow. Therefore it is not possible to have irrigation of crops without increasing the drainage to the subsoil.*

15.5.10 Irrigating Misty Peaks was also considered by experts acting for the Council, the Ngāi Tahu parties and Friends of Banks Peninsula in the third Joint Statement of Technical Experts dated 26 April 2017[15]. The experts stated:

- *Assessing the risk of shallow instability, it is generally agreed that trees may be irrigated up to a maximum slope of 19 degrees. For irrigation of trees on land sloping at more than 19 degrees the risk of shallow instability is increased with the application of wastewater at any rate. For this reason irrigation of treed slopes at greater than 19 degrees is not considered advisable….*
- *We conclude that irrigation of trees at slopes greater than 19 degrees, or to pasture at slopes greater than 15 degrees, would increase the risk of instability, even if the application rate is reduced to a level where the average drainage rate is unchanged from an unirrigated scenario. Based on this assessment the two scenarios described are considered inadvisable.*

15.5.11 Therefore we do not support irrigating Misty Peaks, as this would create an unacceptable instability risk which could affect the irrigation area and/or land downslope.

[14] https://ccc.govt.nz/assets/Documents/Services/Wastewater/Akaroa-Treated-Wastewater-Reuse-Options-Working-Party-Notes-of-Meeting-15-March-2017.pdf
[15] https://www.ccc.govt.nz/assets/Documents/Services/Wastewater/Akaroa-Wastewater-Irrigation-of-Treated-Wastewater-to-Land-Joint-Statement-of-Technical-Experts-No-3.pdf

15.6 **Storage ponds**

Suggested amendments to options or new options	No. of comments	Submitter ID #
Use groundwater replenishment with highly treated wastewater (e.g. reverse osmosis) to reduce storage	3	34114, 34050, 34104
Provide several ponds for fire fighting at or near Hinewai Reserve	2	33869, 34115
Include more re-use options to water more parks, use in toilets, areas of NZ bush and replenishing streams to reduce storage	2	34138, 34104,
Allow farmers to pump water from the storage ponds for use on their properties	1	33587

Project team comments:

15.6.1 For commentary on including reverse osmosis and/or introducing treated wastewater to groundwater, please refer to paragraphs 6.5.1 to 6.5.5 and 8.4.12 to 8.4.20. We do not support these options for the reasons explained in those paragraphs.

15.6.2 We agree with the suggestion that fire fighting ponds could provide additional benefits if they were included and this could be the case for any of the irrigation scheme options. In terms of fire fighting ponds near Hinewai, this could be added to the Goughs Bay or Pompeys Pillar irrigation options, but would be an additional cost.

15.6.3 We agree with the suggestion to maximise the reuse of the treated wastewater, such as for flushing toilets. However, we do not support using it for replenishing streams to reduce storage unless it has been appropriately treated through a wetland or similar natural treatment system to restore the mauri of the water.

15.6.4 We agree with the suggestion that farmers should be allowed to use treated wastewater on their properties. The consultation document stated that treated wastewater would be made available to land owners along the pipeline route.

15.7 **Combine treated wastewater schemes**

Suggested amendments to options or new options	No. of comments	Submitter ID #
Connect Wainui and Duvauchelle to a harbour or ocean outfall option	4	34050, 34048, 34006, 33882
Combine inner bays option with Duvauchelle wastewater	2	34103, 33565
Join Akaroa wastewater to Duvauchelle scheme and irrigate onto the golf course	1	34080
In the long term add Little River and Birdlings Flat to the scheme	1	34048

Project team comments:

15.7.1 We have investigated combining the Duvauchelle and Akaroa wastewater schemes. Please refer to our comments in paragraphs 15.5.6 to 15.5.8.

15.7.2 The Wainui wastewater scheme already discharges to land and has ample capacity for the planned expansion of the wastewater scheme in future. There would be no benefits to discharging this wastewater to the harbour with the wastewater from Akaroa and/or Duvauchelle. Given there is an existing and well-functioning land based disposal system, it would be extremely difficult to obtain a consent to discharge directly to the harbour. We do not support this option.

15.7.3 Combining wastewater schemes in Akaroa Harbour with possible future schemes in Little River and Birdlings Flat would be extremely expensive. There would also be long retention times in the pipeline, which would create odour and septicity issues.

15.8 **Treatment plant**

Suggested amendments to options or new options	No. of comments	Submitter ID #
Divert stormwater from sewer and only treat sewer waste to reduce the amount that needs treating	2	34149, 34113
Make the treatment plant building attractive, so it fits into the environment	1	33932
Need to include an outflow buffer in the system, to ensure wastewater is tested before it leaves the treatment site	1	34099
The new treatment plant should be placed on suitable land 200 m around from the current site out of site	1	34043
Build the new treatment plant near the existing treatment plant with the outfall to save costs	1	33840

Project team comments:

15.8.1 We agree that work should be undertaken to significantly reduce the amount of stormwater getting into the wastewater network and have government funding for this work.

15.8.2 We have already bought the land and obtained resource consents for the treatment plant so is not a topic for this consultation.

15.8.3 The treated wastewater will be tested regularly, and this will undoubtedly be required in the conditions of the resource consents for whichever option is chosen. It is unnecessary to hold the treated wastewater in an outflow buffer pond to achieve this. An outflow buffer pond would be an extra cost and would take up precious space on the flat land opposite the treatment plant that would be better used for raw wastewater peak flow storage and a wetland. We do not support this suggestion.

Christchurch City Council

15.9 **Transport of wastewater**

Suggested amendments to options or new options	No. of comments	Submitter ID #
Transport wastewater by trucks to Rolleston and treat it here instead of pumping over the hill	1	34048
Drive treated wastewater in trucks to Bromley to be treated	1	33960

Project team comments:

15.9.1 As described in section 3.2 of the Beca options report, tankering wastewater to Christchurch was considered as a long list option in 2015. It would require approximately 20 tanker trips per day, with additional trips required during wet weather and the peak summer holiday season. It was discounted because it would be operationally very expensive and would have negative environmental effects and impacts on traffic to and from Akaroa. We do not support this option.

15.9.2 We do not support the option of tankering wastewater to Rolleston, for the same reasons as we do not support tankering wastewater to Christchurch.

15.10 **Land based options**

Suggested amendments to options or new options	No. of comments	Submitter ID #
Put Takamātua on a reticulated system if the inner bays option is chosen	1	34142
If the inner bays option went ahead, it would be good to have options for a community garden, bee hives, orchard or food forest to encourage self sufficiency	1	33729
Need to have a plan for replacement land when trees need felling	1	34099
Generate power on the run back down the hill, to alleviate cost of pumping over the hill	1	34083
To protect the heritage site, keep storage ponds in lower terrace, create exclusion zones around heritage features, conserve above ground features and include promotion of the site to connect the history	1	33963

Project team comments:

15.10.1 We recognise that the irrigation options would be sited in areas without wastewater reticulation. While this could be added to the scope of the project, it would significantly increase the cost. We therefore do not recommend that this is added to the project.

15.10.2 We agree that adding other aspects that would have community benefits and increase self-sufficiency such as a community garden, bee hives, orchard or food forest would be good additions to the Inner Bays irrigation scheme. We would be happy to incorporate these suggestions in the design with input from the community.

15.10.3 Our intent with the irrigation schemes is to establish new areas of native bush. We do not propose to fell the trees, so we do not need a plan for replacement land.

15.10.4 We agree that generating electricity on the run back down the hill to alleviate the cost of pumping over the hill would be a good idea. We could consider adding this to the Goughs Bay or Pompeys Pillar option if one of these options were chosen, subject to a business case assessment.

15.10.5 We agree that the heritage site should be protected and conserved.

15.11 **Other suggestions**

Suggested amendments to options or new options	No. of comments	Submitter ID #
The newly established central government ‘three waters steering group’ should be used to finance and implement a solution	10	33783, 34045, 34139, 34114, 34086, 34081, 33738, 34145, 34083, 34095
Charge for water use and waste removal so people take ownership of the resource	2	34083, 33886

Project team comments:

15.11.1 We are very aware of the Government’s Three Waters Reform programme and the Three Waters Steering Group. The Council has signed a Memorandum of Understanding with the Government regarding Three Waters Reform and in return will receive a grant of $40.52 million. The Government’s objectives in this funding are to stimulate the economy post Covid-19 and to address the deficit in water and wastewater renewals and maintenance across the country. The Council approved the draft list of projects to be funded by this grant at its meeting on 25 August 2020, including $3.1 million for reducing inflow and infiltration in Akaroa’s wastewater network. The Akaroa wastewater scheme does not meet the criteria for the grant.

15.11.2 We agree that charging for water supply and wastewater would increase people’s awareness of the resource, reduce demand and improve sustainability. We are planning to consult on this for the whole Christchurch district in the next Long Term Plan.

16. Details / Te Whakamahuki

Decision Making Authority / Te Mana Whakatau

16.1 The Hearing Panel is to present its recommendations to the Council.

16.2 The Council will then pass resolutions to support the recommendations or direct the Hearing Panel to review its recommendation.

Legal Implications / Ngā Hīraunga ā-Ture

16.3 The Hearings Panel is making its recommendations (and ultimately the Council is making its decisions) under the requirements of sections 76-81 of the Local Government Act 2002. As identified at the start of this report, this matter involves a significant decision. That means appropriate observation of the decision-making requirements is required.

16.4 The previous work, reports and this consultation process demonstrate Council is meeting those requirements.

16.5 Once the Council's decision is made the Resource Management Act 1991 processes will follow, which will include further consideration of environmental effects of the chosen option.

Risks / Ngā Tūraru

16.6 Please refer to section 13 of the Beca options report and our comments on the risks raised in the submissions.

Next Steps / Ngā Mahinga ā-muri

16.7 At the conclusion of the hearings process the Hearings Panel will report to Council with recommendations on:

16.7.1 Which of the four options for Akaroa's treated wastewater best meets the requirements of the Local Government Act.

16.7.2 Whether or not non-potable reuse of treated wastewater should be included in the scheme for use in public park irrigation and in public amenities.

16.7.3 Whether or not Council staff should explore the feasibility of a purple pipe scheme for Akaroa, so that residential property owners could use the water for garden watering and other non-drinking purposes.

16.8 The Hearings Panel may recommend additional actions to enhance the scheme and community outcomes or to reduce impacts on effected parties.

16.9 The Hearings Panel will issue their recommendations to the Council in the form of their report.

16.10 Councillors will consider the recommendations and pass resolutions to support those recommendations or to direct the Hearings Panel to reconsider specific aspect(s) of their findings.

16.11 Once an option is chosen by the Council, staff will then get underway with implementing the option. This will include assessments of environmental effects, resource consent applications, design, tendering and construction.

16.12 On the basis of the Council resolutions, staff will include revised project costs in the draft Long Term Plan 2021 - 2031.

Attachments / Ngā Tāpirihanga

No.	Title	Page
A ⇩	Proposed Council Officer recommendations	52
B ⇩	Akaroa treated wastewater options booklet	54
C ⇩	A field trial to determine the effect of land application of treated municipal wastewater onto selected NZ-native plants on Banks Peninsula (Alexandra Meister and Brett Robinson, September 2020)	78

Confirmation of Statutory Compliance / Te Whakatūturutanga ā-Ture

Compliance with Statutory Decision-making Requirements (ss 76 - 81 Local Government Act 2002).

(a) This report contains:

- (i) sufficient information about all reasonably practicable options identified and assessed in terms of their advantages and disadvantages; and
- (ii) adequate consideration of the views and preferences of affected and interested persons bearing in mind any proposed or previous community engagement.

(b) The information reflects the level of significance of the matters covered by the report, as determined in accordance with the Council's significance and engagement policy.

Signatories / Ngā Kaiwaitohu

Authors	Kylie Hills - Senior Project Manager Bridget O'Brien - Programme Manager Mike Bourke - Senior Technician Water and Waste Planning Tara King - Senior Engagement Advisor Judith Cheyne - Associate General Counsel
Approved By	Carolyn Gallagher - Programme Director Strategic Support

Proposed Officer Recommendations / Ngā Tūtohu

1.1 The Officer recommendations on the five questions asked in the consultation booklet are below.

Should we discharge highly treated wastewater to land or the harbour?

1.2 The New Zealand Coastal Policy Statement and the Regional Coastal Environment Plan aim to avoid the discharge of treated human waste into water in the coastal environment, unless there has been adequate consideration of alternative methods. A harbour outfall may not be sustainable management under the Resource Management Act and may not be considered a reasonably practicable option under the Local Government Act if there are other options for disposal to land that achieve the purpose of those acts.

1.3 Discharging to the harbour undermines the relationship of tangata whenua and their culture and traditions with water, valued flora and fauna, and other taonga.

1.4 The Ngāi Tahu parties (Ōnuku Rūnanga, Te Rūnanga o Koukourarata, Wairewa Rūnanga, the Akaroa Taiāpure Management Committee and Te Rūnanga o Ngāi Tahu) see the discharge of human sewage, even as highly treated wastewater, into the harbour as being highly offensive. Ngāi Tahu say the ability to harvest kaimoana (sea food) from the harbour is central to the ability of marae to practice manaakitanga (hospitality, care) for visitors. They are strongly opposed to the treated wastewater being put into the harbour, which is used for mahinga kai and is home to tribal taonga (treasures) such as the pahu (Hectors dolphin). They say stopping discharges of contaminants to the harbour is in the interest of all harbour users and the community as a whole, not just tangata whenua.

1.5 There are viable land-based alternatives to a harbour outfall, and so we recommend that the highly treated wastewater is discharged to land.

If the decision is made to irrigate to land, should this be to the Inner Bays (Robinsons Bay, Hammond Point, Takamātua) or Goughs Bay or Pompeys Pillar?

1.6 We recommend the Inner Bays irrigation scheme option because it is the least expensive and most resilient option that avoids discharging treated wastewater to the harbour. Creating a wetland and three new areas of native trees makes good use of the highly treated wastewater, with ecological, educational and recreational benefits. It provides for the cultural needs and aspirations of the Ngāi Tahu parties and aligns well with our Climate Smart Strategy and Integrated Water Strategy. It was the most preferred location for the land-based options in submissions.

1.7 We acknowledge that the local community has concerns with the scheme, but believe that these concerns can be appropriately addressed through the design and consenting process.

Should we irrigate highly treated wastewater on public parks?

1.8 We recommend that highly treated wastewater is irrigated onto public parks, if the Council is prepared to provide additional budget for this. It would be a demonstration of safe non-potable reuse and could pave the way for a more extensive non-potable reuse system in Akaroa. This idea was well supported in submissions.

Should we explore further a purple pipe option for Akaroa?

1.9 We recommend that staff are asked to explore the feasibility of a non-potable reuse (purple pipe) scheme for Akaroa, including working with the Ministry of Health, the Canterbury District Health Board and other local authorities that are interested in non-potable reuse to develop non-potable reuse guidelines or standards for New Zealand. Akaroa is short of drinking water in summer and the highly treated wastewater is a valuable resource that could reduce demand on the drinking water supply, and increase the resilience of the town. This idea was well supported in submissions.

HAVE YOUR SAY

Akaroa treated wastewater options

Tell us what you think by Sunday 23 August 2020

ccc.govt.nz/haveyoursay

Christchurch City Council

Introduction

We are building a new wastewater system for Akaroa. In our Long Term Plan 2018-2028 we budgeted $35 million for this work, which includes a new wastewater treatment plant, upgrades to pipes and pump stations, and a new system for disposing of treated wastewater.

Akaroa's current wastewater treatment plant and harbour outfall are in a culturally and historically sensitive place and they are old and need to be replaced. Doing nothing is not an option.

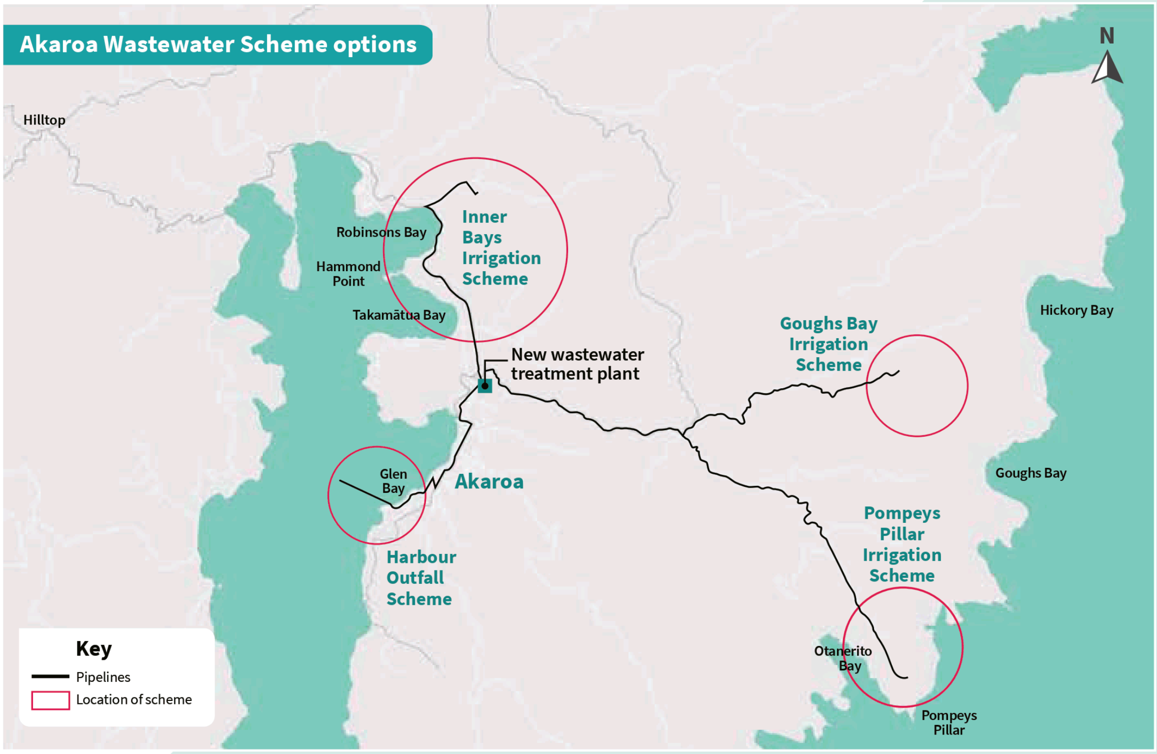
We already have consents for the new wastewater treatment plant to be built on Old Coach Road and for the new pump station in the boat park at Childrens Bay.

We are seeking feedback only on what to do with the highly treated wastewater when it leaves the plant.

What we're asking

What should we do with highly treated wastewater from Akaroa?

- **Continue sending it into Akaroa Harbour?**
  - Harbour Outfall Scheme
- **Reuse it on land to irrigate native trees?**
  - **Which one of our three land-based options would be best?**
    - Inner Bays Irrigation Scheme
    - Goughs Bay Irrigation Scheme
    - Pompeys Pillar Irrigation Scheme



This map gives a simple overview of the option locations.

Overview

The environment around Akaroa township features a harbour, steep slip-prone hillsides and soils with poor drainage. This limits our treated wastewater disposal options.

We have worked with the Ngāi Tahu parties and the Akaroa Treated Wastewater Reuse Options Working Party (working party) on the four options outlined in this booklet.

The Ngāi Tahu parties we refer to are Ōnuku Rūnanga, Te Rūnanga o Koukourarata, Wairewa Rūnanga, the Akaroa Taiāpure Management Committee and Te Rūnanga o Ngāi Tahu.

The working party comprises two members of the Banks Peninsula Community Board, Banks Peninsula Councillor Andrew Turner, two representatives each from Ōnuku Rūnanga and Te Rūnanga o Koukourarata, members representing various communities of the peninsula, and an independent chairperson. It was established by the Banks Peninsula Community Board to help us investigate land-based alternatives to discharging treated wastewater into Akaroa Harbour.

The working party noted that getting to this point, with four final options, was a long and difficult process.

Our consultant's technical report, detailed maps, the working party's terms of reference, its joint statement, the Ngāi Tahu parties' statement, and other information about this project are available on our Have Your Say website. This booklet is a summary of the options developed from that information.

Decision-making process

We want as many people as possible in Christchurch and Banks Peninsula to give us feedback on the options.

Feedback we receive will help us understand the views of individuals and the wider community.

Council staff have expressed an opinion on each option and identified a preferred option. These opinions, and those of the working party, are summarised on pages 20 and 21.

It's important to understand that Council staff will not decide which option is chosen as the new treated wastewater disposal system for Akaroa.

A hearings panel will consider all the feedback received during consultation. The panel then makes a recommendation to the Council. The view of the panel may differ from the staff opinion.

It is the Mayor and the Councillors who will make the final decision.

Key considerations

Relevant law

- The decision by the Council on which option to pursue is subject to the Local Government Act. This Act sets out the purpose of local government and the principles local authorities must apply. These include taking a sustainable development approach and taking into account the social, economic environmental and cultural wellbeing of communities now and in the future.
- The Local Government Act decision-making process requires us to consider all reasonably practicable options for achieving the objective of the decision and to consider the advantages and disadvantages of each option. We must take into account the relationship of Māori and their culture and traditions with their ancestral land, water, sites, waahi tapu, valued flora and fauna, and other taonga. We must also consider the views and preferences of people likely to be affected by, or with an interest in, the decision to be made. We are consulting for this reason, including to better understand the social and cultural wellbeings of the community.
- Implementation of the chosen option will then be subject to the Resource Management Act.

Risks

As with any big infrastructure project, we need to consider the risks – both the project risks and the risks of not doing anything. Risks identified with the option eventually chosen will be managed appropriately during the design and construction stages. They will also be considered and evaluated through the resource consenting process. For more information about risks, please refer to the technical report.

Ngāi Tahu perspective

To recognise Crown obligations under Te Tiriti o Waitangi – The Treaty of Waitangi we provide opportunities for Iwi to contribute to and participate in our decision making.

Ngāi Tahu rights and interests associated with Akaroa Harbour are strongly focused on mahinga kai, food gathering. Discharging treated human waste into the harbour is culturally offensive to Ngāi Tahu and is not compatible with their customary use of the harbour as a 'food basket'.

As tāngata whenua, Ngāi Tahu have kaitiaki (guardianship) rights and responsibilities to actively protect natural resources in Akaroa for future generations. To protect and enhance the mauri, or life force, of the harbour Ngāi Tahu want the discharge of wastewater into Akaroa Harbour to stop.

ccc.govt.nz/haveyoursay

About wastewater

Wastewater, or sewage, is the used water from households, businesses and industries. It includes everything flushed down a toilet and water used for bathing and showering, washing clothes and dishwashing. It also includes groundwater and storm water that has seeped into the network. There are high levels of this infiltration into the Akaroa network, with groundwater and storm water accounting for about half of the overall wastewater flow in some years, depending on rainfall.

What we currently do

Treated wastewater from an old (1960) treatment plant is discharged into Akaroa Harbour at Takapūneke-Red House Bay, via a 100 metre long pipeline known as an outfall.

Common to all four options

Treatment process

- All wastewater will be treated at the new treatment plant on Old Coach Road (consented but not yet built).
- All wastewater will be treated to a significantly higher level than is possible at the existing plant. Akaroa's wastewater will be treated to a level that is among the highest anywhere in New Zealand.
- The new treatment plant will include a covered storage pond for untreated wastewater, to smooth out peak flows to the treatment plant. It will be surrounded by landscape planting and will not be visible from the road once the plants have grown. We will be seeking consents to build it on land we own over the road from the new treatment plant.
- The wastewater scheme, including storage ponds, will be designed and engineered to be resilient to earthquakes, land slips, storms and flooding.

Purple pipe scheme

Any of the four options could include a non-potable (not for drinking) water reuse scheme (purple pipe scheme). To make the treated wastewater safe for such use, we would include ultraviolet (UV) treatment as an additional level of treatment.

This highly treated non-potable (not for drinking) water supply could be used for irrigating Council-owned parks and sports grounds and for flushing public toilets. It would use approximately 4 per cent of the treated wastewater.

It would cost an additional $3.7 million to install a purple pipe if one of the land-based options is chosen, or $270,000 if the harbour outfall is chosen (lower cost because the outfall pipe through town would double as the purple pipe).

A purple pipe scheme, if added to the chosen scheme, would include a second covered storage pond for highly treated wastewater on land we own over the road from the new treatment plant, to ensure a safe and reliable supply.

At present reusing treated wastewater on residential properties is not approved by the Ministry of Health because central government agencies are yet to set the necessary health and other standards for this type of water recycling.

We anticipate such use will be possible and widespread in New Zealand in future as communities grapple with water shortages due to climate change.

In this consultation we are interested to know what people think about this idea. If it receives a good level of support, we would consider lobbying central government agencies to change the regulations to allow non-potable reuse schemes in New Zealand.

Common to the three land-based options

Irrigating native trees

The three land-based options all involve planting native trees and irrigating them with the highly treated wastewater.

The irrigation would be by pipes with drippers on the ground, which would not be visible in the landscape. Small pumps would be used to disperse the highly treated wastewater to the drippers.

These new areas of native trees would create new habitats for insects, birds and other wildlife, increasing the biodiversity of the area and providing ecological benefits.

The trees would thrive on the plentiful water supply and would not be subjected to drought.

All three land-based options support our goal to be carbon neutral by 2030 (native trees absorb and store more carbon than the scheme would emit) and we could apply to the government's One Billion Trees Programme for funding. They also align well with our Climate Smart Strategy and Integrated Water Strategy (search the strategy name at **ccc.govt.nz**).

Land selection

We used the following criteria to identify land suitable for irrigation:

- A slope of less than 19 degrees in the irrigation area and not more than 15 degrees downhill of the irrigation area (relatively flat land, to reduce instability in the irrigation area and to downhill land).
- A buffer of 1 hectare around individual houses in the possible irrigation area, to allow for onsite wastewater disposal, such as a septic tank or composting toilet.
- A buffer of 5 metres to the property boundary.
- A buffer of at least 25 metres to permanent streams and the coast, and 10 metres to ephemeral streams.
- Property size of at least 2 hectares.
- No land stability issues found in preliminary investigations.

The land needed for irrigation and storage ponds could be acquired by purchase, lease and/or licence. Our strong preference is to negotiate with willing landowners. However, if that is not possible, we could seek to use the Public Works Act, as a last resort, to acquire the land.

Pipes

The treated wastewater will be piped to the irrigation areas along public roads and the pipes will be buried.

Property owners along the pipeline routes could join the irrigation scheme if they wished, for farm irrigation and stock water, but would need a resource consent.

Storage ponds

Storage ponds are needed to hold the treated wastewater during times when irrigation is not possible and to supply the irrigation system.

In periods of sustained wet weather irrigation would be stopped, to avoid run-off risks, with the highly treated wastewater being stored in ponds at the irrigation site. This water would be used when irrigation resumes.

The land criteria for storage ponds are similar to those for irrigation and include a slope of no more than 4 degrees and a buffer distance of at least 100 metres from any house.

The four options

The Mayor and Councillors will be asked to select one of our four options as the new wastewater disposal scheme for Akaroa.

In the following pages we explain each option in more detail, with a map for each option.

There will be information sessions in Akaroa and Christchurch during the consultation period. Staff will be available at these sessions to discuss the proposals and to answer questions. For more information about these sessions, see page 22.

Comparative photos

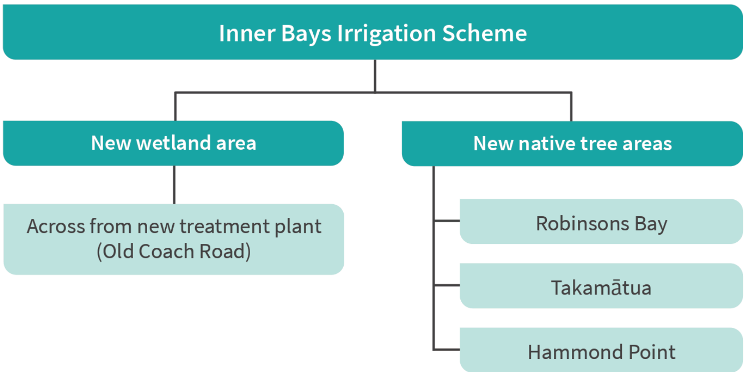
We have used photos of how the landscape looks now and artist's impressions showing how they would look in the future for each option. The artist's impressions are indicative only and are not visual simulations.

Inner Bays Irrigation Scheme

Capital cost range
$54 million to $63 million

Operating cost
$510,000 per year

Carbon impact
8,900 tonnes stored over 35 years



This option involves developing three new areas of native trees on four properties and a new wetland on land we own opposite the new treatment plant, in addition to the storage pond on the site.

The irrigation sites and the storage ponds at the irrigation sites would be closer to the treatment plant than in the other land-based options and closer to settled areas and houses.

New areas of native trees

Three new areas of native trees would be planted and irrigated with highly treated wastewater.

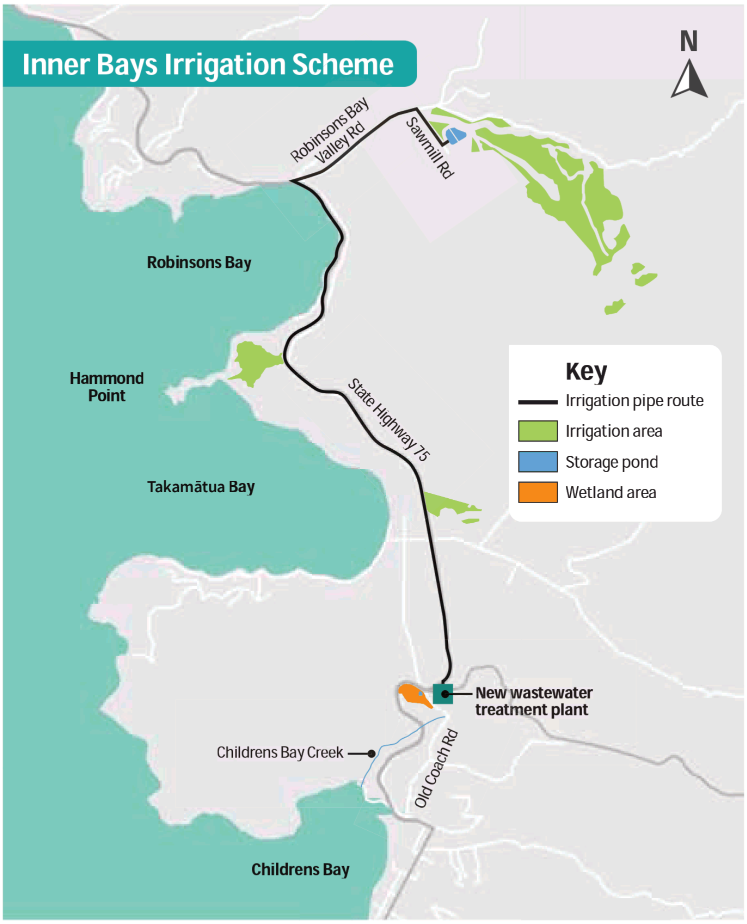
The total area of land needed for irrigation would be 40 hectares, over the three sites.

We have identified the following areas of land as being most suitable:

- A farm on Sawmill Road in the Robinsons Bay valley and a strip of land neighbouring the farm.
- The flat land on the north side of Takamātua Valley, on the east side of State Highway 75.
- Land on Hammond Point, on the west side of State Highway 75 between Takamātua and Robinsons Bay.

There are other areas of land in Takamātua Valley and Robinsons Bay that also meet the criteria for irrigation, but they are less favoured because the irrigation areas are smaller.

The new native tree areas would be open to the public.



Item 4

Attachment B

Robinsons Bay

How the landscape looks now in upper Robinsons Bay (view from Okains Bay Road).

Artist's impression: How the same landscape would look with native trees and storage ponds.

Attachment B Item 4

Hammond Point

How the landscape looks now at Hammond Point (viewed from walking track off Archdalls Road).

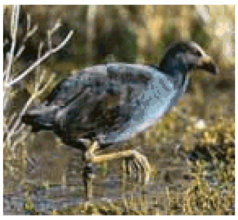
Artist's impression: How the same landscape would look with native trees.

Takamātua Valley

How the Takamātua Valley landscape looks now (viewed from SH75).

Artist's impression: How the same landscape would look with native trees.

Please note that if the Duvauchelle A&P Showground and Pony Club need to move to this site because of the wastewater project there, this area would be irrigated pasture and more trees would be planted at the Hammond Point irrigation site.



New wetland

A wetland would be created across the road from the new treatment plant on Old Coach Road, next to the covered storage pond.

The wetland is an important part of this scheme and would provide 2,200 cubic metres of additional storage for highly treated wastewater (without it we would need bigger storage ponds at Robinsons Bay). The wetland would also provide the treated wastewater with additional treatment through naturally occurring processes.

The wetland would also make the new treatment plant and disposal system more resilient to wet weather events. Natural biological and chemical cleansing would further reduce contaminants, giving us the ability to release the highly treated wastewater from the wetland to the harbour, in the event of a period of extreme wet weather (expected on average once every five years).

In this scenario, highly treated wastewater would discharge from the wetland into the harbour at Childrens Bay, via the Childrens Bay Creek.

Normally there would be no discharge from the wetland.

The wetland would be planted with native wetland plants, providing new habitats for insects, birds and other wildlife.

We would maximise opportunities to improve the ecology and biodiversity, and ensure community and Ōnuku Rūnanga participation in some aspects of the site design, including which species to plant there. The wetland would be open to the public. Over time, it would offer opportunities for recreation, education and other activities.

Pipeline and storage

A 5.6 kilometre gravity-fed pipeline would run 4.4 kilometres along State Highway 75 and 1.2 kilometres along Robinsons Bay Valley Road and Sawmill Road.

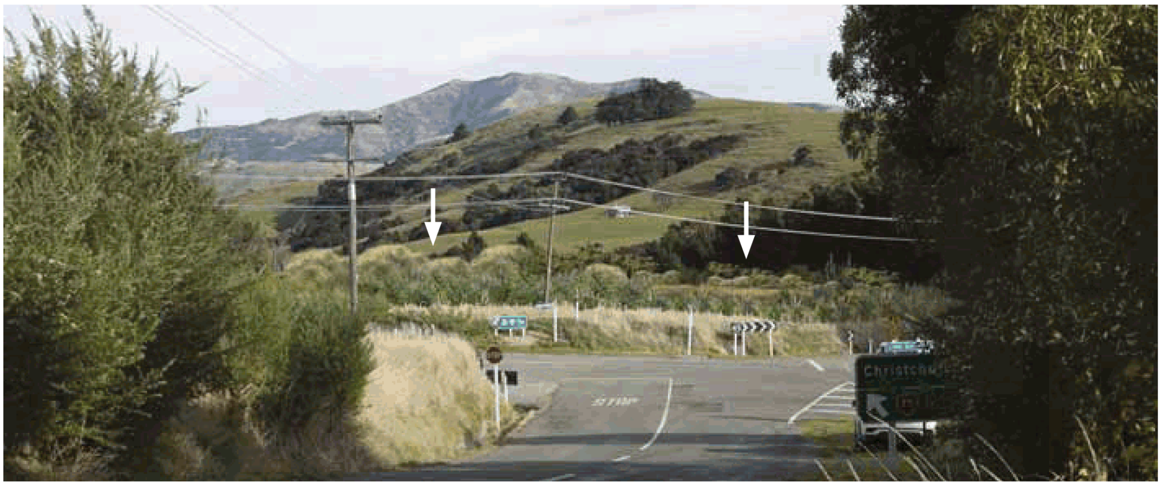
Two storage ponds, each with a capacity of 9,500 cubic metres, would be built on the irrigation site on Sawmill Road in Robinsons Bay. They would store highly treated wastewater from the new treatment plant during periods of wet weather, when the land is too wet to irrigate, so would be only partially full most of the time.

They would be built with earth embankments (bunds) and lined with high-density polyethylene. The ponds would be cut into the existing slope with a bund 4 metres high extending above ground at the downhill end. The area around the ponds would be landscaped and planted with native trees.

The two ponds would be side by side and separated by an earth embankment.

An additional bund would be built on Sawmill Road to prevent a neighbouring house from flooding in the unlikely event of a storage pond failure.

How the landscape looks now (viewed from Long Bay Road at the intersection of SH75).



Artist's impression: How the same landscape would look with the wetland.

Council staff see these advantages

- All Akaroa's treated wastewater would be beneficially reused to create a new wetland and three new native bush areas
- Ecological, cultural, recreational and educational benefits from wetland and native bush areas
- Storage ponds gravity-fed from the new wastewater treatment plant
- Pipeline more resilient than for the other land-based disposal options
- Highly treated wastewater available for farm irrigation and stock water along pipeline route
- Least expensive land-based option (lower capital and operating costs)
- Most land owners appear willing to negotiate with us

Council staff see these disadvantages

- More expensive than the Harbour Outfall Scheme

Christchurch City Council

Attachment B Item 4

Goughs Bay Irrigation Scheme

Capital cost range
$61 million to $71 million

Operating cost
$580,000 per year

Carbon impact
4,500 tonnes stored over 35 years

New area of native trees

The Goughs Bay irrigation site is relatively remote, with no onsite dwellings and few neighbouring properties. It is a considerable distance, about 11 kilometres, from the new wastewater treatment plant.

This option would give us the opportunity to develop a new area of native trees. It may be open to the public but this is not decided yet.

Highly treated wastewater would be piped to land above Goughs Bay and used to irrigate native trees. The total area of irrigated land needed would be 33 hectares.

Treated wastewater would be stored onsite in up to three ponds.

Pipeline and storage

Treated wastewater would be pumped through a high-pressure pipeline up over the hills east of Akaroa to an elevation of 677 metres.

The pipeline would run up Long Bay Road to its summit then along Hickory Bay Road for 8.2 kilometres. It would then follow a paper road, travelling 2.4 kilometres along the ridge between Hickory and Goughs bays. We own the paper road, which passes through several farms. The existing track (along the paper road) would need to be upgraded for the pipeline construction and would continue to be used by the farms it passes through.

Up to three storage ponds would be built on the farm. They would be dug into the hill with earthen bunds and lined with high-density polyethylene. The total volume of the storage ponds would be about 30,000 cubic metres. The ponds would be only partially full most of the time and there would be no discharge into the sea, except in an extreme emergency.

How the landscape looks now at Goughs Bay (looking north from Paua Bay Road).

Artist's impression: How the same landscape would look with native trees.

Council staff see these advantages

- All Akaroa's treated wastewater would be beneficially reused to create a new native bush area
- Ecological benefits from new areas of native bush
- Highly treated wastewater would be available for farm irrigation and stock water along the pipeline route

Council staff see these disadvantages

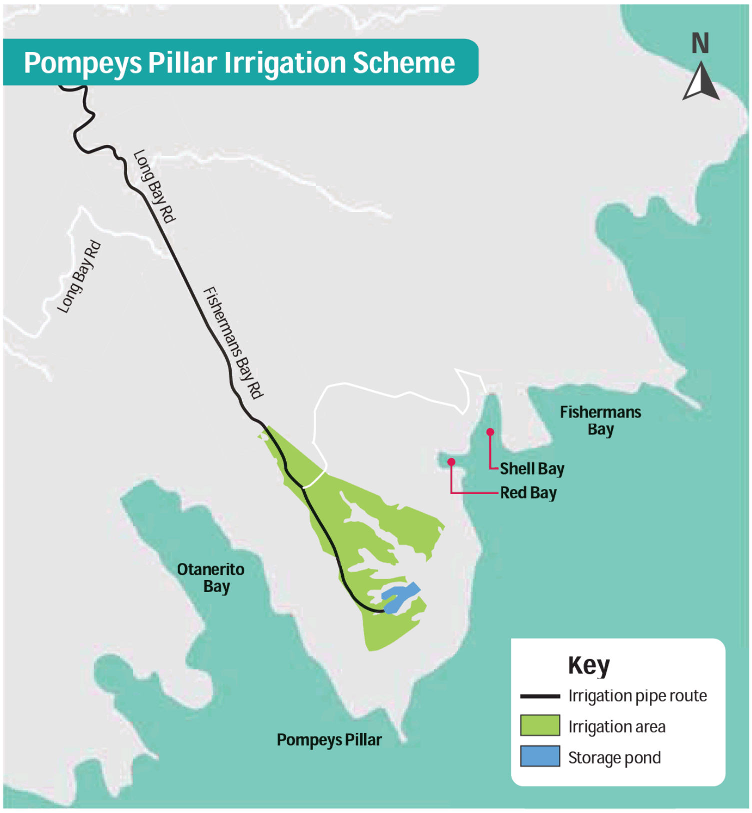
- More expensive than Inner Bays Irrigation Scheme or Harbour Outfall Scheme, with higher capital and operating costs
- Pumping treated wastewater up and over the hill along remote rural roads may make it vulnerable to breakdown and/or damage
- Landowner not willing to sell their land or use treated wastewater on it

Pompeys Pillar Irrigation Scheme

Capital cost range
$66 million to $76 million

Operating cost
$580,000 per year

Carbon impact
8,300 tonnes stored over 35 years



New area of native trees

Pompeys Pillar is relatively remote, with few onsite dwellings and few neighbouring properties, and is a considerable distance – about 13 kilometres – from the new wastewater treatment plant.

Treated wastewater would be piped to land at Pompeys Pillar and used to irrigate native trees. The total area of irrigation land needed would be 48 hectares.

There would be no discharge into the sea, except in an extreme emergency.

The new native bush area may be open to the public, but this is not decided yet.

Pipeline and storage

The treated wastewater would be pumped, through a high-pressure pipeline about 13 kilometres long, up and over a hill with an elevation of 631 metres.

The pipeline would run up Long Bay Road to its summit then down Fishermans Bay Road to the irrigation area.

A single storage pond would be built on the farm by damming an ephemeral stream (ephemeral streams are temporary and appear only after rainfall). The pond capacity would be 36,000 cubic metres.

How the landscape looks now at Pompeys Pillar (looking south from Paua Bay Road).

Artist's impression: How the same landscape would look with native trees.

Council staff see these advantages

- All Akaroa's treated wastewater would be beneficially reused to create a new area of native bush
- Ecological benefits from new native bush
- Highly treated wastewater available for farm irrigation and stock water along the pipeline

Council staff see these disadvantages

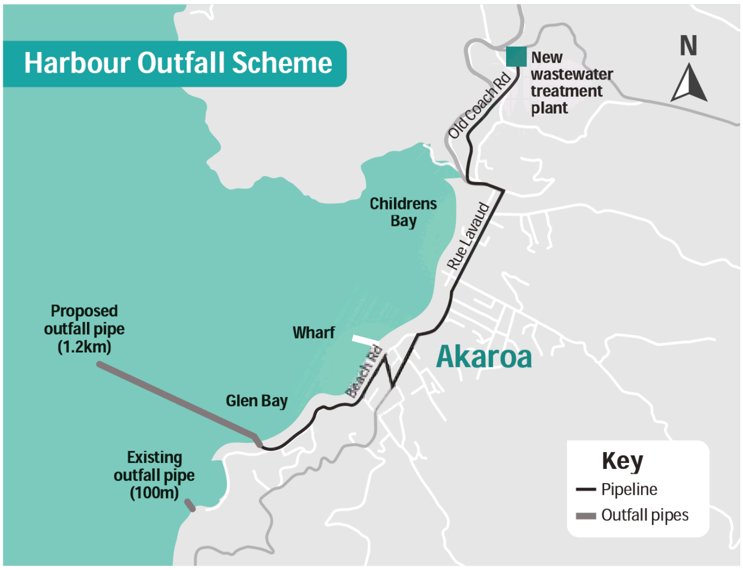
- Most expensive option, with the highest capital and operating costs
- Pumping treated wastewater up and over the hill along remote rural roads may make it vulnerable to breakdown and/or damage
- Landowner not willing to sell their land or use treated wastewater on it

Harbour Outfall Scheme

Capital cost range
$45 million to $52 million

Operating cost
$470,000 per year

Carbon impact
1,300 tonnes emitted over 35 years



Highly treated wastewater would be discharged into the middle of Akaroa Harbour via a new, longer outfall pipeline.

A new wastewater pipe would run from the new treatment plant on Old Coach Road, through Akaroa and out into the middle of the harbour from the south end of town, probably entering the harbour at Glen Bay (depending on final design work).

The pipeline would be fully buried for its entire length along Council-owned land and roadway, and below the sea floor out into the harbour.

The harbour section of the pipeline would extend 1.2 kilometres into the mid-harbour, where the treated wastewater would be discharged via a diffuser.

The diffuser would be 9.5 metres below the water surface. The treated wastewater discharged would be diluted at least 78 times before it reached the surface then further diluted by natural currents and tidal flows. There would no visible effect.

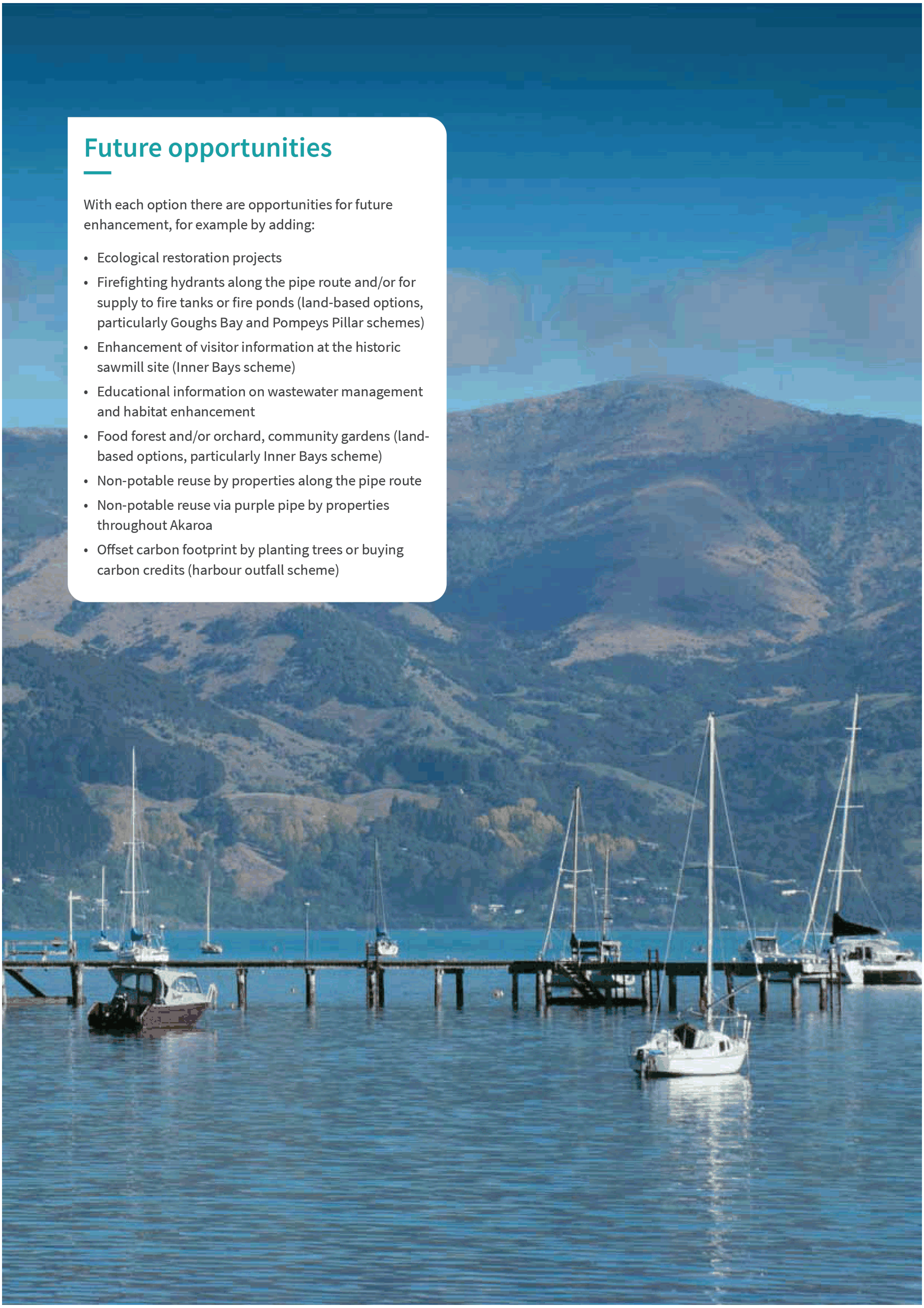
As the wastewater entering the harbour would be highly treated, the public health risk to people using the harbour for recreational activities or for gathering shellfish would be very low (the wastewater would be treated to a much higher level than that which is discharged to the harbour at present). However, the adverse effect on the Ngāi Tahu parties' cultural value in gathering fish and shellfish would be high.

Council staff see these advantages

- No additional land needed
- Treated wastewater would flow by gravity to the outfall
- Lower capital, operating and maintenance costs than for any of the other options

Council staff see these disadvantages

- No beneficial reuse of highly treated wastewater, unless purple pipe system included
- May be risk, albeit very low, to public health from swimming, other recreational activities and from eating raw shellfish from the area
- Conflicts with our goal to be carbon neutral by 2030.
- It undermines the relationship of tangata whenua and their culture and traditions with their ancestral land, water, sites, waahi tapu, valued flora and fauna, and other taonga.
- The New Zealand Coastal Policy Statement and the Regional Coastal Environment Plan aim to avoid the discharge of treated human waste into water in the coastal environment, unless there has been adequate consideration of alternative methods. A harbour outfall may not be sustainable management under the Resource Management Act and may not be considered a reasonably practicable option under the Local Government Act if there are other options for disposal to land that achieve the purpose of those acts.



Future opportunities

With each option there are opportunities for future enhancement, for example by adding:

- Ecological restoration projects
- Firefighting hydrants along the pipe route and/or for supply to fire tanks or fire ponds (land-based options, particularly Goughs Bay and Pompeys Pillar schemes)
- Enhancement of visitor information at the historic sawmill site (Inner Bays scheme)
- Educational information on wastewater management and habitat enhancement
- Food forest and/or orchard, community gardens (land-based options, particularly Inner Bays scheme)
- Non-potable reuse by properties along the pipe route
- Non-potable reuse via purple pipe by properties throughout Akaroa
- Offset carbon footprint by planting trees or buying carbon credits (harbour outfall scheme)

Views on the four options

Council staff, the Ngāi Tahu parties and the Akaroa Treated Wastewater Reuse Options Working Party have had long involvement in identifying suitable disposal options for highly treated wastewater from Akaroa.

Each group has its own view of each option and these are summarised below. The full statements are available on our Have Your Say website: **ccc.govt.nz/haveyoursay/**

Inner Bays Irrigation Scheme

Ngāi Tahu view
Ngāi Tahu prefer this option. They say one of the roles of Papatūānuku (Earth Mother) is to cleanse. By having the treated wastewater pass through or over land and allowing for natural filtration to occur, Ngāi Tahu consider it will no longer compromise the harbour, making it safe for the cultural practices that occur there, such as mahinga kai (food gathering). Ngāi Tahu see the wetland as enhancing the natural cleansing process.

Working party view
The working party could not reach an agreed opinion of this scheme. Some members strongly oppose it, citing concerns about risk and a belief that it will have unacceptable environmental, social and cultural impacts and will affect the quality of life of nearby residents in a negative way. Other members, including rūnanga appointees, favour this option over all others, citing environmental and ecological benefits and viewing it as the most sustainable, affordable, resilient and practical of the three land-based options.

Council staff view
Council staff prefer this option because it is the least expensive and most resilient option that avoids discharging treated wastewater to the harbour. Creating a wetland and three new areas of native trees makes good use of the highly treated wastewater, with ecological, educational and recreational benefits. It provides for the cultural needs and aspirations of the Ngāi Tahu parties and aligns well with our Climate Smart Strategy and Integrated Water Strategy.

Goughs Bay Irrigation Scheme

Ngāi Tahu view
Ngāi Tahu support this option because it allows Papatūānuku (Earth Mother) to further cleanse the highly treated wastewater as it passes over and through the land through natural filtration processes. When the wastewater eventually reaches the sea it is no longer considered a risk to cultural practices such as mahinga kai (food gathering).

Working party view
The working party could not reach an agreed opinion of this scheme, although it has more support than other options with most members supporting it as either their first or second choice. Some members support the scheme because of its remoteness and distance from dwellings. Others oppose it, citing concerns about the high-pressure pipeline, costs and a belief it would have a negative effect on the environment and the community.

Council staff view
This option is the second preference of staff because it avoids a discharge to the harbour, makes good use of the treated wastewater to irrigate native trees and supports the cultural needs and aspirations of the Ngāi Tahu parties. This option is the third most expensive to build, operate and maintain and the pipeline may be vulnerable to breakdown and/or damage. We would be negotiating with an unwilling land owner.

Pompeys Pillar Irrigation Scheme

Ngāi Tahu view
Ngāi Tahu support this option because it allows Papatūānuku (Earth Mother) to further cleanse the highly treated wastewater as it passes over and through the land through natural filtration processes. When the wastewater eventually reaches the sea it is no longer considered a risk to cultural practices such as mahinga kai (food gathering).

Working party view
The working party does not favour this scheme. Members see no benefit in the option being included for consideration and would like it withdrawn. Members cite its distance from Akaroa, which is further than Goughs Bay, and that the farm has been in family ownership for seven generations.

Council staff view
This option is the third preference of staff because it avoids a discharge to the harbour, makes good use of the treated wastewater to irrigate native trees and supports the cultural needs and aspirations of the Ngāi Tahu parties. It is the most expensive to build, operate and mainatin and the pipeline may be vulnerable to breakdown and/or damage. As with the Goughs Bay scheme, we would be negotiating with an unwilling land owner.

Harbour Outfall Scheme

Ngāi Tahu view
Ngāi Tahu do not support this scheme. They see the discharge of human sewage, even as highly treated wastewater, into the harbour as being highly offensive. Ngāi Tahu say the ability to harvest kaimoana (sea food) from the harbour is central to the ability of marae to practice manaakitanga (hospitality, care) for visitors. They are strongly opposed to the treated wastewater being put into the harbour, which is used for mahinga kai and is home to tribal taonga (treasures) such as the pahu (Hectors dolphin). They say stopping discharges of contaminants to the harbour is in the interest of all harbour users and the community as a whole, not just tangata whenua.

Working party view
The working party was established to help us identify land-based alternatives to a harbour outfall, and therefore did not assess the harbour outfall option.

Council staff view
This is the option staff least prefer because highly treated wastewater would be discharged directly to the harbour, which does not support the cultural needs and aspirations of the Ngāi Tahu parties. It also does not beneficially reuse any of the wastewater unless a purple pipe scheme is included.

The four options at a glance

	Comparisons			
	Inner Bays Irrigation Scheme	**Goughs Bay Irrigation Scheme**	**Pompeys Pillar Irrigation Scheme**	**Harbour Outfall Scheme**
Capital cost range ($ millions)	$54m to $63m	$61m to $71m	$66m to $76m	$45m to $52m
Operating cost (per year)	$510,000	$580,000	$580,000	$470,000
Carbon impact (over 35 years)	8,900 tonnes stored	4,500 tonnes stored	8,300 tonnes stored	1,300 tonnes emitted
Distance from treatment plant (approximate kilometres)	5.6km	11km	13km	4km

Next steps

21 July–23 August 2020 → August/September 2020 → October 2020 → October/November 2020 → December 2020

- **21 July–23 August 2020**: Public consultation period (community feedback collected)
- **August/September 2020**: Community feedback analysed and included in a report to the hearings panel
- **October 2020**: Hearings panel to listen to any verbal submissions
- **October/November 2020**: Hearings panel report provided to the Mayor and Councillors
- **December 2020**: Council decision on a preferred option

How to make a submission

We would like your feedback on the Akaroa wastewater project. There are several ways you can give feedback. Submissions can be made from Tuesday 21 July 2020 until midnight Sunday 23 August 2020.

Written feedback

Fill out our online submission form at **ccc.govt.nz/haveyoursay**

Email your feedback to **Tara.King@ccc.govt.nz**

Fill out the submission form in the summary document available at any of our libraries or service centres

Post a letter to:
Freepost 178 *(no stamp required)*
Tara King, Engagement Team
Akaroa wastewater project
Christchurch City Council
PO Box 73016
Christchurch 8154

Or deliver to the Civic Offices at 53 Hereford Street. (To ensure we receive last-minute submissions on time, please hand deliver them to the Civic Offices.)

You need to include the following details with your submission: your full name, postal address, post code and email address. If you wish to speak to your submission at the public hearings in October, please also provide a daytime phone number.

Whether you are completing the submission for yourself or on behalf of a group or organisation. If it is the latter, please include your organisation's name and your role in the organisation.

Submissions are public information

Subject to the provisions of the Local Government Official Information and Meetings Act 1987, we will make all submissions publicly available, including all contact details you provide on your submission. If you consider there are reasons why your contact details and/or submission should be kept confidential, please contact the Council by phoning (03) 941 8999 or 0800 800 169.

Any questions? Contact Tara King on **(03) 941 5938** or email **Tara.King@ccc.govt.nz**

Be heard in person

Come and talk to us

Information sessions

Gaiety Hall supper room, Rue Jolie, Akaroa
Sunday 2 August
2pm–3.30pm

Civic Offices, first floor function room, 53 Hereford Street, Christchurch
Tuesday 4 August
5.30pm–7pm

Gaiety Hall supper room, Rue Jolie, Akaroa
Monday 10 August
5.30pm–7pm

Hearings

For this project, there will be a hearings panel with at least three members. At this stage the hearings are expected to take place in October 2020.

Once consultation closes, staff (led by a senior engagement advisor) will analyse all the submissions and write a report to the hearings panel. The panel will consider the staff report, which will include staff recommendations on the matters raised in the submissions.

The panel will then listen to any submitters who have indicated they would like to speak about the proposal. It will then make a recommendation to the Mayor and Councillors, who will make the final decision on which option to proceed with.

All submitters will receive written updates on the project, including details of the staff recommendations, meetings and details on speaking to the hearings panel.

Once the Council has made a decision the chosen proposal will be further developed and resource consents sought for the new Akaroa Wastewater Scheme.

Public hearings will be held in October 2020.

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HAVE YOUR SAY

Akaroa treated wastewater options

We need to decide how to dispose of treated wastewater from Akaroa.

For this project, there will be a hearings panel with at least three members.

Once consultation closes, staff (led by an engagement advisor) will analyse all the submissions and write a report to the hearings panel. The panel will consider the staff report, which will include staff recommendations on the matters raised in the submissions.

The panel will then listen to any submitters who have indicated they would like to speak about the proposal.

It will then make a recommendation to the Councillors and the Mayor, who will make the final decision on which option to proceed with.

All submitters will receive written updates on the project, including details of the staff recommendations, meetings and details on speaking to the hearings panel.

Once the Council has made a decision the chosen proposal will be further developed and resource consents sought for the new Akaroa Wastewater Scheme.

Please indicate your preferences using the questions below.

1. Should we discharge highly treated wastewater from our new treatment plant to land or should we continue to discharge into Akaroa Harbour?
   - ☐ To land
   - ☐ To the harbour

cut

2. If the Mayor and Councillors decide to develop a scheme where highly treated wastewater is used on land for irrigation, where would you prefer we irrigated?

   Please rank your preference from 1 being your preferred to 3 being your least preferred.
   - ☐ Inner Bays (Robinsons Bay, Hammond Point, Takamātua)
   - ☐ Goughs Bay
   - ☐ Pompeys Pillar

3. Would you support us irrigating public parks in Akaroa with highly treated wastewater?
   - ☐ Yes
   - ☐ No

4. Would you like us to explore the feasibility of a purple pipe scheme for Akaroa, so that residential property owners could use the water for garden watering and other non-drinking purposes (see page 5)?
   - ☐ Yes
   - ☐ No

5. Is there anything else you'd like us to consider?

   If you wish to attach extra paper, please insert inside this freepost envelope.

Hearings are planned for October 2020 (subject to change).

Would you like to speak to the hearings panel about your submission? ☐ Yes ☐ No

If yes, please provide a daytime phone number so we can arrange a time for you to speak. Phone: ____________________

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Christchurch City Council

Name* ....

Organisation ....

Role ....

Address* ....

....

Postcode* ....

Email* ....

*required

We require your contact details as part of your feedback – it also means we can keep you updated throughout the project.

Your feedback, name and address are given to Councillors to help them make a decision.

Your responses, with names only, go online when the decision meeting agenda is available on our website.

If requested, responses, names and contact details are made available to the public, as required by the Local Government Official Information and Meetings Act 1987.

If there are good reasons why your details and feedback should be kept confidential, please contact our Engagement Manager on (03) 941 8999 or 0800 800 169 (Banks Peninsula).

Please fold with the reply paid portion on the outside, seal and return by **Sunday 23 August 2020**

fold staple or tape here fold

If you wish to attach extra paper, please ensure the folded posted item is no thicker than 6mm. Alternatively, you can send your feedback in an envelope of any size and address it using "Freepost Authority No. 178"

fold fold

FREEPOST Authority No.178

Christchurch City Council

Free

tape here

Freepost 178 (no stamp required)
Tara King, Engagement Team
Akaroa treated wastewater options
Christchurch City Council
PO Box 73016
Christchurch 8154

A field trial to determine the effect of the land application of treated municipal wastewater onto selected NZ-native plants on Banks Peninsula

Alexandra Meister[1] and Brett Robinson[1*]

[1]School of Physical and Chemical Sciences, University of Canterbury, 20 Kirkwood Ave, Christchurch 8041

[*]brett.robinson@kiwiscience.com

Executive Summary

- The application of Treated Municipal Wastewater (TMW) on NZ-native vegetation is a management option under consideration for towns on Banks Peninsula and elsewhere. There is little information on the effect of TMW on the growth of NZ-native plants or the fluxes of nutrients or contaminants in the underlying soil.

- In July 2015, 1350 native species were planted onto a 20 m x 55 m plot on Piper's Valley Road, Duvauchelle, Banks Peninsula. The plants were arranged into 27 blocks (4.5 m x 4 m), with 12 of the blocks receiving TMW. There were three NZ-native vegetation types tested: Type 1 (*Phormium tenax, Phormium colensoi, Cordyline australis, Griselinia littoralis, Pittosporum eugenioides),* Type 2 (*Leptospermum scoparium*, *Kunzea robusta*) and Type 3 (*Coprosma robusta, Pseudopanax arboreus, Podocarpus laetus, Olearia paniculata*). Irrigation with TMW at a rate of 1000 mm/yr started in January 2016.

- In October/November 2018 forty soil pits were opened and samples taken from five depths (0-5, 15, 30, 45 and 60 cm). From January 2016 to the time of sampling, the soils received a total of 3400 mm of TMW. Soils were analysed for pH, total elements, and soluble ('phytoavailable') fractions of key nutrients and contaminants (ammonium, nitrate, Olsen phosphorus, heavy metals).

- There was no visible evidence of changes in soil structure as a result of TMW application that have been reported to occur in other soils receiving TMW due to the accumulation of sodium. Nor was there any visible evidence of runoff.

- On average the Na concentrations in the topsoil (0-5 cm) was significantly higher in the TMW-irrigated plots compared to the control plots. This is only a 25% increase, despite a disproportionately large mass of Na that was added with the effluent. This indicates that Na is moving down the soil profile and not accumulating in the root-zone, where it may cause degradation of the soil structure.

- There was a significant (6%) increase in the total nitrogen concentration in the topsoil (0-5 cm) but at greater soil depths, the total nitrogen in the TMW-treated plots was not significantly greater than the control plots. There were no significant differences in ammonium in any of the soils. Nitrate was significantly higher in the surface soil but not deeper in the soil profiles. It is likely that most excess nitrogen added to the soil (200 kg/ha/yr) is either taken up into the vegetation, denitrified into N_2 and N_2O or leached.

- There was no evidence of phosphorus accumulation in the soil, probably because the amount of phosphorus added in the TMW (110 kg/ha/yr, total of 312 kg/ha) was small compared to the mass of P in the soil profile (7606 kg/ha). This is consistent with the findings of our previous report, modelling the accumulation of P in these soils. Available phosphorus (Olsen-P) was within the range (10 - 30 mg/kg) typically found on extensive farming systems, and well below concentrations reported on soils irrigated with high-P effluent.

- Soil concentrations of potentially toxic heavy metals, including copper, cadmium, lead, and zinc, were not affected by TMW application. The concentrations of these elements were similar to background values reported for Canterbury Soils.

- Plant survival and growth was monitored throughout the trial. Growth (biomass) was assessed initially by canopy volume, and following canopy closure, by plant height. Harvested biomass will be determined at the conclusion of the trial. Plant suitability for effluent application on Banks Peninsula was determined by survival and growth.

- The effluent had a negligible effect on the concentrations of nutrients and contaminants in the plant tissues. While the growth of all species was accelerated by the effluent, there was no indication of luxury uptake of plant nutrients or increased concentrations of elements that may be harmful. This indicates that TMW is unlikely to affect ecological food chains.

- This trial demonstrated the feasibility of establishing NZ-native vegetation using TMW. We recommend irrigation rates of 500 - 800 mm/yr. Further experimental plantings should be conducted with these species to explore the possibility of using TMW to re-establish rare or endangered plants that may significantly enhance the ecological value of the area. A critical success factor for the establishment of New Zealand native vegetation on Banks Peninsula that are to receive TMW is the control of exotic weeds. It is likely that some weeds will have a greater growth response to TMW than the native species. It is therefore critical that these weeds be suppressed as the native vegetation becomes established.

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Introduction

In 2014, the Christchurch City Council (CCC) commissioned an investigation to determine whether Treated Municipal Wastewater (TMW) from the township of Duvauchelle could be irrigated onto the local golf course or surrounding grazed pasture. Subsequent engagement with the community during public open days in 2015 and 2016, this brief was expanded to include cut-and-carry pasture as well as New Zealand (NZ) native vegetation. The feasibility of irrigating TMW onto pasture was demonstrated for two soil types, Barry's soil and the Pawson Silt Loam, from Duvauchelle and the Takamatua Peninsula in lysimeter experiments (Gutierrez-Gines et al., 2017, 2020).

Potentially, TMW from the town of Akaroa, Banks Peninsula, could be irrigated onto NZ-native vegetation, instead of being discharged into Akaroa harbour. Such an approach is consistent with land application being the preferred option over discharge into waterways or the ocean (Sparling et al., 2006), where it can exacerbate eutrophication and/or toxic algal blooms (Sonune and Ghate, 2004). The Irrigation of TMW onto land reduces the contaminants that enter waterways and therefore has positive effects on the water quality (Herath, 1997). While there is significant interspecific variation, the root-zones of plants remove nutrients contained in the TMW, mitigate pathogens (Mandal et al., 2007), and break down or immobilise contaminants (Chaudhry et al., 2005) that would otherwise degrade water bodies. The application of TMW can accelerate the growth of some plants by providing water and nutrients (Overman and Nguy, 1975).

The rate that TMW can be applied to soil depends on the soil type and quality of the TMW (Gutiérrez-Ginés et al., 2020). There are numerous examples of where land application of TMW has been discontinued because of excessive nutrient leaching (Houlbrooke et al., 2003), or degradation of soil quality to the point TMW runoff degraded surface waters (Cameron et al., 1997). Elevated concentrations of monovalent cations, especially sodium and potassium, can degrade soil structure through the dispersion of clays (Mojid and Wyseure, 2013), and reduce plant growth through salinity and sodicity (Bernstein, 1975). The successful application of TMW to land on Banks Peninsula requires particular attention to soil quality. Soils of the lowland areas of the peninsula where TMW could potentially be applied are mostly derived from loess with a relatively high clay content (Griffiths, 1973). They are often imperfectly drained and may contain a fragipan (a layer of impermeable soil). These soils present a higher risk of infiltration problems compared to free-draining soils and consequently an improperly designed TMW application system may be susceptible to surface runoff and erosion. Gutierrez-Gines et al. (2017) demonstrated the feasibility of irrigating TMW at rates up to 1500 mm/yr onto Barry's soil and the Pawson Silt Loam, with a recommended irrigation rate of 500-800 mm/yr. An infiltration study on the Pawson Silt Loam showed that infiltration of up to 1500 mm of TMW irrigation was unimpeded, even when the TMW was spiked with additional Na up to 325 mg/L (McIntyre, 2018).

The irrigation of TMW from the towns of Duvauchelle or Akaroa onto NZ-native vegetation could potentially increase the production of valuable native products and create zones of ecological value (Meurk, 2008; Franklin et al., 2015). *Leptospermum scoparium* (mānuka) is an obvious candidate species because of its associated high-value honey and essential oils (Seyedalikhani et al., 2019). Moreover, *L. scoparium* has been shown to kill soil-borne pathogens (Prosser et al., 2016) and reduce nitrate leaching (Esperschuetz et al., 2017b). Other potential valuable native species are *Kunzea robusta* (kānuka) for essential oil production, P*hormium tenax* (harakeke) for fibre production, and a whole suite of species, including *Griselinia littoralis* (kapuka) that may be a nutritious supplement due to tannins and trace elements (Dickinson et al., 2015).

In many countries, including NZ, TMW is used to irrigate forestry (Capra and Scicolone, 2004; Barton et al., 2005), however, there is as yet a lacuna of data on the effects of TMW irrigation onto soils supporting NZ-native vegetation. There is demonstrable evidence that some NZ-native species, such as *L. scoparium*, *K. robusta*, *P. tenax*, *Cordyline australis* (tī kouka), *Myoporum laetum* (ngaio) and *Austroderia australi*s (toetoe) thrive in high-nutrient environments, even if some of these species (*L. scoparium* and *K. robusta*) are adapted to low-fertility soils (Gutiérrez-Ginés et al., 2017; Esperschuetz et al., 2017a). However, Gutierrez-Gines et al. (2017) showed that some other species, such as *Hebe salicifolia* (koromiko) and *Coprosma acerosa* (sand coprosma) had a limited or negative response to increased nutrients. Therefore, selection of NZ-native species that will tolerate TMW irrigation is critical for a successful operation.

When establishing an ecosystem of NZ-native plants that is receiving TMW, the response of exotic weeds to the TMW also needs to be considered. Species such as *Rubus fruticosus* (blackberry), *Solanum mauritianum* (wooly nightshade), *Solanum dulcamara* (woody nightshade), *Phytolacca octandra (*inkweed), and C*lematis vitalba* (old-man’s beard) may have a greater growth response to TMW than the NZ-native species, thereby making their control more difficult.

Transitioning grazed pasture to TMW irrigated native plants will eliminate the application of mineral fertilisers such as superphosphate, which contain elevated concentrations of toxic cadmium, fluorine and uranium that can accumulate in soil (Kim and Robinson, 2015). Irrigation with UV-sterilized TMW, such as that resulting from treatment at Duvauchelle or Akaroa, will also result in a lower environmental pathogen load than grazed pasture. A native ecosystem receiving TMW would likely remain unharvested or have only a small fraction of the biomass removed. Therefore, unlike a cut-and-carry pasture receiving TMW, there would lower-rates of nutrient removal from the system. Therefore, it is likely that nitrate leaching and phosphorus accumulation in the soil would be greater than in a grazed pasture.

Aims

We aimed to determine whether NZ-native vegetation on Banks Peninsula could be established while receiving TMW irrigation at a rate of 1000 mm per year. Specifically, we sought to determine, whether this rate of irrigation would result in ponding, excess nitrate leaching, accumulation or depletion of elements in soil, changes in the survival and growth of individual NZ-native plant species.

Methods

Field trial

In June 2015 a field trial was established at Piper's Valley Road, Duvauchelle, Banks Peninsula (Figure 1). The area of ca. 20 m x 55 m was fenced off from an adjacent paddock under sheep grazing. The soil was a Pawson Silt Loam (Table 1) supporting a pasture dominated by *Dactylis spp.* (cocksfoot) with some *Holcus lanatus* (Yorkshire fog).

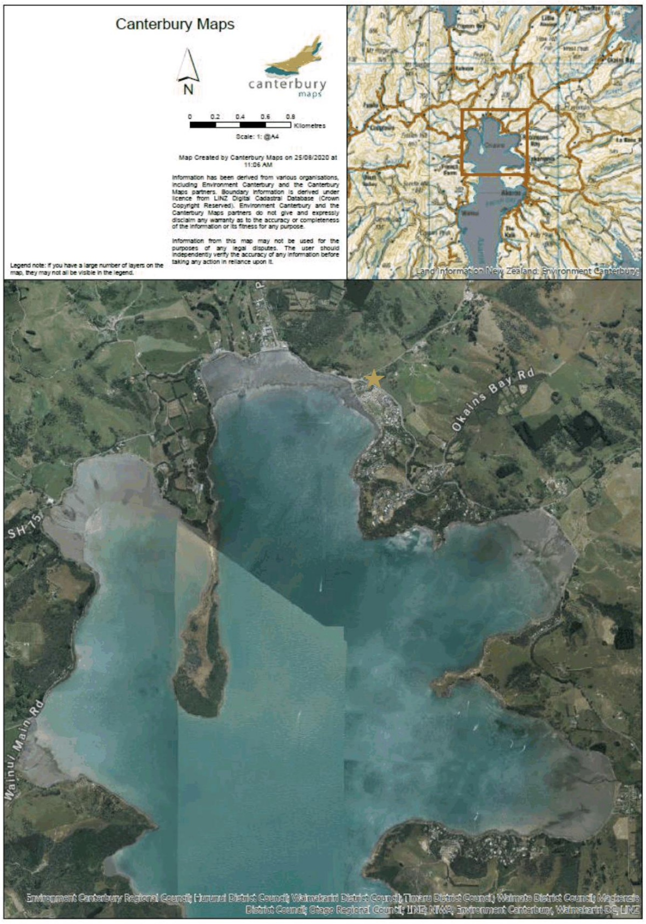

Figure 1: Location of the field site in Duvauchelle (yellow star).

Table 1: Physical properties of the Pawson Silt Loam from the field site at Duvauchelle. Values in brackets represent the standard error of the mean, n=5. (Griffiths 1973; McIntyre 2018).

Horizon	A	Bw	Bg
Depth (m)	0.20-0.28	0.28-0.39	0.39-0.60
Clay (%)	8 (1.3)	9.8 (0.9)	8.3 (0.7)
Silt (%)	22.5 (2.5)	25.4 (1.8)	23.5 (1.6)
Sand (%)	68.5 (3.5)	64.8 (2.8)	68.3 (2.2)

In July 2015, 1350 native trees were planted. The trees were divided into 27 blocks of 4 m x 4.5 m (Figure 2). Eleven native New Zealand species were split into three different vegetation types: monocot dominated, Myrtaceae and broadleaves (Table 2). Twelve of the 27 blocks received TMW irrigation at a rate of 1000 mm per annum (Table 3). Irrigation started in January 2016. Weed control was conducted by lawnmower from 2015 to 2017. In June 2017, all areas within the plot that were not under native vegetation were planted with silver tussock (*Poa cita*) to minimise the need for further weed control. Thereafter, weeds were occasionally removed using a weedeater.

MC	MC	MC
3W	2W	1W
1C	3C	2C
2W	3W	1W
2C	1C	3C
1W	2W	3W
3C	2C	1C
3W	2W	1W
1C	3C	2C

C: control
W: TMW irrigation
1/2/3: vegetation type
M: mixed vegetation

Figure 2: Recent satellite photo of the field site with visible treatment blocks (left) and schematic overview of the trial (right).

Table 2: Vegetation types at the field site.

Vegetation	Species	Botanical reference	Māori name	Common name
Type 1 (Myrtaceae)	*Leptospermum scoparium*	J.R. Forst. & G. Forst.	mānuka	tea tree
	Kunzea robusta	De Lange & Toelken	kānuka	tea tree
Type 2 (Broadleaves)	*Coprosma robusta*	Raoul	karamu	-
	Olearia paniculata	Druce	akiraho	-
	Pseudopanax arboreus	Philipson	puahou	five finger
	*Podocarpus laetus**	Hooibr. ex. Endl.	tōtara	Hall's tōtara
Type 3 (Monocot dominated)	*Phormium tenax*	J.R. Forst. & G. Forst.	harakeke	flax
	Phormium colensoi	Hook.f.	wharariki	mountain flax
	Cordyline australis	Hook.f.	tī kōuka	cabbage tree
	Pittosporum eugenioides	A.Cunn.	tarata	lemonwood
	Griselinia littoralis	Raoul	kapuka	broadleaf

* Referred to as *Podocarpus cunninghamii* in previous reports.

Table 3: Characteristics of irrigated TMW from the Duvauchelle wastewater treatment plant. Mean and standard deviation, n=54. Total applied refers to a 34-month period from the start of the irrigation in January 2016 to soil sampling in October/November 2018.

Compound	TMW		Amount applied kg/ha/yr	Total applied kg/ha
pH	7.5			
Electric Conductivity	423 (40)	uS/cm		
Total suspended solids	32	g/m^3		
Ammonium-nitrogen	0.49 (0.15 – 0.80)*	mg/L	4.9	13.9
Nitrate-nitrogen	18 (7.5)	mg/L	180	510
Nitrite-nitrogen	0.86 (0.09)	mg/L	8.6	24.4
Total nitrogen	<25	mg/L	<250	<708
Aluminium	0.43 (0.11 – 1.7)*	mg/L	4.3	12.2
Boron	0.10 (0.04)	mg/L	1	2.8
Calcium	59 (12)	mg/L	59	1672
Cadmium	<0.001	mg/L	<0.01	0.03
Copper	0.04 (0.03)	mg/L	0.4	1.13
Iron	0.96 (0.25 – 3.6)*	mg/L	9.6	26.9
Potassium	22 (5.0)	mg/L	220	623
Magnesium	19 (5.5)	mg/L	190	538
Manganese	0.06 (0.03)	mg/L	0.6	2.7
Sodium	95 (21)	mg/L	950	2692
Phosphorus	11 (5.0)	mg/L	110	312
Sulphur	25 (11)	mg/L	250	708
Zinc	0.17 (0.11)	mg/L	1.7	4.8
Sodium Accumulation Ratio	15 (2.6)			

*Geometric mean and standard error range.

Sample collection

Soil samples were collected between 25.10.2018 and 08.11.2018. The soil was sampled under 5 species; *Phormium tenax*, *Cordyline australis*, *Leptospermum scoparium*, *Kunzea robusta* and *Coprosma robusta*. Four soil pits were opened per species and treatment (TMW/control) combination, resulting in a total of forty pits. A spade was used to open soil pits of 0.6 m x 0.6 m x 0.6 m next to the plant base. This ensured that the collected soil sample originated from the root zone of the plant. Following removal of the surface litter, a trowel was used to sample soil at 0-5 (referred to as 0 in Figures), 15, 30, 45, and 60 cm, resulting in a total of 200 samples (Figure 3).

Figure 3: Sample collection from a soil pit.

Plant growth was assessed in July 2019. At that time plant canopy had closed and the estimation of the biomass was made by measuring plant height. Each of the 1350 plants at the site was measured with a measurement tape. Plant samples were taken from the forty plants that had soil pits dug at their base in 2018. For each plant, 10 branches/leaves from different heights were cut by secateurs and combined to generate a representative sample.

Chemical analyses

Soil nitrate and exchangeable ammonium were extracted from the soil with 2 M KCl (Blakemore, 1987). 40 mL of 2M KCl was added to 4 g of fresh soil, shaken for 1 hour at 120 cycles/min in a horizontal shaker, and filtered through Whatman No. 42 filter paper. Colorimetric methods were used to determine nitrate (Miranda et al., 2011) and ammonium (Mulvaney, 1996) in the extract, using a Cary 100 Bio (Agilent Technologies) UV-visible spectrophotometer.

Soils were spread on aluminium trays, dried at 40 °C for 4 days and sieved to <2mm. Plants were washed with deionised water before being dried at 60 °C for 4 days. Leaves were separated from the stems. Plant leaves and subsamples of soils were ground with a Rocklabs ring mill.

Soil moisture content was determined by drying 10-20 g of moist soil at 105 °C for 24 hours. Soil weight was recorded before and after drying and the difference used to determine the moisture factor (Blakemore et al., 1987).

A Vario-Max CN Elemental Analyser (Elementar, Germany) was used to determine total carbon and nitrogen contents in the ground soil samples. A LECO CN828 Carbon/Nitrogen analyser (LECO, U.S.) was used to determine total carbon and nitrogen contents in the ground plant samples.

Soil pH was determined in deionised water using a 1: 2.5 g soil: water ratio. The extracts were shaken vigorously and left to equilibrate overnight. The pH was determined using a HQ 440d Multi-Parameter Meter (HACH, U.S.) with pH probe PHC735 (HACH, U.S.).

Soil and plant samples were digested to determine total element concentrations. 1.0 g of ground soil was digested with 4 mL HNO_3 and 10 mL HCl. Samples were left to pre-digest overnight and were then digested on an aluminium heating block at 90 °C for 1 hr. Samples were left to cool down, diluted to 20 mL with ultrapure water (18.2 MΩ cm) and filtered through Whatman No. 42 filter paper. 0.2 g of ground plant sample was digested with 15 mL ultrapure conc. HNO_3 on an aluminium block at 120 °C for 1 hr. Digests were diluted to 25 mL with ultrapure water. Certified reference material was included for soil and plant digestions (SRM 2710a – Montana I Soil and SRM1573a – Tomato Leaves, National Institute of Standards and Technology, U.S. Department of Commerce). Element concentrations in the digests were determined by Microwave Plasma-Atomic Emission Spectrometer (MP-AES) Agilent 4200 (Agilent Technologies, U.S.)

$Ca(NO_3)_2$ was used to extract phytoavailable metals from the soil (Gray et al., 1999). 5.0 g of soil (air-dried, sieved to <2mm) was shaken with 30 mL of 0.05 M $Ca(NO_3)_2$ for 120 min at 15 rpm in an end-over-end shaker, followed by centrifugation at 10,000 rpm for 10 min. Extracts were filtered through Whatman No. 42 filter paper. Extracts were diluted 21 times with 2% ultrapure HNO_3 and element concentrations analysed by Inductively coupled plasma mass spectrometry (ICP-MS) Agilent 7500 CX (Agilent Technologies, U.S.)

To determine plant-available phosphorus (Olsen P), 1.0 g of soil (air dried, <2mm) was extracted with 20 mL 0.5 M $NaHCO_3$ extractant (Blakemore et al., 1987). Samples were shaken for 30 min in an end-over-end shaker at 50 rpm and centrifuged at 2,000 rpm for 10 min. The extract was filtered through Whatman No. 42 filter paper. The P concentration in the extract was determined colorimetric (Olsen, 1954), using a Cary 100 Bio UV-visible spectrophotometer (Agilent Technologies, U.S.).

Calculation of nitrate leaching

Nitrate leaching was calculated using the drainage and the concentration of nitrate measured at 60 cm depth, a zone that is depauperate in organic matter and NZ-native plant roots (Franklin, 2014). Assuming an average annual precipitation is 1000 mm (ClimateData.org, 2020) and the average annual evapotranspiration is 500 mm (Stats, 2020), the drainage from the site will be:

Drainage = 1000 mm irrigation + 1000 mm rainfall - 500 mm = 1500 mm (15000 m^3/ ha)

Nitrate leaching (kg/ha) was calculated using nitrate-nitrogen concentrations at 0.6 m depth, which was below all but the deepest roots. Nitrate at this depth is assumed to leach into groundwater.

Statistical analysis

Data was analysed, graphed and tabulated in Microsoft Excel 2016. A one-way t-test was used to compare treatments at different soil depths. The significance level was $p<0.05$.

Results and discussion

Infiltration and accumulation of sodium and other basic cations

No evidence of ponding or runoff throughout the trial indicating that infiltration was adequate and not significantly perturbed by the application of TMW. This is consistent with the findings of other studies investigating infiltration of similar rates of TMW into Banks Peninsula soils (McIntyre, 2018; Gutiérrez-Ginés et al., 2020). The effluent in Duvauchelle has Sodium Accumulation Ratio (SAR) of 15 (Table 3), below this threshold. In some of the plots, irrigation with TMW significantly increased soil sodium concentrations. While sodium in the topsoil increased by 25% (Table 4), we have strong evidence that sodium is not continuing to accumulate in this system. Over the three-year irrigation period, some 2700 kg/ha sodium equivalent was added to the soil. However, the measured increase in sodium in the soil profile was only 735 kg/hg. This indicates that excess sodium was leaching through the soil profile and not accumulating in the top 0.6 m. These findings are consistent with (Gutiérrez-Ginés et al., 2020), who demonstrated that while TMW increased soil Na concentrations in Barry Silt Loam (Duvauchelle), there was no long-term accumulation of sodium in a lysimeter trial.

Figure 4 shows the concentrations of sodium in the soil profile[1]. Accumulation of sodium can also change soil pH (Figure 5). Our results indicate soil pH was significantly increased on the *L. scoparium* and *K. robusta* plots. This pH value of the TMW soils and the magnitude of change is similar to what may be achieved in agriculture by adding lime to the soils (McLaren and Cameron, 1996). The pH of all the plots was within the optimal range for most plants (Rengel, 2002).

Total sodium was not significantly increased on average (all species). However, some species showed significant increases. Using e.g. *P. tenax* as an example, the topsoil (0-5 cm) contained 174 mg/kg more sodium in the treatment compared to the control (a 25% increase). On a per-hectare basis, this equates to 120 kg extra sodium per ha. In contrast, some 2700 kg of sodium were added - indicating that 2580 kg have leached to deeper horizons. This indicates that sodium is only accumulating to a certain level in the topsoil - consistent with the findings of Gutiérrez-Ginés et al. (2020).

Continual application of sodium can result in the increased leaching of other basic cations, especially potassium, magnesium and calcium (K^+, Mg^{2+} and Ca^{2+}) (FAO, 2020). The results at Duvauchelle indicate that all three of these elements significantly increased in the topsoil (Table 4). Calcium and magnesium increased by 7% and 37% respectively, thereby offsetting the increase in sodium. Unlike sodium, the increase in soil calcium was proportional to the calcium added in the effluent, indicating that there will be a long-term accumulation of calcium. This is beneficial for the system, because calcium improves soil structure (McLaren and Cameron, 1996) and plants can thrive in soils containing several percent calcium (Valentinuzzi et al., 2015).

[1] Provisional results. These results are precise (i.e. relatively correct. Relative Standard Error <4%), however, accuracy (i.e. absolute value) to be revised.

Table 4: Soil properties of the irrigated and non-irrigated plots for the Duvauchelle field trial at 0-5 cm. Mean and standard error of the mean in brackets (n=20). The chemical parameters of the deeper profiles are given in Tables A-1 to A-4 (Appendix 1).

	Total		$Ca(NO_3)_2$-extractable	
	Control	TMW application	Control	TMW application
pH	5.54 (0.04)	5.66 (0.05)*	na	na
Carbon (%)	3.32 (0.10)	3.48 (0.10)	na	na
Plant nutrients				
Nitrogen (%) Ammonium (mg/kg) Nitrate (mg/kg)	0.33 (0.01) 17.6 (1.70) 5.9 (0.86)	0.35 (0.01)* 19.2 (1.69) 11.5 (1.51)*	na	na
Phosphorus (mg/kg) Olsen-P	1133 (36.3) 14.0 (1.17)	1261 (58.0)* 17.3 (2.71)	na	na
Potassium (mg/kg)	2340 (138)	2410 (124)	nd	nd
Sulphur (mg/kg)	<816 (75.7)	947 (66.5)	nd	nd
Calcium (mg/kg)	7145 (257)	7653 (355)	nd	nd
Magnesium (mg/kg)	7232 (910)	9941 (1577)	nd	nd
Copper (mg/kg)	16.0 (0.55)	19.3 (2.13)	<0.012 (0.004)	<0.046 (0.019)*
Manganese (mg/kg)	1159 (53.2)	1322 (115)	1.91 (0.16)	1.86 (0.41)
Zinc (mg/kg)	88.9 (3.30)	89.0 (3.37)	0.096 (0.012)	0.106 (0.017)
Contaminants				
Sodium (mg/kg)	705 (34.2)	>879 (52.6)*	nd	nd
Cadmium (ug/kg)	nd	nd	0.67 (0.05)	0.50 (0.05)*
Lead (ug/kg)	nd	nd	0.57 (0.17)	<1.21 (0.43)

na=not applicable
nd=not determined
* significant difference between treatments (p<0.05)
< actual mean is lower due to sample concentrations being below detection limit
> actual mean is higher due to samples concentrations being above measurement range

Sodium

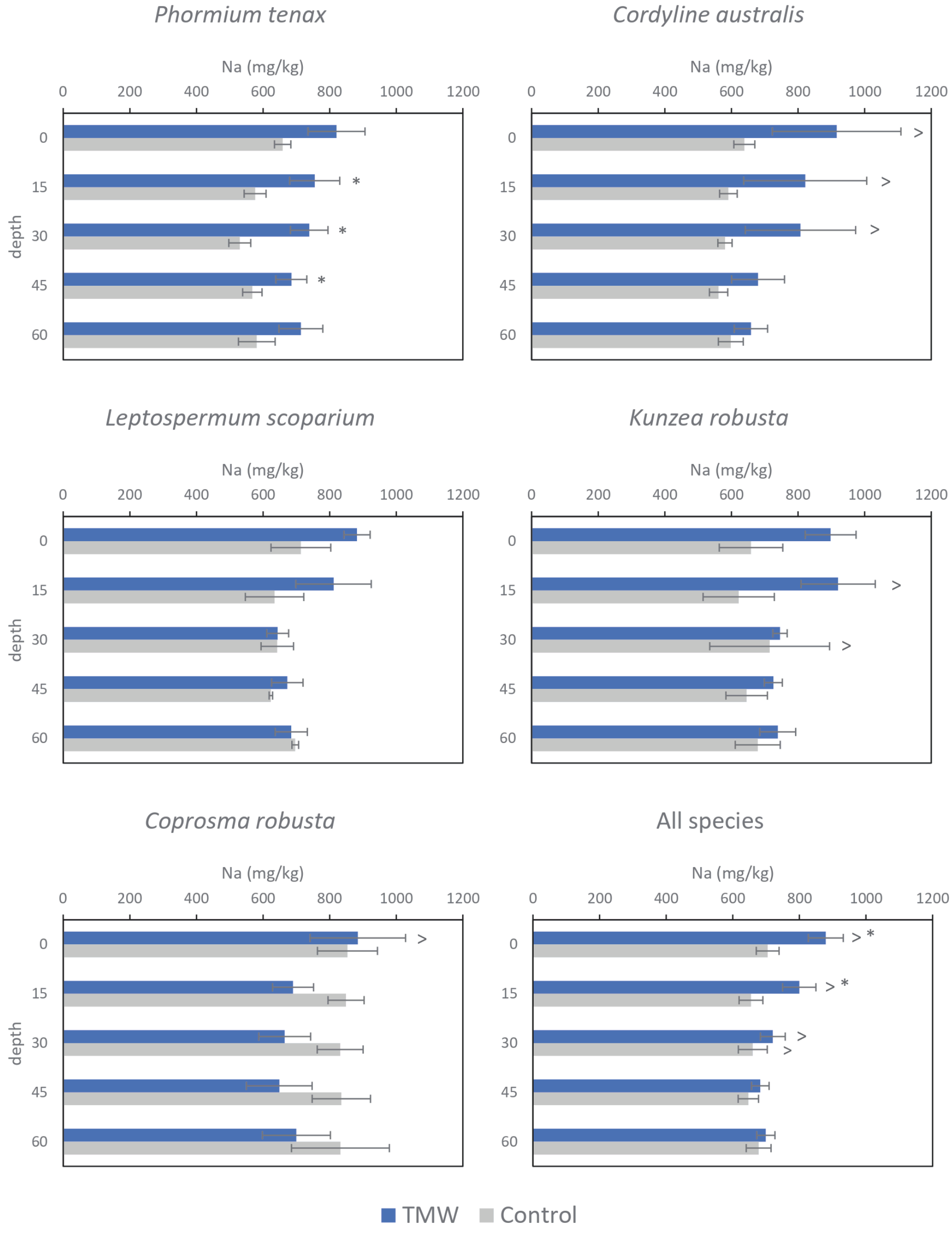

Figure 4: Soil sodium concentration (mg/kg) under different species. Mean and standard error of the mean (n=4). Significant difference between treatments at p<0.05 indicated by (*).

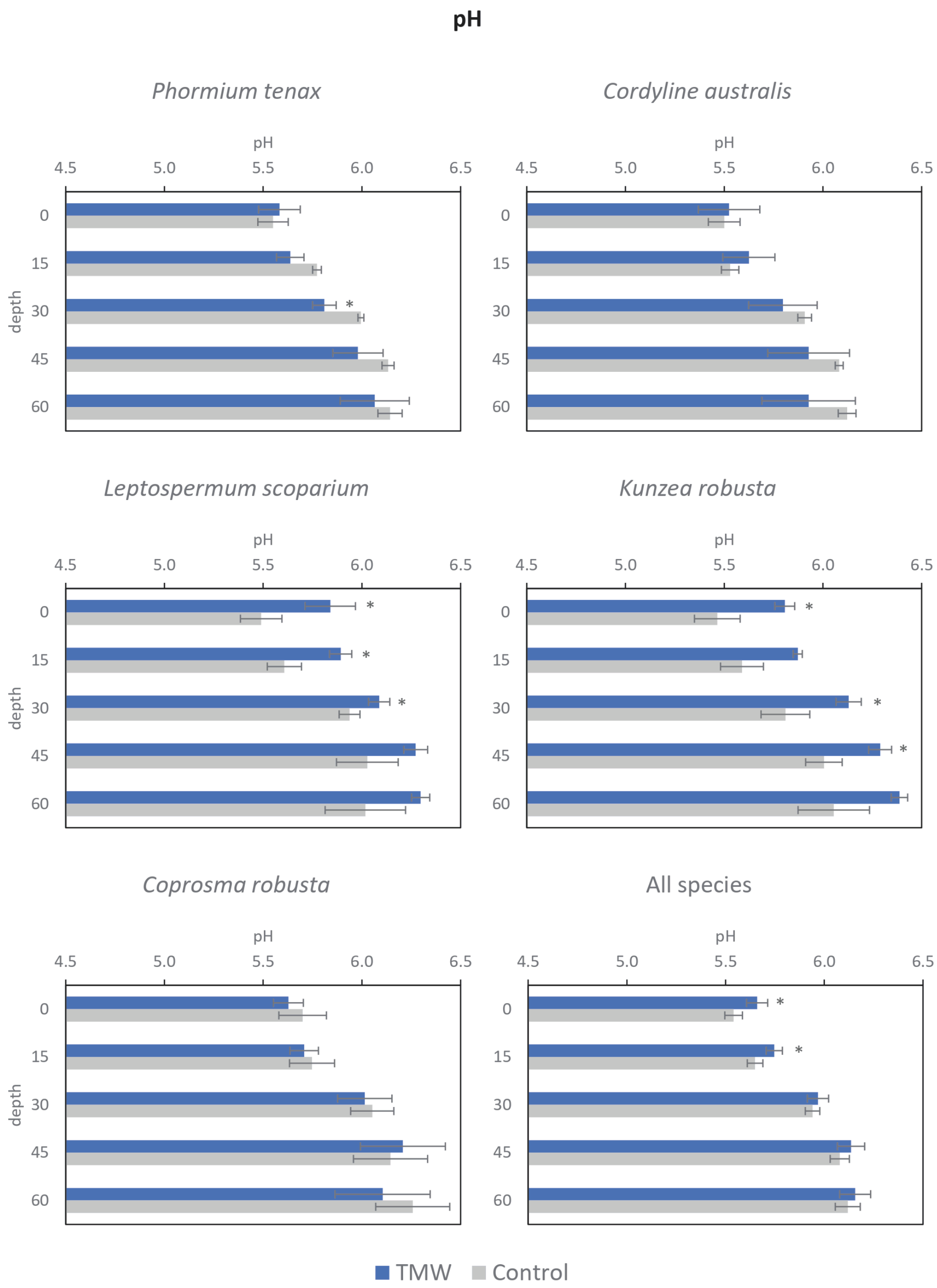

Figure 5: Soil pH under different species. Mean and standard error of the mean (n=4). Significant difference between treatments at p<0.05 indicated by (*).

Carbon and Nitrogen

Across all the plots, the application of TMW did not significantly change soil carbon (Table 4). In the *P. tenax* and *K. robusta* plots, there was a significant increase in soil carbon in the topsoil (Figure 6). This indicates that TMW application is not reducing soil organic matter, despite the potential for elevated nitrogen and phosphorus, applied with the TMW, to increase the oxidation of soil organic matter (McLaren and Cameron, 1996). We would expect there to be a decrease of soil carbon as grazed pasture is converted into forest (Scott et al., 2006). Such a decrease would occur with or without TMW application.

Irrigation with TMW increased soil nitrogen by just 6%, despite an application rate of 250 kg N/ha/yr equivalent (Figure 7). This may be due to increased plant uptake, and increased leaching, and increased denitrification due to increased soil moisture content (Clough et al., 2004) and high pH (SImek and Cooper, 2002) in the TMW irrigated plots. Overseas studies have shown that 25 - 150 kg/ha of applied nitrogen can be lost through denitrification (Paul and Zebarth, 1997; Mahmood et al., 1998). In New Zealand, studies with Dairy Shed Effluent reported that some 60 kg/ha/yr were lost through denitrification (Di and Cameron, 2000).

Soil ammonium concentrations were not significantly different in the TMW and control plots (Figure 8). However, TMW significantly increased soil nitrate concentrations (Table 4, Figure 9) in many of the soils. Higher nitrate is consistent with higher application rates of nitrogen through TMW and higher rates of nitrification caused by higher pH (Ste-Marie and Paré, 1999; Sahrawat, 2008). Nitrate concentration in the irrigated plots is highest in *K. robusta*, followed by *L. scoparium*. Any nitrogen that is added to the soil in the TMW will either be taken up by plants, denitrified into nitrogen gas or nitrous oxide (N_2O), or leached down through the soil profile as nitrate (Figure 10 and Appendix 2).

Just 1% of the applied nitrogen is expected to be emitted as nitrous oxide following TMW irrigation, indicating that 2.5 kg N_2O-N/ha/yr is emitted from the irrigated plots in Duvauchelle (van der Weerden et al., 2016). This is lower than nitrous oxide emissions from grazed pasture, which can be as high as 11.7 kg N_2O-N/ha/yr (Saggar et al., 2007).

Total Carbon

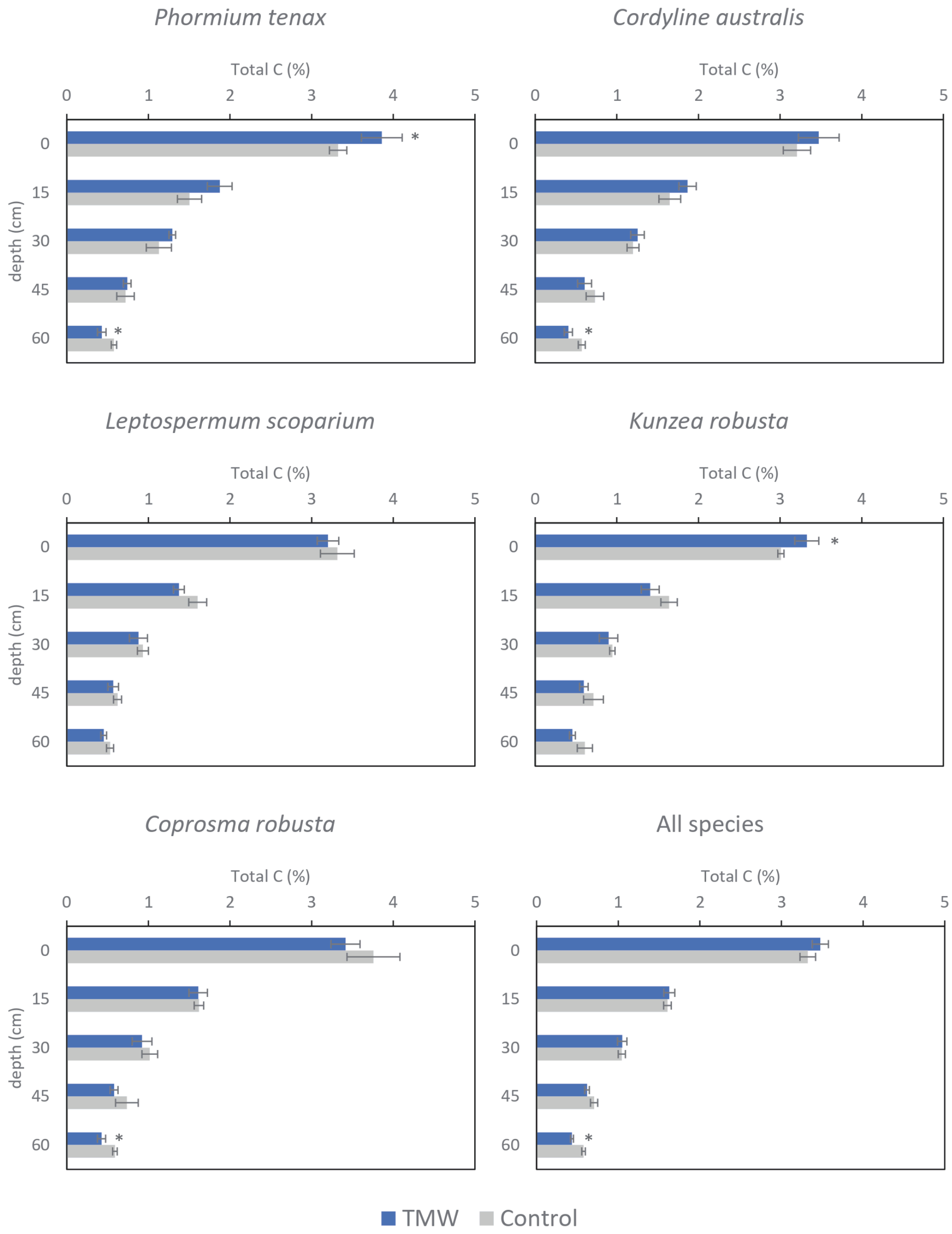

Figure 6: Soil total carbon concentration (%) under different species. Mean and standard error of the mean (n=4). Significant difference between treatments at p<0.05 indicated by (*).

Total Nitrogen

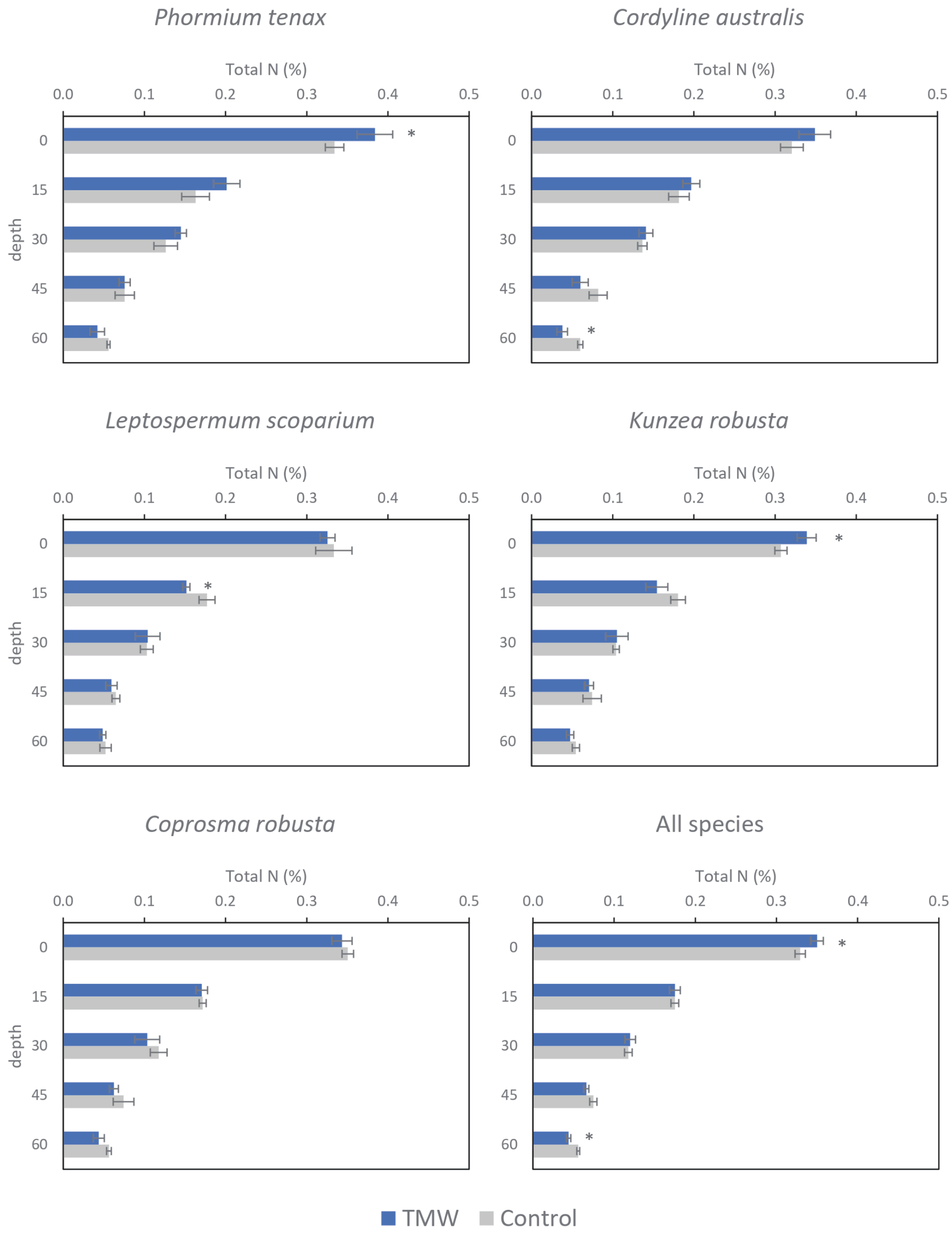

Figure 7: Soil total nitrogen concentration (%) under different species. Mean and standard error of the mean (n=4). Significant difference between treatments at p<0.05 indicated by (*).

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Attachment C Item 4

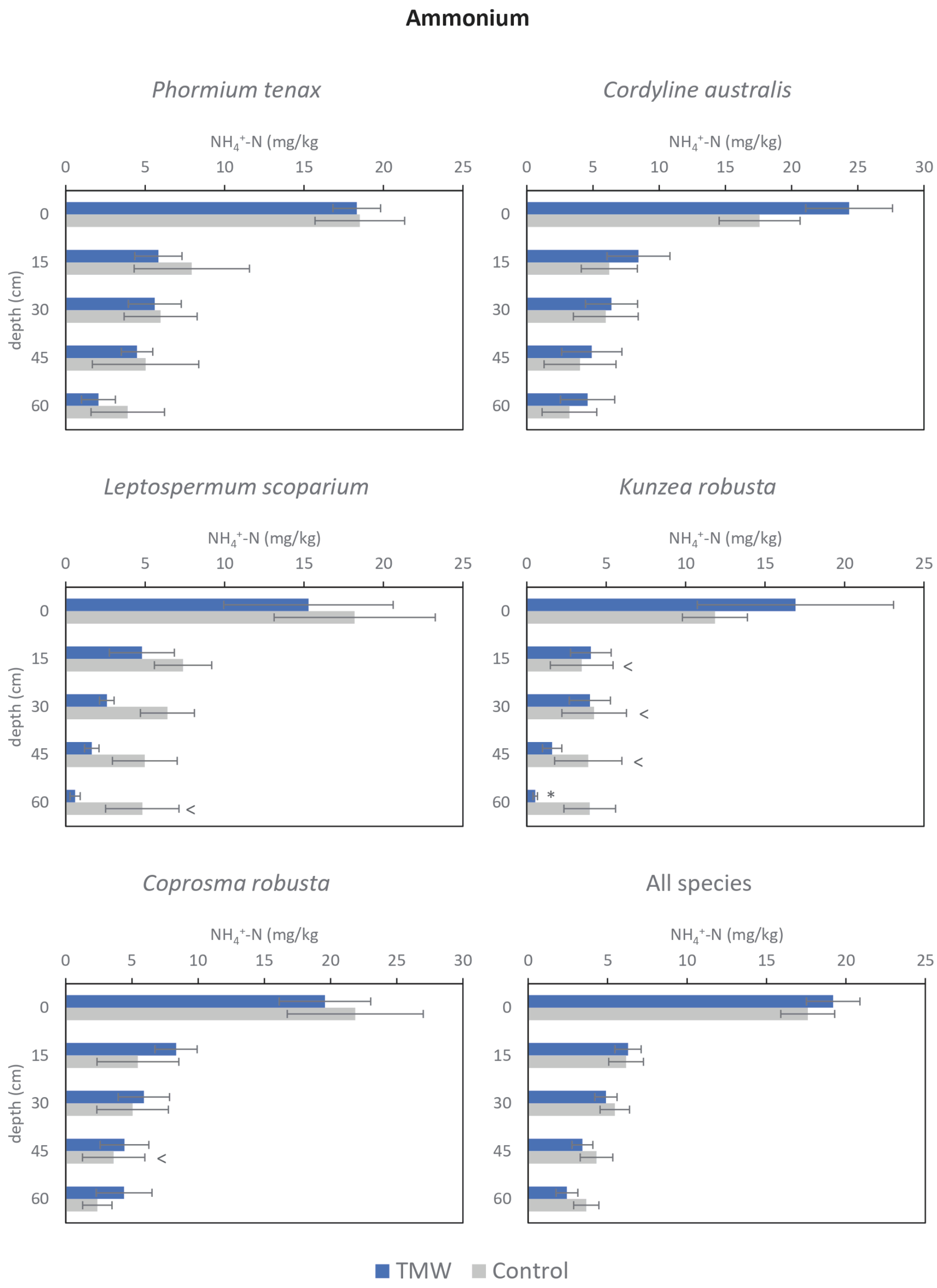

Figure 8: Soil ammonium concentration (mg/kg) under different species. Mean and standard error of the mean (n=4). Significant difference between treatments at $p<0.05$ indicated by (*).

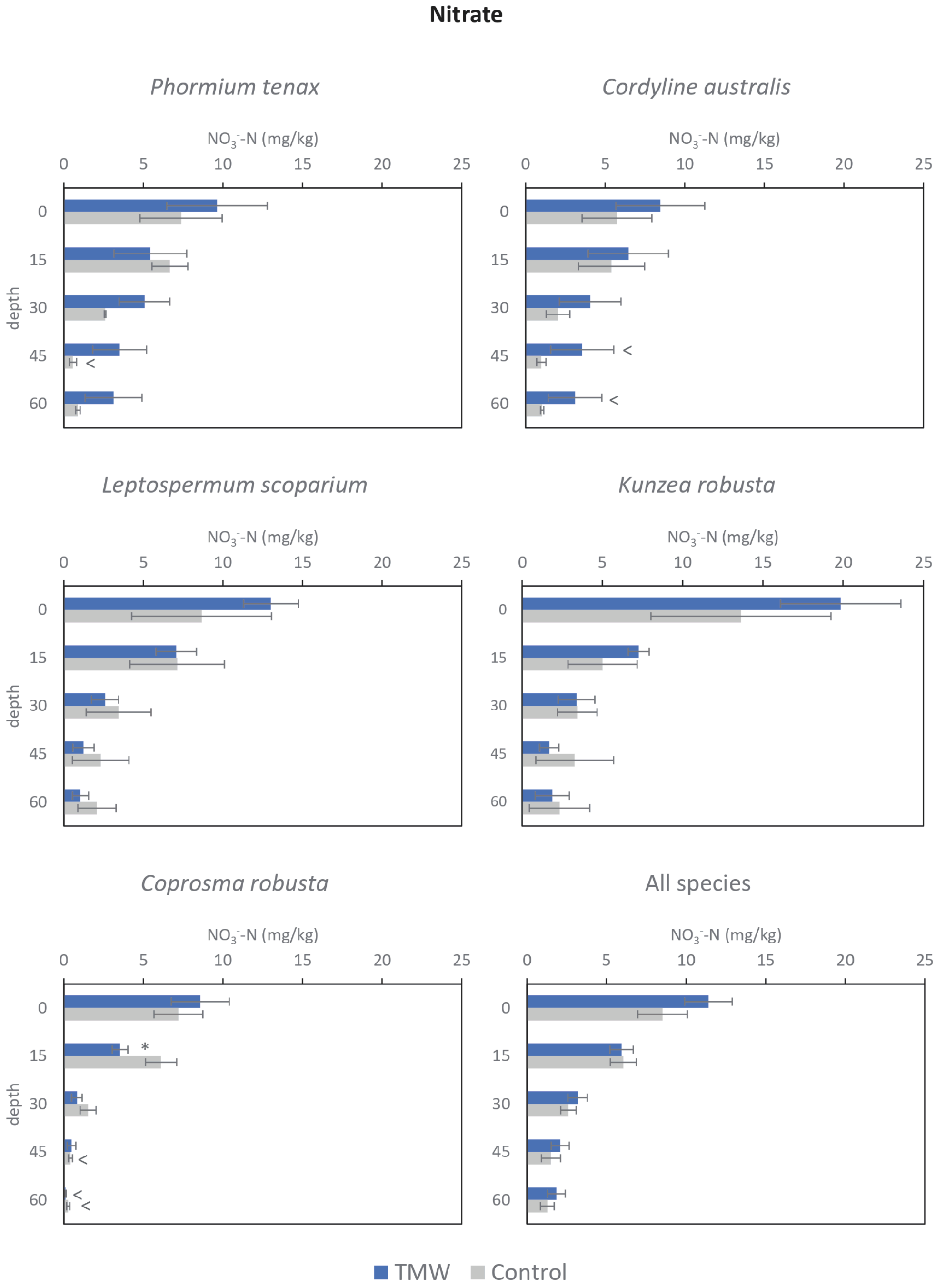

Figure 9: Soil nitrate concentration (mg/kg) under different species. Mean and standard error of the mean (n=4). Significant difference between treatments at $p<0.05$ indicated by (*).

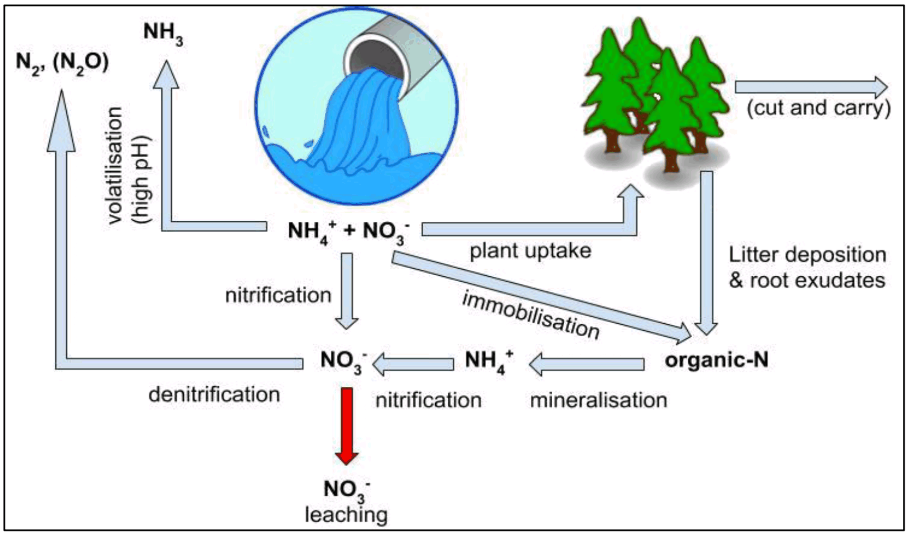

Figure 10: Nitrogen fluxes in irrigated systems (Meister et al. 2019, Appendix 2).

Nitrate leaching

Table 5 shows the calculated nitrate-nitrogen concentrations under the five species with and without TMW irrigation. These results (2 - 47 kg/ha) are lower than those estimated in our preliminary report (15 - 60 kg/kg). Overall, there was a 44% increase in nitrate leaching under the effluent-irrigated vegetation. These values are significantly greater than nitrate leaching that would occur under TMW irrigated cut-and-carry pasture (Gutiérrez-Ginés et al., 2020) and are similar to nitrate leaching rates that occur under grazed-pasture in conventional farming systems (Stats, 2019). There were significant differences between C. robusta and the other species: NO3- leaching was negligible (<4 kg/ha/yr). This may, in part, be due to the greatly accelerated growth of C. robusta under TMW irrigation (see section plant development). These results indicate that under a TMW irrigation rate of 500 - 800 mm/yr, nitrate leaching will be similar to grazed pasture.

Table 5: Mass of nitrate-nitrogen leached (kg/ha/yr equivalent) calculated from measurements taken in October/November 2018.

	Control	TMW irrigated
Phormium tenax	13.2	46.8
Cordyline australis	15.6	46.5
Leptospermum scoparium	31.1	15.7
Kunzea robusta	35.0	28.2
Coprosma robusta	4.04	1.59
All species	19.2	27.8

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Phosphorus[2]

Irrigation with TMW caused a significant (11%) increase in the total phosphorus concentration in the topsoil (Table 4), although there was no significant difference when considering the whole soil profile (0-60 cm). This is because the amount of phosphorus added over the entire experimental period (312 kg) was small compared to the total phosphorus in the soil profile (7606 kg). The rate of accumulation is similar to that calculated using a model system for the potential Akaroa wastewater system (Appendix 3).

The strong adsorption of phosphorus in soil means that only a small part of the applied phosphorus is taken up by plants or leached (McLaren and Cameron, 1996). Therefore, in a TMW irrigated soil, phosphorus will accumulate, just as it does in all NZ soils that receive fertilizers. Under flax, where we observed higher levels of P down to 45 cm depth (Figure 11), preferential flow might lead to the percolation of TMW through the soil profile, and accumulation of phosphorus at greater depths (Gupta et al., 1999). Phosphorus can cause serious environmental issues when it enters waterways (Tilman et al., 2001). This could occur via runoff from a TMW-irrigated area, particularly if it was accompanied by soil erosion. However, no signs of runoff and increased erosion were observed in Duvauchelle. Phosphorus losses will be higher from grazed pasture (irrigated or otherwise) than TMW irrigated NZ-native vegetation due to the mechanical disturbance of soil by the animals (McDowell et al., 2009).

Only a small fraction of phosphorus in soil is available for plants, this is commonly measured by an extraction to give so-called 'Olsen-P' (Olsen, 1954). There were no significant differences in the concentrations of Olsen-P between the TMW-irrigated plots and the controls (Figure 12). This may be because the available P was being accumulated by the vegetation. Available phosphorus (Olsen-P) was within the range (10 - 30 mg/kg) typically found on extensive farming systems (Moir et al., 1997), and well below concentrations reported on soils irrigated with high-phosphorus effluent (Bickers 2005).

[2] Provisional results. These results are precise (i.e. relatively correct. Relative Standard Error <4%), however, accuracy (i.e. absolute value) to be revised.

Phosphorus

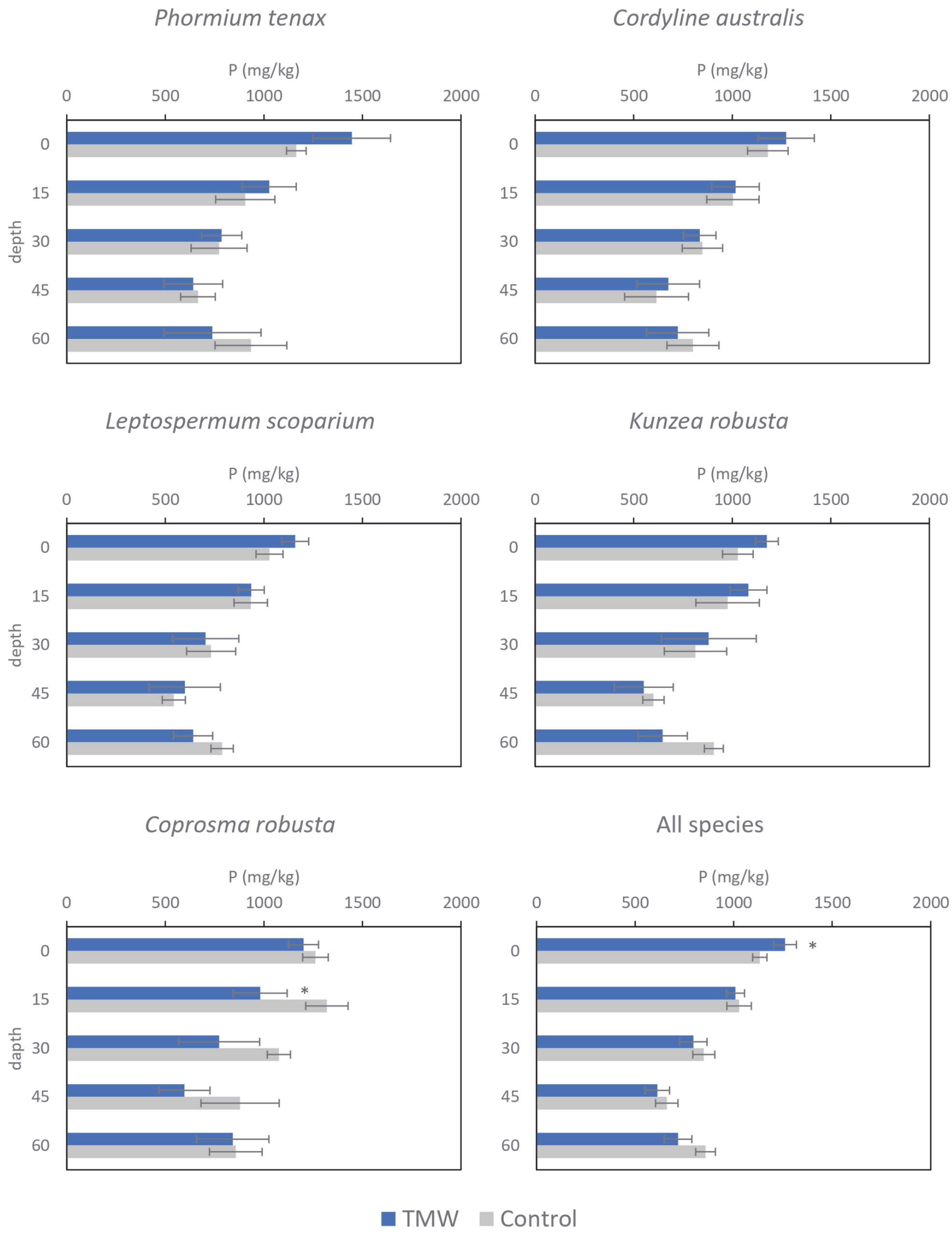

Figure 11: Soil phosphorus concentration (mg/kg) under different species. Mean and standard error of the mean (n=4). Significant difference between treatments at p<0.05 indicated by (*).

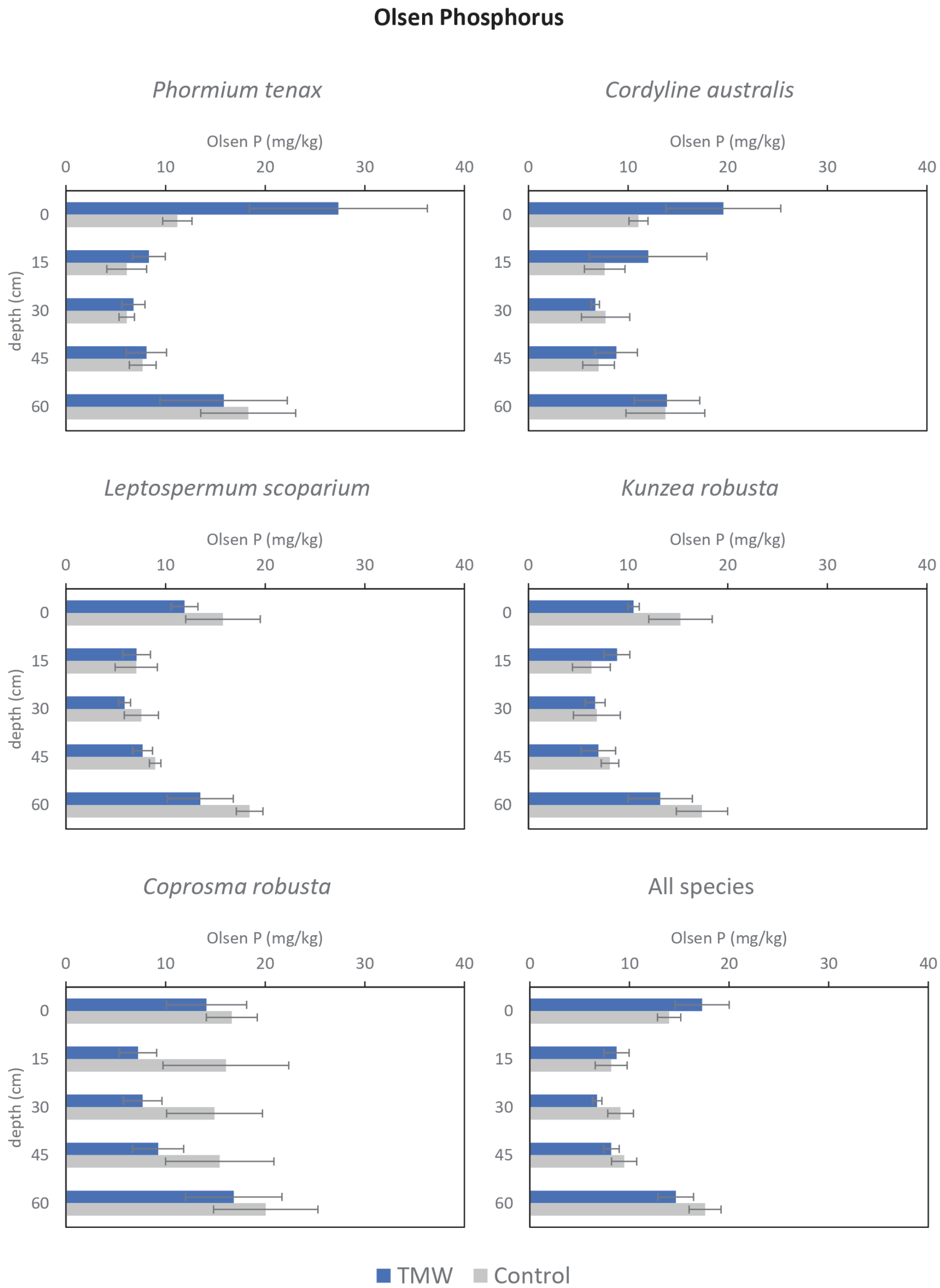

Figure 12: Olsen Phosphorus concentration (mg/kg) under different species. Mean and standard error of the mean (n=4). Significant difference between treatments at p<0.05 indicated by (*)

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Other elements

None of the other elements were significantly affected by the TMW application. Soil concentrations of copper, manganese and zinc were similar to the background concentrations reported for Canterbury soils (Percival et al., 1996). Similarly, with the soluble trace elements, there were few significant differences between the TMW irrigated plots and the controls. Only aluminium and chromium were significantly reduced by TMW application in the topsoil (0-5 cm, Table A-5, Appendix 1). Neither of these elements are essential for plant growth, and a reduction in soluble aluminium can benefit plant growth in acid soils (Jones, 1960). These results indicate that the accumulation of toxic heavy metals in soils receiving TMW as a nutrient source is likely to be less than soils receiving nutrients through mineral fertilizers (Taylor et al., 2016).

Plant development

Most of the plant deaths occurred shortly after planting and before the onset of TMW irrigation: the spring of 2015 was extraordinarily dry. During the first two years of growth (measured in May 2017), the application of effluent either had no effect on growth (*K. robusta, O. paniculata*, *G. littoralis, P. cookianum, P. eugenioides)* or significantly increased growth *(L. scoparium, C. robusta, P. arboreus, P. hallii, P. tenax, C. australis* (Figure 15).

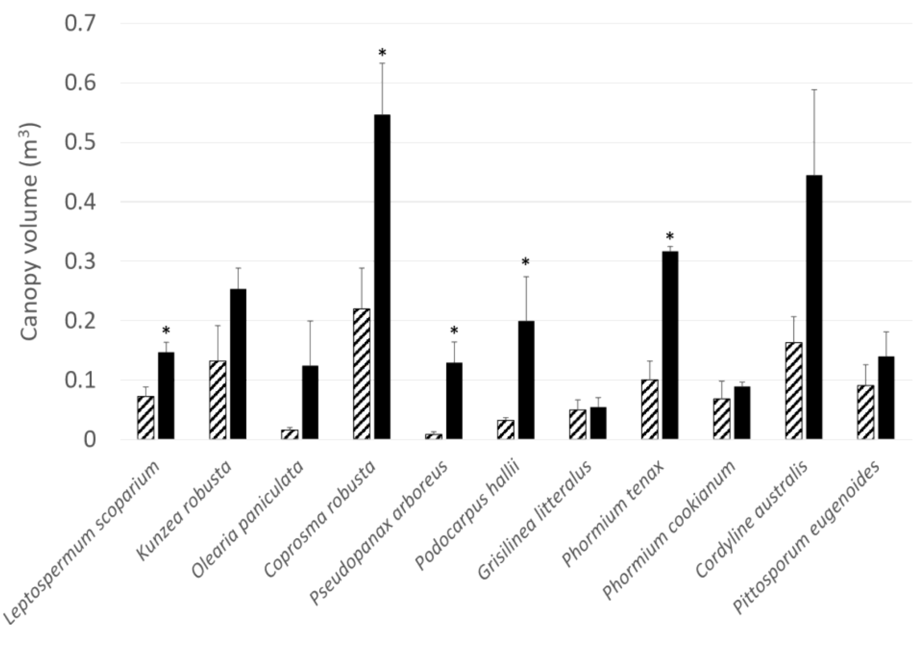

Figure 13: Canopy volume of the plants in the field plot as of May 2017. (*) indicates significant differences between the control (striped bars) and TMW (black bars), Gutierrez-Gines et al. 2017.

By autumn 2018, the canopy of the plants had closed (Appendix 4), eliminating the need to weed between the plants, although weeding occurred on the plot margins. The establishment of *Poa cita* in 2017, reduced the need to remove weeds between the plots and at the margins of the site. This species did not receive TMW. As of 2020, there was no indication of invasive weeds such as *R. fruticosus, S. mauritianum*, *S. dulcamara, P. octandra* or *C. vitalba* that may threaten the site. The weed burden may have been reduced by establishing the native trees into pasture, rather than into bare ground (for example if the site were sprayed-out before planting). In a full-scale planting operation, the plant spacing would likely be 5000 stems per hectare compared to the 20000 stems per hectare equivalent that was planted in the trial plot (to enable results to be obtained in a shorter time frame). At a lower planting density, weeding is likely required for at least another year.

In July 2019, there were 857 surviving plants on the site. The plants have begun to self-thin, i.e. smaller specimens are succumbing to competition from their larger neighbours. Across all species average height of the native vegetation receiving TMW (2.1 m) was significantly greater than the controls (1.9 m). Figure 14 shows the heights of the individual species. While all native species tolerated TMW irrigation (i.e. there were no significant decreases in height), there were significant differences between species.

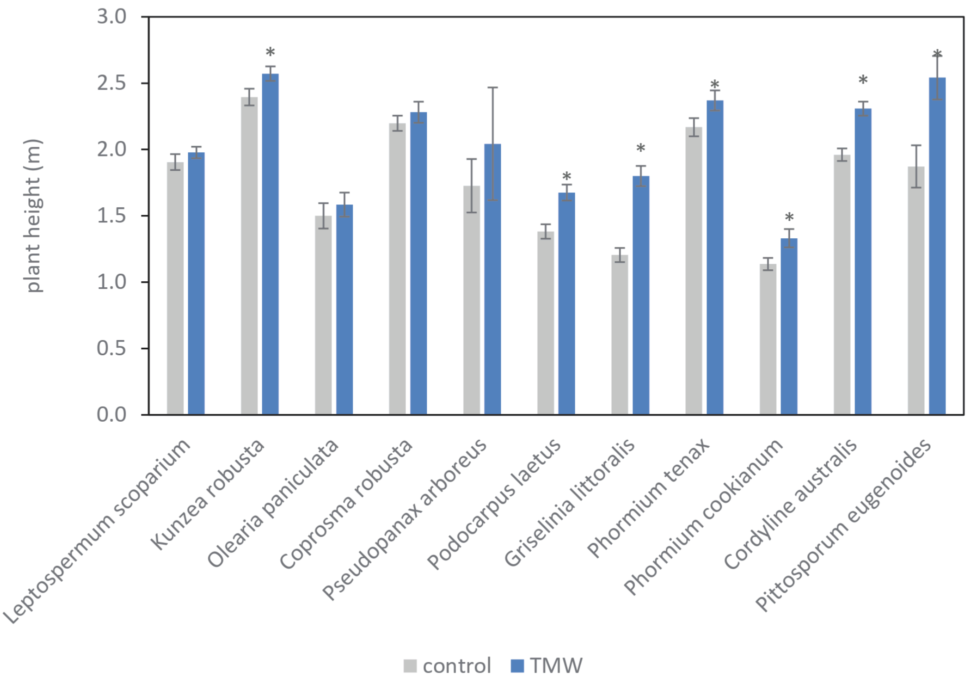

Figure 14: Plant height in July 2019 by species and treatment. Mean and standard errors of the mean.

Observations of individual species, however, indicate that *C. robusta, C. australis*, and *G. littoralis* performed particularly well at the site (Figure 15). In contrast, *L. scoparium*, *P. arboreus,* and *O. paniculata* were not well adapted to the site, with evidence of stress (chlorosis) or disease on trees in both the control and TMW-irrigated plots. In particular, *L. scoparium* has become infected with the common manuka-scale insect (*Eriococcus orariensis*) resulting in sooty-mould growth on the leaves (Figure 15). The survival of *L. scoparium* at this site is uncertain.

Figure 15: *C. robusta* (left), *C. australis* and *P. tenax* (middle) performed well at the site. *L. scoparium* (right) became infected with *E. orariensis,* resulting in the growth of sooty mould.

Plant elemental composition

There were no significant differences in plant-N concentration between the TMW-irrigated plots and the control plots, although there were significant differences between species (Figure 17). This indicates that nitrogen was the limiting factor for plant growth (Marschner, 1995). If nitrogen levels were sufficient, the plant nitrogen concentration would have increased due to luxury uptake (McLaren and Cameron, 1996). This is consistent with previous findings in a lysimeter study by Gutiérrez-Ginés et al. (2020) who measured pasture growth. This indicates that there will be no negative effects on the ecosystem by increased plant nitrogen, such as the biological food chain.

The phosphorus concentration increased in all plants following TMW application. This indicates that P was not limiting plant growth and that plants took up higher amounts of P following TMW application (luxury uptake). This is also consistent with findings by Gutiérrez-Ginés et al. (2020).

There were few other differences in the elemental compositions of the other plants (Table A-6, Appendix 1). Even sodium, which was significantly elevated in the soil, was unchanged by TMW irrigation. These results indicate that irrigating TMW onto NZ-native vegetation will not perturb nutrient status of the plants, nor introduce toxic elements into local ecosystems.

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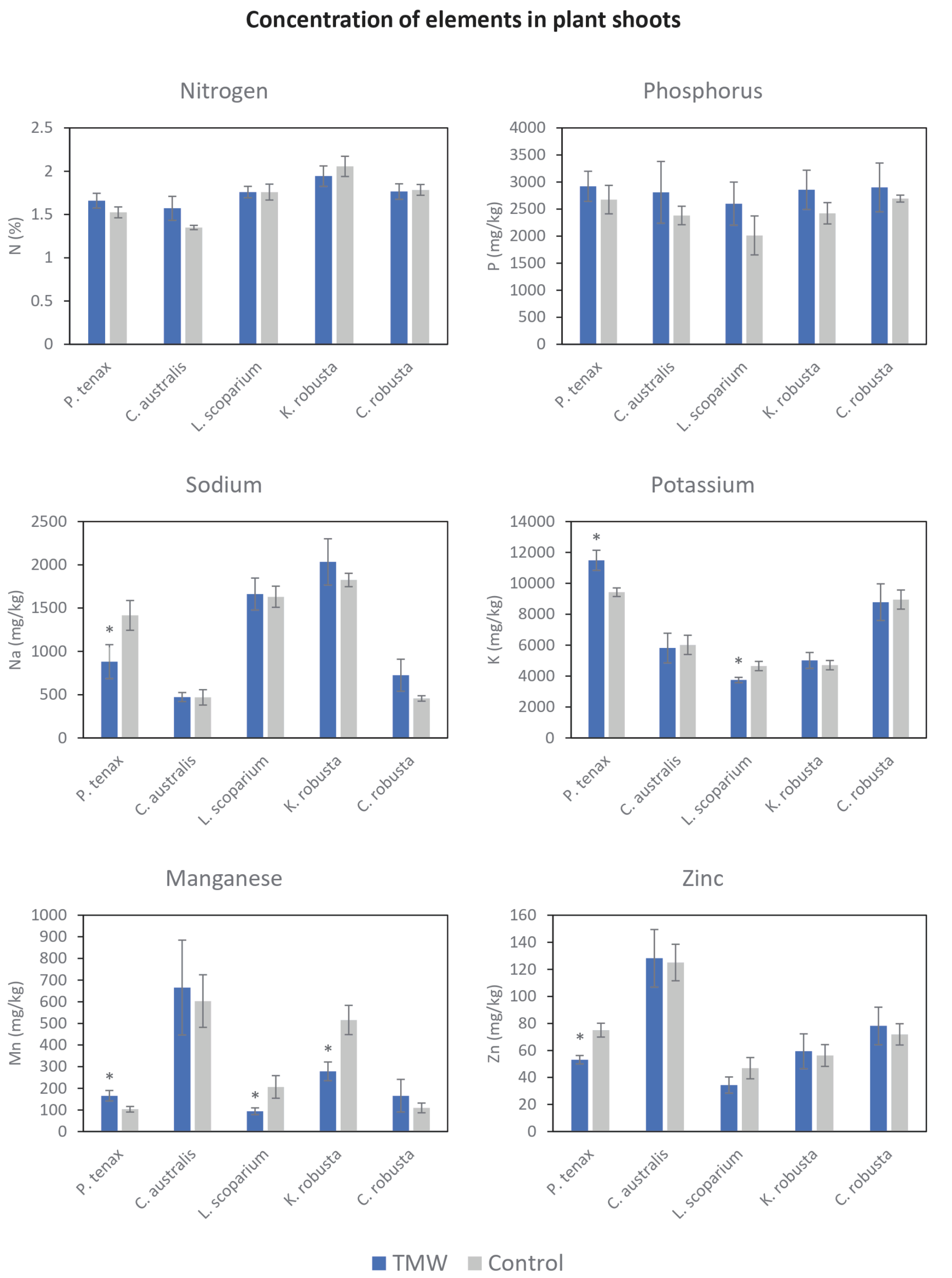

Figure 17: Concentration of elements in the plant shoot dry matter (mg/kg). Mean and standard error of the mean (n=4). Significant difference between treatments at p<0.05 indicated by (*).

Conclusions

The application of TMW to the Pawson Silt Loam on Banks Peninsula can occur at rates of at least 1000 mm/yr without significant soil degradation, accumulation of toxic elements, or induction of nutrient imbalances. However, we recommend a rate of 500 - 800 mm/yr, at least initially. The continual application of sodium may eventually result in depletion of soil calcium, which could be replaced by the occasional application of gypsum ($CaSO_4$). While there was a small increase in the total nitrogen concentration in the topsoil (0-5 cm), the total nitrogen in the TMW-treated plots was not significantly greater than the control plots. There was no evidence of phosphorus accumulation in the soil, probably because the amount of phosphorus added in the TMW was small compared to the mass of P in the soil profile. Available phosphorus (Olsen-P) was within the range typically found on extensive farming systems, and well below concentrations reported on soils irrigated with high-P effluent. Soil concentrations of potentially toxic heavy metals were not affected by TMW application. The concentrations of these elements were similar to background values reported for Canterbury Soils.

The effluent had a negligible effect on the concentrations of nutrients and contaminants in the plant tissues. While the growth of all species was accelerated by the effluent, there was no indication of luxury uptake of plant nutrients or increased concentrations of elements that may be harmful. This indicates that TMW is unlikely to affect ecological food chains.

None of the tested species showed reduced growth following TMW irrigation. However, some species were not well adapted to the site, including *L. scoparium*, *P. arboreus* and *O. paniculata*. In contrast, *C. robusta*, *C. australis* and *G. littoralis* performed particularly well at the site and showed accelerated growth under TMW irrigation compared to the control.

The critical success factor for establishing NZ-native vegetation are **species selection** and **weed control**. The trial at Pipers Valley Road has indicated the NZ-native species that respond well to TMW. These species should be selected for the majority of plantings on Banks Peninsula. Weed control should form part of the planting plan and include the contractors who will do the weeding. Planting into grass such as *Holcus lanthus* (Yorkshire Fog), has better outcomes than blanket spraying and planting into bare soil. Spot spraying may be appropriate. Close (1 m x 1 m, 10,000 stems/ha) plant spacing reduces the time that the site needs to be weeded but can reduce weeding options. Close planting is also more expensive. Compared to close planting, Lower density planting (e.g. 4000 stems per hectare) is less expensive to plant and to remove weeds, but weed control will be required for a longer period, adding to costs. A critical success factor is the appointment of a site manager who can monitor weeding and intervene as appropriate.

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Appendix 1: Supplementary data

Soil properties at 15, 30, 45 and 60 cm

Table A-1: Soil properties of the irrigated and non-irrigated plots for the Duvauchelle field trial at 15 cm. Mean and standard error of the mean in brackets (n=20).

	Total		$Ca(NO_3)_2$-extractable	
	Control	TMW application	Control	TMW application
pH	5.65 (0.04)	5.75 (0.04)*	na	na
Carbon (%)	1.60 (0.05)	1.63 (0.07)	na	na
Plant nutrients				
Nitrogen (%) Ammonium (mg/kg) Nitrate (mg/kg)	0.17 (0.02) <6.16 (1.09) 6.06 (0.81)	0.17 (0.03) 6.29 (0.83) 5.95 (0.73)	na	na
Phosphorus (mg/kg) Olsen-P	1028 (62) 8.17 (1.60)	1009 (47) 8.71 (1.25)	na	na
Potassium (mg/kg)	2363 (131)	2475 (139)	nd	nd
Sulphur (mg/kg)	462 (58)	549 (52)	nd	nd
Calcium (mg/kg)	6787 (264)	7220 (411)	nd	nd
Magnesium (mg/kg)	7241 (959)	9378 (1443)	nd	nd
Copper (mg/kg)	15.1 (0.55)	17.7 (1.40)*	0.023 (0.007)	<0.011 (0.003)
Manganese (mg/kg)	1678 (120)	1821 (162)	1.06 (0.12)	1.18 (0.14)
Zinc (mg/kg)	81.5 (4.29)	72.8 (1.68)*	0.074 (0.013)	0.047 (0.005)*
Contaminants				
Sodium (mg/kg)	655 (36)	>800 (47)*	nd	nd
Cadmium (ug/kg)	nd	nd	0.53 (0.06)	0.49 (0.03)
Lead (ug/kg)	nd	nd	<0.90 (0.29)	1.11 (0.74)

na=not applicable
nd=not determined
* significant difference between treatments (p<0.05)
< mean is lower than reported value due to some sample concentrations being below detection limit
> mean is higher than reported value due to some sample concentrations being above the measurement range

Table A-2: Soil properties of the irrigated and non-irrigated plots for the Duvauchelle field trial at 30 cm. Mean and standard error of the mean in brackets (n=20).

	Total		$Ca(NO_3)_2$-extractable	
	Control	TMW application	Control	TMW application
pH	5.94 (0.04)	5.97 (0.05)	na	na
Carbon (%)	0.20 (0.04)	0.26 (0.06)	na	na
Plant nutrients				
Nitrogen (%) Ammonium (mg/kg) Nitrate (mg/kg)	0.12 (0.00) <5.46 (0.93) 2.60 (0.49)	0.12 (0.01) 4.89 (0.70) 3.19 (0.61)	na	na
Phosphorus (mg/kg) Olsen-P	849 (56) 9.11 (1.29)	796 (42) 6.76 (0.47)	na	na
Potassium (mg/kg)	2386 (135)	2603 (173)	nd	nd
Sulphur (mg/kg)	258 (28)	388 (42)*	nd	nd
Calcium (mg/kg)	6790 (312)	6792 (287)	nd	nd
Magnesium (mg/kg)	7114 (897)	10103 (1600)	nd	nd
Copper (mg/kg)	13.0 (0.75)	14.0 (1.28)	<0.012 (0.004)	<0.009 (0.003)
Manganese (mg/kg)	1902 (172)	2027 (181)	0.52 (0.09)	0.68 (0.09)
Zinc (mg/kg)	70.1 (2.03)	69.6 (2.08)	0.066 (0.041)	0.024 (0.003)
Contaminants				
Sodium (mg/kg)	>660 (43.4)	>720 (37.3)	nd	nd
Cadmium (ug/kg)	nd	nd	0.32 (0.06)	0.30 (0.04)
Lead (ug/kg)	nd	nd	<0.51 (0.16)	<0.40 (0.11)

na=not applicable
nd=not determined
* significant difference between treatments ($p<0.05$)
< mean is lower than reported value due to some sample concentrations being below detection limit
> mean is higher than reported value due to some sample concentrations being above the measurement range

Table A-3: Soil properties of the irrigated and non-irrigated plots for the Duvauchelle field trial at 45 cm. Mean and standard error of the mean in brackets (n=20).

	Total		$Ca(NO_3)_2$-extractable	
	Control	TMW application	Control	TMW application
pH	6.08 (0.22)	6.14 (0.31)	na	na
Carbon (%)	0.70 (0.04)	0.62 (0.03)	na	na
Plant nutrients				
Nitrogen (%) Ammonium (mg/kg) Nitrate (mg/kg)	0.07 (0.02) <4.30 (1.03) <1.51 (0.60)	0.07 (0.01) 3.41 (0.66) <2.09 (0.57)	na	na
Phosphorus (mg/kg) Olsen-P	661 (57) 9.46 (1.26)	613 (62) 8.18 (0.80)	na	na
Potassium (mg/kg)	2116 (109)	2505 (183)*	nd	nd
Sulphur (mg/kg)	166 (27)	254 (39)*	nd	nd
Calcium (mg/kg)	6178 (169)	6434 (303)	nd	nd
Magnesium (mg/kg)	7036 (712)	10833 (1709)*	nd	nd
Copper (mg/kg)	13.5 (0.79)	13.9 (0.91)	<0.016 (0.008)	<0.012 (0.003)
Manganese (mg/kg)	911 (93)	1177 (168)	0.14 (0.02)	0.24 (0.05)
Zinc (mg/kg)	63.6 (8.35)	52.7 (3.34)	<0.032 (0.015)	0.022 (0.009)
Contaminants				
Sodium (mg/kg)	647 (31)	683 (26)	nd	nd
Cadmium (ug/kg)	nd	nd	<0.10 (0.02)	0.11 (0.02)
Lead (ug/kg)	nd	nd	<0.66 (0.28)	<0.63 (0.21)

na=not applicable
nd=not determined
* significant difference between treatments (p<0.05)
< mean is lower than reported value due to some sample concentrations being below detection limit
> mean is higher than reported value due to some sample concentrations being above the measurement range

Table A-4: Soil properties of the irrigated and non-irrigated plots for the Duvauchelle field trial at 60 cm. Mean and standard error of the mean in brackets (n=20).

	Total		$Ca(NO_3)_2$-extractable	
	Control	TMW application	Control	TMW application
pH	6.12 (0.06)	6.16 (0.08)	na	na
Carbon (%)	0.58 (0.02)	0.43 (0.02)	na	na
Plant nutrients				
Nitrogen (%) Ammonium (mg/kg) Nitrate (mg/kg)	0.06 (0.00) 3.66 (0.79) 1.28 (0.43)	0.04 (0.00)* <2.44 (0.69) <1.85 (0.55)	na	na
Phosphorus (mg/kg) Olsen-P	857 (50) 17.6 (1.61)	718 (70) 14.7 (1.77)	na	na
Potassium (mg/kg)	1992 (100)	2225 (187)	nd	nd
Sulphur (mg/kg)	<125 (33)	181 (38)	nd	nd
Calcium (mg/kg)	5967 (164)	6217 (308)	nd	nd
Magnesium (mg/kg)	7618 (817)	11699 (1828)*	nd	nd
Copper (mg/kg)	15.1 (0.71)	15.1 (0.92)	<0.011 (0.003)	<0.023 (0.007)
Manganese (mg/kg)	731 (60)	849 (115)	<0.11 (0.02)	0.16 (0.04)
Zinc (mg/kg)	44.4 (4.40)	40.3 (3.25)	<0.016 (0.003)	<0.019 (0.005)
Contaminants				
Sodium (mg/kg)	678 (37)	699 (27.4)	nd	nd
Cadmium (ug/kg)	nd	nd	<0.06 (0.01)	<0.04 (0.01)
Lead (ug/kg)	nd	nd	<0.55 (0.15)	<1.03 (0.31)

na=not applicable
nd=not determined
* significant difference between treatments (p<0.05)
< mean is lower than reported value due to some sample concentrations being below detection limit
> mean is higher than reported value due to some sample concentrations being above the measurement range

Available elements in the topsoil (0-5 cm)

Table A-5: Concentration of $Ca(NO_3)_2$-extractable metals in topsoil (0-5 cm) under different species. Mean and standard error of the mean in brackets, n=4. Significant differences between treatments are expressed in %.

		P. tenax		*C. australis*		*L. scoparium*		*K. robusta*		*C. robusta*	
Al	W	495	(220)	742	(257)	146	(91.5)	137	(88.8)	452	(113)
	C	660	(213)	800	(145)	1085	(292)*	1076	(365)*	462	(142)
	%					-87%		-87%			
Cr	W	0.58	(0.39)	0.12	(0.02)	0.05	(0.01)	< 0.10	(0.06)	0.14	(0.03)
	C	0.10	(0.01)	0.16	(0.06)	0.16	(0.09)	0.25	(0.04)*	0.32	(0.20)
	%							-59%			
Mn	W	2150	(260)	2236	(412)	1203	(533)	1061	(414)	2300	(343)
	C	1612	(291)	1765	(262)	2329	(342)	1983	(437)	1949	(505)
	%										
Fe	W	32.1	(6.55)	26.3	(6.72)	16.8	(6.22)	15.3	(6.94)	24.8	(7.50)
	C	32.2	(4.43)	40.3	(2.51)	30.6	(7.52)	35.9	(8.34)	31.0	(11.9)
	%										
Co	W	4.84	(1.00)	5.51	(0.61)	3.11	(0.94)	2.78	(0.73)	5.23	(1.07)
	C	7.51	(2.30)	7.61	(1.23)	7.10	(1.10)	6.25	(1.48)	7.80	(2.84)
	%										
Ni	W	6.54	(1.48)	8.14	(0.93)	4.36	(2.17)	3.93	(2.21)	8.56	(1.31)
	C	7.63	(1.52)	9.00	(1.02)	9.75	(0.96)	8.73	(1.85)	6.96	(1.69)
	%										
Cu	W	91.8	(70.9)	< 14.8	(13.5)	92.7	(59.5)	< 25.7	(14.3)	9.60	(3.33)
	C	< 18.3	(12.5)	< 13.1	(5.97)	18.0	(14.2)	7.01	(3.55)	< 4.25	(2.62)
	%										
Zn	W	150	(46.1)	91.9	(9.15)	94.0	(29.7)	108	(83.4)	82.3	(12.8)
	C	117	(51.1)	83.7	(18.4)	107	(16.3)	85.9	(14.8)	90.5	(24.4)
	%										
As	W	0.48	(0.13)	0.38	(0.09)	0.41	(0.12)	0.31	(0.02)	0.33	(0.05)
	C	0.40	(0.07)	0.45	(0.09)	0.48	(0.04)	0.44	(0.12)	0.36	(0.07)
	%										
Cd	W	0.54	(0.12)	0.52	(0.12)	0.38	(0.13)	0.36	(0.13)	0.63	(0.13)
	C	0.62	(0.06)	0.68	(0.10)	0.71	(0.11)	0.67	(0.18)	0.67	(0.17)
	%										
Pb	W	0.77	(0.41)	< 0.69	(0.46)	3.53	(2.17)	< 1.04	(0.76)	0.55	(0.23)
	C	0.76	(0.61)	0.42	(0.28)	0.99	(0.61)	0.33	(0.13)	< 0.46	(0.20)
	%										

* significant difference between treatments ($p<0.05$)

< mean is lower than reported value due to some sample concentrations being below detection limit

Plant elemental composition

Table A-6: Element concentrations in plant shoots (mg/kg, unless stated otherwise). Mean and standard error of the mean in brackets, n=4.

	P. tenax		*C. australis*		*L. scoparium*		*K. robusta*		*C. robusta*	
	Control	TMW	Control	TMW	Control	TMW	Control	TMW	Control	TMW
Carbon (%)	46.5 (0.16)	45.9 (0.65)	47.0 (2.44)	45.6 (0.48)	52.0 (0.34)	40.4 (1.71)	50.3 (0.12)	50.4 (0.43)	46.1 (1.42)	43.5 (0.09)
Nitrogen (%)	1.52 (0.06)	1.66 (0.09)	1.35 (0.03)	1.57 (0.14)	1.76 (0.09)	1.76 (0.07)	2.06 (0.12)	1.94 (0.12)	1.78 (0.06)	1.77 (0.09)
Calcium	3038 (153)	6322 (3410)	12934 (1635)	12850 (1212)	5781 (581)	5878 (480)	4281 (652)	3403 296)	15391 (889)	12263 (4177)
Copper	13 (0)	21 (8)	17 (4)	17 (4)	17 (4)	19 (4)	17 (4)	19 (4)	13 (0)	16 (3)
Potassium	9428 (278)	9031 (652)*	6022 (622)	5816 (960)	4653 (300)	3747 (174)*	4709 (302)	5013 (516)	8953 (618)	8784 (1186)
Magnesium	7875 (255)	8575 (1089)	8391 (481)	8297 (801)	8794 (453)	8156 (407)	8366 (287)	7538 (688)	9009 (369)	8209 (682)
Manganese	103 (13)	166 (24)*	603 (122)	666 (219)	206 (52)	94 (16)*	516 (68)	278 (43)*	109 (22)	166 (76)
Sodium	1416 (172)	881 (196)*	469 (89)	472 (53)	1631 (122)	1663 (185)	1825 (77)	2034 (267)	456 (32)	725 (185)
Phosphorus	2675 (263)	2922 (277)	2381 (171)	2809 (570)	2013 (360)	2600 (399)	2422 (197)	2856 (362)	2694 (64)	2900 (451)
Sulphur	5441 (1359)	6169 (1989)	5591 (1230)	6231 (1654)	6053 (988)	4391 (1346)	6113 (1024)	4678 (1280)	5747 (836)	5878 (1352)
Zinc	75 (5)	53* (3)	125 (14)	128 (21)	47 (8)	34 (6)	56 (8)	59 (13)	72 (8)	78 (14)

* significant difference between treatments ($p<0.05$)

Appendix 2: Nitrogen report

Impacts of nitrogen application to Pasture and Native Plantings on Banks Peninsula

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Executive summary

- Based on effluent flow-rate data, effluent chemistry, and the land available for irrigation, the nitrogen (N) application rate in Robinsons Bay would be 125 - 172 kg N/ha/yr, which is below the threshold of 200 kg/ha/yr set by many jurisdictions in New Zealand and overseas.
- Applied N will either accumulate in the soil (which is environmentally benign), be removed in the vegetation, be denitrified into nitrogen gas or nitrous oxide, or leach into groundwater.
- Irrigation of the Treated Municipal Effluent (TMW) onto cut-and-carry pasture is likely to result in negligible (<2 kg/ha/yr) nitrate leaching. Experiments have demonstrated that the pasture will remove nearly all of the N that is applied.
- Irrigation of TMW onto grazed pasture will have similar nitrate leaching to a regular grazed pasture where fertiliser has been applied.
- Preliminary data indicate that Irrigation of TMW onto NZ native vegetation will result in nitrate leaching of 15 - 60 kg/ha/yr, similar to grazed pastures. These figures will change as data from experiments in Pipers Valley come to hand. This is expected in early 2020.
- Species selection and weed control are the critical success factors for establishing NZ native vegetation under TMW irrigation.

Introduction

Nitrogen (N), in the form of ammonium (NH_4^+) or nitrate (NO_3^-), is the most important plant macronutrient in soil. Other forms of N, such as nitrogen gas (N_2) and organic N are not available to plants and must be converted to available forms by biological processes (McLaren and Cameron, 1996). New Zealand agriculture relies on N supplementation to soil, via fertilisers (mainly urea), soil conditioners (such as compost), or N-fixation from legumes such as clovers.

While N addition usually improves plant growth, excessive N application can lead to NO_3^- leaching through the soil profile where it may contaminante surface waters or groundwater (Martin et al., 2017). Elevated N application may also result in increased emissions of nitrous oxide (N_2O), a greenhouse gas with a global warming potential some 300 times greater than carbon dioxide (Taghizadeh-Toosi et al., 2011). High concentrations of NO_3^- in drinking water can be harmful to human health, particularly infants (Knobeloch et al., 2000), while elevated NO_3^- concentrations in aquatic or marine ecosystems can exacerbate eutrophication (de Jonge et al., 2002). The New Zealand Drinking Water Standard for NO_3^- is 11.3 mg/L NO_3-N (Di and Cameron, 2000). The Australian and New Zealand Guidelines (NIWA, 2013) for NO_3^- in

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freshwater range from 1 mg/L NO_3-N for pristine environments with high biodiversity and conservation values (99% species protection) through to 6.9 mg/L NO_3-N for environments which are measurable degraded (80% species protection).

Treated Municipal Wastewater (TMW) contains agronomically significant concentrations of N, making it a potential fertiliser replacement but also a potential source of groundwater or surface water contamination. When irrigated onto soil, this N undergoes biologically and chemically-mediated cycling (Fig. 1). Ultimately, the applied N leaves the soil via plant uptake (and removal of the harvested or grazed biomass), volatilisation as N_2 or N_2O, or leaching (as NO_3^-). The amount of NO_3^- leaching or N_2O emissions from an area irrigated with TMW depends on the irrigation rate, the N-concentration in the TMW, the climatic conditions, and the land use.

This report aims to determine the likely effect of TMW irrigation on growth of NZ-native vegetation, grazed pasture, and cut-and-carry pasture on 35 hectares of irrigable land from the Thacker farm, Banks Peninsula. The production rate and chemistry of the TMW was provided by the Christchurch City Council. The soil properties, pasture uptake rates were assessed in a previous report (Robinson et al., 2017) as well as data from an ongoing field trial in Pipers Valley, Duvauchelle. At the time of writing (August 2019), we are awaiting the final results of N-fluxes from the field trial, which is due to conclude in December 2019. As such, we will amend this report with the results of the field trial as they come to hand.

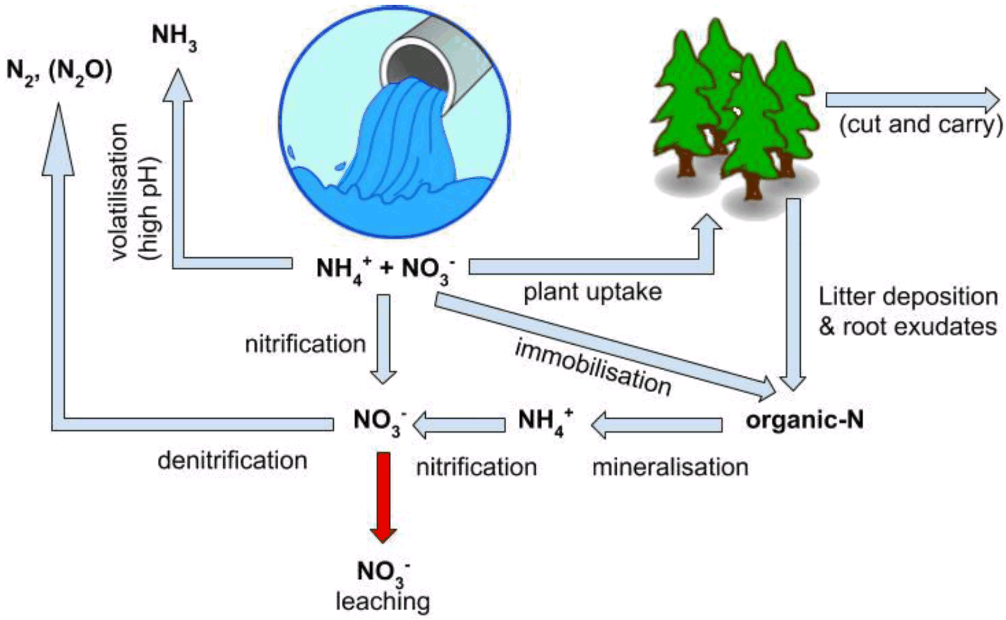

Fig. 1. Nitrogen fluxes following the application of Treated Municipal Wastewater to soil. This diagram assumes that the Wastewater has been treated to a high standard (such as is the case on Banks Peninsula) and the concentration of dissolved organic matter (and organic N) is low.

Nitrogen in the Treated Municipal Wastewater and nitrogen application rates

TMW from Duvauchelle and Akaroa (Feb 2017 - Feb 2019) had average total N concentrations of 18.5 and 25.4 mg N/L, with standard deviations of ca 7.5 mg/L in both cases. At the time of measurement, some 50% of the N was present as NH_4^+, with the remainder mostly comprising NO_3^-. However, the NH_4^+ is rapidly oxidised to NO_3^- in the environment or when the effluent is stored. (Clough et al., 2001). Once irrigated onto soil, any N added that is not taken up by plants will either oxidise to NO_3^- thence be denitrified back to N_2 (or N_2O) gas, become immobilised into soil organic matter, or leach into groundwater (Fig. 1). The rate of application affects the fate of N, with higher application rates resulting in increased N-leaching and potentially increased N_2O emissions. The likely N application rates on Banks Peninsula are 125 - 172 kg N/ha/yr shown in Table 1. These values are below the 200 kg/ha/yr threshold, which is set by many jurisdictions (Clark and Harris, 1996).

Table 1. Annual nitrogen Application (kg N/ha/yr) as a function of irrigation rate and effluent N concentration, given the area of potentially irrigable land in Robinsons Bay is some 35 ha (Barton, 2017). The likely irrigation rate is 678 mm/yr, resulting from an effluent flow rate of 650 m^3/day.

	TMW @ 18.5 mg N/L	TMW @ 25.4 mg N/L
Irrigation 500 mm	92.5	127
Irrigation 678 mm	**125**	**172**
Irrigation 1000 mm	185	254

Nitrate leaching under cut-and-carry pasture, grazed pasture and NZ - native vegetation

Previous research using lysimeter experiments on Banks Peninsula soil (Robinson et al., 2017) has shown that under cut-and-carry pasture, these irrigation rates resulted in negligible NO_3^- leaching (<1 kg N/ha/yr), even at application rates of 207 kg N/hr/yr equivalent. Compared to the previous lysimeter experiments, the groundwater at Robinsons Bay is deeper (at least 4 m (Barton, 2017), which will result in more denitrification of the applied N, thereby reducing N-leaching. However, this effect may be offset by the greater precipitation (ca. 1000 mm/yr) on the peninsula compared to the 660 mm/yr that fall at the Lincoln University lysimeter facility. Even with a small increase in drainage caused by high rainfall events on Banks Peninsula, it is likely that cut-and-carry pasture on the Thacker Farm receiving TMW will have negligible N-leaching.

In contrast to TMW-irrigated cut-and-carry systems, grazed pastures over much of the Canterbury Plains and small parts of Banks Peninsula typically leach >45 kg N/ha/yr (Stats, 2019). If the TMW-irrigated pasture were used for grazing, it is likely that the N-leaching rates would be similar to those of a non-TMW-irrigated pasture where N-fertiliser had been applied.

New Zealand native plant species have an N concentration of 0.8 - 2% (dry weight), which is significantly less than pasture, which can have up to 5% N (Dickinson et al., 2015). Given a dry biomass production under optimal conditions (i.e. under TMW-irrigation) of 5 t/ha/yr, native plants containing 1% N would remove 50 kg N/ha/yr. This is significantly less than the N being applied to the soil. Moreover, unless the vegetation is removed periodically, the N accumulated in the plants will eventually be returned to soil via leaf-fall and tree senescence (and subsequent decomposition of dead material). After the accumulation of N in soil via immobilisation, additional N will be lost via leaching or denitrification. Overseas studies have shown that 25 - 150 kg/ha of N applied N can be lost through denitrification (Paul and Zebarth, 1997; Mahmood et al., 1998). In New Zealand, studies with Dairy Shed Effluent reported that some 60 kg/ha/yr were lost through denitrification (Di and Cameron, 2000). Evidence of iron mottling in the soil profile in Robinsons Bay (Barton, 2017), indicates low-oxygen conditions that favour denitrification (Clough et al., 2001). Any N that is not removed by the biomass, fixed into soil organic matter or denitrified, will leach. Given the current data, we estimate that leaching under NZ-native vegetation under nominal conditions will be 15-60 kg N/ha/yr at Robinsons Bay, which is comparable to grazed pasture (Stats, 2019). A more accurate assessment of the likely N-leaching under NZ-native vegetation will be provided in an update report in Early 2020.

Establishing NZ native vegetation under Treated Municipal Wastewater irrigation

Irrigation with TMW significantly increases the growth of pasture and some exotic plants (Esperschuetz et al., 2016; Robinson et al., 2017). The response of NZ-native vegetation is species-dependent: while many species show significantly increased growth when irrigated with TMW, other species are unaffected or may even have lowered growth. The field trial in Pipers Valley has indicated that *Leptospermum scoparium* (mānuka), *Kunzea robusta* (kānuka), *Coprosma robusta* (karamu), *Cordyline australis* (cabbage tree), *Phormium tenax* (harakeke, flax) respond well to TMW irrigation with significantly increased growth over the four-year trial. In contrast *Griselinia littoralis* (kapuka, broadleaf)*, Phormium cookianum* (mountain flax)*, and Pittosporum eugenioides* (tarata, lemonwood) have no positive growth response. The contrasting responses of NZ-native species can result in increased weed competition during the establishment phase.

The critical success factor for establishing NZ-native vegetation are **species selection** and **weed control**. The trial at Pipers Valley Road has indicated the NZ-native species that respond well to TMW. These species should be selected for the majority of plantings in Robinsons Bay. Weed control should form part of the planting plan and include the contractors who will do the weeding. Planting into grass such as *Holcus lanthus* (Yorkshire Fog), has better outcomes than blanket spraying and planting into bare soil. Spot spraying may be appropriate. Close (1 m x 1 m, 10,000 stems/ha) plant spacing reduces the time that the site needs to be weeded but can reduce weeding options. Close planting is also more expensive. Compared to close planting, Lower density planting (e.g. 1 m x 3 m, 3333 stems per hectare) is less expensive to plant and to remove weeds, but the weeding will have to continue for several more years. A critical success factor is the appointment of a site manager who can monitor weeding and intervene as appropriate.

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Appendix 2: Phosphorus report

Phosphorus in Treated Municipal Wastewater irrigated onto NZ-native vegetation

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Executive summary

- Potentially, irrigating Treated Municipal Wastewater (TMW) onto NZ-native vegetation could result in the accumulation of phosphorus (P) in the soil to the point that the soil becomes infertile and excess P degrades local waterways. The Christchurch City Council commissioned the University of Canterbury to determine acceptable levels of P in TMW that is to be applied to NZ-native vegetation.

- An assessment was made using calculations of the likely effects of adding TMW on soil P concentrations and P losses that could lead to waterway degradation. These results of these calculations were compared with literature reports of the effects of soil P on soil fertility and P-losses. Note that the P concentration in TMW from the Akaroa wastewater treatment plant has a median P concentration of 6.6 mg/L and a maximum of 8.4 mg/L.

- Calculations revealed that irrigating 500 mm/yr of TMW containing either 5, 10 or 15 mg/L P would result in P accumulation in the soil. This is because P losses through vegetation removal, leaching, and runoff from TMW-irrigated native vegetation, are negligible compared to the P that is added to the soil.

- Over a 50-year period, the concentrations of soil P in the Pawson Silt Loam and Barry's Soil receiving 500 mm/yr of effluent containing 10 mg/L would increase by 84% and 100%, respectively. Nevertheless, even with these increases, the total average P concentrations in the top 0.3 m would remain within the range of total P concentrations found in NZ's agricultural soils.

- In the aforementioned scenario, Olsen-P, a measure of plant-available P, would also significantly increase in both soils but still remain within ranges considered optimal for a high-fertility soil (the PSL), and within a low-fertility soil (BSL). The increase in Olsen-P may be unfavourable for some NZ-native species, however, there are many other NZ-native species that will thrive under these high-P conditions. This indicates the importance of plant-selection for any treatment system.

- In the aforementioned scenario, there would be an increase in the amount of P-leaching below the top 0.3m of topsoil to around 2.2 kg/ha/yr after 50 years of application. However, most of this P would be retained in the subsoil before it reaches waterways. Given that NZ-native vegetation will decrease surface runoff and soil loss, the increase in P leaching will be

more than offset by the reduction of P entering waterways through erosion and overland flow: There is likely to be less P lost under TMW-irrigated NZ-native vegetation than an intensively-grazed pasture.

- Estimations using these calculations indicate that the application of 50 kg P/ha/yr with TMW is unlikely to cause serious soil fertility or environmental issues over a 50-year period. The life of the system could be extended using lower rates of P addition or by periodically harvesting the native vegetation.

Introduction

Treated Municipal Wastewater (TMW) contains environmentally significant concentrations of plant nutrients, including phosphorus (P). While the application of P to soil can improve plant growth (McLaren and Cameron 1996), excess P is can accumulate in soil where it may become toxic to plants (Hawkins et al. 2008). High concentrations of P in soil can increase the chance that this element can enter waterways via runoff, erosion or to a lesser extent, leaching (McDowell and Condron 2004). Elevated levels of P in waterways exacerbate eutrophication, including the uncontrolled growth of aquatic macrophytes and algae (Tilman et al. 2001).

Phosphorus is routinely added to agricultural soil in NZ. Most soils require more P to be added than is removed by plants, because much of the added P becomes immobilized and unavailable for plant uptake (McLaren and Cameron 1996). Measuring the total P in soil is a poor indicator of the P-availability to plants or P that is likely to leach into waterways, because only a fraction of the total P in soil is mobile and available to plants. Plant availability is often indicated by measurements using a mild chemical extractants. In New Zealand and elsewhere, 'Olsen-P' provides good information on the plant-availability of P in a soil (LandcareResearch 2017). Similarly, extractions using calcium chloride ($CaCl_2$), indicate the concentration of P in soil solution, which has the potential to leach through the soil profile (Sanchez-Alcala et al. 2014).

To convert a low-fertility soil, such as a forest soil, into productive pasture, a large application of P, 'capital P', is required. This can be as much as 500 kg P/ha (Dollery 2017). Thereafter, 'maintenance P' is applied, depending on the land use, usually between 5 and 40 kg P/ha/yr (McLaren and Cameron 1996). The application of P from TMW can be higher than that, which would be applied from P fertilisers. For example, the application of 500 mm/yr TMW from the Duvauchelle wastewater treatment plant, which contains an average of 11 mg/kg P(Gutierrez-Gines, McIntyre, et al. 2017) is the equivalent of 55 kg P/ha/yr. The P concentration in TMW from the Akaroa wastewater treatment plant has a median P concentration of 6.6 mg/L and a maximum of 8.4 mg/L. Irrigating 500 mm/yr of TMW from Akaroa would add 33 kg P/ha/yr.

While a significant amount of P that is added to agricultural soil is removed in the produce, the application of P to NZ native vegetation, where no plants are removed, will result in an accumulation of P in the system. This may result in toxicity to plants and or environmental degradation.

This report aims to determine the likely rate of P accumulation, P toxicity, and P mobility, resulting from the irrigation of TMW onto native vegetation on Bank's peninsula.

To assess these aims, the effects of irrigating 500 mm of TMW onto two Bank's Peninsula soils, the Pawson Silt Loam (PSL), 43°45'8.78"S 172°56'35.55"E and Barry's Soil (BSL), 43°44'53.06"S 172°55'41.44"E, also a silt loam, were estimated using mass balance calculations. These calculations used data from the PSL, BSL reported in (Gutierrez-Gines, McIntyre, et al. 2017) as well as other unpublished data from ongoing investigations. It was assumed that the amount of P removed in the NZ native vegetation was negligible. The calculations were run over a simulation period of 50 years. Other parameters used in the calculations are given in the Table.

The calculations assume that there is negligible runoff and erosion under the native vegetation because (a) the TMW would only be irrigated onto gently sloping land (<15° for pasture and <19° for NZ-native vegetation), (b) tree roots stabilize the soil, mitigating soil loss (Robinson et al. 2009), and (c) increase infiltration and preferential flow around the tree roots mitigate overland flow (Knechtenhofer et al. 2003; Sidle et al. 2006).

Table. Parameters used in the mass balance calculations for P application to NZ native vegetation on two soil types on Bank's Peninsula

	Pawson Silt Loam (PSL)	Barry's Soil (BSL)
Effluent P concentration (mg/L)	5, 10 or 15	5, 10 or 15
Effluent application rate (mm/yr)	500	500
P application rate (kg/ha/yr)	25, 50, or 75	25, 50, or 75
[1]Water flux (mm)	800	800
[2]Initial soil P concentration (mg/kg)	1046	599
[3]Olsen-P (mg/kg)	39	9
[4]Water soluble P ($CaCl_2$) (mg/L)	0.18	0.04
[2]Soil density (t/m^3)	1.4	1.4
Simulation depth (m)	0.3	0.3

[1]Estimated from rainfall (922 mm/yr) + TMW irrigation (500 mm/yr) – evapotranspiration (ca. 622 mm/yr)
[2]Measurements from (Gutierrez-Gines, McIntyre, et al. 2017)
[3]Unpublished data, Lincoln University
[4]Estimated from ratios with Olsen-P on similar soils from McDowell and Condron (2004) and Sanchez-Alcala et al. (2014).

Fig. 1 shows the results of these calculations. Under the nominal case of irrigating 500 mm/yr of TMW containing 10 mg/L P, over a 50-year period the total P concentration in the top 0.3 m will increase from 1046 to 1624 mg/kg in the PSL and from 599 to 893 mg/kg in the BSL. Even with this increase, the total concentration at the end of the 50-year period is still well within the range of P concentrations reported for NZ agricultural soils reported by McDowell and Condron (2004) and Reiser et al. (2014). It should be noted that the concentrations calculated here are averages and due to the highly heterogeneous nature of flow pathways in a forested soil (Knechtenhofer et al. 2003), it is likely that there will be localized areas with significantly higher concentrations. Gutierrez-Gines, McIntyre, et al. (2017) reported no significant increases in total soil P in a lysimeter experiment following the application of 2375 mm of TMW containing 11 mg/L P, probably because the total increase in P was within the measurement error and because of heterogeneity in the system.

In the nominal case, the plant-available or 'Olsen P' in these soils is likely to increase from 39 to 61 mg/kg in the PSL and increase from 9 to 14 mg/kg in the BSL. The initial Olsen-P concentration in the PSL is within the range (35-40 mg/kg) recommended by Dairy NZ to maintain high productivity on sedimentary soils (DairyNZ 2018). This is undoubtedly a result of good soil management under previous land use, grazed pasture. In contrast, the BSL, with an initial Olsen-P concentration of 9 mg/L is consistent with non-productive but managed land, in this case a golf course. Even with an increase to 14 mg/kg, the plant-available P would only be sufficient for low P-requiring crops such as for winter wheat (Tang et al. 2009). For pasture, Olsen-P values above 100 are excessive and values are considered 'high' from 50 – 100 (LandcareResearch 2017).

It is likely that the high plant-available P concentration on the PSL would inhibit the growth of some NZ-native species that are adapted to a low-P environment. LandcareResearch (2017) reports that for native vegetation, Olsen-P values of 8-12 mg/kg is considered high and 12 – 15 mg/kg is excessive. However, there are many reports that some NZ-native species can thrive with Olsen-P values manifold higher e.g. Gutierrez-Gines, Robinson, et al. (2017) and Reis et al. (2017). Indeed, 11 species of native plants are thriving on the very same PSL (with an initial Olsen-P of 39 mg/kg), which has received TMW for nearly 3-years (Figure 2).

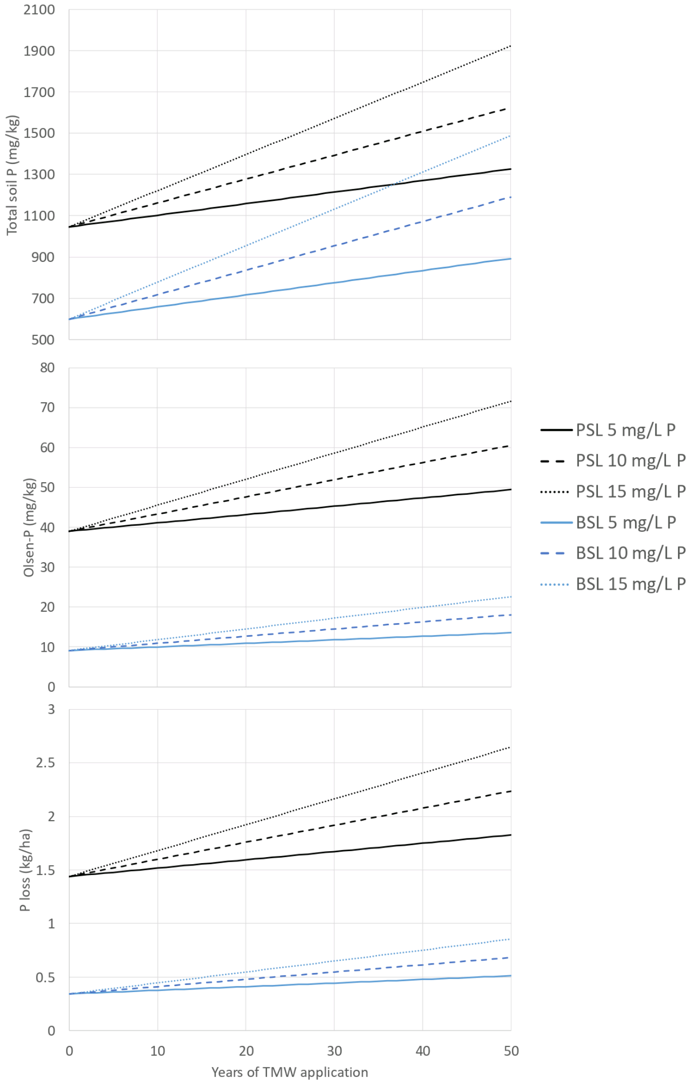

Figure 1.

Calculated phosphorus (P) in the top 0.3m of the Pawson Silt Loam (PSW) and Barry Soil (BSL) under irrigation with TMW at 500 mm/yr with a P concentration in the effluent of 5, 10 or 15 mg/L. The parameters used for the calculations are given in Table 1.

Fig. 1 also shows that irrigating TMW onto native vegetation will result in a significant increase in P leaching from the top 0.3 m of topsoil. This is because of the additional P added to the system in the TMW and the increased water flux through the soil. In the aforementioned scenario, P leaching below the top 0.3m would increase to 2.2 kg/ha/yr in the PSL and to 0.9 kg/ha/yr in the BSL after 50 years. It should be note that, depending on the depth of groundwater, most of this P lost from the top 0.3 m will be retained by the subsoil, which is rich in P-binding oxides of iron and aluminium (McLaren and Cameron 1996). In comparison, the estimated current total P-loss through soil loss from the same area under grazed pasture ranges from 2 – 15 kg/ha/yr, based on soil loss maps (https://statisticsnz.shinyapps.io/soil_erosion/). Under native vegetation irrigated with TMW, significantly less P would be lost through runoff or soil loss compared to a grazed pastureland because the trees increase infiltration and stabilize the soil (Robinson et al. 2009; Sidle et al. 2006). It is therefore likely that irrigating NZ-native vegetation with 500 mm/yr of TMW containing 10 mg/kg P will result in less P-loading on surface waters than a conventional grazed pasture.

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Fig. 2. PhD candidate Alexandra Meister and Dr Jacqui Horswell among NZ native vegetation receiving Treated Municipal Wastewater, Pipers Valley Road, Duvauchelle. 12th February 2018.

The calculations indicate that TMW irrigated onto NZ-native vegetation with application P at a rate of 50 kg/ha/yr will result in soil and plant-available P concentrations that are still within the ranges of NZ agricultural soils and that excessive P-leaching is unlikely. This would be the case when irrigating 500 mm/yr of TMW from the Akaroa wastewater treatment plant, which would add the equivalent of 33 kg P/ha/yr. While it is likely that some NZ-native species will not tolerate these levels of plant-available P, there are published studies showing that many NZ-native species can tolerate such levels (Gutierrez-Gines, Robinson, et al. 2017; Reis et al. 2017). Lower P application rates will prolong the life of the system, as would periodic removal of some of the vegetation e.g. periodic harvesting of manuka or kanuka to produce high value essential oils.

The application of any element to a system at a rate than is greater than the rate that it is removed is ultimately unsustainable (Mills et al. 2005). If a soil P concentration were reached when a NZ-native ecosystem collapsed or if unacceptable concentrations of P were leaching, then the soil could usefully be converted to high-fertility agricultural soil for pasture or cropping.

Note that this report is based on calculations using soils from the Duvauchelle Golf Course and Pipers Valley Road. Soils from other locations on the peninsula (e.g. Robinson's Valley) may have different initial conditions due to differences in soil use history.

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Appendix 4: Development of the field trial from 2015 to 2019

August 2015

September 2015

November 2015

August 2016

November 2016

April 2017

Figure A-1: Development of the field trial from August 2015 to April 2017.

Figure A-2: Development of the field trial from June 2017 to September 2019.

Christchurch City Council

5. Volumes of Submissions

Reference / Te Tohutoro:	20/1118316
Report of / Te Pou Matua:	Samantha Kelly, Team Leader Hearings and Committee Support, samantha.kelly@ccc.govt.nz
General Manager / Pouwhakarae:	Mary Richardson, General Manager Citizens and Community, mary.richardson@ccc.govt.nz

Item 5

1. Purpose / Te Pūtake Pūrongo

1.1 The purpose of this report is to collate, for the consideration of the Hearings Panel, the submissions received in response to the consultation on the Akaroa Treated Wastewater Options.

1.2 The volumes of submissions are as follows:

1.2.1 **Attachment A** - Volume 1 heard – Submitters who have asked to be heard in person by the Hearings Panel.

1.2.2 **Attachment B** – Volume 2 not heard submissions – Submitters who did not indicate that they wished to be heard by the Hearings Panel. This also includes any late submissions received on the Proposal.

1.2.3 **Attachment C** – Schedule of submitters who have asked to be heard in person by the Hearings Panel *(to be circulated separately)*.

1.3 Note, that the Local Government Act 2002 requires, as one of the principles of consultation, that "the views presented to the local authority should be received by the local authority with an open mind and should be given by the local authority, in making a decision, due consideration" (section 82(1)(e)).

2. Officer Recommendations / Ngā Tūtohu

That the Hearings Panel:

1. Accepts the written submissions, including any late submissions, received on the Akaroa Treated Wastewater Options consultation.

Attachments / Ngā Tāpirihanga

No.	Title	Page
A ⇨	Volume 1 Heard Submissions *(Under Separate Cover)*	
B ⇨	Volume 2 Not Heard Submissions *(Under Separate Cover)*	
C	Schedule of Submitters *(to be circulated separately)*	

6. Hearing of Submissions / Ngā Tāpaetanga

Submitters who indicated that they wished to be heard in person will present to the Hearings Panel. A schedule of presenters will be separately circulated.

The dates of the hearings are as follows:

- Monday 12 October 2020, 9am, The Gaiety Hall, Rue Jolie, Akaroa
- Tuesday 13 October, 12.30pm, The Gaiety Hall, Rue Jolie, Akaroa
- Friday 16 October, 2pm, Civic Offices, 53 Hereford Street, Christchurch
- Wednesday 28 October, 2pm, Civic Offices, 53 Hereford Street, Christchurch *(for considerations and deliberations)*

7. Hearings Panel Consideration and Deliberation / Te Whaiwhakaarotanga