MEMO

TO	FRIENDS OF BANKS PENINSULA INCORPORATED
FROM	TEKTUS CONSULTANTS LIMITED, JACK TURNER & EMILY AFOA
SUBJECT	AKAROA WASTEWATER • REVIEW OF PROPOSED DISPOSAL SOLUTIONS
DATE	21 August 2020

1 Introduction and Scope

1.1 This memo summarises our review relative to Christchurch City Council's (CCC) proposed Akaroa treated wastewater options, notified for consultation on 21 July 2020. We provide a brief comment on the state of the industry, to demonstrate the basis of our assessment seeking a sustainable development approach that is resilient to changing climate conditions and future uncertainty; a critique of the current solutions proposed, focusing on CCC's preferred option to discharge to land via the Inner Bays Irrigation Scheme; and present alternative solutions.

2 Background

2.1 Akaroa's current public wastewater treatment plant and harbour outfall at Takapūneke are in a culturally and historically sensitive location and need replacement. Christchurch City Council have gained consent for a new full tertiary wastewater treatment plant with membrane filtration to be built on Old Coach Road and for a new pump station in the boat park at Children's Bay. This assessment encompasses proposed disposal of treated wastewater effluent from the future plant.

2.2 Akaroa's public water supply is currently served by six consented water takes – two groundwater (18L/s combined), and four surface water (55.6L/s combined) (Stewart, La Roche, Currie, & Pink, 2015). Water resources are in Akaroa are limited, and peak summer demand is typically coincident with large numbers of seasonal visitors. As a result, water restrictions are relatively common – with Feb-Mar 2020 a more severe, and recent, example.

2.3 Climate change and future resilience is a considerable concern and requires due consideration in all future infrastructure planning. *Climate Change Projections for New Zealand* (MfE, 2018) predict trends of reduced rainfall and increased temperatures in Northern Canterbury. *Climate change projections for the Canterbury Region* (NIWA, 2020) refine this assessment for the region, identifying five climate zones – of key relevance Banks Peninsula (and the coastal strip north of Amberley), with relatively mild winters, and rather high annual rainfall with a winter maximum. Key predictions include:

a. Increased annual number of dry days
b. Decreases in summer rainfall of 5-15% for Bank Peninsula (by 2090 under RCP8.5)
c. Increased accumulated potential evapotranspiration deficit (PED), therefore increased drought potential
d. Reduced mean annual discharge from surface waters and mean annual low flow
e. Scenario assessment for sea level rise. **At 0.65 metres of sea level rise (predicted for 2070-2155, if achieving emissions targets), every high tide is above the spring tide mark (compared to 10% now).**

The potential combined effect of these parameters, particularly for summer, is reduced surface and ground water quantity available for supply and an increase in seasonal demand. Furthermore, low lying infrastructure is at risk of inundation by rising sea level and groundwater levels – including storm surge, coastal inundation coastal and erosion (MfE, 2017). This is further reinforced by coastal hazards research commissioned by CCC and reported in 2017 (T&T, 2017), which predicts changes for the area relative to different Representative Concentration Pathways (RCP).

2.4 New Zealand's first national climate change risk assessment has been completed to help the Government identify where it needs to prioritise action to make New Zealand more resilient – being the newly-released *National Climate Change Risk Assessment for New Zealand – Arotakenga Tūraru mō te Huringa Āhuarangi o Aotearoa* (MfE, 2020). This identifies: "Risk to potable water supplies (availability and quality) due to changes in rainfall, temperature, drought, extreme weather events and ongoing sea-level rise" as an extreme risk, and in New Zealand's top ten most significant climate change risks based on consequence and urgency.

2.5 *Te Wai Ora o Tāne Integrated Water Strategy* (Christchurch City Council, 2019) seeks to "support the ongoing recovery activities following the earthquakes and set a path for our future management of our water resources and water services and associated infrastructure". Drawing upon the Urban Water Principles – Ngā Wai Manga the strategy references sustainable and integrated water management and highlights 11 key strategic issues including, of particular relevance:

a. Treated wastewater discharges into Akaroa Harbour
b. Responding/adapting to the anticipated effects of sea-level rise on water resources and related infrastructure
c. Long term availability of water for water supply
d. Long term sustainable wastewater treatment and disposal
e. Infrastructure efficiency and resilience

The document presents long-term aspirations with implementation over a horizon extending beyond 100yrs. It sets annual commitments to reporting on implementation plans and progress, and six-yearly reviews to encompass changing national and international state of knowledge.

2.6 The *Water Services Regulator Bill – Taumata Arowai*, enacted Aug-20, implements the Government's decision to create a new regulatory body to administer and enforce the new drinking water regulatory system, while contributing to improved environmental outcomes from wastewater and stormwater networks. A complementary Bill, the *Water Services Bill*, introduced Jul-20, is intended to give effect to Cabinet's decisions on reforming the drinking water regulatory framework, and Taumata Arowai's new wastewater and stormwater monitoring functions. The *Water Services Bill* comprises a significant part of the Government's response to the Havelock North Drinking Water Inquiry which found the contamination was a result of systemic failure across service provision, regulation, and source protection (noting all aspects of the system were implicated). With significant change in the Water Industry, this poses opportunity for considerable reform from continuing the status quo and is likely to bring comprehensive oversight and greater consistency, particularly in our collective transition to climate risk adaptation.

2.7 There is currently no regulatory framework for the reuse/recycling of treated wastewater in New Zealand. Careful consideration of all regulatory aspects including, for example, the Building Act, Health Act (drinking water supplies), and Resource Management Act, is required to ensure appropriate risk prevention mechanisms, monitoring and compliance programs, and/or verification systems are implemented to effectively manage public health risk. Given availability and quality of potable water supplies are identified as a national risk due to climate change, this may be a task tackled by Taumata Arowai.

2.8 Australian Guidelines for Water Recycling provide relevant guidance in response to increasing climate variability and population levels leading to serious water shortages across many areas of Australia. There, alternative sources of water are becoming more important as water restrictions become more widespread. Two areas are addressed – augmentation of drinking water supplies and managed aquifer recharge. Both methods are a form of indirect augmentation – similarly utilised in Singapore, the United Kingdom, and the United States of America

– whereby discharge of highly treated recycled water into a receiving body such as a river, stream, reservoir or aquifer (through indirect injection or soil aquifer percolation), before re-treatment and subsequent supply as drinking water. This allows for additional time, additional treatment, and dilution. Detention time, the time between augmenting the water supply and extracting (blended/diluted) recycled water for reuse, is a key parameter enabling operators and regulators to assess recycled water treatment and recycled water quality and, where necessary, to intervene before water is supplied to consumers.

2.9 Overall, this is an ever evolving and exciting area with wide-reaching implications across our existing social fabric. **Opportunities for forward-thinking and future-proofed solutions are often inter- if not multi-generational, responding to the understanding and perspective of that time, and Akaroa's overall water management regime is now at that juncture.**

3 Christchurch City Council Proposed Solutions

3.1 This a complex issue, and one which has been subject to extensive and comprehensive investigations over many years. From our reading of the consultation material and other preceding documents, the comprehensiveness and quality of this assessment work is commendable. That being said, the four discharge/disposal solutions resolved and proposed by CCC and CH2M Beca pose several questions which we maintain should be carefully considered before a decision is made on the preferred solution. **These issues collectively challenge the basis for the four options, to the point that further consideration of alternatives is warranted.** This appears pivotal to achieving the purpose of the Local Government Act 2002 (LGA) and its four well-beings – i.e. *promoting the social, economic, environmental, and cultural well-being of their communities, taking a sustainable development approach* (LGA Section 3(d) – Purpose).

3.2 The consented wastewater treatment plant is a full tertiary wastewater treatment plant with membrane filtration, to be located at 80 Old Coach Road.

a. Design water quality standards of 15 mg/L Total Nitrogen, increased to 30 mg/L for the short-term summer peak and 7 mg/L Total Phosphorus (Table 2-6 Proposed Wastewater Quality Standards; CH2M Beca, 2020). Concept design provides for future dosing to ensure treatment of peak summer load meets the design threshold of 15 mg/L Total Nitrogen, should the 30 mg/L short-term threshold be declined.

Inflow and Infiltration (I&I) to the existing wastewater network

3.3 The position on network I&I in the context of the treatment plant and discharge/disposal options is summarised through Section 2.2 of the CH2M Beca report. This identified that "the Council selected a 20% I&I reduction as likely to be achievable for the Akaroa wastewater network" – based on results of using Distributed Temperature Sensing (DTS) and experience from other councils in New Zealand. CH2M Beca further outline that it "will be very difficult and costly to reduce groundwater derived I&I in Akaroa to this extent". We also note that the stated target 20% reduction is relative to the existing I&I rates, rather than an overall network flow reduction.

3.4 **The 20% reduction target seems to underplay the problem** in this context, given the modelling results for the year 2052 annual flow projections (based on CCC population projections) shown in Table 2-3 of the CH2M Beca report indicates that in an average year, groundwater infiltration contributes 43% and rain derived inflow and infiltration contributes 18% of the total flow – with total I&I being 61% of the total annual flow. A 20% reduction in I&I would lead to a residual I&I rate of 55% of the total wastewater flows to the treatment plant – a number measurably below best practice guidance.

3.5 The WaterNZ guideline Infiltration & Inflow Control Manual, 2015, proposes Key Performance Indicators for I&I across New Zealand (Figure 1). These are based on Groundwater Infiltration (GWI), Rainfall Dependent Inflow and Infiltration (RDII), and a Wet Weather Peak Flow factor, defined by stormwater inflow (SWI). Overall, KPI targets for RDII and GWI are in the order of 40% combined (refer Table 6-1 in Figure 1, sum of GWI_1 and $RDII_1$), with a collective trigger value of 30% (refer Table 6-2 in Figure 1, sum of RDII and GWI_1).

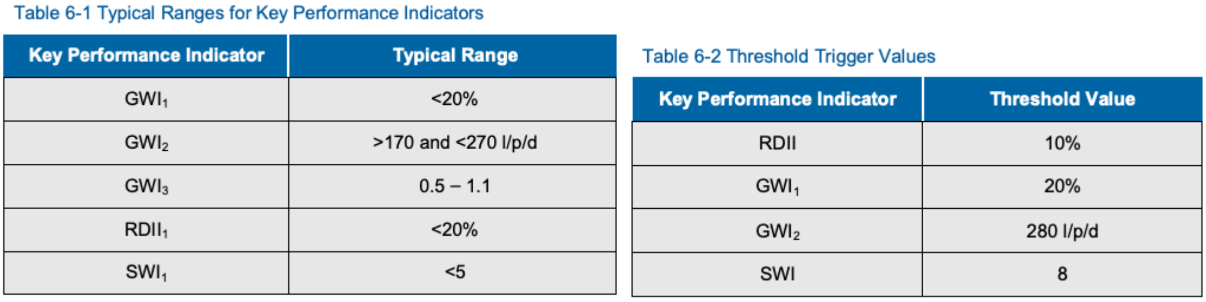

Table 6-1 Typical Ranges for Key Performance Indicators

Key Performance Indicator	Typical Range
GWI_1	<20%
GWI_2	>170 and <270 l/p/d
GWI_3	0.5 – 1.1
$RDII_1$	<20%
SWI_1	<5

Table 6-2 Threshold Trigger Values

Key Performance Indicator	Threshold Value
RDII	10%
GWI_1	20%
GWI_2	280 l/p/d
SWI	8

Figure 1: Extract of Tables 6-1 & 6-2 from the WaterNZ Guideline for Infiltration and Inflow Control Manual, 2015

3.6 It is also not clear from the current reporting as to how seasonal differences are impacted by the high existing and target I&I rates. It would be beneficial to understand the seasonal differences in summer period peak population loads, aligned with dry soil conditions – and the storage/disposal design requirements in this period. Versus winter periods with low population flows, but likely higher proportion of I&I, together with wet soil conditions limiting the timing/potential for land disposal. This would likely further emphasise the significance of the current I&I loads (existing and target).

3.7 That being said, Appendix B to the CH2M Beca report includes Table 6 which "shows that the maximum storage volume is most sensitive to reductions in I&I. Maximum storage generally occurs during the winter period and after a series of significant rainfall events which cause a large I&I flow into the storage. Therefore, reducing the I&I flow significantly reduces the maximum storage volume required." This reinforces how significant the I&I rates are to the overall disposal system and storage design.

3.8 Targeted network upgrades to improve I&I are noted in the report but with little detail. These upgrades are briefly outlined in Appendix AD of the CH2M Beca report (largely based on replacing 2km of 225mm diameter pipework) and indicate that they will be budget constrained (estimated at $2.68M with $3.32M allowed in the Concept Estimate Whole Scheme High Level Summary), but contribute to the 20% reduction goal. We also note that the network upgrade referred to in Section 9.1 of the CH2M Beca Report, ostensibly for I&I reduction, appears to overlap with network modifications required to facilitate the new treatment plant (primarily the 2km of 225mm PVC pipe replacement outlined in Appendix AD).

3.9 The report also notes that a "key consideration is that most of this infiltration occurs in low lying and older parts of the network located near the coastline. These parts of the network may be at or below the level of shallow groundwater which is also tidally influenced." This raises several concerns – particularly around future climate and earthquake resilience.

3.10 Further – "It has been found at other similar locations (e.g. Motueka) that **fixing individual infiltration points causes shallow groundwater levels to rise slightly until the groundwater finds another place to leak into the sewer." This suggests limited benefits to localised network improvements and supports a wider scale network assessment and solution.**

3.11 CH2M Beca conclude that **"It is recommended that a 20% reduction in I&I is retained as a reasonable basis for network improvements."** This appears to be largely based on CCC's direction conveyed through the CH2M Beca report around targeted network improvements and the inherent limitations in that regard. **However, we strongly question this adopted position and discuss this further as follows.**

3.12 The extent of groundwater infiltration is significant (noting the WaterNZ KPI target of less than 20%, see Figure 1), suggesting potentially extensive issues with the network. Limited detail is included in this regard, and there is no discussion on the relationship between the existing network and potential damage caused through the Christchurch earthquakes – nor future resilience to further ground movements and climate change.

3.13 Interestingly, and in contrast to the above understanding, the RPS New Model Build Calibration Report in Appendix A of the CH2M Beca report states in respect of ground infiltration that: "*The model audit report alluded to the fact that the catchment may see some ground infiltration flows. However, although this may seem reasonable given the topography and land use of the surrounding area, the flow survey data from 2013 (Phase 1 Calibration) suggested that ground infiltration was not present. As such there was no need to utilise the Ground Water Infiltration module in the Akaroa wastewater model. This was also found to be the case for the Phase 2 Calibration (2017-18). However, it should be noted that the 2017-18 flow survey in particular, was carried out during the summer months; during a particularly dry period. It is therefore a recommendation that to fully understand the potential for ground infiltration that a long-term flow survey is carried out. This will enable seasonal variation to be understood across the catchment with regards to slow response flows.*" The RPS report notes the model did not show ground infiltration contributions, as anticipated by CCC and now known to be a significant contributing factor, due to the short flow survey period during a dry summer. It concludes this is a major limitation to the model, specifically for use in scheme design and recommends long term flow survey to understand seasonal variation in these potential flows, also recommending further work on the model prior to designing future network upgrades.

3.14 Based on the significant I&I rates, mostly, seemingly attributable to groundwater infiltration (contrary to the RPS reporting above), CH2M Beca also acknowledge an alternative approach to the network. "*As an alternative to remediating the existing network, the entire wastewater network could be completely replaced, either using pressure sewer or a combination of gravity plus pressure sewer.*" But this is ruled out on the basis of prohibitive costs and disruption – and "has not been incorporated into scheme proposals thus far." In this regard, it would be valuable to better understand the feasibility of remediating/lining the network to prevent I&I, or to more clearly understand the constraints. We address this further below.

3.15 **Evidence highlights that the existing network regime is in a poor state given the quantum of I&I currently experienced, and long-term, the current network is likely further compromised relative to future climate change and earthquake resilience.** With reference to Figure 2 below (drawn from CCC / Canterbury Map GIS data), the lower portions of the network appear to have invert levels in the order of RL1m[1]. As highlighted in paragraph 2.3 above, the CCC coastal hazards research indicates potential for a 1m sea level rise (SLR) over a 100 year horizon, which combined with storm tides and wave set-up, could lead to total coastal inundation levels for Akaroa North in the order of RL3.2m. Hence over this timeline, there is real potential for the functionality of the existing gravity networks in low-lying areas of Akaroa to become compromised. This is a common scenario for council's around New Zealand (close to the coast and of a low elevation, together with shallow groundwater levels), and will likely be a particular focus of Taumata Arowai.

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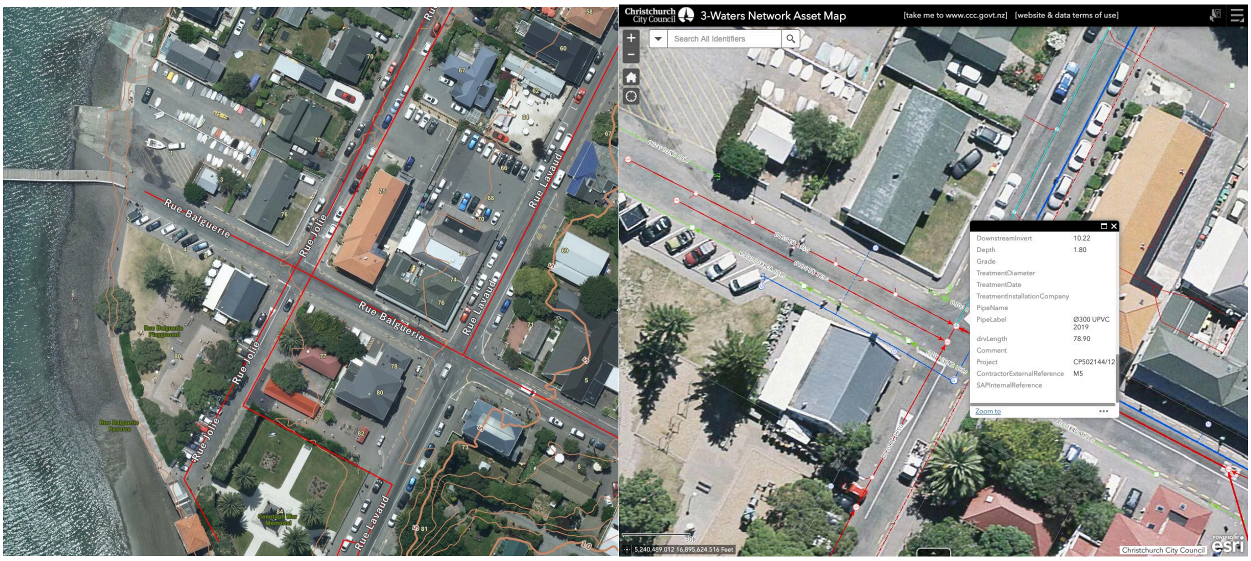
[1] Relative Level (RL) is the vertical distance between a survey point and the adopted datum. In this instance Canterbury elevation contours with reference to the New Zealand Vertical Datum 2016 (NZVD2016), which is the official vertical datum for New Zealand.



DownstreamInvert	10.22
Depth	1.80
Grade	
TreatmentDiameter	
TreatmentDate	
TreatmentInstallationCompany	
PipeName	
PipeLabel	Ø300 UPVC 2019
drvLength	78.90
Comment	
Project	CP502144/12
ContractorExternalReference	M5
SAPInternalReference	

Figure 2: Images from Canterbury Maps GIS data – highlighting lower-lying areas of gravity WW network with invert levels of approximately RL1m.

3.16 The existing networks are also typical of systems built earlier in the 20th century, and utilise brittle materials such as earthenware (EW) and asbestos cement (AC) that are not resilient to ground movement. These older parts of the network may have been impacted as a result of the Canterbury earthquakes, as well as age and typical ground movements from settlement and groundwater variations.

3.17 **It is hence pivotal that consideration be given to a comprehensive rehabilitation programme or replacement network at this juncture.** For example, a pressure sewer replacement regime – as touched on in the CH2M Beca report. This would provide several benefits (including future climate and earthquake resilience), but specifically, a significant reduction in I&I through which to base the wastewater treatment/disposal design. While it may not ultimately be the preferred outcome, given the current extent of I&I it is appropriate to consider this option further. We address this further below.

3.18 Such an approach would be in-line with experience from other councils. A recent example is the Ōpōtiki Sewerage Project. Here, the "sewers under the Opotiki township were first installed in 1956 and most of the pipework is still in service today [similarly for Akaroa]. Pipes are reaching the end of their life and the system is not working for the town as it should be… At the March 2017 Council meeting, Council resolved to rehabilitate the existing sewers." Following successful pilot repairs in 2015-16, an options analysis in 2016-17 found that rehabilitation of the network by repairing private property pipe lines and relining main pipe lines was the most cost effective solution compared with full replacement. For context, the population of Ōpōtiki is approximately 9,300. Given the tenfold scale of permanent population, as compared with Akaroa, the "find and fix" pilot programme may be an effective mechanism to substantially reduce I&I for Akaroa, rather than extensive investigations.

3.19 **Overall, the 20% target I&I reduction (and resulting 55% I&I rate to the wastewater treatment plant) is an unreasonable baseline from which to approach the treatment discharge/disposal design on – as is currently the case**. Questions remain on the resilience of the existing network to future conditions, and combined with the evidential poor condition relative to significant I&I rates (particularly groundwater), alternative network solutions should be carefully considered at this point, rather than overdesigning the treatment/disposal system.

Disposal to Land – Inner Bay Irrigation Scheme

3.20 The Inner Bays Irrigation Scheme proposes use of four separate land parcels for 40 h of land disposal via drip irrigation to native plantings and storage of treated wastewater effluent in a double-celled pond holding

19,000m³. In addition, 6,000m³ covered raw wastewater storage is proposed at the wastewater treatment plant. The scheme outline (Section 5.1) includes reference to 1,000m³ treated storage; however the report later states CCC has advised that treated storage will only be provided in this option if the non-potable “purple pipe” reuse scheme is also implemented (Section 9.2.13).

3.21 Furthermore, a proposed 3,800m² subsurface wetland provides additional storage and facilitates infrequent (approximately once per 5yrs) overflow via the Children's Bay Creek to the Harbour:

a. The option for a subsurface wetland (providing passage through land) was identified, through hui with Ngāi Tahu representatives, as a suitable solution to enhance the mauri of treated wastewater plan effluent (considered as having severely degraded mauri).
b. The influent to the wetland is treated to a high degree by the treatment plant. Therefore, the wetland provides additional storage and a polishing function, primarily addressing cultural concerns by connecting treated wastewater to Papatūānuku and restoring the mauri of the water prior to infrequent discharges to the harbour.

3.22 We consider it is a viable option to maintain the health and functionality of the sub-surface wetland, while reserving storage volume for when required, by restricting flow to approximately match evapotranspiration requirements. However, we note:

a. The literature provides mixed performance results on the efficacy of nitrogen removal, although consistently indicates opportunity to improve nitrogen removal efficiency through aeration, cyclic filling of the system to restore bed aerobic conditions, dosing, and/or through managing detention times.
b. We have not identified in the literature similar systems without at least nominal base flow through the system. **We propose further consideration is required in response to potential accumulation risk and subsequent pulse loading with the absence of throughflow for up to 5yr periods, particularly for nitrogen but also potential emerging contaminants.**

3.23 Banks Peninsula soils, topography, geology, land use, and catchment configurations make large scale year-round wastewater land application of treated domestic wastewater technically challenging. The design and sizing for the Inner Bays Irrigation Scheme (and the Outer Bays Schemes) is based on a number of key assumptions, including (Appendix B, PDP Irrigation modelling): 20% reduction in I&I, population growth parameters, 37% interception of rainfall by the tree canopy (assumed mature), plant available water and evapotranspiration rates, year-round irrigation except for when daily rainfall is in excess of 50mm/day, and long-term acceptance rate of the soils.

3.24 **Due to the constrained space available, there is a lack of resilience in the design for variation between in-situ properties and the modelled design parameters.**

a. The design sizing for storage ponds – both of treated and raw wastewater – is sensitive to reductions in I&I. It is considered critical that I&I is more robustly addressed, if significant reductions in I&I can be achieved, then the current system is oversized. If the intended 20% I&I reduction cannot be achieved, the proposed site will have insufficient capacity which may result in more frequent discharged from the subsurface wetland to Children’s Bay Creek than intended.
b. With year-round irrigation proposed to achieve design flow rates based on available storage, soils may remain at field capacity for extended periods of time. Potential geotechnical concerns need to be addressed, in addition to risk of inducing anaerobic conditions that negatively impact plant health (associated with slope stability, interception, and estimated evapotranspiration rates). Nitrification is an effective treatment concept and it is important that the aerobic status of the irrigation field is preserved for this process.

c. The rate of application affects the fate of Nitrogen, with higher application rates resulting in increased N-leaching and potentially increased N_2O emissions. The current design for land disposal within the Inner Harbour areas predicts nitrate leachate of 15–60 kg/ha/yr which is considered comparable to grazed pasture. This could be concluded as no net change from existing, as land is currently grazed pasture; however, Statistics NZ shows Nitrate-nitrogen leached from livestock as <30 kg/ha/yr. Given the considerable investment to upgrade the treatment system, it would be appropriate to consider an improved outcome from existing for the proposed irrigation fields. It is, however, an improvement on existing treated wastewater effluent quality of 25.4 mg/L Total Nitrogen from the current Akaroa wastewater treatment plant (2017-2019 data, Appendix C).

Deep Bore Injection (DBI) and Managed Aquifer Recharge (MAR)

3.25 Both DBI and MAR have been discounted as discharge/disposal mechanisms in the Akaroa context. However, in our view, legitimate potential remains for further consideration of these options to resolve a future-resilient water management regime. Our rationale is outlined as follows.

3.26 The CH2M Beca report summarises that: *Based on the results of the deep bore drilling investigation, and the considerable cost of conducting further investigations at other sites with no indication of likely success, a decision was taken by Council staff to discontinue bore injection as a possible wastewater disposal option.*

3.27 In respect of MAR, CCC resolved on 5 August 2019 that: *Central government has embarked on a comprehensive programme of regulatory reform to ensure the safety of community drinking water supplies. In this context I* [on behalf of CCC] *consider that managed aquifer recharge presents too great a risk to Akaroa's drinking water supply to continue exploring this option further.*

3.28 Appendix E of the CH2M Beca report (Deep Bore Injection Investigations) included a valuable literature review of existing deep bore discharge regimes in New Zealand and beyond. Several findings were significant; however the Perth example was of particular relevance. This summary is relevant to both DBI and MAR. The CH2M Beca report explains that (with emphasis added): "*In 2010, Perth began a three-year trial of a groundwater replenishment scheme, modelled in part off the Orange County scheme. Wastewater is treated at the Water Corporation's Beenyup facility in Craigie* ***to drinking water standards*** (***including ultrafiltration, reverse osmosis and ultraviolet disinfection stages***) *and pumped to two recharge sites 13 km offsite.* This has been a success." Note also that this regime has since been expanded due to the first stage success together with a heightened awareness of pending climate change impacts (Water Corporation, 2019).

3.29 Appendix F addressed MAR, building on research and investigations relative to DBI. There is also research on this area in New Zealand, including this article – Managed Aquifer Recharge – A Potential Water Treatment Method in New Zealand – which indicated positive results and good potential for MAR.

3.30 The supporting CH2M Beca Interpretative Report on Feasibility Investigation of Deep Bore Injection (Appendix E Deep Bore Injection Investigations) outlined two key assumptions:

a. The expected flows from the wastewater treatment plant are currently in the order of 15 litres/second (l/s).
b. A target of 4-5 l/s per deep bore.

3.31 The report notes that: *Deep bore injection could be used as an alternative to a harbour outfall and compliment other disposal and reuse options. The injection methodology sought to avoid interference with springs and other supply wells in the area by targeting strata below sea level and set back from the coast such that direct discharge to the harbour was avoided and a minimum travel time of one month could be demonstrated to meet cultural requirements.*

3.32 The report then concludes that: *Based on the results of the investigative drilling, deep bore injection* ***at the proposed wastewater treatment plant site is not feasible****. Due to the lack of open connected fractures and low permeability ground conditions, the exfiltration bore capacity was very low and not feasible for deep bore injection. Even at shallower depths i.e. above sea level, the ground conditions encountered were unlikely to be suitable for disposal of treated wastewater*.

3.33 In contrast, the report states: *Other sites could be investigated for deep bore injection however this investigation shows how variable the ground and groundwater conditions can be around Akaroa. There are water supply bores in the area that show suitable hydraulic capacity for bore injection, however these are generally used for public water supply and mixing of the waters may not be acceptable to the community. Bore injection further up the catchment away from the coast is a possibility however injection would need to be at depth to avoid spring interaction and impact on water quality for instream and groundwater users. These matters would need to be considered as part of a feasibility study*.

3.34 Given the acknowledged variability in geological conditions across Banks Peninsula, and the associated variability in permeability rates, it seems a missed opportunity to discount this approach on the basis of only two nearby boreholes within the future treatment plant site with overlying loess soils – each achieving discharge flow rates in the order of 0.7-0.8 l/s. The report acknowledges broader potential for higher flow rates elsewhere on the peninsula, and records known boreholes with higher hydraulic conductivity. Further, **if the treatment plant discharge rate were proportionally reduced by targeting an improved best practice, or even leading practice I&I rates for the network, then the number of boreholes required, and associated cost could also be reduced. The land area requirements for both DBI and MAR are significantly less than the four proposed options, and the associated benefits of this approach could hence be tangible relative to the LGA four well-beings**.

3.35 Furthermore, the CH2M Beca report explains that in the context of MAR: *Council staff determined that potential connectivity between the groundwater injection and groundwater abstraction for potable supply, presented a significant risk to water supply security in Akaroa, and determined that the option should not be considered further.* This could be explored further given the potential separation distances achievable on Banks Peninsula – evident by the outer bays land disposal options put forward. The MAR research noted above indicated positive pathogen removal capacities across a 40-80m separation distance between the infiltration and abstraction well locations. The Perth successes are a further present-day example of the potential for MAR.

3.36 We note the CH2M Beca report indicated a neutral/medium score for DBI, and a worst score for MAR relative to cultural acceptance. However, with further understanding of this solution, potentially together with ground-level pre-treatment via a sub-surface wetland or similar, this may be a more acceptable approach for mana whenua. It would also be valuable to understand if the scores posed in the multi-criteria analysis were determined by the assessment team alone or in consultation with Ngāi Tahu. It is our interpretation that discharge to ground via DBI or MAR would be preferable to a surface water or coastal outfall solution – and potentially comparable to discharge to land.

3.37 Collectively overall, this suggests strong merit in further exploration of DBI and MAR in other parts of Banks Peninsula – away from the primary drinking water supply catchment for Akaroa. As identified in the supporting CH2M Beca Interpretative Report (Appendix E Deep Bore Injection Investigations), *DBI could be used as an alternative to a harbour outfall and compliment other disposal and reuse options.* Later we discuss the benefits of combining Reverse osmosis with MAR.

Harbour Outfall

3.38 The proposed harbour outfall option is based upon the 2014 consent application for which consents were declined – a mid-harbour outfall where the depth of water is greatest (about 8m depth at mean sea level) to provide the most efficient dilution and dispersion of wastewater released:

a. While an improvement on the original design, with elimination of bypass and inclusion of a "purple pipe" non-potable reuse option, we consider direct discharge to the harbour remains unlikely to be a suitable solution on cultural grounds.

b. Ngāi Tahu submitters for the 2015 hearing notes that the cultural impacts of the discharge would not be satisfied until all the effluent made contact with Papatūānuku (land) before entering any water body. This aligns with the more recent Ngāi Tahu statement noting that by passing wastewater through or over Papatūānuku (land) and allowing for natural filtration to occur, the eventual receiving water is not impaired.

4 Alternative Solutions

4.1 Based on our review of the consultation material, we are of the opinion that an alternative solution to the four discharge/disposal mechanisms currently proposed would achieve improved and broader benefits. Specifically, relative to *promoting the social, economic, environmental, and cultural well-being of their communities, taking a sustainable development approach*.

4.2 In the following subsections we outline a number of components. We do not propose a single solution but consider each of these elements, whether singularly or jointly, could contribute to a more sustainable solution for utilising and/or disposing of treated wastewater effluent. It would be appropriate to workshop further with stakeholders, particularly Te Rūnanga o Ōnuku, to appropriately address opportunities to enhance the mauri of the treated wastewater effluent prior to discharge to the ultimate receiving environment. In all scenarios we recommend:

a. Greater action to reduce I&I, and better understand the contributing proportion of I&I under winter conditions when irrigation to land is most constrained.

b. Inclusion of at least the 1,000m^3 treated storage area proposed at the wastewater treatment plant, for quality control, and to facilitate a non-potable reuse scheme (either now or future proofed) and/or diversion to alternate disposal options.

Enhanced Reduction in Inflow and Infiltration

4.3 The peak design flow rate for the wastewater treatment plant has influenced many factors in the proposed disposal options, including storage volume and land area requirements for disposal to native plantings and suitability of managed aquifer recharge. Assessment for all solutions was informed by the 14 L/s peak design flow (treating 1,200 m^3/day) for the consented treatment plant design. Noting, we understand the design peak flow rate remains unchanged since the discovery of the faulty flow meter in 2017 and knowledge of increased I&I. The impact is the design now includes a raw wastewater pond at the plant site to buffer peak wet weather flows and diurnal peaks during the peak summer period.

4.4 We note inflow and infiltration was not previously a significant issue, as ultimate disposal of treated wastewater was to the harbour and therefore not volume limited.

4.5 The WaterNZ guidance (Figure 1) supports a greater reduction target than the 20% proposed in the existing design. The current 20% target reduces combined I&I from 61% to 55% of average annual flow. A reduction target of 57% is needed to meet the KPI of 40% combined Groundwater Infiltration and Rainfall Dependent

Inflow when using the existing network as a baseline. This is particularly relevant considering potential increased groundwater intrusion with the effects of climate change.

4.6 Increasing the I&I reduction target from 20% to 57% has the effect of reducing the storage volume required for the Inner Harbour land disposal option from 24,000m³ to ~10,000m³ (assuming 40Ha irrigation area and 0% population flow reduction, per Appendix B Table 6). This reduction in storage will provide future resilience for the wastewater treatment plant and provide design efficiencies for all possible disposal options.

4.7 One alternate to reduce I&I beyond 20% that does not appear to have been addressed is a widescale renewal using Cured in Place Pipe (CIPP), rather than full replacement of the network.

a. CIPP lining provides quantifiable structural strength to a pipeline, can suit various loading conditions and pipe shapes, and offers minimal loss of capacity (which may be offset by reducing groundwater infiltration).
b. Given the significant contribution of I&I to the network an approach taken by other Councils has been to avoid costly investigations and start on the basis of full renewal. Any sections of network in good condition when CCTV'd to design for renewal are then excluded from the total cost.
c. Total length of wastewater reticulation is ~17km with an average nominal diameter of ~150mm, together with a total of ~400 manhole chambers in the entire network, serving approximately 900 dwellings (CCC 3-Waters Network Asset Map)
d. Based on standard rates of $150/m to supply & install lining to existing pipes, $240 per lateral to cut out lining and retain lateral connections to the network, and double the number of manhole repairs and replacements (50 × internal, 50 × external, 50 replacement – likely focused in the lowest coastal sections of network) the cost of physical works to line all 17km of public network and repair/replace just over one-third of the manholes would be ~$4.5 million. This accounts for a 20% P&G rate.
e. For additional context, a CIPP solution to line the 2km pipe proposed to be renewed in the CH2M Beca scenario (Appendix AD), while maintaining the same number of manhole repairs and replacements, would reduce the predicted cost from $2.7 million to $0.9 million using the linear rate for CIPP lining above.
f. This indicates that the total estimated cost of $4.5 million to line the entire network would be needed, $1.8 million more than currently allocated, but the solution would reduce the combined costs for treatment plant and disposal options, releasing funds for future reuse and recycling options and improving overall system resilience.
g. This proposed solution does not directly address surface water intrusion via access manholes in low lying portions of the network that will be impacted by sea level rise, potential for cross-connections from stormwater network into the wastewater system, nor groundwater intrusion via lengths of private network prior to connection to the public network. However, the cost estimate conservatively assumes lining of the entire public network – it may be reasonable to consider reallocation of funds from upper portions of the network which are more resilient to climate change, or newer portions less likely to require renewal, to initially focus energy in the lower lying older parts of the network at greater risk. Similarly, a "find and fix" solution, as undertaken by Ōpōtiki District Council, may also prove effective.

Upgrade Existing Network to Low Pressure Wastewater System

4.8 In addition to repairs of the existing network to reduce I&I, it is also important to consider network replacement at this juncture. This is reinforced by the referenced WaterNZ guidance which outlines that: "The option of replacement of the asset should be considered and a financial comparison against renewal performed. A cost/benefit analysis should also be used to compare the option of re-lining pipes versus replacing pipes, and to determine the most cost effective method of rehabilitation (re-line vs. replace) for a particular project area." It further highlights that: "The useful life of pipe rehabilitated using CIPP is expected to be 50 years, while pipe replacement (open trench or pipe-bursting) is 50 – 100 years" – noting challenges to further rehabilitation of lined-pipes beyond that 50-year life span.

4.9 Full or partial replacement of the network would have the added benefit of a prolonged, extended asset life span – circa 100 years – which is significant in the context of predicted climate change impacts. With this horizon, we can anticipate sea level increases to the extent that would impact the existing network hydraulics and pose surface-level inundation risks, coupled with increased groundwater pressures, particularly on the lower-lying areas of the network. This collectively lends weight to closed-conduit pressurised sewer systems – as identified in the CH2M Beca report.

4.10 The CH2M Beca report highlights that: "As an alternative to remediating the existing network, the entire wastewater network could be completely replaced, either using pressure sewer or a combination of gravity plus pressure sewer. This would involve extensive construction works affecting every household connection in every street, and may also require a financial commitment from landowners as leakage from privately owned laterals is a contributor to overall I&I. This scenario would be prohibitively expensive as well as disruptive and so has not been incorporated into scheme proposals thus far."

4.11 Construction works would indeed be extensive with works required on every lot (in the case of total replacement). However, works in the road network would be limited largely to the comparatively shallow and directionally drilled installation of small diameter PE/plastic pipes. This has many benefits, including keeping excavation depths to a minimum because of the high ground water levels, and shallower depths to improve access for maintenance or repair work with lesser associated traffic and residential disruption. The life-cycle costs should be carefully considered in this regard; noting the limited lifespan of remediated/lined existing pipe networks, and potential for 100-year + horizons for new PE pipes.

4.12 Pressure sewer systems operate like conventional gravity sewers, but rely on pump stations, commonly located on individual private properties, and which grind up solids and transfers all the waste to the treatment plant (with no treatment on site). The combined power of each individual pump moves the sewage to the treatment plant. Such systems are becoming common place around New Zealand, particularly in growth areas, and with Christchurch leading the way relative to replacement networks in response to the 2010/2011 earthquakes. Vacuum Sewer Systems have also been pioneered by CCC for replacement networks in areas of Christchurch; however we understand the results to be inconclusive at this point (WaterNZ paper, 2018).

4.13 There is potential for parts or all of the existing network to be replaced by a pressure solution – noting the existing planned approach with a centralised pump station to facilitate the replacement treatment plant at the north end of Akaroa. Relevant design guidance is now provided by a recently-released WaterNZ publication, Pressure Sewer National Guidelines.

4.14 For a partial pressure system approach, as an example arrangement, this could target lower lying areas of the network with higher risks from sea level rise and shallow groundwater levels with associated infiltration, while maintaining gravity flows from high-ground areas. This approach would likely result in several public pump chamber / wet wells within the network, and rely on further individual pump systems on private lots in the lower-lying areas. Consideration could be given to pressure networks below a surface level of RL5m, roughly aligning with the eastern berm of Rue Lavaud, such that belowground wastewater infrastructure in these lower-lying areas would be complete closed conduits.

a. Based on a nominal length of wastewater reticulation of ~6km replaced with small bore PE pressure sewer pipes – with 3km of trunk pressure and 3km of low pressure networks, together with a nominal number of trunk pressure wet wells (8) and 180 lower-lying sites fitted with low pressure pump chambers.

b. Based on estimated rates of between $150-180/m to supply & install new PE pressure sewers, $50,000 for trunk network wet wells, and $20,000 allowed for each on-site low-pressure chamber, the cost of physical works would be ~$6.1 million. This accounts for a P&G rate of 20%.

4.15 A complete shift to a pressure system would rely on small pump chambers on each private lot, and would be unusual given the moderate to steep topography across much of the existing urban extents. That being said, an indicative price estimate is summarised as follows:

a. Total length of wastewater reticulation of ~17km replaced with small bore PE pressure sewer pipes, together with low pressure pump chambers on all lots (circa 900) and in-network trunk pressure wet wells.
b. Based on estimated rates of $180/m to supply & install new PE pressure sewers with in-road trunk pressure wet wells, and $20,000 allowed for each on-site low-pressure chamber, the cost of physical works would be ~$23.7 million. This accounts for a lower P&G of 10% based on the higher capital value.

4.16 Table 1 summarises the options proposed to reduce I&I and increase resilience of the wastewater network in response to climate change. The preferred option would incorporate Full CIPP lining, a Partial Pressure System, or perhaps a combination of Partial Pressure in the low-lying areas, with "find and fix" CIPP lining for higher-elevation portions of the network. Regardless, we consider greater investigation is warranted to enhance I&I reduction from the 20% currently proposed to achieve the 57% reduction required to meet industry key performance indicators.

Table 1: Comparative options to reduce I&I

Option	Cost	Comment on Concept Option
Current Option (replacement)	$2.7M	2km pipe renewal via replacement, 50 manholes repaired, 25 manholes replaced. Possible surface intrusion via manholes due to rising sea level.
Current Option (CIPP lining)	$0.9M	2km pipe renewal via lining, 50 manholes repaired, 25 manholes replaced. Possible surface intrusion via manholes due to rising sea level.
Full CIPP Lining	$4.5M	17km pipe renewal via lining, 100 manholes repaired, 50 manholes replaced. Possible surface intrusion via manholes due to rising sea level.
Partial Pressure System	$6.1M	3km trunk pressure network, 3km low pressure network, nominal (8) trunk pressure wet wells, 180 lower-lying sites fitted with low pressure pump chambers. Sealed network prevents water intrusion.
Full Pressure System	$23.7M	17km pressure network, 900 sites fitted with low pressure pump chambers. Sealed network prevents water intrusion. Unlikely to be preferred option given topography across existing urban extents.

Land Disposal

4.17 If land application is to proceed, given variability in application rates and ability for the system to respond as modelled, we recommend commitment to compliance monitoring and application in stages, perhaps over years.

4.18 This may be initiated with reduced application rates, or limiting application to summer periods, to provide knowledge regarding current unknowns and to validate the assumptions used in modelling assessments. The ultimate intention would be to set functional environmental limits for wastewater application to native planting in the Banks Peninsula to mitigate and protect for geotechnical, public health, environmental, social/cultural, and economic risk. Over this staging period, an alternate disposal source would be required to balance predicted flow, options including stream recharge or harbour outfall (discussed further as follows).

a. Irrigation modelling does not take into consideration the effects of climate change, presenting long term results based on 1972 to 2018 data. While summer increase in soil water deficit and reduced rainfall may support summer application of treated wastewater to native plantings, even a small increase in winter rainfall (NIWA, 2020) may increase storage requirements or frequency of overflow to the Children's Bay Creek.

b. There is currently little information available on the nutrient uptake from wastewater by native vegetation, with research in progress by Dr Brett Robinson. The provided assessment (Appendix C; Brett Robinson Reports) concludes that a more accurate assessment of the likely N-leaching under NZ-native vegetation will be provided in an updated report, originally anticipated early 2020. Any updates to the research outputs will further inform the design parameters used.

c. Both Nitrogen and Phosphorus removal are enhanced through reduced loading or periodic removal of the vegetation; **nutrient uptake diminishes as trees mature.** It is also noted that plant selection and weed control, particularly during establishment, will be critical success factors. Greater confidence is recommended to demonstrate these elements are factored into the life of the system – with regard to long term site specific nutrient uptake coefficients and nutrient pathways. The provided assessment (Appendix C; Brett Robinson Reports) appears founded on a 50-yr design life for the system, which could be extended through reduced application rates or periodic harvesting of the native vegetation.

Reverse Osmosis

4.19 **Inclusion of reverse osmosis removes risks to human health associated with disposal of treated wastewater to receiving environments, and facilitates a future potable reuse scheme via either indirect reuse (stream recharge, upstream of existing water takes; MAR) or direct reuse (plumbed to the water supply; to the WWTP, potentially using the existing raw water supply pipe passing the WWTP from the Takamātua Stream). Both options provide increased resilience for Akaroa's water supply in response to climate change.**

a. Reverse osmosis is a water purification process that uses a partially permeable membrane to remove ions, unwanted molecules, and larger particles from drinking water, resulting in very high-quality water.

b. Emerging Contaminants include chemicals, microorganisms, and nano-chemicals (i.e. pharmaceuticals, chemicals in personal care products, and natural steroid hormones). They are different from traditional persistent organic pollutants (i.e. DDT) due to bioactive properties. Apart from chemical industry discharges, the primary source into the environment is from wastewater treatment plant effluents. With particular reference to **Emerging Organic Contaminants, full removal is not achieved by primary & secondary wastewater treatment processes but can be with reverse osmosis.**

4.20 Membrane filtration (pre-treatment) and Reverse Osmosis (RO) can be used for large scale wastewater treatment. Reverse Osmosis (RO) units singularly have specified permeate flows, specific to each device and tested at different temperatures.

a. Reverse Osmosis units come in small units with the ability to combine multiple units in series to act as a single unit to increase the volume intake. This allows for more flexibility within the design for placement and set up of the reverse osmosis system within the allowable space for the treatment plant. As shown on Filtec NZ website you can see multiple membranes stacked together. Each membrane is around 2m in height with a flow range of 45–180 m^3/day.

b. Through a well-designed process of proper pre-treatment of the water before flowing through the Reverse Osmosis membranes, as well as the use of anti-scalant chemicals and low fouling membranes, the Bedok Wastewater Treatment Plant in Singapore (32,000m^3/day) were able to reduce frequency of membrane cleaning to six monthly periods.

4.21 Membrane filtration (hollow fibre ultra-filtration, in tank, low pressure) has been specifically included in the concept design to remove suspended solids and pathogens from the treated wastewater. Reverse osmosis uses nano membranes that are sensitive to blockages from larger particles.

a. **Ultrafiltration provides good pre-treatment filtering more contaminants (i.e. than microfiltration) before the reverse osmosis process which in turn results in less frequent cleaning, and possibly less replacement and discard of membranes.**

b. Additionally, pre-treatment may include addition of anti-scalant chemicals as well as using membranes with anti-scaling / fouling properties.

4.22 Reverse Osmosis Concentrate

a. Reverse osmosis concentrate (also referred to as retentate) from wastewater reclamation in water reuse retains concentrated toxic bio-refractory organics and developing technologies for their removal is essential. A 2019 paper reviews innovative treatment technologies for organic contaminants within, and proposes an integrated treatment process comprising forward osmosis, pre-coagulation, short-time and/or solar-driven advanced oxidation processes (e.g. a rotating advanced oxidation contactor), and post-biological treatment is proposed as an energy-saving and cost-effective technology for reverse osmosis concentrate treatment.

b. A study into the Impacts of Reverse Osmosis Concentrate Recirculation on MBR Performances identified the return of the RO concentrate to the membrane bioreactor (MBR) could be a good alternative for the reduction of concentrate quantities before disposal to the environment. However, it was noted that there was some increase in membrane fouling in the MBR, dependant on careful management of operating parameters.

c. A recent study in support of Tasman District Council's Motueka WWTP Upgrade highlights: "The chemical waste generated by this plant (backwash of CIP ['clean in place' chemicals for membrane maintenance] and retentate) will be returned to Pond 2 which is large enough to provide sufficient dilution and assimilation of the backwash. Existing membrane filtration plants in New Zealand at Dunedin Airport, Dannevirke, and Matamata use this method of backwash disposal."

4.23 The Singapore Water Reclamation Study ("NEWater Study") uses **microfiltration, reverse osmosis, and ultraviolet technologies to purify treated wastewater prior to blending the treated water with reservoir water for indirect reuse.**

a. Cost for production and transmission of water was S$1.30/m^3 in 2003

b. The system caters for 10,000m^3/d.

c. The average unit power consumption is from 0.7 to 0.9 kWh/m^3

d. It was noted that blending treated water with alternate water supplies after reverse osmosis will provide trace minerals, which have been removed in the reverse osmosis process, necessary for health and taste.

4.24 For context and comparative purposes, we have reviewed documentation prepared in support of the Queensland Urban Utilities Water Reclamation Plant at Luggage Point; specifically their Planning Study/Report dated June 2010. Section 8.15 *MFRO Plant Renewals* outlines projected membrane replacement costs, with A$4,700,000 for Microfiltration (MF) membrane replacement every 10 years, and A$2,100,000 for RO membrane replacement every 5 years budgeted for. This system caters for up to 14 Ml/d – or 162 l/s – orders of magnitude larger than the flow rates anticipated in Akaroa. Scaled by an order of magnitude, this could indicatively equate to NZ$230,000 every 5-yrs for Akaroa. However, we note the Queensland plant may benefit from cost efficiencies (due to scale), but the proposed Akaroa Plant offers a higher degree of pre-treatment within its current design (ultrafiltration compared to microfiltration) which will extend the life of the RO membranes. Furthermore, Akaroa is sized to process the peak summer average daily flow but is anticipated to operate at lower flow rates for much of the year, which may further extend the life of the membranes.

Deep Bore Injection (DBI) and Managed Aquifer Recharge (MAR)

4.25 As outlined in Section 3, there remains potential for DBI and/or MAR to form part of the overall solution for Akaroa. DBI has been discounted on the basis of two closely located bore hole trials at the treatment plant site, despite acknowledgement of variable volcanic geology across Banks Peninsula with known potential for higher permeability rates. MAR has been discounted due to regulatory barriers and perceived risks of cross-contamination of water supply springs – despite an ever-changing regulatory framework and potential for MAR to be located at distances away from supply springs, or for water quality to be further enhanced with RO prior to aquifer recharge.

4.26 There is evidence to support such an approach, including successful adoption of MAR via DBI in Perth forming a critical part of the overall water management regime for western Australia. In that case, wastewater treatment included ultrafiltration, reverse osmosis and ultraviolet disinfection stages prior to direct injection to the underlying aquifers which in turn provide Perth's main municipal water supply source. This is supported by the Australian Guidelines for Water Recycling: Managed Aquifer Recharge, the world's first MAR Guidelines based on risk-management principles that also underpin the World Health Organisation's Water Safety Plans, which reinforces that MAR is the purposeful recharge of water to aquifers for subsequent recovery or environmental benefit, rather than a method for waste disposal.

4.27 Collectively, there is robust merit in further exploration of DBI and MAR in other parts of Banks Peninsula – for example, away from the primary drinking water supply catchment for Akaroa or after RO. As identified in the supporting CH2M Beca Interpretative Report (Appendix E), *DBI could be used as an alternative to a harbour outfall and compliment other disposal and reuse options.* There is real potential for DBI and/or MAR to provide cost-effective options to manage residual disposal needs while building up toward maximum re-use without direct discharge to surface-level water bodies.

Subsurface Wetlands

4.28 A similar subsurface wetland design was proposed in the previous treated wastewater disposal options publicly notified in 2016 (prior to identification of faulty flow meters) (*Akaroa Wastewater - Concept Design Report for Alternatives to Harbour Outfall*; CH2M Beca, 2016).

a. Surface area of ~0.7Ha area at 0.5m deep plus a 0.7Ha storage pond at 2.5m deep, treating a 6L/s design flow with a two-day residence time.
b. The infiltration gallery was a structure composed of locally sourced rock with a central slotted or drilled pipe 20m long and running along its length, buried in the beach in the intertidal zone.
c. These systems were not supported by Ngāi Tahu representatives, on the basis that treatment was not using a natural process and ultimate disposal was still to the harbour via a coastal infiltration gallery.
d. We can understand the reticence of Ngāi Tahu to accept this solution as suitably recognising te mana o te wai. The subsurface wetland is a lined and engineered system, which then discharges via an engineered solution providing no measurable improvement to water quality direct to the harbour in the beach in the intertidal zone, and therefore insufficient to mitigate cultural concerns.
e. It is noted the previous publicly notified design did not provide for raw wastewater storage and included bypass of primary treated flows direct to the harbour on average two days per year.

4.29 Since the solutions proposed in 2016, Ngāi Tahu representatives appear more supportive of sub-surface wetland solutions. Ngāi Tahu representatives consulted on the Duvauchelle disposal solution (discussed further as follows) which discharges during winter periods (when land disposal is unavailable) via sub-surface wetland to Pawsons Stream, and proposed the sub-surface wetland in the current Inner Bay Irrigation Scheme which discharges infrequently to Children's Bay Creek.

4.30 We propose enhanced subsurface wetland design, developed in conjunction with Ngāi Tahu representatives, may provide an alternate solution to reduce or avoid reliance on constrained land disposal options:

a. Maximise reductions in I&I to reduce peak wet weather storage requirements (target 57% reduction).
b. Inclusion of proposed UV treatment to meet Australian Guidelines for Water Recycling (AGWR) disinfection requirements for Viruses, Protozoa, and Bacteria, given absence of current NZ legislation and guidance.
c. Maintain appropriate minimum residence time in the wetland, indicative target 2-3 days.
d. Relatively simple modifications to the design would make it more effective for nitrogen removal – careful plant selection, vertically fed, pulse fed, and aerated. A constructed wetland with vertical flow can potentially reach 90% removal of nitrogen, phosphorous and BOD.
e. While the relationship will not be linear, indicatively doubling the previous design to provide for the 14 L/s design flow of the treatment plan 3 Ha would be required to provide sufficient capacity for all flows to pass through the wetland system. Suitable locations would need to be identified; however, this could be completed using the previous analysis to identify land disposal areas, with considerably less land required.

4.31 A well-designed stream discharge solution after flows have been disinfected and passed through the enhanced subsurface wetland, has improved alignment with the Ngāi Tahu position that it is more appropriate to pass even highly treated WW through or across land for Papatūānuku to cleanse. It may be appropriate to consider such a wetland as part of a staged solution supporting stream or harbour disposal (discussed further as follows), and as an interim measure until a reuse solution is tenable.

Stream discharge

4.32 We propose stream recharge could provide beneficial reuse for a portion (i.e. balancing "purple pipe" demand or DBI/MAR capacity) or for all (as a standalone solution) of the treated wastewater, supplemented by:

a. Maximised I&I reductions (target 57% reduction).
b. Enhanced disinfection to achieve Australian Guidelines for Wastewater Recycling non-potable reuse standards.
c. Treated wastewater storage at the treatment plant to enable quality control, and to direct water for either non-potable reuse or to a wetland.
d. Utilisation of treated wastewater for non-potable use (or future potable use with change in regulation)
e. Enhanced wetland treatment prior to discharge to streams, flow dispersal method to be designed in conjunction with Ngāi Tahu – preferably setback from watercourse, via filterstrip or vegetated swale and at an angle sensitive to the direction of flow.

4.33 Stream discharge is not considered as a discrete option within the current application material. However, infrequent overflows from the proposed subsurface wetland are proposed to the Children's Bay Creek. There is no assessment of the existing stream condition, likely due to the infrequent nature of intended discharges (approximately once per 5yrs, flows range from controlled wetland outflow of 2 L/s up to 14 L/s full flow of the treatment plant). We propose consideration of regular base flows through the wetland to the stream, considering:

a. An ecological evaluation to assess erosion risk in response to grade and substrate (likely highly erodible loess soils), and to quantify existing stream condition and base flows to inform suitable mixing. The catchment is not large, so may limit suitable flow rates, and it is unknown if the stream maintains permanent flow in the upper reaches adjacent to the proposed wetland site.
b. Discharges via ~620m of stream corridor from Christchurch Akaroa Rd to Children's Bay Creek mouth

c. The length of watercourse allows for considerable detention time to interact with the stream substrate.
d. It is anticipated the stream grade and heterogeneity will enhance aeration and dissolved oxygen with mature vegetation in the stream gully providing bank stability and shading along the riparian margins.
e. We note what appears to be a flax wetland area at the Children's Bay Creek mouth (Figure 3). It is not known if this is natural or planted (perhaps a pā harakeke) and whether it is providing formal or informal water quality treatment. However, there is potential to further enhance natural treatment of flows in the Children's Bay Creek prior to discharge to the harbour.

Figure 3: Google Street View image of the Children's Bay Creek looking upstream from Children's Bay Rd

4.34 The proposed wetland for the Duvauchelle Wastewater Scheme will irrigate to land (via spray to the golf course, meeting ARWG standard for spray irrigation) during summer months and discharge to Pawson's Stream in winter months, due to limitations identified with infiltration to land. This proposal has been developed in consultation with Ngāi Tahu.

a. The 1 ha wetland with 5,000m³ additional storage treats 1.2 L/s and has a residence time of 2-3 days.
b. Discharge is managed to achieve a minimum level of dilution in the stream at all times, e.g. 20 times dilution within the mixing zone and 100 times dilution with the total flow.
c. Discharge preferably be allowed to vary depending on base flow in the stream, e.g. during wet weather when stream flows are higher, higher wastewater discharge flows would be allowed
d. Wastewater is fully mixed with receiving waters before it reaches the coastal marine area.

4.35 On the basis of the Duvauchelle model, aiming to achieve comparable or better design parameters, we propose alternate stream discharge options may be more suitable than the currently proposed Children's Bay Creek and would facilitate a greater portion of flows to the streams:

a. Provide disinfection, enhanced wetland treatment, and maximise I&I reductions, as discussed prior.
b. Discharge to streams with larger contributing catchments, for example Grehan Stream, Balguerie Stream, and Aylmers Stream all of which ultimately discharge to French Bay, thereby recharging streams within the Akaroa catchment.
c. These streams also have consented water supply takes, and so discharge could provide stream recharge downstream of the existing water take for enhanced environment flows, particularly during summer months.

d. Concerns were raised regarding stream discharges in the CH2M Beca 2016 options report with regards to mixing, referencing wet weather bypasses, and increased contaminant loads. Bypass is eliminated in the current design through provision of additional raw wastewater storage at the treatment plant. Regardless, specific assessment would be required to define suitable seasonal discharge limits for both low flow conditions and high flow (given these stream pass near residential and commercial buildings).

4.36 We note the just-released update to the National Policy Statement for Freshwater Management, August 2020, provides further context – particularly in terms of environmental bottom lines for various contaminants in freshwater habitats.

Reuse of Treated Effluent

4.37 We agree with the background work in this area, and proposed that reuse of treated effluent should be future-proofed and provided for through the overall water management regime in Akaroa, pending clarity in regulatory oversight on this issue. This should be developed in conjunction with other disposal mechanisms that can be staged and scaled over time, responding to changing perceptions and regulation.

4.38 There are several permutations in this regard, including purple pipe / non-potable reuse, and full water supply reuse. Consideration could also be given to discharging to the water supply take streams to supplement and buffer the consented water takes, and recycle the treated effluent for further treatment through the raw water treatment systems. Alternatively, the treated effluent could be directed to the water supply treatment plant via an existing raw water pipe; although we note this is less likely to be acceptable and is not commonly utilised overseas (one example identified in Namibia). We also note an alternate reuse of that pipe if the Takamātua supply take is not required.

4.39 There is precedence of this in other countries; particularly where water shortages and/or demand is at critical levels. We note existing systems in Australia (i.e. South East Queensland & Perth) discharge recycled water to existing storage dams or via managed aquifer recharge, avoiding direct reuse and direct discharge to the final receiving waterbody, but indirectly contributing to the water supply regime and overall system resilience. In this regard, we highlight the addition of UV treatment to meet disinfection requirements for Viruses, Protozoa, and Bacteria from the Australian Guidelines for Water Recycling (AGWR), given absence of current NZ legislation and guidance.

4.40 For context, the CH2M Beca report states "A fully reticulated non-potable reuse network has not been used before in New Zealand and is not currently supported by the Ministry of Health and the Canterbury District Health Board." This is reinforced by communications included in Appendix G to the report. However, attention is drawn to overseas examples and guidance, to broad recognition of the drivers for utilising this resource (including the current water shortage issues in Auckland), and to the role that Taumata Arowai will take in driving this from a regulatory perspective.

4.41 Section 9.2.6 Enhanced Disinfection for Non-potable Reuse reinforces the current state of play in this regard: "There are no nationally accepted guidelines in New Zealand that deal specifically with the reuse of treated municipal wastewater in urban areas. Any municipal wastewater recycling scheme is likely to be subject to the requirements of the Health Act and the Local Government Act. Consultation with the Ministry of Health and other Government agencies is needed to ascertain the acceptability of the Australian framework in the absence of New Zealand regulations and guidelines." Either way, a future focused solution should be resilient to this option.

4.42 The MfE Sustainable Wastewater Management: A handbook for smaller communities from 2003 (part 9) includes a summary of a development scheme called the Golden Valley subdivision in Kuaotunu, Coromandel Peninsula. This comprised a subdivision of 40 residential lots that was designed and constructed in 2000 with a pumped MEDS (modified effluent drainage servicing) collection system. In that case, *filtered septic tank effluent is conveyed in 50 mm pressure sewer lines from a pump within each septic tank to a central recirculating sand-filter treatment plant located in an enlarged and landscaped central median strip on the access road serving the development.* ***The very high-quality effluent produced is in part disinfected and returned to each lot as non-potable reclaimed water for toilet flushing****. The remaining effluent flow is not disinfected, but pumped to an area of steep terrain where it is to be irrigated by driplines into eucalyptus planted plots. A portion of treated effluent will be held in storage for firefighting purposes.*

4.43 Additionally, because of the use of a fully sealed reticulation system, there will be no infiltration into the system, thus protecting the treatment plant from excess flows. The treatment plant performance, including the operational status of all mechanical units and effluent quality readings from treatment stages, is remote monitored by sensors, with the resulting information transferred to computer surveillance at the operating company's headquarters in Auckland. This is a design-build-operate (DBO) project where the performance of the overall treatment system is remote monitored by offsite specialists, but with locally trained service people on standby callout to deal with any operational events that need attention.

4.44 This demonstration case is a positive indication for the potential of wastewater reuse – at least for toilet flushing, as well highlighting the I&I benefits associated with a pressure sewer network. This is worth further investigation.

4.45 There is an ever-increasing technological focus on this area, and a recent advancement that has gained media attention over the past few years is the hydraloop – an at-source domestic grey water recycling unit. The system claims to ensure *perfect and certified recycled water quality to save up to 45% on domestic water consumption. With a Hydraloop system you recycle up to 95% of shower & bath and optionally 50% of washing machine water so you recycle and reuse up to 85% of total in-house domestic water.* Bold claims, but this is at least an example of how the related technology is evolving, with increased potential and realisation for water reuse. The advantages of at-source approaches for water reuse include reduced regulatory barriers (specifically in terms of municipal water supplies) and the reduced potential for cross-contamination. We note that a communal reuse system via a 'purple pipe' would not preclude individual property owners from pursuing further on-site measures.

4.46 The regulatory framework in respect of water reuse continues to evolve, but remains uncertain, unclear, and unresolved. We note the following matters of relevance:

a. An article from the WaterNZ journal titled Greywater Reuse Compliance, 2015 (page 34), noted the following on regulatory compliance of grey water in NZ at that time:
    i. Compares NZ regulation for greywater to overseas, but not overly helpful or detailed
    ii. Acknowledges that a growing number of NZ households are using some form of unregulated and unreported greywater disposal system
    iii. Greywater systems discharging into the environment must comply with the Resource Management Act 1991, Building Act 2004, Health Act 1956, and Local Government Act 2002.
    iv. Some regions (such as Kāpiti Coast) have included a water conservation requirement for new developments into their district plan, which may include a greywater diversion system (KCDC, 2009a).
b. In Kāpiti, *from February 2008, all new homes built on the Kāpiti Coast had to install either a 10,000 litre rainwater tank to supply toilets and outside taps, or a fresh greywater garden irrigation system and a smaller 4500 litre rain tank supplying toilets and outdoor taps*. A progressive approach.
c. The ECan Land and Water Regional Plan does not specifically prohibit reuse, and the intentions of use of an alternate system are provided for within the wider objectives and policies of the Regional Plan. We note that policy 4.13 promotes reuse to reduce the residual effects of discharges of contaminants. Further, other methods section 5.3.5 states that ECan will *enable water conservation and water efficiency through the*

collection, use and reuse of water, and alternative sewage disposal technology. It further promotes that local authorities should encourage *water conservation and water efficiency through the collection, use and reuse of water, provided that the health of individuals of the community is not put at risk* [this reflecting one of the primary barriers].

Taumata Arowai is likely to address this regulatory gap, providing national-level leadership and oversight. It is expected that Taumata Arowai will manage risks to drinking water safety while responding to risk to potable water supplies (availability and quality) due to the effects of climate change and also giving effect to Te Mana o Te Wai. Given increased strain on potable water supplies nationally, we anticipate stormwater harvesting, grey-water reuse, and wastewater recycling to feature in future water resilience planning and guidance.

Harbour Outfall as part of a staged alternative solution

4.47 The current Waimate-based Oceania Dairy pipeline discharge consent process presents a helpful reference. In that case, the Panel chairman Paul Rogers highlighted that policy 23 in the New Zealand Coastal Policy Statement (NZCPS) specifically allows for coastal discharge, with conditions, while iwi management plans take a different stance. Submitter’s evidence on behalf of Ngāi Tahu presents strong opposition to the proposal; however, that of K. Hall representing several Rūnanga, concludes that there is too much uncertainty to determine whether the application is generally consistent with relevant policies. A strong emphasis is placed on the lack of certainty on the potential environmental impacts of the discharge on the coastal water values and the lack of context relative to cumulative effects. It is evident that a balance will need to be made in determining the outcome of this application; to what extent and what angles remains unclear.

4.48 Direct harbour discharge as the sole solution is unlikely to be acceptable from a cultural perspective. However, with enhanced treatment to mitigate health risks and refined wetland design to connect waters with Papatūānuku prior to discharge, we propose it may be a suitable solution to support staging of alternate solutions.

a. Given lack of clear regulatory guidance, there are potential time delays with progressing various non-potable “purple pipe” reuse options. This allows for:
   i. incrementally increasing the extent of Akaroa serviced over time.
   ii. potential regulatory changes extending to include future potable reuse.
b. Land disposal options require additional information to validate the assumptions used in sizing and ensure predicted environmental impacts are adequately mitigated (refer 4.17 and 4.18). Partial discharge via a Harbour Outfall could balance the shortfall in land application rates – with flows to the harbour reducing as land application rates increase (or alternate beneficial reuse schemes are implemented).
   i. This option incurs considerable additional cost due to the need to construct the land irrigation infrastructure, in addition to maintaining a harbour outfall, but is considered necessary to reduce risk associated with the lack of resilience in the Inner Bay land disposal design for variation between in-situ properties and the modelled design parameters.
   ii. The Harbour Outfall will support provision of a “purple pipe” network, as currently proposed.

4.49 For any staged solution including a harbour outfall (similar to stream re-charge as a staged or complete beneficial use) we expect the following would be implemented:

a. Maximised I&I reductions (target 57% reduction).
b. Enhanced disinfection to achieve Australian Guidelines for Wastewater Recycling non-potable reuse standards.
c. Enhanced wetland treatment prior to discharge to the harbour to enhance the mauri of the treated water.

Yours sincerely,

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