Review of conditions for opening Waituna Lagoon

Supporting Information

Prepared for The Whakamana Te Waituna Trust

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1 Purpose

This report has been prepared for the Whakamana Te Waituna Trust and provides technical information to support the development of resource consent conditions for opening Waituna Lagoon to the sea. It presents the rationale for specific lagoon opening triggers aimed at maintaining and restoring the ecological and cultural health of the lagoon ecosystem.

The authors acknowledge that the management of lagoon water levels have impacts beyond the immediate lagoon ecosystem and have gone someway to assess the impact of an ecological based opening regime on land drainage and recreational uses in section 7.

2 Introduction

2.1. Waituna Lagoon

Waituna Lagoon is one of the best remaining examples of a natural coastal lagoon in New Zealand and is recognised for its diverse ecological characteristics and cultural values. The significance of the lagoon and its margins was recognised internationally in 1976 when it was designated a Ramsar Site and nationally by gaining Scientific Reserve status in 1983. The cultural significance to the local Ngāi Tahu people was recognised under a Statutory Acknowledgement with the Ngāi Tahu Claims Settlement Act 1998.

The lagoon and associated wetlands are identified by the Department of Conservation (DOC) as a priority ecosystem for the conservation of New Zealand's natural heritage, it is a focus catchment in the DOC/Fonterra Living Water programme and one of three wetland systems in DOC's Arawai Kākāriki wetland restoration programme. It is also highly valued for its aesthetic appeal, rich native biodiversity, waterfowl hunting, fishing, boating, bird watching, walking and scope for scientific study.

The lagoon covers an area of approximately 1350 hectares and is Southland's largest coastal lake. It is shallow, (water depth is usually <2m) and is usually isolated from the sea by a gravel bar. Prior to human management of the lagoon opening, the bar was breached and an opening to the sea was temporarily established when high lagoon water levels overtopped the barrier bar. When the lagoon was open to the sea it became estuarine and tidal for a time until certain conditions, likely related to neap tides, low inflows and calm wind and sea conditions closed the mouth.

With the advent of farming and land development the lagoon has been mechanically opened to the sea, typically with excavators, to facilitate land drainage. For the last 100 or so years the lagoon has been opened about once a year, usually when the lagoon water level exceeded 2.0m above sea level.

The history of intermittent opening and closing of the lagoon to the sea, alongside the high nutrient and sediment inputs from the catchment above, are features that have strongly influenced the lagoon's ecology and water quality. The fluctuations in water level and salinity have created a highly variable environment with associated high variability in species dominance and ecological community structure. Species alter their distribution and abundance in response to changes in water level, salinity, other environmental factors, and species interactions, creating an ecologically diverse and productive ecosystem, but one that is also at risk of being degraded by additional, anthropogenic stressors.

In 2013, concerns surrounding the state of Waituna Lagoon led to the publication of ecological guidelines to improve the management of the lagoon. These guidelines, which were developed by a Lagoon Technical Group (LTG 2013) described key attributes of the lagoon's ecosystem health in terms of macrophytes, slime/benthic algae, phytoplankton, sediment anoxia, water clarity, hydrology and nutrients.

It is recognised that the ecosystem health of Waituna Lagoon is maintained by submerged native aquatic plants known as Ruppia (two species: *R. megacarpa* and *R. polycarpa*), which are keystone species that help regulate water quality. However, the Ruppia-dominated plant community is vulnerable to a range of stressors including nutrient enrichment, water clarity, high salinity and frequent lagoon opening events.

***Figure 1**. Aerial photograph of Waituna Lagoon showing the encroachment of farmland developed and maintained by the drainage of wetland soils.*

The two main risks to the ecological health of the lagoon are:

- poor water quality largely due to high nutrient and sediment inputs from its catchment
- a hydrological regime that has been altered due to a history of opening the lagoon primarily for land drainage

2.2. Lagoon opening activity and short term consent

For the past ~100 years Waituna lagoon has been primarily opened to the sea for purpose of land drainage. The lagoon was mechanically opened so that water levels in the lagoon receded and allowed for the drainage of low-lying agricultural land surrounding the lagoon.

Prior to 2017, the water level threshold at which the lagoon was consented to be opened to the sea was ~2.0m ASL, although the specific water level when openings occurred varied, as the opening activity was also dependent on suitable wind and sea conditions.

With the increasing risk to ecological health recognised, a short-term (5 year) consent for opening Waituna Lagoon[1] came into effect in February 2017 (Appendix A). This short-term consent retained a primary focus on land drainage but included some provisions to open the lagoon to manage for poor water quality (e.g. opening to disrupt algal blooms) and established a higher opening threshold (2.2m ASL) during spring-summer months in effort to avoid frequent opening events during the early growing season for aquatic macrophytes. The expiry date for this consent is 14 February 2022.

The Department of Conservation, Awarua Runanga, Environment Southland and other agencies recognised that the short-term consent was an interim measure and jointly held aspirations to resolve the conflict between farming operations and higher water levels, thereby improving the long-term management of the lagoon opening.

In 2017 the Waituna Science Advisory Group established that higher water levels would be beneficial to ecology of the lagoon but that 2.5m ASL is the maximum water level that the lagoon should be allowed to reach if it were being managed for ecological values (WSAG, 2017).

In 2019/20 The Whakamana Te Waituna Trust[2] successfully facilitated purchasing most of the farm land affected by inundation at higher lagoon levels (figure 2, also see figure 11), thus, enabling an increase of the maximum allowed water level in the lagoon with the aim of maintaining and enhancing a broad range ecological and cultural values.

A method and rationale for determining which indicators should trigger lagoon opening are described in the following sections of this report.

***Figure 2**. Areas of farm land purchased as part of the Whakamana Te Waituna project (outlined in black/white) and areas of land affected by inundation at high lagoon levels that have not been purchased (outlined in pink/white).*

[1] Environment Southland Coastal Permit AUTH- 20146407-01.

[2] Whakamana Te Waituna Trust is made up of representatives from DOC and Fonterra (representing the Living Water Partnership), Environment Southland, Southland District Council, Awarua Runanga and two independent trustees.

3 Approach

In 2020-21, the Whakamana Te Waituna Trust initiated a work stream to develop an ecologically-based opening regime for Waituna Lagoon. This involved reviewing the current consent conditions for opening Waituna Lagoon to the sea and considering a broad range of ecological and cultural values associated with the lagoon.

As part of the review of conditions, an expert workshop was held in March 2021, involving representatives from NIWA, Cawthron Institute, Kitson Consulting (on behalf of Awarua Rūnanga), Environment Southland, University of Otago, DOC and Ryder Consulting. This group confirmed that the lagoon's water level, open/closed status and water quality remain key factors affecting many of its values. Many attributes of the lagoon and surrounding wetland ecosystem benefit from a closed lagoon (i.e., a freshwater state) while some attributes benefit from an open lagoon.

The technical review of the conditions for opening Waituna Lagoon (described in this report) involved four key steps. These were:

1. Identify Ecological and Cultural Values (section 4):
    - Reconfirm the suite of key ecological and cultural values that are affected by lagoon opening and, therefore, need to be considered in relation to any change in opening regime.

2. Review the Existing Consent Conditions (section 5):
    - Review the impact of the existing consent conditions and monitoring information on key ecological and cultural values of the lagoon.

3. Propose New Consent Conditions (section 6):
    - Conduct an integrated assessment of ecological and cultural values and identify conditions that will maintain or enhance the values identified.

4. Assess the Impact of Proposed Consent Conditions on other values (section 7):
    - Assess the impact of the Proposed Consent Conditions on other key values for the Waituna Community including on land drainage, trout fishing and duck hunting.

4 Ecological and cultural values

A clear understanding of the ecological and cultural values of Waituna Lagoon is fundamental to reviewing the conditions for lagoon opening to the sea. Previously, the ecological guidelines for Waituna Lagoon (LTG 2013), cultural mapping project (Kitson, pers. comm) and other forums and literature have described the lagoon's values.

To develop new consent conditions, a summary of ecological and cultural values for Waituna Lagoon was established through an iterative process based on both existing reports and discussions with experts knowledgeable in the lagoon's biodiversity and its relationship with local Ngāi Tahu people including whanau members from Awarua Rūnanga.

The ecological and cultural values defined in Table 1 relate to: *Water quality, Submerged macrophytes, Fish and bird populations, Fringing wetlands, Taonga species* and *Cultural significance.*

Once the values were defined, it was possible to identify how the different values are affected by anthropogenic pressures, particularly lagoon opening, and what an ideal opening regime would aim to achieve with respect to specific values (Table 1).

The expert group confirmed the importance of the Ruppia-dominated plant community as a key indicator of lagoon ecosystem health. *Ruppia megacarpa* and *R. polycarpa* are keystone species of the lagoon which are sensitive to water level, salinity, and nutrient state. While *Ruppia* spp. may not be recognised as a taonga, the status of Ruppia provides an indication of the lagoon condition, which relates to the health of many taonga species. Similarly, other ecological and cultural values such as the lagoon and catchment's fish community were identified as being sensitive to lagoon open/closed status. The open status allows for the migration of diadromous (require access to the sea to complete their life cycle) species such as īnanga and kanakana/lamprey. While the closed status allows for more successful rearing of giant kokopu (David et al. 2004, Hicks et al. in prep.) in the lagoon and the provision of productive rearing habitat for tuna/eel.

Sections 5-7 of this report provide further assessment of the benefits and risks of lagoon opening on the key values of the lagoon.

Aerial photograph of Waituna Lagoon at Walkers Bay opening site.

Table 1. *Ecological and cultural values of Waituna Lagoon and surrounding wetland.*

Value	Impacted by	Aims of an opening regime
Taonga species Iwi recognise a range of taonga species present in the Waituna wetland system, including (but not limited to); tuna (longfin and shortfin eels), kanakana (lamprey), inanga (whitebait), koura (freshwater crayfish), pātiki (flounder), smelt, kokopu (whitebait), kākahi (freshwater mussel). Around and within the fringes of the lagoon, taonga include swan, water fowl, pukeko, cabbage trees, flax, manuka and other plant species. Māori use local black mud (paru) for dyeing textiles.	• a closed lagoon prevents fish species migrations to and from the sea, including several taonga species • opening the lagoon may increase the presence of exotic species to the detriment of native species, and reduce food and habitat for taonga species • high salinity favours estuarine species over freshwater species	• to enhance taonga species • to maintain the lagoon as close to natural (unmanipulated) state as possible without compromising overall lagoon health
Cultural significance The values of the lagoon include (but are not limited to): aesthetic appeal, mahinga kai, safety of access, identity, landscape and connection to landscape and human health.	• prolonged opening may alter the identity, aesthetic appeal and connection to the lagoon ecosystem • *also refer to impacts on taonga species above*	• move towards a natural opening regime (if it can be done without compromising lagoon health)
Water quality Water quality of the lagoon supports a healthy aquatic ecosystem.	• high nutrients (concentrations in the water column and in lagoon bed sediments) • elevated water temperature • high inflows (increasing nutrient & sediment delivery) • fine sediments (deposited & suspended) • *E. coli* (affecting human contact, food gathering & cultural values) • openings and closings • water levels • activities in the catchment • extent and status of fringing wetlands	• provide a mechanism for excessive nutrients to be flushed to the ocean • provide a mechanism to disrupt prolonged algae blooms • provide a mechanism to maintain keystone macrophytes that regulate water quality • manage algae proliferations including cyanobacteria blooms and macroalgae • reduce level of faecal contamination • improve or maintain the health of fringing wetlands
Submerged macrophytes Sustain and enhance the population of submerged macrophytes including the keystone taxa, *Ruppia* spp. The	• poor water clarity which may be exacerbated under high water levels (light limitation of macrophyte growth) or low	• prevent frequent spring/summer opening to enable macrophyte regeneration

Value	Impacted by	Aims of an opening regime
macrophyte community also supports At-Risk *Ruppia megagcarpa*.	water levels (enhanced sediment resuspension) • low water levels resulting in loss of habitat • elevated salinity when the lagoon is opened • wave action and sediment resupension when the lagoon is shallow • macroalgae and phytoplankton dominance caused by high nutrient concentrations	• ensure maximum water levels do not exceed 2.5m (may cause negative effects on aquatic/wetland plants (due to light limitation) • provide a mechanism for excessive nutrients to be flushed to the ocean • prevent excessive salinity during key Ruppia growing period
Fish and invertebrate populations A diverse population of freshwater fish is present in the lagoon system, including a number of migratory species (refer above to taonga species) as well as marine wanderers such as kahawai. Invertebrates in the lagoon include benthic and pelagic species which likely play important roles in the lagoon's food web. Large invertebrates such as koura (freshwater crayfish) and kākahi (freshwater mussel) are also present in low numbers near the tributary inflows.	• a closed lagoon prohibits fish and invertebrate migration • low water levels may reduce or degrade spawning habitat • an open lagoon reduces food and habitat for freshwater species • poor water quality (including high nutrients and high turbidity, low dissolved oxygen and elevated water temperatures) negatively impact fish and invertebrates	• allow for the timing of opening events to benefit fish spawning and migration where possible • ensure that closures are sufficient in duration to provide food and habitat for multiple species, including for spawning • managing openings for water quality and Ruppia will also benefit fish and invertebrate populations
Bird populations The lagoon and associated wetland provides habitat for a broad range of bird species including many native and threatened species, including waterfowl.	• an open lagoon reduces habitat for wetland bird species and waterfowl in that it affects optimal feeding depths, but increases habitat for waders • a closed lagoon reduces habitat for migratory wading birds, while recognising estuarine habitat for waders is nearby	• provide for water levels that support wetland birds, although it is recognised that differing water levels will favour different bird species over others (e.g., waders vs swimmers, i.e., different functional groups) • provision of habitat for migratory wading birds
Fringing wetlands A diverse native plant community is present within the fringing wetlands surrounding the lagoon. These wetlands provide habitat to support indigenous fauna, including threatened species.	• low water levels and very high water levels can alter native plant communities, with some species/community-types benefiting at the expense of others • high water levels may protect from exotic plant invasion	• manage a fluctuating water regime to support fringing wetlands, e.g. oioi, turf plants • avoid prolonged periods of low water levels that de-water the fringing wetlands

5 Review of existing consent

In February 2017, a 5-year consent for opening Waituna Lagoon to the sea came into effect (Appendix A). The consent retained a primary focus on land drainage but included provisions to open the lagoon to manage for poor water quality (e.g., algal blooms). The consent also established a higher water level opening threshold during spring-summer months in effort to avoid frequent opening events during the germination and early growing season for aquatic macrophytes.

5.1. Water level variation

The 5-year consent has specific conditions providing for:

- A higher opening threshold in spring-summer (2.2m) in effort to reduce the frequency of opening events and decrease negative effects on aquatic plants
- The ability to open lagoon in spring-summer at 2.0m (not 2.2m) if there had been strong macrophyte growth in previous 3 years
- A lagoon opening threshold of 2.0m in winter (May-Sept)
- A lagoon opening threshold of 1.8m in winter, if it had not been open for 12 months
- Emergency opening at >1.5m in the event of prolonged algal blooms or poor water quality.

Water levels in Waituna Lagoon are continuously monitored by Environment Southland at the Waghorns Road/Bridge site. Review of the water level variation between 2015 and 2021 (Figure 3) indicates that there have been five opening events in the lagoon during this period, including four opening events since the commencement of the 5-year consent. There were no reported instances of a prolonged algal bloom requiring the provisions for emergency opening based on water quality to occur.

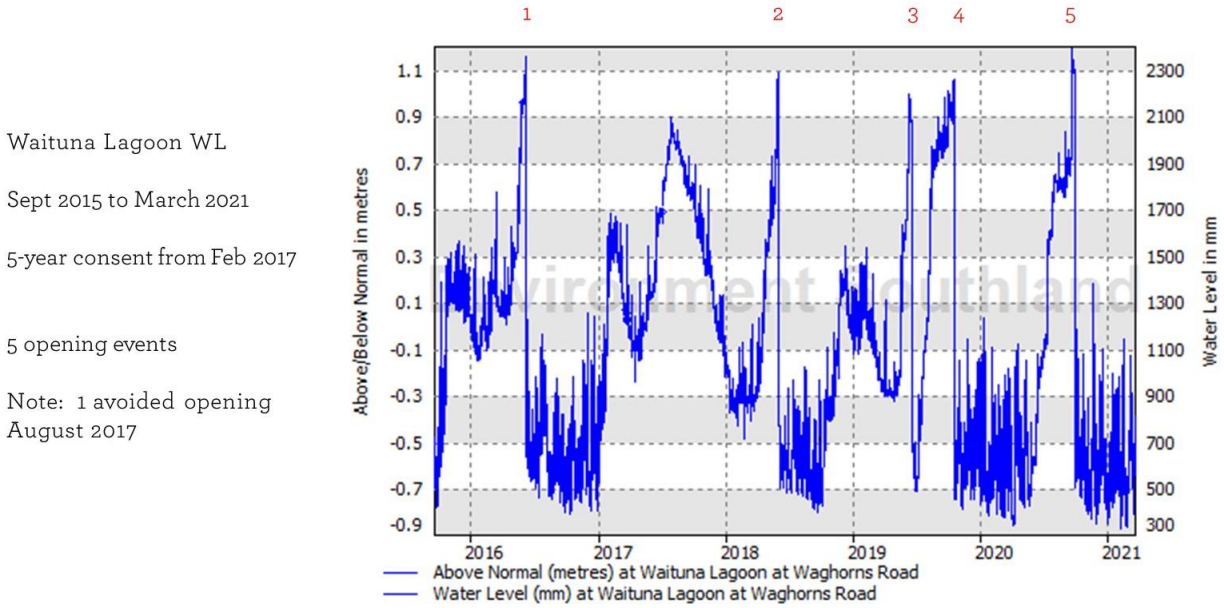

***Figure 3**. Water levels in Waituna Lagoon for the period September 2015 to March 2021*

Since February 2017, only <u>one</u> opening event above 2.0m was avoided due to water levels naturally receding (Figure 3). In this instance, however, the water levels were above 2.0m for several days

during the months of July and August 2017 (Figure 4) so the consent holder was able to open the lagoon in respect of the consent conditions for winter opening but, on this occasion, chose not to do so.

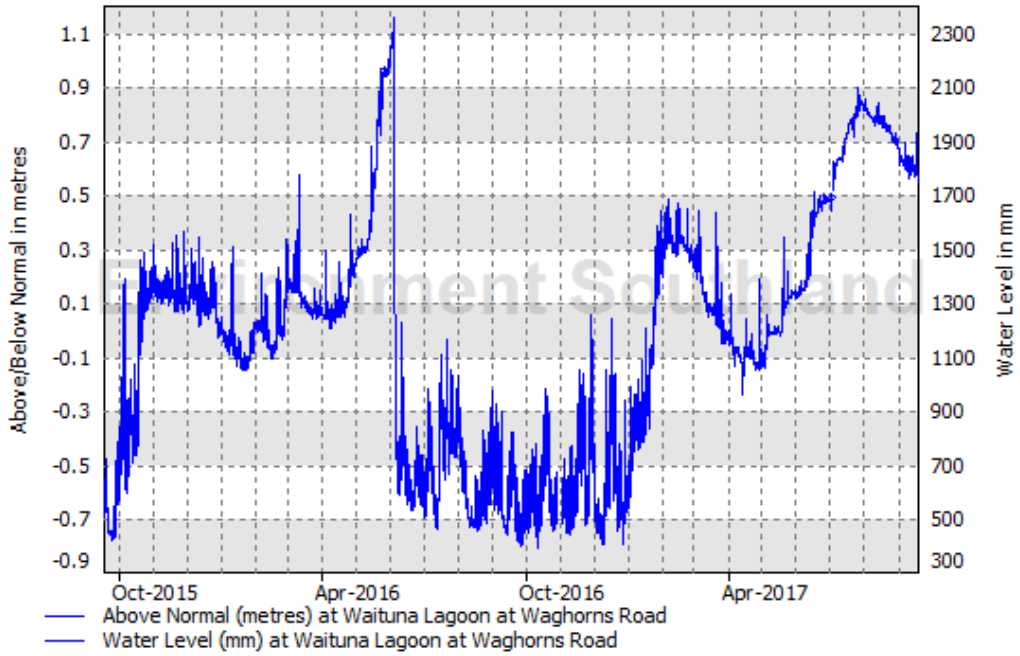

***Figure 4**. Water levels in Waituna Lagoon for the period September 2015 to September 2017*

Notably, since February 2017, 50% of the opening events (2 of 4) resulted in the lagoon being opened during the spring/summer period (Figure 5). That is, <u>the 2017 changes to the water level thresholds for lagoon opening were not sufficient to prevent the consent conditions being triggered and opening events from occurring</u>.

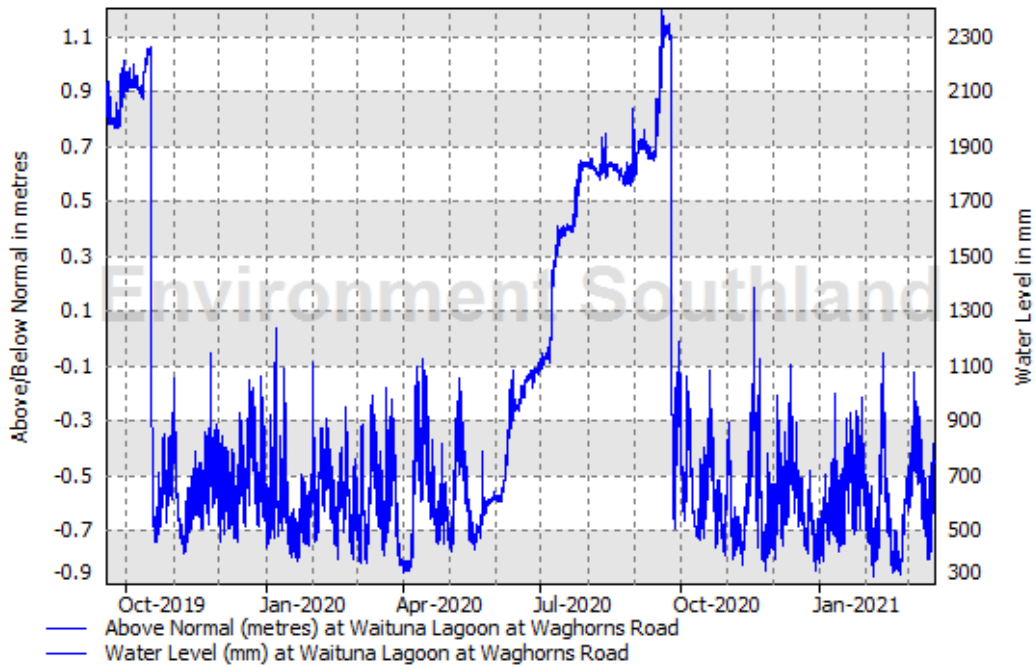

***Figure 5**. Water levels in Waituna Lagoon for the period September 2019 to March 2021*

5.2. Response of lagoon ecosystem

Since the early 2000's, monitoring information on lagoon water quality, the submerged macrophyte population, macroalgae and fish populations in tributary streams has been collated. From this information the response of the lagoon ecosystem to open/closed conditions can be evaluated.

Water quality

Waituna Lagoon is affected by high nutrient loads coming from the catchment that may lead to an increase in phytoplankton blooms that decrease light attenuation through the water column. High nutrient loads can also stimulate macroalgae blooms. The 2013 ecological guidelines included targets relating to total nitrogen (TN), total phosphorus (TP) and chlorophyll-a concentrations in the lagoon's water column.

Since the adoption of the 5-year consent in 2017, there has not been a significant change in water quality in the lagoon, as is suggested by the lack of change in the trophic status of Waituna Lagoon over time (Figure 6).

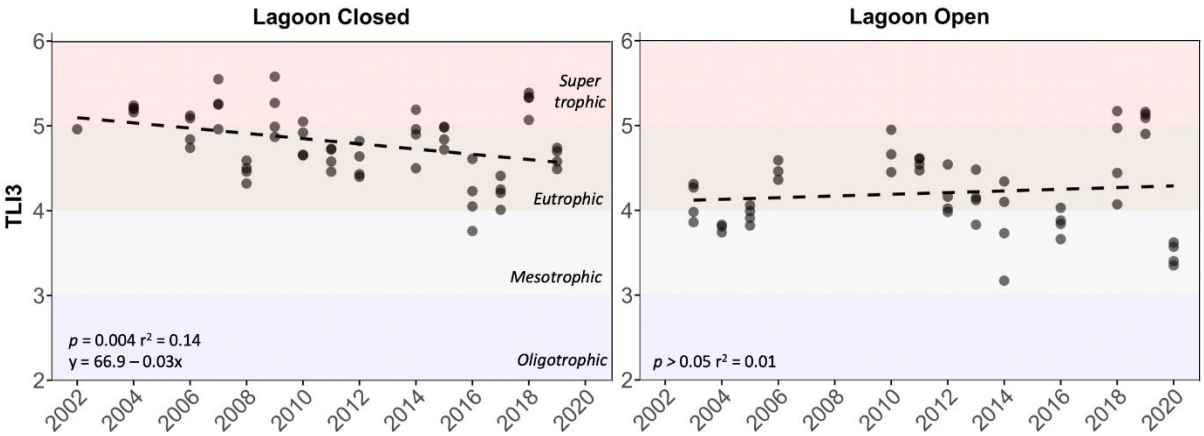

Figure 6. Lagoon-wide trophic status (TLI3) from 2001 to 2020 for when the lagoon is closed (left) and open (right). TLI3 is an index that uses chlorophyll-*a*, TN and TP concentrations, and known relationships to trophic status, to determine the trophic status of a lake.

The specific response of TN, TP and chlorophyll-*a*[3] (chl-a) to lagoon opening is shown in Figure 7. TN concentrations are typically lower when the lagoon is opened to the sea, while TP concentrations are not influenced. Long-term water quality monitoring suggests that dissolved reactive phosphorus, chl-a and turbidity are decreasing over time (when the lagoon is closed), indicating an improvement in these indicators of lagoon water quality (Appendix C, Environment Southland monitoring 2001-2020). However, this does not necessarily equate to an improvement in ecosystem health as other nutrient pools (e.g. sediment, epiphytes) are not measured.

Therefore, closing the lagoon more often may not necessarily result in poorer water quality conditions than have been observed in the past. Although it is recommended that a consent condition is included that enables the lagoon to be opened should water quality and ecosystem indicators reach levels for concern.

[3] An indicator of phytoplankton biomass.

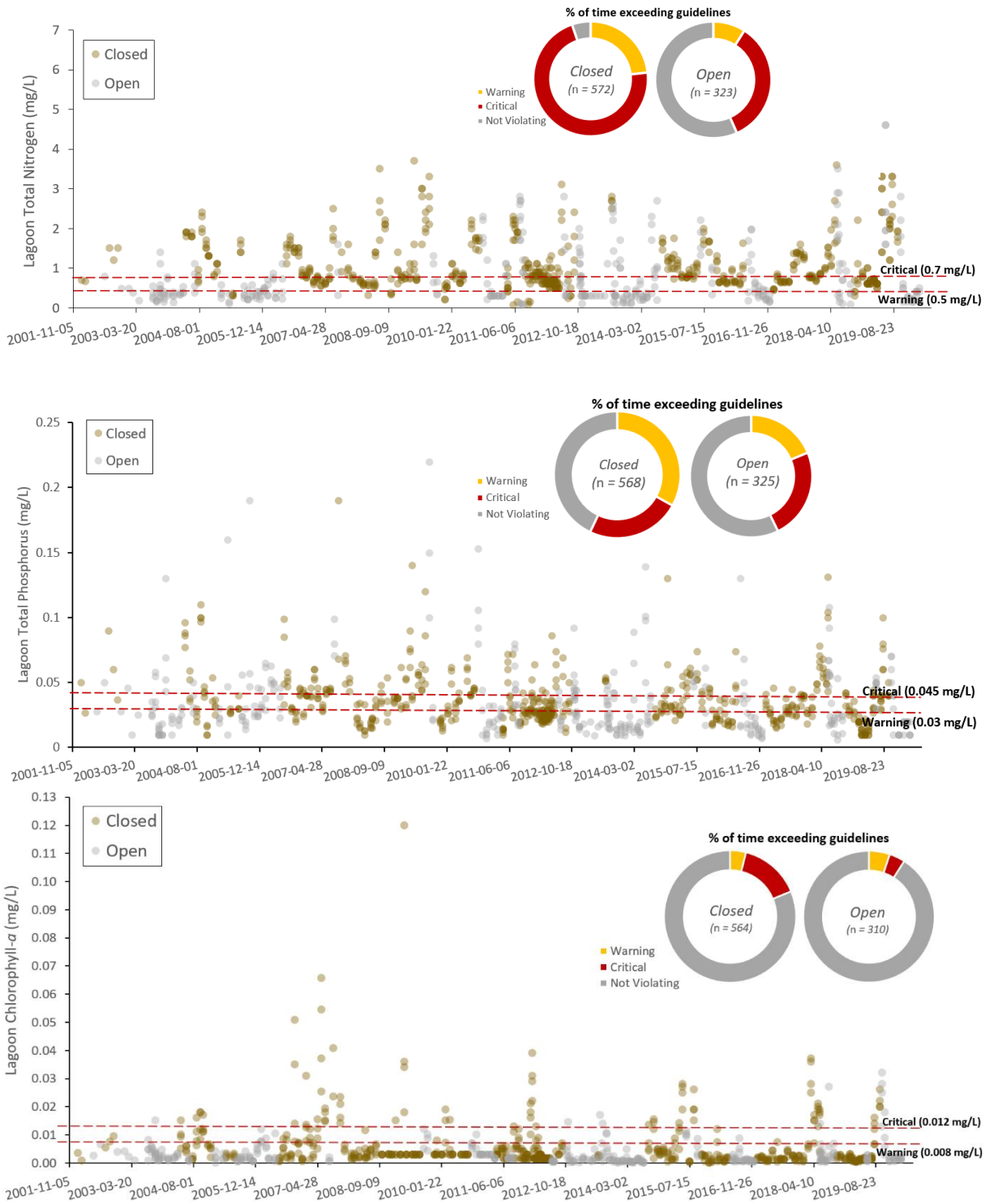

Figure 7. *The total nitrogen (TN), total phosphorus (TP) and chlorophyll-a, concentrations in Waituna Lagoon over time, relative to the 2013 recommendations for water quality.*

Submerged macrophytes and macroalgae

NIWA, on behalf of the Department of Conservation, undertakes annual assessments of the status of submerged macrophytes and macroalgae in Waituna Lagoon (de Winton & Elcock 2021). This monitoring examines whether the lagoon ecosystem is meeting its objectives in terms of lagoon

closure, macrophyte abundance and marcoalgae abundance (Table 2). Overall, six ecological targets are evaluated as outlined in Table 2, including achieving a lagoon-wide cover of 30-60% for *Ruppia* species.

***Table 2**. Summary of results for macrophyte/macroalgae targets since 2009 (de Winton & Elcock 2021). A tick indicates the target has been met, a cross indicates the target has not been met.*

Year	Lagoon closure	*Ruppia* cover	*Ruppia* biomass index	Macroalgae cover	*Ruppia* reproductive success	Status of *Ruppia megacarpa*	Targets met
2009	✓	✗	✗	✓	✗	✗	2
2010	✓	✗	✗	✓	✗	✓	3
2011	✗	✗	✗	✓	✗	✗	1
2012	✓	✗	✗	✓	✓	✗	3
2013	✗	✗	✗	✗	✗	✗	0
2014	✗	✗	✗	✓	✗	✗	1
2015	✓	✗	✓	✗	✓	✗	3
2016	✓	✓	✓	✗	✓	✗	4
2017	✗	✗	✗	✗	✗	✗	0
2018	✓	✗	✓	✓	✓	✓	5
2019	✓	✓	✓	✗	✓	✓	5
2020	✗	✗	✗	✗	✗	✓	1
2021	✗	✗	✗	✗	✗	✗	0

As summarised by NIWA (de Winton & Elcock 2021):

- In 2021, none of the six ecological targets for macrophytes and macroalgae were achieved for Waituna Lagoon;
    - The lagoon was open to the sea over the critical spring-summer period for *Ruppia* growth (for >3 months before monitoring) for the second consecutive year and this is likely responsible for the poor performance of submerged plants in 2021.
    - There has been a further large reduction in the distribution and abundance (biomass) of submerged plants (mainly *Ruppia* species) since reductions were recorded in the 2020 survey,
    - *Ruppia* (and other submerged plants) were not recorded from the south-western sector (approximately half the lagoon area),
    - In 2021, results measuring lagoon-wide *Ruppia* cover, biomass index and *Ruppia* reproductive success were only 1/10th of the ecological target,
    - *Ruppia megacarpa* was limited to only three sites, which was 1/3rd of the ecological target,

    - Macroalgae development exceeded the maximum acceptable threshold of <10% cover.

- Based on all six ecological targets:
    - 2021 is the third monitoring year that fails to achieve any targets, with 2013 and 2017 also not meeting any ecological targets.
    - Surveys that achieved only one or no targets were also years where when the target for lagoon closure (closed >3months before survey) was not met.
    - Current evidence indicates that having a closed lagoon for at least two consecutive growing seasons is important.

Since the commencement of the 5-year consent in 2017, the change in conditions to limit the spring-summer openings has only been partly successful. Five of the six ecological targets were achieved in 2018 and 2019 following a closed lagoon period, however the status of the macrophytes declined again in 2020 (Table 2) and 2021 *(de Winton & Elcock 2021)* in response to prolonged opening events. The abundance of macroalgae remained relatively high in 2020 and 2021 (target was not met), suggesting drivers other than mouth status (e.g. temperature, sediment and nutrients) are also important.

Ultimately, the increase of the lagoon opening threshold in 2017 (to 2.2m during spring/summer) has not prevented lagoon openings from occurring during the germination and early growing season. Furthermore, the two recent occurrences of spring/summer openings, in consecutive years, has negatively impacted *Ruppia* populations.

Fish populations

Waituna Lagoon and its catchment has relatively strong populations of indigenous and taonga fish species. Twelve freshwater fish species (excluding marine wanderers) have been recorded in the Waituna Lagoon catchment tributaries and within Waituna Lagoon itself. The catchment has no known introduced pest fish, with brown trout being the only introduced fish present. Waituna lagoon is known for its significant population of giant kokopu as well as other fish species including, common bullies, shortfin eel, longfin eel and flounder. Many of the species found within the Waituna Lagoon catchment are migratory (e.g. kanakana/lamprey, īnanga), meaning that at least one aspect of their life stage requires access to or from the sea or brackish water. As such, the timing of lagoon opening to the sea has substantial impacts on fish populations and fish community as a whole. On the one hand, fish such as giant kokopu are thought to benefit from the conditions created by prolong lagoon closures (especially during summer). On the other hand, migratory species such as kanakana/lamprey would temporarily disappear from the catchment if the lagoon stayed closed for more than four years. This is because four years is the period that juvenile kanakana/lamprey spend in freshwater after the adults migrate into the catchment from the sea to spawn.

Monitoring undertaken by the Cawthron Institute (Holmes 2019) examined the influence of recent (2014-2019) lagoon open and closed periods on the abudance of fish species in Waituna Creek. This study observed that:

- both īnanga and kanakana/lamprey abundance in Waituna Creek tends to increase with the number of days that the lagoon is open to the sea—either during the preceding spring for īnanga or the winter-spring period (three years previous) for lamprey/kanakana.

- Giant bullies also showed a positive (but weaker) correlation with increasing open days during summer (two years previous).
- No patterns were observed between eel density or biomass and lagoon opening duration.

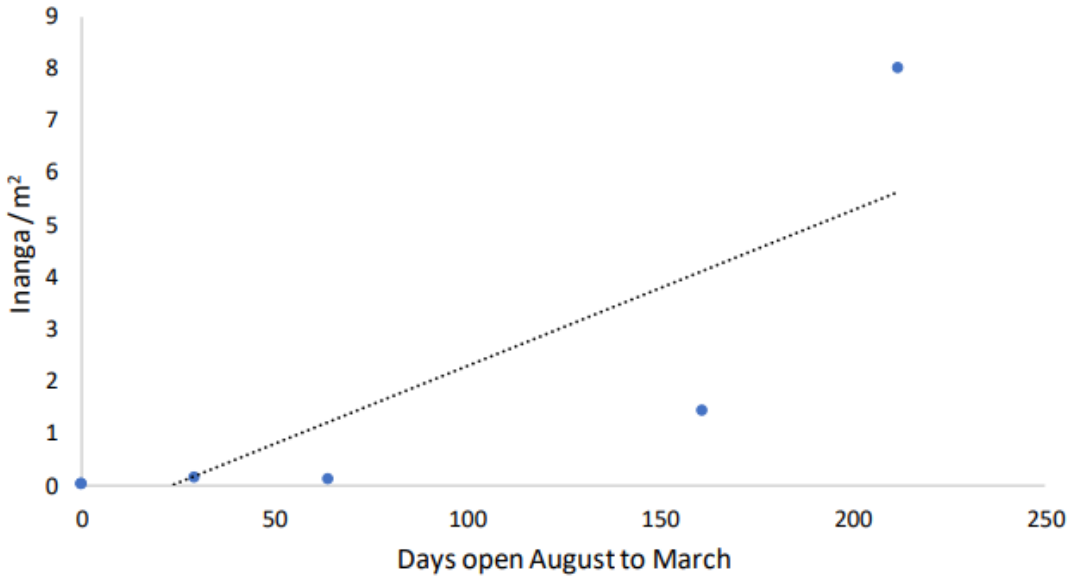

Figure 8. Average inanga density (fish/m²) from all sites during the annual March fish population sampling in Waituna creek (2014-2019) correlated against the number of days Waituna Lagoon was open to the sea from the preceding August to March (inclusive). From Holmes (2019)

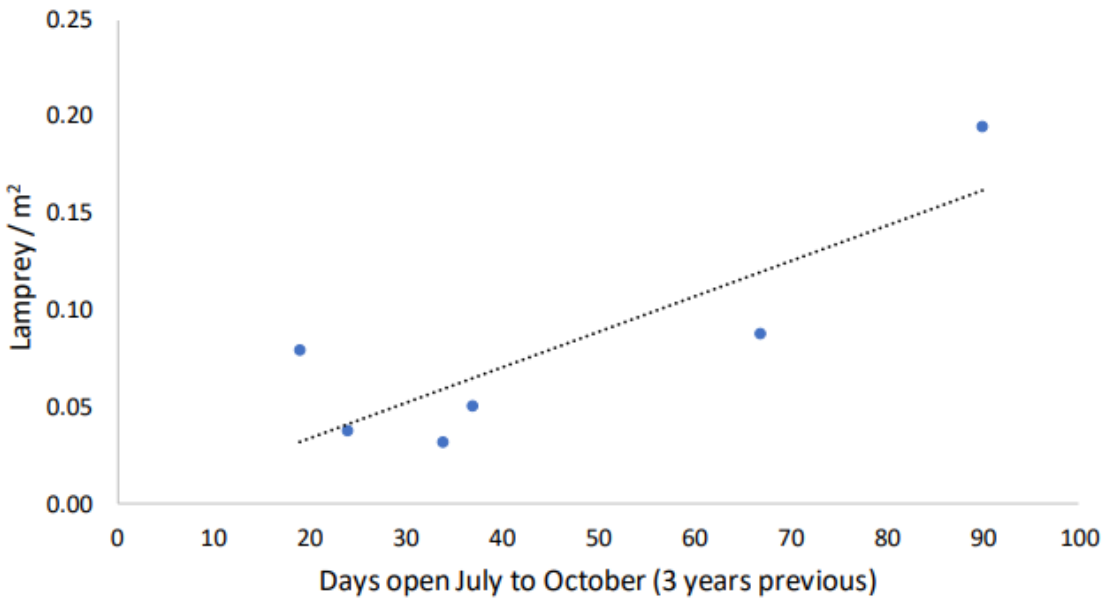

Figure 9. Average kanakana/lamprey density (fish/m²) from all sites during the annual March fish population sampling in Waituna Creek (2014-2019) correlated agaist the number of days Waituna Lagoon was open to the sea from July to October (inclusive) in the three years prior to the sampling date. From Holmes (2019)

Since February 2017, there have been regular periods when the lagoon was open during the winter-spring period which is critical migration period for most ocean migratory species in the Waituna

catchment (Table 3). This indicates that although the lagoon was not opened for the specific purpose of facilitating fish migration, opening events for other reasons may support ocean migratory fish populations.

Table 3.

Year (July-June)	**Lagoon open**	**# Months open**	**Season/s**	**Supported fish migration**
2017-2018	Yes	1	Winter 2018	Yes
2018-2019	Yes	3	Winter-Spring 2018	Yes
2019-2020	Yes	8	Spring-Winter 2019-20	Yes
2020-2021	Yes	6	Spring - Autumn 2020-21	Yes

It may be especially important to consider the frequency of lagoon openings required to support a healthy and persistent population of īnanga in the catchment. When īnanga migrate into the lagoon and catchment, they provide an abundant food supply for other species such as giant kōkopu, trout and tuna (Holmes, pers. comm), enabling the latter populations to flourish. The life cycle of īnanga is annual (with a very small proportion of fish spawning twice). However, considering other values, we recommend that the lagoon is opened during August to October at least every two years. This would allow a two-yearly pulse of īnanga to migrate into the lagoon and catchment and supply predators, such as longfin eel, with high numbers of forage fish. The August to October period also coincides with the upstream migration of adult kanakana/lamprey. Juvenile kanakana/lamprey rear in fresh water for up to four years, and so a limit of a two year closed period during the August to October ought to maintain continuous populations of lamprey within the catchment.

5.3. Issues for consideration

From the technical review of the existing consent, there are five key issues that are considered most important to address in developing conditions for the long-term management of Waituna Lagoon.

These five issues are:

- Incorporating conditions that reduce the frequency of spring/summer opening events. The 2.0m and 2.2m water level thresholds were not sufficient to prevent openings.
- Reviewing the mechanisms for lagoon openings to address poor water quality.
- Incorporating lagoon openings to facilitate fish migration, particularly if there are prolonged periods when the lagoon is closed
- Ensuring the proposed lagoon opening regime considers the benefits/risks to all ecological and cultural values, including the risks to surrounding wetlands
- Ensuring the proposed lagoon opening regime considers the potential impacts on land drainage.

6 Proposed new conditions

6.1. Long-term objective

Waituna Lagoon is a highly significant coastal lake ecosystem that supports a broad range of cultural, ecological, and recreational values. The lagoon forms part of the Waituna Wetlands Scientific Reserve, is designated under the Ramsar Convention, recognised under a Statutory

Acknowledgement with the Ngāi Tahu Claims Settlement Act 1998 and is important to local community.

As guided by the Whakamana Te Waituna project, the long-term objective for opening the Waituna Lagoon to the sea is to **maintain and restore the ecological health and cultural values of the lagoon ecosystem**.

6.2. Proposed amendments

To achieve the goals of the Whakamana Te Waituna project and implement management actions that support the long-term safeguarding of the lagoon, several amendments to the conditions for lagoon opening are proposed. These amendments address the specific issues outlined in section 5.3 of the review of the existing consent.

The proposed amendments to the conditions (triggers) for lagoon opening are presented in Appendix B. The key amendments include:

- An increase in the lagoon opening trigger level to 2.5m to enhance ecological health and cultural values
- Inclusion of new conditions to facilitate fish passage
- Refinement of the conditions providing for emergency lagoon opening in order to mitigate risks to water quality

A rationale for these proposed amendments is provided in sections 6.3 to 6.6.

6.3. Lagoon opening to enhance ecological health and cultural values

Review of the existing 5-year consent identified that the 2.0m/2.2m lagoon opening trigger levels did not prevent spring-summer opening events, and these events corresponded with poor health of submerged macrophytes.

Subsequently, the potential for a higher water level trigger to enhance the ecological and cultural values of Waituna Lagoon was considered.

In 2017, the Waituna Science Advisory Group (WSAG, 2017) investigated lagoon opening levels that support ecosystem health (Table 4), with a specific objective of recommending a maximum level for opening as well as retaining the option to open at lower levels to mitigate poor water quality (algal blooms)[4].

The 2017 review concluded that the health of the lagoon would benefit from higher water levels, but that 2.5m is a recommended maximum water level for the benefit of ecological values. The Whakamana Te Waituna Trust subsequently used a lagoon water level of 2.5m to identify where to purchase surrounding land to allow the lagoon to be managed for ecological reasons[5].

Table 4. *Summary of trigger level considerations*

Value/Driver	Maximum level (mASL)	Details
Preventing spring/summer openings during 'years of concern' to enable macrophyte regeneration	2.5m	Summer openings stress macrophytes and favour macroalgae. *Ruppia* benefits from closure and low salinity during key growth stage (spring/summer)

[4] Schallenberg, M. & Robertson, H. (2017). Report on the findings of the Waituna Science Advisory Group (SAG) into water levels in Waituna Lagoon for the management of the lagoon's ecological health.
[5] To date, three properties adjacent to the lagoon have been purchased though the Whakamana Te Waituna programme to ease the impact of high lagoon levels on farming operations.

Allowing the timing of opening events to benefit fish spawning and migration where possible	na	Issue for fish include timing of events and the maximum water level.
Managing a fluctuating water regime to support fringing wetlands – e.g. Oioi, turf plants	2.5m	LiDAR elevation models indicate that most wetland vegetation will be inundated when lagoon levels are ~2.3m. Irregular inundation at higher levels is positive for these systems.
Providing a mechanism for excessive nutrients to be flushed to the ocean	>1.8m	Flushing of nutrients can occur above 1.8m when there is sufficient hydraulic gradient. The higher the water level the better the flushing when opened.
Providing a mechanism to disrupt a prolonged algal bloom	>1.5m	Ecological guidelines suggested that if needed an opening could occur at 1.5m to disrupt a prolonged algal bloom. A minimum height is needed for an effective opening, not a maximum.
Ensuring maximum water levels do not cause negative effects on aquatic/wetland plants (e.g. light limitation)	2.0m*	Light limitation is likely to have an impact on submerged vegetation in deeper parts of the lagoon. Prolonged inundation (>20 days per annum) at higher water levels (e.g. >2.3m) may limit productivity. *Note: Because the gravel barrier is leaky – such prolonged events may be unlikely. Unknown potential positive effect of raised level on turbidity and light penetration.
Recommendation	**2.5 mASL**	

The proposed 2.5m opening trigger level, however, is based on some assumptions, specifically:

- that increasing the opening trigger level to 2.5m will reduce the frequency of opening events,
- the duration of high water levels will be limited (e.g. less than 20 days above 2.2m), and therefore periods of light limitation on submerged plants and inundation of ex-farmed soils will be minimal
- that opening events will still occur to support fish passage and ecological and cultural values that benefit from open lagoon conditions

To test these assumptions, the hydrological model of Waituna Lagoon developed by Chris Jenkins (Team Leader Hydrological Response, Environment Southland) was applied. This model uses a 48-year hydrological record to predict the number and duration of water level events exceeding specified levels.

A series of opening scenarios were examined by the model, including a base scenario (existing consent conditions), lagoon opening at 2.5m and other permutations to provide for fish passage. The specific scenarios assessed were:

- **First Scenario:** open when level is at 2.2 m or above for 7 consecutive days
- **Current consent:** open when level is at 2.0 m for the period May – 19 Sep, and open when level is at 2.2 m for the period 20 Sep – 30 Apr
- **Scenario A:** open when level is at 2.5 m or above for 7 consecutive days
- **Scenario B – option 1**: open when level is 2.5 m or above for 7 consecutive days; or if no opening in the previous year days open if the level exceeds 2 m (for fish passage)
- **Scenario B – option 2:** open when level is 2.5 m or above for 7 consecutive days; or if no opening in the previous year open if the level exceeds 1.5 m (for fish passage)
- **Scenario C – option 1**:
  open when level is 2.5 m or above for 7 consecutive days; or if no opening in the previous 2 years open if the level exceeds 2 m (for fish passage)

Scenario C – option 2

- open when level is 2.5 m or above for 7 consecutive days; or if no opening in the previous 2 years open if the level exceeds 1.5 m (for fish passage)

A summary of the model results is presented in Table 5. In broad terms, the analysis indicates that under the current consent conditions (2.0m/2.2m) lagoon openings are likely to occur about once every year (0.99 openings/year). If the opening trigger were raised to 2.2m (First Scenario) for the entire year, opening events would occur with a slightly lower frequency (0.86 openings/year). Whereas, if a trigger level of 2.5m were applied (Scenario A), this would result in lagoon openings decreasing substantially in frequency (0.41 openings/year).

The less frequent openings under Scenario A will support the Ruppia-dominated plant community and the overall ecological function of the coastal lake ecosystem, as it has been previously shown that Ruppia biomass and recruitment is adversely affected when the lagoon remains open over spring/summer when the plant is flowering, producing seeds and generally growing faster. Specifically, under Scenario A spring/summer openings are likely to occur almost half as frequently as they do now (0.13 vs 0.22).

Scenario A would result in approximately 35 more days per year when water level is above 2.0 m relative to the current situation, and the average duration of the period when the lagoon is above 2.0 m would be approximately 15 days longer for Scenario A relative to the current situation. Scenario A would result in 3.5 days above 2.4m per year, compared to 0.7 days for the current consent, indicating that the duration of high-water levels will remain limited. This indicates that periods of prolonged light limitation on submerged aquatic plants and macroalgae would not be expected to occur if the opening trigger level were raised to 2.5m.

Table 5. *Opening scenarios and probabilities of the lagoon opening and for how long based on historic data (modified table supplied by Chris Jenkins, Environment Southland).*

Scenario	Average Openings per Year	Average Num. Openings 19 Sep to 30 April	Annual average days above 2.0m	Annual average total # events of 2.0m	Average duration of events above 2.0m (days)	Annual average days above 2.2m	Annual average total events of 2.2m	Average duration of events above 2.2m (days)	Annual average days above 2.4m	Annual average total events of 2.4m	Average duration of events above 2.4m (days)
First Scenario (open at 2.2m)	**0.86**	**0.28**	18.49	1.68	11	1.99	0.91	2.2	0.47	0.11	4.27
Current consent Open at 2.0m May to 19 Sep and 2.2m 20 Sep to 30 April	**0.99**	**0.22**	15.47	1.59	9.73	2.35	0.92	2.55	0.74	0.15	4.93
Scenario A (open at 2.5 m)	**0.41**	**0.13**	51.68	2.08	24.85	20.87	1.46	14.3	3.54	0.71	4.99
Scenario B (open at 2.5m or, if not opened in previous year, open for fish passage) at levels above 2m	**0.70**	**0.18**	30.8	1.69	18.22	11.91	1.04	11.45	2.06	0.45	4.58
Scenario B (open at 2.5m or, if not opened in previous year, open for fish passage) at levels above 1.5m	**0.76**	**0.20**	32.82	1.48	22.17	12.71	0.98	13	2.27	0.48	4.7
Scenario C (open at 2.5m or, if not opened in previous 2 years, open for fish passage) at levels above 2m	**0.50**	**0.14**	43.36	1.97	22.01	16.9	1.26	13.4	2.64	0.61	4.33
Scenario C (open at 2.5m or, if not opened in previous 2 years, open for fish passage) at levels above 1.5m	**0.52**	**0.14**	44.73	1.91	23.4	17.87	1.25	14.3	2.86	0.62	4.6
Observed (2016-2021)	1	0.4	14.66	1.6	9.16	3.6	1.2	3	0	0	0

It is therefore recommended to amend the general conditions for lagoon opening as follows:

Lagoon Opening – general opening for ecological health, cultural values and land drainage.

4. (a) Regardless of the time of the year, the lagoon may be opened to the sea when the water level in the lagoon reaches 2.5 metres, as measured on the Waghorn's Road bridge gauge board, and remains at or above that level for at least 24 hours continuously.

6.4. Lagoon opening to promote fish passage

It is recognised that setting a single trigger level of 2.5m may not appropriately provide for all key ecological and cultural values of Waituna Lagoon. In particular, while Scenario A (2.5m) supports the long-term management of the macrophyte community and the natural functioning of the coastal lake ecosystem, it may not adequately support the migration of indigenous and taonga fish species. Consequently, further details around the opening conditions (triggers) are recommended.

Based on knowledge of lifecycles of indigenous and taonga fish species in Waituna Lagoon (Table 6), the key months for upstream and downstream migration were identified to show when lagoon openings would benefit multiple fish species and life-stages (Table 6). Thus, there are key times of the year, such as August-October, when an open lagoon would support the migration and recruitment of several fish species.

To examine whether it would be possible to reduce the frequency of spring/summer openings and provide for fish passage, four additional scenarios were examined through hydrological modelling. These scenarios consider an opening trigger of 2.5 m together with an option to open for fish passage if no opening had occurred in the previous 12 (Scenario B) or 24 months (Scenario C):

- **Scenario B – option 1**: open when level is 2.5 m or above for 7 consecutive days; or, if no opening in the previous year, open if the level exceeds 2 m (for fish passage)
- **Scenario B – option 2:** open when level is 2.5 m or above for 7 consecutive days; or, if no opening in the previous year, open if the level exceeds 1.5 m (for fish passage)
- **Scenario C – option 1**:
  open when level is 2.5 m or above for 7 consecutive days; or, if no opening in the previous 2 years, open if the level exceeds 2 m (for fish passage)
  Scenario C – option 2
- open when level is 2.5 m or above for 7 consecutive days; or, if no opening in the previous 2 years, open if the level exceeds 1.5 m (for fish passage)

As would be anticipated, Scenario B (open for fish passage after 12 months) results in a greater average number of spring/summer openings per year (0.18 - 0.20 openings/year) relative to Scenario A (0.13 spring/summer openings per year). Therefore, Scenario B would favour fish migration but would likely have detrimental effects on the macrophyte community and natural lake ecosystem function due to the high frequency of spring/summer lagoon opening.

However, under Scenario C (open for fish passage after 24 months) there would be only 0.14 spring/summer opening events per year - about the same frequency as Scenario A (0.13). Note that the average number of days when water levels are above 2.0m and average duration of events are broadly similar for Scenario A (2.5m only) and Scenario C (2.5m and fish passage).

Table 6. *Downstream and upstream migration periods for native fish in the Waituna Catchment (Smith 2014)*

Common name	**Upstream migration period**	**Peak upstream migration period**	**Downstream migration period**
Shortfin eel (glass eel)	July-December	August-November	March-September
Longfin eel (glass eel)	August-January	September-December	February-July
Giant kōkopu	October-January	November	?
Banded kōkopu	August-January	September-November	March-July
īnanga	May-December	August	March-September
Kanakana/lamprey	May-December	August-October	March-September
Common bully	December-April	December-April	September-January
Giant bully	December-April	December-April	September-December
Redfin bully	November-April	November-April	September-December
Common smelt	August-December	September-November	November-May
Black flounder	September-December	December-December	November-May

The preferred opening regime to benefit the migration of fish species and the overall health of the coastal lake ecosystem, consequently, is Scenario C (2.5m; open for fish passage after 24 months).

It is, therefore, recommended to include specific conditions for fish passage as follows:

Lagoon Opening for the purpose of providing fish passage

Z. (a) Notwithstanding conditions 4 and 6 of this consent, the lagoon may be opened to the sea to provide for passage for diadromous fish species when the water level in the lagoon is above 1.5 metres, as measured on the Waghorn's Road bridge gauge board, during the period 1 April to 30 November, provided that:

(i) The lagoon has not been opened in the previous 24 months, and

(ii) The Technical Advisory Group has considered the lagoon water quality and ecosystem health indicators listed in Appendix 1 and Appendix 2, and any other relevant scientific information, and has advised the consent holder and Consent Authority (in writing) that opening the lagoon to the sea is recommended to enable fish passage.

While lagoon opening every three years would have the least potential for spring/summer openings that adversely affect the Ruppia-dominated community, the 2-yearly cycle is proposed as a compromise to ensure life-cycles of important migratory fish and taonga species are protected, including īnanga and kanakana/lamprey, while minimising openings in spring/summer.

Ongoing monitoring of the status of fish populations, macrophytes and macroalgae will be critical. If monitoring indicates that opening the lagoon for fish passage every two years could potentially sustain the fish community, then the frequency of opening events for fish passage could be reduced. Alternatively, if fish populations are found to decline substantially then the conditions can be reviewed accordingly.

6.5. Lagoon opening to manage water quality

Review of Environment Southland water quality monitoring, and NIWA vegetation monitoring (de Winton 2019, 2020) shows that lagoon can be subject to periodic algal blooms, regardless of whether the lagoon is open or closed.

Water quality monitoring indicates that chlorophyll-*a*[6] concentrations have exceeded the warning trigger level (0.008 mg/L) 18% of the time within the past 5 years, and concentrations have exceeded the critical trigger level (0.012 mg/L) 15% of the time within the past 5 years when the lagoon has been closed (Figure 7). For persistent algal blooms, opening the lagoon to the sea provides a valuable mechanism to disrupt the bloom and decrease chlorophyll-*a* concentrations.

While chlorophyll-*a* concentrations in the lagoon have been trending downwards over the last 5-10 years (Appendix C, Environment Southland monitoring 2001-2020), retaining conditions for emergency opening of the lagoon to disrupt phytoplankton and cyanobacteria blooms remains important, and considering the complex nature water quality and algal interactions. The previous consent did not specifically include 'cyanobacteria' as a primary trigger for water quality and it is recommended this is amended in Appendix 1 because of the threat to human health and wildlife from cyanobacterial blooms.

It is therefore recommended to amend the conditions for water quality as follows:

Lagoon Opening in the case of poor water quality events

6. (a) Notwithstanding condition 4 of this consent, the lagoon may be opened to the sea at any time of the year when water level in the lagoon is above 1.5 metres, as measured on the Waghorn's Road bridge gauge board, provided that:

(i) One or both Water Quality (Primary) Indicators set out in Appendix 1 has reached its Critical Indicator Level, and

(ii) A Technical Advisory Group, convened jointly by Environment Southland, Te Ao Marama Inc. and the Department of Conservation, with scientific knowledge of coastal lagoon ecosystems, has considered the Primary Indicators in Appendix 1, and any other relevant scientific information, including additional indicators of Ecosystem Health set out in Appendix 2, and has advised the consent holder and Consent Authority in writing that opening the lagoon to the sea is advisable to disrupt an actual or probable algal bloom in order to avoid a significant adverse ecological effect on the lagoon.

Appendix 1

Water Quality or Ecosystem Health Indicator	***Critical Indicator Level***
Primary Indicators	
Chlorophyll-a	*a sustained visible algal bloom* over a period of 14 days or longer*
Cyano-bacteria	*≥ 500 cells/mL or ≥ 0.5 mm^3/L biovolume [of potentially toxin producing species].*
Interpretation	

[6] An indicator of phytoplankton biomass.

** A "visible algal bloom" shall be identified by:* *(i) A chlorophyll-a concentration of ≥ 0.012 mg/L (or other figure identified in writing by the Technical Advisory Group referred to in condition 6; and/or* *(ii) The observations of an appropriately qualified person. These observations shall include the location and approximate scale and intensity of the visible algal bloom on each day of observation.*

Appendix 2

Water Quality or Ecosystem Health Indicator	Critical Indicator Level
Secondary Indicators Total phosphorus concentration Total nitrogen concentration	 sustained above ≥ 0.045 mg/L sustained above ≥ 1.000 mg/L
Tertiary Indicators** Nuisance epiphytes or benthic algae Macrophytes *Ruppia megacarpa*	 >10% cover <20% cover Present at less than <20% of lagoon monitoring sites
Other indicators that may be considered Turbidity RPD (Redox Potential Discontinuity) – bottom sediments Bottom water dissolved oxygen concentration Aquatic and surrounding wetland life	
** Based on the results from annual surveys undertaken in late summer.	

6.6. Integrated assessment of ecological and cultural values

Development of proposed conditions for lagoon opening (section 7.2-7.5 above) was based on a subset of the ecological and cultural values of Waituna Lagoon, specifically: submerged macrophytes, fish/taonga species populations and water quality.

There may be concerns that the proposed regime will have negative consequences on other values at Waituna Lagoon, such as the fringing wetlands and bird populations. An integrated assessment of the predicted impact of the proposed changes to lagoon opening on all key values is summarised in Table 7. This indicates that, overall, the proposed conditions (Scenario C) will have a beneficial impact. Although for some values the proposed conditions will have a neutral impact (bird populations, water quality), it is not predicted that significant negative effects on the coastal ecosystem will occur.

Table 7. Multi-value assessment of the predicted impact of recommended conditions

Value	Impact of existing consent conditions	Predicted impact of recommended conditions (SCENARIO C)	Predicted change in value
Taonga species	Does not specifically provide for fish passage for taonga species. Opening events may or may not align with key migratory periods	Specific provisions for fish migration. Increased focus on monitoring	Improvement/Neutral
Cultural significance	Frequent opening events (>1x/year) not aligned with restoring ecosystem to more natural regime	Conditions specifically target a transition to a more natural state (longer freshwater phase)	Improvement
Water quality	Included provision for emergency opening to disrupt phytoplankton bloom	Conditions for emergency opening retained in case of poor water quality. Lagoon flushing will still occur (given conditions for fish passage)	Neutral
Submerged macrophytes	Spring/summer openings led to regular decline in abundance of submerged macrophytes	Conditions specifically target improved management of macrophytes due to higher (2.5m) opening trigger	Improvement
Fish and invertebrate populations	Does not specifically provide for fish passage. Opening events may or may not align with key migratory periods	Specific provisions for fish migration. Increased focus on monitoring	Improvement/Neutral
Bird populations	Conditions provide for both open and closed lagoon conditions that support broad range of bird species.	Conditions provide for both open and closed lagoon conditions that support broad range of bird species. Longer freshwater phase will benefit threatened species (Bittern) and waterfowl (incl. ducks). A reduction in the estuarine phase is not considered to have a significant impact on the bird species that favour an open lagoon due to the availability of other estuarine habitats in the area (e.g. New River estuary)	Neutral
Fringing wetlands	Fringing wetlands often dewatered for long periods when lagoon in open phase	Inundation at levels >2.2m. will enhance native wetland vegetation and promote habitat diversity	Improvement

For example, in terms of bird populations, different bird functional groups have different habitat preferences (Arctic migrant waders and overwintering waders –-> shoreline feeding; Swamp birds –-

> flooded reeds/rushes; Waterfowl and shags –-> open water). Given the contrasting habitat preferences, the open and closed status of the lagoon will have a varied effect on bird functional groups. As the proposed conditions for lagoon opening still include both closed (freshwater) and open (tidal) phases, the overall impact on bird populations was considered neutral.

In terms of the cultural significance of Waituna Lagoon (which incorporates the aesthetic appeal, mahinga kai, safety of access, identity, landscape and connection to landscape and human health), the overall purpose of proposed new conditions (Scenario C) is to return the lagoon to as natural state as possible. The predicted impact on the lagoon's cultural values is, therefore, also expected to be positive, while taking a holistic approach that considers the opportunities to enhance fish passage/mahinga kai and addressing poor water quality.

7 Impacts of proposed consent conditions on other values

7.1. Land drainage and road/track infrastructure

This review of the conditions for lagoon opening was focused on determining the optimal management approach to enhance the ecological and cultural values of Waituna Lagoon. As outlined in section 6 it is proposed to increase the trigger level for lagoon opening to 2.5mASL. That is, the lagoon opening (under Scenario C) will occur when water levels are at or above 2.5m for a period of 24 hours.

Recommendation of 2.5m as the opening trigger level considered the potential adverse effects on land drainage. A detailed investigation of the effects of lagoon water levels on land drainage was previously undertaken by NIWA (Walsh et al. 2016). This investigation used complex hydrological models, LiDAR elevation data, flow and level monitoring data, in combination with a channel roughness coefficient (to simulate a cleared or vegetated channel) to map the extent of land that is affected directly by inundation (figure 11), and impeded land drainage (figure 10), at different lagoon water levels. It should be noted that the area of land affected by direct inundation and impeded drainage is a function lagoon level, flow rate and plant growth in the creeks. The relative importance of these factors varies spatially with the most downstream parts of the creek strongly affected by lagoon level but further upstream the influence of flow rate and vegetation dominate. This is important to consider when interpreting figure 10 where the land drainage impacts furthest from the lagoon are caused by vegetation rather than lagoon level (Walsh et al. 2016).

The NIWA investigation supported the purchase of low-lying land by Whakamana Te Waituna. Land purchase specifically targeted agricultural land adjacent to Waituna, Moffat and Carran Creek with inundation or restricted drainage when lagoon water level is at 2.5m. Consequently, it is no longer necessary to maintain drainage to most of the agricultural lands that were vulnerable to inundation and impeded land drainage. However, under the recommended opening regime, some properties have residual areas with short-term restricted access or drainage limitations (figure 10).

A few small sections of roads and tracks on Waghorn Road are similarly affected by inundation at lagoon levels above 2.0m ASL (figure 12). When the lagoon water level is at approximately 2.0m ASL, Southland District Council estimates that about 300m of road/track is inundated. When the water level is at 2.5m ASL this increases slightly to approximately 400m of road/track being inundated. However it is important to note this limits access only to the Department of Conservation viewing platform and one of the properties purchased through the Whakamana Te Waitua project.

One property on the southern side of Waituna Lagoon between the lagoon and the sea is most easily accessed by a track through Conservation Land. Approximately 500m of this track is affected by inundation when lagoon levels get to about 2.2m. An unformed track exists on the seaward side of the Conservation Land (on the beach) that provides alternative and legal access.

A concern for road infrastructure, access to private land and agricultural land drainage may be that lagoon water levels will be high (>2.4m) for prolonged periods of time. However, the results from hydrological modelling (Table 5) indicate that under proposed lagoon opening (Scenario C) water levels will be >2.4 for approximately 2.6 days per year, and >2.2m for approximately 17 days per year.

Therefore, any residual effects on land drainage for low-lying properties not purchased by Whakamana Te Waituna are considered minor in both extent and frequency. Similarly, the duration of inundation on road infrastructure is relatively short-lived.

Figure 10. Land that is drainage-affected under mean flow conditions with a vegetated channel. Purchased land is outlined in black/white and land affected by inundation is outlined in pink/white. Left panel is Waituna Creek, middle panel is Moffat Creek and right panel is Currans Creek. NB channel vegetation is the dominant cause of impeded drainage furthest away from the lagoon as shown as 0.5m lagoon level (Walsh et al. 2016).

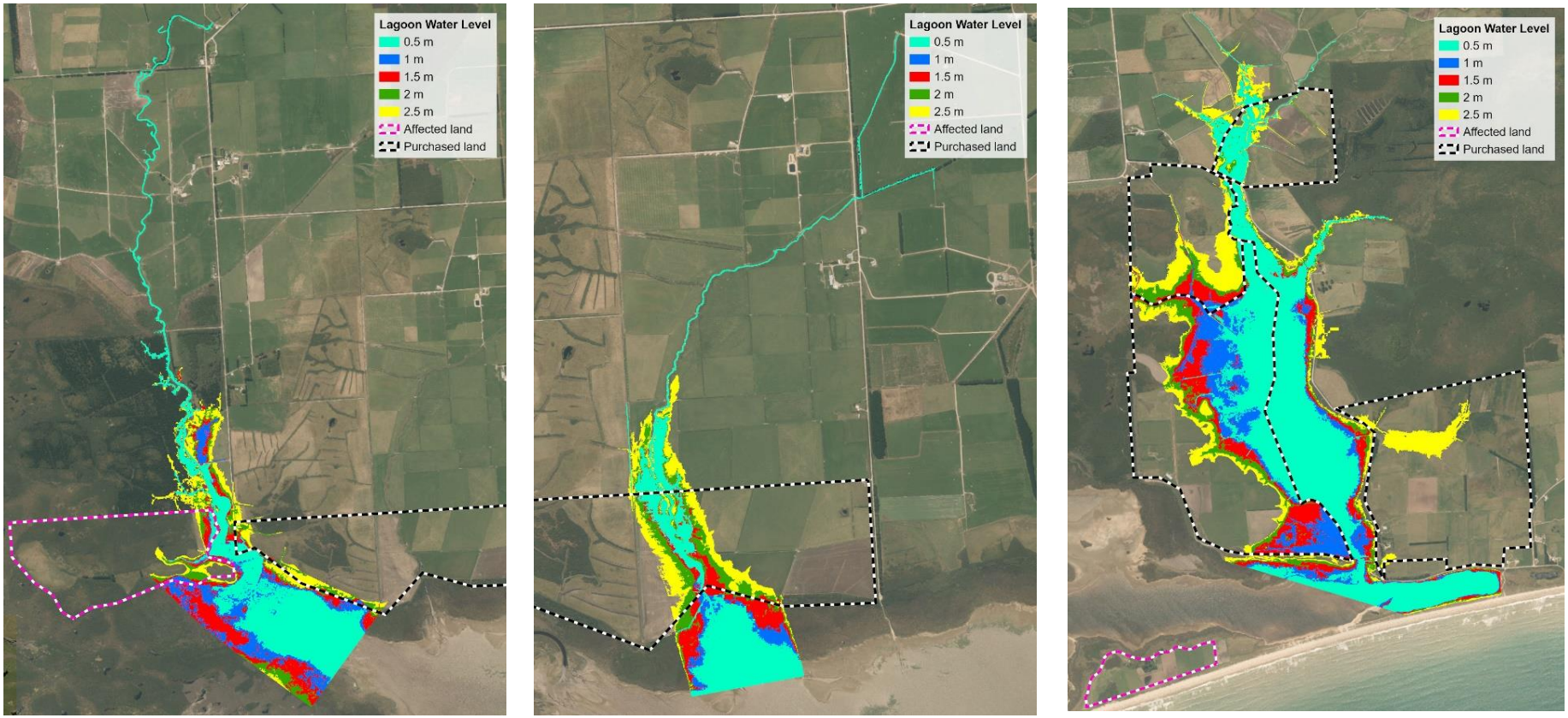

Figure 11. Extent of inundated land from Waituna creek (left), Moffat Creek (middle) and Curran Creek (right) at different lagoon levels, modelled under a scenario of mean flow and channel vegetated. Purchased properties outlined in black/white, land affected by inundation but not purchased outlined in pink/white. Walsh et al 2016

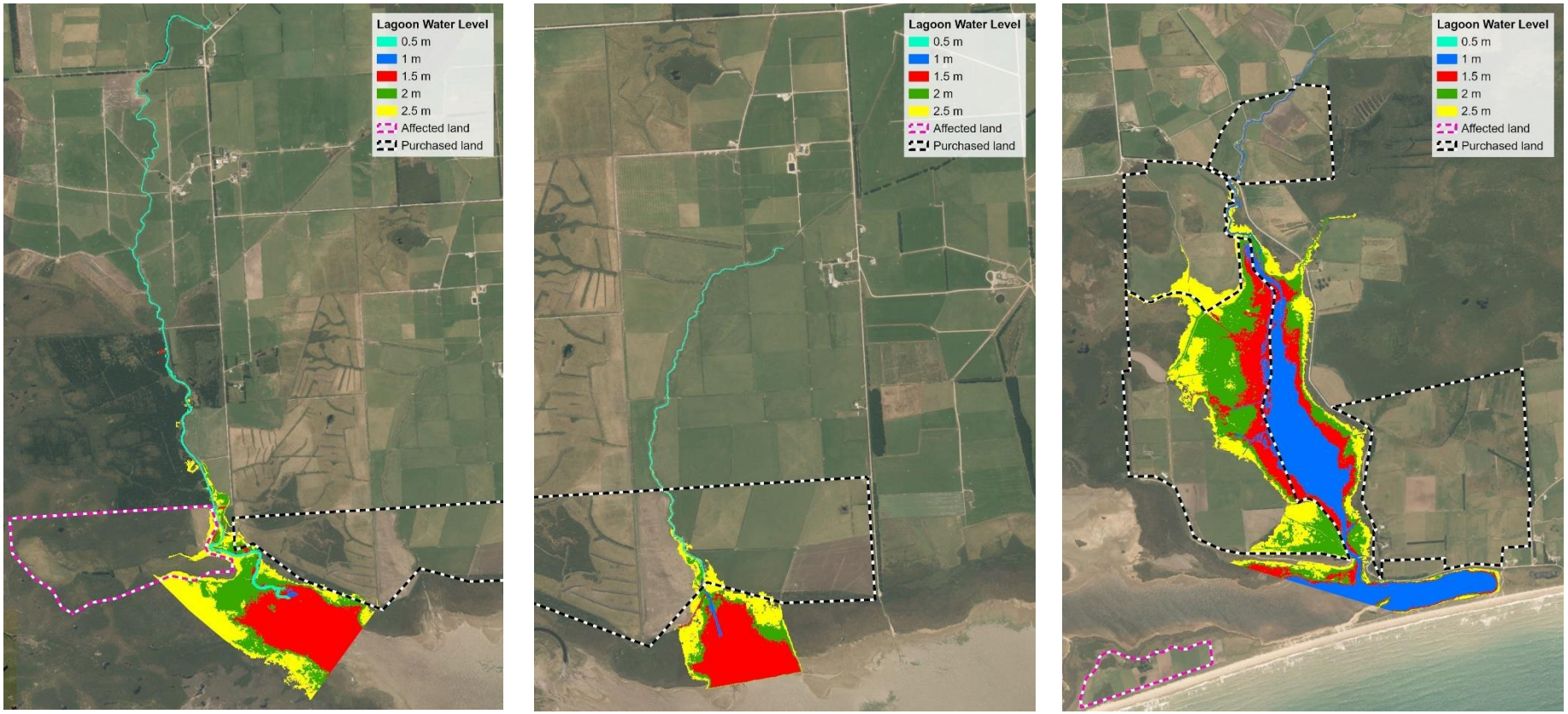

Figure 12 Extent of inundation of Waghorn road and Waghorn Road Bridge at different lagoon levels

7.2. Trout fishery

Waituna lagoon is highly valued regionally for its brown trout fishery and particularly for the opportunity to catch 'sea-run' trout when the lagoon is open. Anglers specifically target trout at the lagoon outlet when the lagoon opening coincides with upstream īnanga migration (whitebait run) which provides a feeding opportunity for trout.

Holmes (2019) observed no detectable pattern between brown trout density (or biomass) and lagoon open-closure status, stating that the effects of lagoon opening and closed status on trout populations may be indirect or subtle, likely though food web effects.

Inward migration of īnanga provides a significant pulse of food into the Waituna catchment, contributing in the order of 20% of total fish biomass in Waituna Creek during strong recruitment years. This addition of food into the wider ecosystem ultimately increases productivity of the whole system, including the brown trout population.

Compared to the status quo, the proposed consent conditions have specific provisions to ensure native fish, particularly īnanga, can regularly migrate into the lagoon and catchment, thereby ensuring the opportunity for catching sea run trout continues, at least during every two years. While opportunities to target sea-run fish will be reduced during years when the lagoon is closed, the resident trout population will likely benefit from closed lagoon conditions. The lagoon is highly productive when closed over the summer periods and the available foraging area for trout will be increased. This will likely provide good fishing conditions for anglers targeting trout around the lagoon edge and near tributary inflows.

In addition, optimising the lagoon for ecological health will protect the trout population by helping to maintain water quality and clarity. Overall, the impact of an ecologically-focused opening regime should protect and enhance the brown trout population and its fishery values.

7.3. Duck hunting

Waituna Lagoon and surrounding wetlands are highly valued for the opportunity for duck hunting.

The proposed lagoon opening conditions (Scenario C) outlined in this report will result in a reduced frequency of lagoon opening events, including a reduced likelihood of lagoon opening during the opening of the duck hunting season. Increased duration of freshwater conditions, with extensive open water areas that support a healthy lagoon ecosystem dominated by submerged macrophytes, will provide habitat and food resources for waterfowl (ducks, swans).

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Walsh, J., Measures, R., Bind, J. (2016). Waituna Lagoon level impacts on land drainage and inundation. Investigation stages 1 and 2. Prepared for the Department of Conservation. NIWA publication.

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9 Appendix A – Current consent to open Waituna Lagoon

Coastal Permit

Pursuant to Section 104B of the Resource Management Act 1991, a resource consent is hereby granted by the Southland Regional Council to **Lake Waituna Control Association,** care of **E R Pirie, 389 Kapuka North Road, RD 3, Wyndham 9893** from **14 February 2017**.

Please read this Consent carefully, and ensure that any staff or

contractors carrying out activities under this Consent on your behalf

are aware of all the conditions of the Consent.

Details of Permit

Purpose for which permit is granted: To periodically open Lake Waituna to the sea

Location - site locality Walker's Bay and Hansen's Bay, Lake Waituna

- map reference Between NZTM 1262340E 48311370N and 1261460E 4831000N (Walker's Bay), and

about NZTM 1265350E 4832550N (Hansen's Bay)

Legal description at the site: Section 29 Block XIII Oteramika Hundred and Crown Land (seabed)

Expiry date: 14 February 2022

Schedule of Conditions

1. This consent authorises the opening of the Waituna Lagoon to the sea through the gravel barrier at either:

(a) Walker's Bay between NZTM 1,262,340E 4,831,360 N and 1,261,460E 4,831,000N; or

(b) Hansen's Bay, between NZTM 1,265,305E 4,832,570N and 1,265,405E 4,832,605N

2. Except as specified in Condition 6, the openings authorised by this resource consent shall be at the Walker's Bay site specified in Condition 1(a).

(i) Openings under Condition 6 may be at either the Walker's Bay or the Hansen's Bay sites, dependent upon the recommendation of the technical advisory group as described in Condition 6(b).

3. (a) Immediately prior to lagoon opening, the consent holder must notify the Consent Authority (email: escompliance@es.govt.nz), the Kaupapa Taiao Manager at Te Ao Marama Inc and Operations Manager (Murihiku) of the Department of Conservation about the proposed opening location. The notification shall be in writing and shall include:

(i) the current water level at the Waghorn's Road bridge gauge board[7]; and

(ii) note of the prevailing wind conditions (direction and strength)[8], and comment whether or not there is any reason to suspect that the water level is only temporarily raised at the gauge board by strong wind conditions; and

(iii) information to show compliance with the opening criteria specified in Conditions 4, 5 or 6.

Note: 'in writing' may be by email.

Lagoon Opening May to 19 September inclusive

4. (a) During the months from 1 May to, and including, 31 August the lagoon may be opened to the sea when water level in the lagoon reaches 2.0 metres, as measured on the Waghorn's Road bridge gauge board.

[7] Continuous water level readings are available at: http://www.es.govt.nz/rivers-and-rainfall/graph/?site=Waituna-Lagoon-at-Waghorns-Road&measurement=river level&start=12-May-2016&end=19-May-2016&owner=0

[8] Wind conditions at Invercargill airport can be viewed at: http://www.metservice.com/towns-cities/invercargill?gclid=CIuft6z1gM8CFQGavAod19kAsA#!/your-weather

(b) During the period 1 September to 19 September the lagoon may be opened to the sea when water level in the lagoon reaches 2.0 metres, as measured on the Waghorn's Road bridge gauge board once the lagoon has been above that level for 7 days out of a continuous period of ten days.

(c) During the month of July the lagoon may be opened when water level in the lagoon reaches 1.8 metres as measured on the Waghorn's Road bridge gauge board, if the lagoon has not been opened in the previous 12 month period.

Lagoon Opening 20 September to April inclusive

5. (a) During the months from 20 September to, and including, 30 April the lagoon may be opened to the sea when the water level in the lagoon reaches 2.2 metres, as measured on the Waghorn's Road bridge gauge board;

(b) During the months from 20 September to, and including, 30 April the lagoon may be opened to the sea when the water level exceeds 2.0 metres, as measured on the Waghorn's Road bridge gauge board, provided that:

(i) the lagoon has been above that level for 14 days out of a continuous period of twenty days; and

(ii) the mean aquatic plant (macrophyte) cover in the lagoon has exceeded 30 percent for the previous three years, as determined by annual summer surveys or monitoring by a suitably qualified person

Lagoon Opening in the case of poor water quality events

6. (a) Notwithstanding conditions 4-6 of this consent, the lagoon may be opened to the sea when water level in the lagoon is above 1.5 metres, as measured on the Waghorn's Road bridge gauge board, provided that:

a primary ecological trigger (outlined in Appendix 1) has been reached, and

a technical advisory group, convened jointly by Environment Southland, Te Ao Marama Inc and the Department of Conservation, with scientific knowledge of coastal lagoon ecosystems, has considered the secondary and tertiary indicators (Appendix 1), and any other relevant scientific information, and has advised the consent holder and Consent Authority in writing that opening the lagoon to the sea is advisable to disrupt an actual or probable algal bloom in order to avoid a significant adverse ecological effect on the lagoon,

(b) If the technical advisory group required by Condition 6(a)(ii) specifies a preference (in writing) for the opening to occur at one or the other of the locations specified in Condition 1, the opening in accordance with this condition shall only occur at that location.

(c) In the event that the lagoon is opened to the sea in accordance with condition 6(a), the consent holder shall notify the following parties that a primary ecological trigger has been reached and that opening the lagoon to the sea has been recommended. The notification shall include evidence that the ecological trigger has been reached and a copy of the written advice from the technical advisory group specified in condition 6(a):

Kaupapa Taiao Manager, Te Ao Marama Inc, PO Box 7078, South Invercargill 9844

Operations Manager, Murihiku District Office, Department of Conservation, PO Box 743, Invercargill 9840

The Manager, Fish & Game New Zealand, PO Box 159, Invercargill 9840

The Consent Authority

7. (a) With regard to the Primary indicator in Appendix 1, a "visible algal bloom" shall be identified by:

(i) ≥ 0.012 mg/l Chlorophyll *a* (or other figure identified in writing by the technical advisory group referred to in condition 6); and/or

(ii) The observations of an appropriately qualified person. These observations shall include the location and approximate scale and intensity of the visible algal bloom on each day of observation.

(b) These observations or readings are to be recorded and shall be made available to the Lagoon technical advisory group and the Consent Authority.

Responses to disturbance of artefacts or fuel spills

8. In the event of:

(a) the discovery, or suspected discovery, of a site of cultural importance (Waahi Taonga/Tapu), the consent holder shall immediately cease operations in that location and inform the local Iwi authority (Te Ao Marama Inc) and the Consent Authority Operations may recommence at a time as agreed upon in writing with the Consent Authority. The discovery of Koiwi (human skeletal remains) or Taonga or artefact material (e.g. pounamu/greenstone) would indicate a site of cultural importance. Appendix 2 to this consent outlines the process that is to be followed in the event of such a discovery.

(b) contamination of the lagoon or foreshore, such as with fuel or oil spilt from the digger during the lagoon opening, the consent holder shall remove the contaminants immediately from the site and notify, without undue delay, the Consent Authority (email: compliance@es.govt.nz or phone 03 211 5115) and the Area Manager (Murihiku) of the Department of Conservation.

Information Gathering Requirements

9. The consent holder shall record the following information:

(a) when and where the lagoon is opened to the sea;

(b) the water level in the lagoon at the time it was opened;

(c) information to show compliance with the opening criteria specified in Conditions 4, 5 or 6.

(d) when and at what gauge board level access across Carran Creek bridge was lost for stock and farm vehicles and when was this access re-established.

(e) how long the lagoon is open to the sea and when it closes (to the nearest week);

10. The consent holder shall provide the information specified in condition 9, to the Consent Authority and to the Operations Manager (Murihiku) of the Department of Conservation within one month of the opening of the lagoon to the sea, and without undue delay following closure of the channel to the sea.

Consent Review and Council Charges

11. The Consent Authority may, in accordance with Sections 128 and 129 of the Resource Management Act 1991, serve notice on the consent holder of its intention to review the conditions of this consent during the period 1 February to 30 September each year, or within two months of any enforcement action being taken by the Consent Authority in relation to the exercise of this consent, or on receiving monitoring results, for the purposes of:

determining whether the conditions of this permit are adequate to deal with any adverse effect on the environment, including cumulative effects, which may arise from the exercise of the permit, and which it is appropriate to deal with at a later stage, or which become evident after the date of commencement of the permit;

ensuring the conditions of this consent are consistent with any National Environmental Standards Regulations, relevant plans and/or Policy Statement;

amending the monitoring programme to be undertaken; or

adding or adjusting compliance limits.

Note: Under s127 of the Resource Management Act the Consent Holder can apply for a change or cancellation of a resource consent condition (other than the consent duration) at any time during the consent period.

12. The consent holder shall pay an annual administration and monitoring charge to the Consent Authority, collected in accordance with Section 36 of the Resource Management Act, 1991.

Meetings

13. The consent holder shall hold liaison meetings, at least once each year, to report and discuss available monitoring information regarding the following in Lake Waituna:

water level

water quality, particularly nutrients

algae, particularly chlorophyll a

macrophytes

fish

The consent holder shall invite the following to the liaison meetings:

representatives of each of the organisations in Section 3.1 of Appendix 3; and

each of the individuals (or their representatives) in Section 3.2 of Appendix 3

Any other person or group at the discretion of the applicant.

The consent holder shall record a summary of the attendees and discussion at each meeting, and report the summary to the consent authority within 20 working days of the meeting.

In the event that contact details for any of the individuals or organisations in Appendix 3 becomes outdated, and the consent holder has not been notified of updated contact details, the consent holder may omit invitation of that individual or organisation to the meeting.

for the **Southland Regional Council**

Vin Smith

Director of Policy, Planning & Regulatory Services

Appendix 1

Indicators

Primary Indicator	**Critical Trigger**
Chlorophyll *a*	a sustained visible algal bloom over a period of 14 days or longer
Secondary Indicators	Critical Indicator Levels
Total Phosphorus concentration	≥ 0.045 mg/l
Total Nitrogen concentration	≥ 0.700 mg/l
Tertiary Indicators	
Nuisance epiphytes or benthic algae	
Ruppia and other macrophytes	
RPD (Redox Potential Discontinuity) – bottom sediments	
Turbidity	
Bottom water dissolved oxygen concentration	
Aquatic and surrounding wetland life	
Algal blooms	

Appendix 2

Protocol in the event of a discovery, or suspected discovery, of a site of cultural importance (Waahi Taonga/Tapu)

1. *Kōiwi tangata accidental discovery*

If Kōiwi tangata (human skeletal remains) are discovered, then work shall stop immediately and the New Zealand Police, Heritage New Zealand (details below) and Te Ao Marama Inc (Ngai Tahu (Murihiku) Resource Management Consultants) shall be advised. Contact details for Te Ao Marama Inc are as follows:

Te Ao Marama Inc

Murihiku Marae, 408 Tramway Road, Invercargill

P O Box 7078, South Invercargill 9844

Phone: (03) 931 1242

Te Ao Marama Inc will arrange a site inspection by the appropriate Tangata Whenua and their advisers, including statutory agencies, who will determine how the situation will need to be managed in accordance with tikanga māori.

2. *Archaeological Sites*

Archaeological sites are protected under the Heritage New Zealand Pouhere Taonga Act (2014), and approval is required from Heritage New Zealand before archaeological sites can be modified, damaged or destroyed.

Not all archaeological sites are known or recorded precisely. Where an archaeological site is inadvertently disturbed or discovered, further disturbance must cease until approval to continue is obtained from Heritage New Zealand. As stated above, the New Zealand Police and Te Ao Marama Inc also need to be advised if the discovery includes kōiwi tangata/human remains.

Heritage New Zealand, C/- Dr M Schmidt, Regional Archaeologist Otago/Southland

PO Box 5467, Dunedin 9058

Phone: (03) 470 2364 Mobile 027 240 8715 mschmidt@heritage.org.nz

3. *Taonga or artefact accidental discovery*

If taonga or artefact material (e.g. pounamu/greenstone artefacts) other than kōiwi tangata is discovered, disturbance of the site shall cease immediately and Southland Museum and Te Ao Marama Inc shall be notified of the discovery by the finder or site archaeologist in accordance with the Protected Objects Act 1975. All taonga tuturu are important for their cultural, historical and technical value and are the property of the Crown until ownership is resolved.

4. *In-situ (natural state) pounamu/greenstone accidental discovery*

Pursuant to the Ngai Tahu (Pounamu Vesting) Act 1997, all natural state pounamu/greenstone in the Ngai Tahu tribal area is owned by Te Runanga o Ngai Tahu. Ngai Tahu Pounamu Management Plans provide for the following measures:

any *in-situ* (natural state) pounamu/greenstone accidentally discovered should be reported to Te Runanga o Ngai Tahu staff as soon as is reasonably practicable. Te Runanga o Ngai Tahu staff will in turn contact the appropriate Kaitiaki Papatipu Runanga;

in the event that the finder considers the pounamu is at immediate risk of loss such as erosion, animal damage to the site or theft, the pounamu/greenstone should be carefully covered over and/or relocated to the nearest safe ground.

The find should then be notified immediately to the Programme Leader – Ohanga, at Te Rūnanga o Ngāi Tahu. Their details are as follows:

Te Rūnanga o Ngāi Tahu, c/o Programme Leader - Ohanga

Te Whare o Te Wai Pounamu

15 Show Place, P O Box 13-046, Otautahi/Christchurch 8021

Phone: (03) 366 4344 Web: www.ngaitahu.iwi.nz

Appendix 3

Contact details for persons identified in Condition 13

The following lists identify the organisations and persons to be invited to the liaison meetings.

The postal and email addresses are based on information in the submissions to the application but could become outdated during the term of the resource consent.

3.1 Organisations:

Te Runanga o Awarua, C/- Te Ao Marama Inc, PO Box 7078, South Invercargill 9844 dean.whaanga@teaomarama.maori.nz

Department of Conservation, Private Bag 4715, Christchurch Mail Centre 8140. Attn: G Deavoll gdeavoll@doc.govt.nz

Fish & Game New Zealand, P O Box 159, Invercargill 9840 zane@southlandfishgame.co.nz

Royal Forest & Bird Protection Society, PO Box 6230, Dunedin North 9059 s.maturin@forestandbird.org.nz

Waituna Affected Farmers, C/- J Crack, 108 Moffat Road, RD 5, Invercargill 9875 jo@farmnews.co.nz

Waituna Recreational Users Group, C/- B McNaughton, 502 Elles Road, Kingswell, Invercargill 9812 bevan@ocs.net.nz

Federated Farmers New Zealand, PO Box 176, Invercargill 9840. Attn: Tanith Robb trobb@fedfarm.org.nz

Dairy New Zealand, Private Bag 3221, Hamilton 3240 David.burger@dairynz.co.nz

Stagger Inn Hunting Group, C/- Craig Booth, 11 Judge Road, Tisbury, Invercargill 9812

3.2 Individuals:

S Carston, 5 /3 Fortuna Place, Gold Coast, Queensland, Australia ycats7@gmail.com

J & D Crack, 108 Moffat Road, RD 5, Mokotua, Invercargill 9875 jo@farmnews.co.nz

O Kelly, 433 Waituna Lagoon Road, RD 5, Invercargill 9875 oakelly@netspeed.nz

L McCallum, 1100 Wilsons Crossing Road, RD 1, Winton 9781 lloyd.kathy@xtra.co.nz

G McKenzie, 32 Bungalow Hill Road, RD 1, Riverton 9881 Graeme@orakafarms.co.nz

B J McNaughton, 502 Elles Road, Kingswell, Invercargill 9812 bevan@ocs.net.nz

R McNaughton, 168 Walker Road, RD 1, Woodlands, Invercargill 9871 roger@ocs.net.nz

A Owen, 275 Waimatuku Township Road, RD 4, Invercargill 9874 aowen444@gmail.com

L Paddon, 19 Manapouri Street, Invercargill 9812

J Pannett, 113 Chelmsford Street, Invercargill 9810 john.chick@xtra.co.nz

S Perriam, 904 Rimu Seaward Downs Road, RD 1, Waituna, Invercargill 9871 jane.shayne@woosh.co.nz

B Pirie, 206 Drakes Hill Road, RD 1, Invercargill 9871 drakeshillfarming@gmail.com

D J Simms, 54 Awatea Gardens, Wigram, Christchurch 8042 Don.simms@xtra.co.nz

R W Simms, 6 /58 Douglas Street, Frankton, Queenstown 9300 sue_raysimms@xtra.co.nz

S R Simms, 50A Bantry Street, Alexandra 9320

R van Gool, 90 Smiths' Way, RD 3, Cromwell 9383 towyn@vodafone.co.nz

M J Waghorn, 961 Waituna Lagoon Road, RD 5, Invercargill 9875 murraywaghorn@hotmail.com

R C Waghon, 837 Waituna Lagoon Road, RD 5, Invercargill 9875 rcwaghorn@gmail.com

J Watson, 2132 Winton Lorneville Highway, RD 6, Invercargill 9876 jim.watson@xtra.co.nz

C A Williams, 380 Waituna Lagoon Road, RD 5, Invercargill 9875 craig.heidi@farmside.co.nz

10 Appendix B – proposed amendments to consent conditions

Proposed Resource Consent conditions for opening Waituna Lagoon based on maximising ecological and cultural values

NOTE: Proposed amendments are shown in highlighted text

Details of Permit

Purpose for which permit is granted: To periodically open Lake Waituna to the sea

Location - site locality Walker's Bay and Hansen's Bay, Lake Waituna

- map reference Between NZTM 1262340E 48311370N and 1261460E 4831000N (Walker's Bay), and

about NZTM 1265350E 4832550N (Hansen's Bay)

Legal description at the site: Section 29 Block XIII Oteramika Hundred and Crown Land (seabed)

Expiry date: XXXX

Schedule of Conditions

Note: conditions 1 & 2 unchanged from existing consent

1. This consent authorises the opening of the Waituna Lagoon to the sea through the gravel barrier at either:

(a) Walker's Bay between NZTM 1,262,340E 4,831,360 N and 1,261,460E 4,831,000N; or

(b) Hansen's Bay, between NZTM 1,265,305E 4,832,570N and 1,265,405E 4,832,605N

2. (a) Except as specified in condition 6, the openings authorised by this resource consent shall be at the Walker's Bay site specified in condition 1(a).

(b) Openings under condition 6 may be at either the Walker's Bay or the Hansen's Bay sites, dependent upon the recommendation of the technical advisory group as described in condition 6(b).

3. (a) Immediately prior to any lagoon opening undertaken in relation to conditions 4, 5 and 6, the consent holder must notify:

Kaupapa Taiao Manager, Te Ao Marama Inc, PO Box 7078, South Invercargill 9844;

Operations Manager, Murihiku District Office, Department of Conservation, PO Box 743, Invercargill 9840;

The Manager, Fish & Game New Zealand, PO Box 159, Invercargill 9840;

Private landowners adjacent to Waituna Lagoon specified in Appendix 4;

The Consent Authority.

(b) The notification in condition 3(a) shall be in writing and shall include:

(i) the current water level at the Waghorn's Road bridge gauge board and average daily water levels for the previous seven days[9]; and

(ii) note of the prevailing wind conditions (direction and strength)[10], and comment whether or not there is any reason to suspect that the water level is only temporarily raised at the gauge board by strong wind conditions; and

(iii) any lagoon monitoring information necessary to show compliance with the opening criteria specified in conditions 4, 6 or Z.

Advice note: 'in writing' may be by email.

Lagoon Opening – general opening for ecological health and land drainage.

4. (a) Regardless of the time of the year, the lagoon may be opened to the sea when the water level in the lagoon reaches 2.5 metres, as measured on the Waghorn's Road bridge gauge board, and remains at or above that level for at least 24 hours continuously.

[4(b), 4(c), 5(a), 5(b) from existing consent deleted. Not considered necessary due to proposed amendments to 4(a)]

[9] Continuous water level readings are available at: http://www.es.govt.nz/rivers-and-rainfall/graph/?site=Waituna-Lagoon-at-Waghorns-Road&measurement=river level&start=12-May-2016&end=19-May-2016&owner=0[check web link]

[10] Wind conditions at Invercargill airport can be viewed at: http://www.metservice.com/towns-cities/invercargill?gclid=CIuft6z1gM8CFQGavAod19kAsA#!/your-weather [check web link]

Lagoon Opening in the case of poor water quality events

6. (a) Notwithstanding condition 4 of this consent, the lagoon may be opened to the sea at any time of the year when water level in the lagoon is above 1.5 metres, as measured on the Waghorn's Road bridge gauge board, provided that:

One or both Water Quality (Primary) Indicators set out in Appendix 1 has reached its Critical Indicator Level, and

A Technical Advisory Group, convened jointly by Environment Southland, Te Ao Marama Inc. and the Department of Conservation, with scientific knowledge of coastal lagoon ecosystems, has considered the Primary Indicators in Appendix 1, and any other relevant scientific information, including additional indicators of Ecosystem Health set out in Appendix 2, and has advised the consent holder and Consent Authority in writing that opening the lagoon to the sea is advisable to disrupt an actual or probable algal bloom in order to avoid a significant adverse ecological effect on the lagoon.

(b) If the Technical Advisory Group specifies a preference (in writing) for the opening to occur at one or the other of the locations specified in condition 1, the opening in accordance with this condition shall only occur at that location.

(c) In the event that the lagoon is opened to the sea in accordance with condition 6(a), the consent holder shall notify the ~~following~~ parties specified in condition 3(a) that a Water Quality Indicator has reached its Critical Indicator Level and that opening the lagoon to the sea has been recommended.

~~Kaupapa Taiao Manager, Te Ao Marama Inc, PO Box 7078, South Invercargill 9844;~~

~~Operations Manager, Murihiku District Office, Department of Conservation, PO Box 743, Invercargill 9840;~~

~~The Manager, Fish & Game New Zealand, PO Box 159, Invercargill 9840;~~

~~Private landowners adjacent to Waituna Lagoon;~~

~~The Consent Authority.~~

The notification shall include evidence that a Critical Indicator Level has been reached and a copy of the written advice from the Technical Advisory Group specified in condition 6(a):

[7(a), 7(b) from existing consent deleted. Content is covered in Appendix 1 and 2]

Lagoon Opening for the purpose of providing fish passage

Z. (a) Notwithstanding conditions 4 and 6 of this consent, the lagoon may be opened to the sea to provide for passage for diadromous fish species when the water level in the lagoon is above 1.5 metres, as measured on the Waghorn's Road bridge gauge board, during the period 1 April to 30 November, provided that:

The lagoon has not been opened in the previous 24 months, and

The Technical Advisory Group has considered the lagoon water quality and ecosystem health indicators listed in Appendix 1 and Appendix 2, and any other relevant scientific information, and has advised the consent holder and Consent Authority (in writing) that opening the lagoon to the sea is recommended to enable fish passage.

(b) If the Technical Advisory Group specifies a preference (in writing) for the opening to occur at one or the other of the locations specified in condition 1, the opening in accordance with this condition shall only occur at that location.

(c) In the event that the lagoon is opened to the sea in accordance with condition Z(a), the consent holder shall notify the parties specified in condition 3(a) that an opening of the lagoon to the sea to provide for fish passage has been recommended. The notification shall include evidence that the lagoon has not been open to the sea in the previous 24 months and a copy of the written advice from the Technical Advisory Group specified in condition Z(a)(ii)

Responses to disturbance of artefacts or fuel spills

Note: condition 8 unchanged from existing consent

8. In the event of:

(a) The discovery, or suspected discovery, of a site of cultural importance (Waahi Taonga/Tapu), the consent holder shall immediately cease operations in that location and inform the local Iwi authority (Te Ao Marama Inc) and the Consent Authority Operations may recommence at a time as agreed upon in writing with the Consent Authority. The discovery of Koiwi (human skeletal remains) or Taonga or artefact material (e.g. pounamu/greenstone) would indicate a site of cultural importance. Appendix 2 to this consent outlines the process that is to be followed in the event of such a discovery.

(b) Contamination of the lagoon or foreshore, such as with fuel or oil spilt from the digger during the lagoon opening, the consent holder shall remove the contaminants immediately from the site and notify, without undue delay, the Consent Authority (email: compliance@es.govt.nz or phone 03 211 5115) and the Area Manager (Murihiku) of the Department of Conservation.

Information Gathering Requirements

9. The consent holder shall monitor and record the following information:

(a) changes in the Primary, Secondary and Tertiary indicators of lagoon Water Quality and Ecosystem Health set out in Appendix 1 and Appendix 2.

(b) when and where the lagoon is opened to the sea;

(c) the water level in the lagoon at the time it was opened;

(d) information to show compliance with the opening criteria specified in conditions 4, 6 or Z;

~~when and at what gauge board level access across Carran Creek bridge was lost for stock and farm vehicles and when was this access re-established.~~

(e) how long the lagoon is open to the sea and when it closes (to the nearest week).

10. Information gathered under condition 9 shall be made available to the Technical Advisory Group and the Consent Authority.

Consent Review and Council Charges

Note: conditions 11-12 unchanged from existing consent

11. The Consent Authority may, in accordance with Sections 128 and 129 of the Resource Management Act 1991, serve notice on the consent holder of its intention to review the conditions of this consent during the period 1 February to 30 September each year, or within two months of any enforcement action being taken by the Consent Authority in relation to the exercise of this consent, or on receiving monitoring results, for the purposes of:

Determining whether the conditions of this permit are adequate to deal with any adverse effect on the environment, including cumulative effects, which may arise from the exercise of the permit, and which it is appropriate to deal with at a later stage, or which become evident after the date of commencement of the permit.

Ensuring the conditions of this consent are consistent with any National Environmental Standards Regulations, relevant plans and/or Policy Statement.

Amending the monitoring programme to be undertaken.

Adding or adjusting compliance limits.

Note: Under s127 of the Resource Management Act the Consent Holder can apply for a change or cancellation of a resource consent condition (other than the consent duration) at any time during the consent period.

12. The consent holder shall pay an annual administration and monitoring charge to the Consent Authority, collected in accordance with Section 36 of the Resource Management Act, 1991.

Meetings

13. The consent holder shall hold liaison meetings, at least once each year, to report and discuss available monitoring information recorded in accordance with condition 9 ~~in Lake Waituna:~~

~~water level;~~

~~water quality, particularly nutrients;~~

~~algae, particularly chlorophyll a and cynaobacteria;~~

~~macrophytes;~~

~~fish.~~

The consent holder shall invite the following to the liaison meetings:

X

X

To be determined

The consent holder shall record a summary of the attendees and discussion at each meeting, and report the summary to the consent authority within 20 working days of the meeting.

In the event that contact details for any of the individuals or organisations in Appendix 4 becomes outdated, and the consent holder has not been notified of updated contact details, the consent holder may omit invitation of that individual or organisation to the meeting.

Appendix 1

Waituna Lagoon Water Quality - Primary Indicators

Water Quality or Ecosystem Health Indicator	Critical Indicator Level
Primary Indicators	
Chlorophyll-*a*	a sustained visible algal bloom* over a period of 14 days or longer
Cyano-bacteria	≥ 500 cells/mL or ≥ 0.5 mm^3/L biovolume *[of potentially toxin producing species].*
Interpretation * A "visible algal bloom" shall be identified by: (i) A chlorophyll-*a* concentration of ≥ 0.012 mg/L (or other figure identified in writing by the Technical Advisory Group referred to in condition 6; and/or (ii) The observations of an appropriately qualified person. These observations shall include the location and approximate scale and intensity of the visible algal bloom on each day of observation.	

Appendix 2

Waituna Lagoon Water Quality and Ecosystem Health – Additional Indicators

Water Quality or Ecosystem Health Indicator	Critical Indicator Level
Secondary Indicators	
Total Phosphorus concentration	≥ 0.045 mg/L
Total Nitrogen concentration	≥ 1.000 mg/L
Tertiary Indicators**	
Nuisance epiphytes or benthic algae	>10% cover
Macrophytes	<20% cover
Ruppia megacarpa	Present at less than <20% of lagoon monitoring sites

Other indicators that may be considered Turbidity RPD (Redox Potential Discontinuity) – bottom sediments Bottom water dissolved oxygen concentration Aquatic and surrounding wetland life	
** Based on the results from annual surveys undertaken in late summer.	

Appendix 3

Protocol in the event of a discovery, or suspected discovery, of a site of cultural importance (Waahi Taonga/Tapu)

Note: Appendix 3 unchanged from existing consent

1. *Kōiwi tangata accidental discovery*

If Kōiwi tangata (human skeletal remains) are discovered, then work shall stop immediately and the New Zealand Police, Heritage New Zealand (details below) and Te Ao Marama Inc (Ngai Tahu (Murihiku) Resource Management Consultants) shall be advised. Contact details for Te Ao Marama Inc are as follows:

Te Ao Marama Inc.

Murihiku Marae, 408 Tramway Road, Invercargill

P O Box 7078, South Invercargill 9844

Phone: (03) 931 1242

Te Ao Marama Inc will arrange a site inspection by the appropriate Tangata Whenua and their advisers, including statutory agencies, who will determine how the situation will need to be managed in accordance with tikanga māori.

2. *Archaeological Sites*

Archaeological sites are protected under the Heritage New Zealand Pouhere Taonga Act (2014), and approval is required from Heritage New Zealand before archaeological sites can be modified, damaged or destroyed.

Not all archaeological sites are known or recorded precisely. Where an archaeological site is inadvertently disturbed or discovered, further disturbance must cease until approval to continue is obtained from Heritage New Zealand. As stated above, the New Zealand Police and Te Ao Marama Inc also need to be advised if the discovery includes kōiwi tangata/human remains.

Heritage New Zealand, C/- Dr M Schmidt, Regional Archaeologist Otago/Southland

PO Box 5467, Dunedin 9058

Phone: (03) 470 2364 Mobile 027 240 8715 mschmidt@heritage.org.nz

3. *Taonga or artefact accidental discovery*

If taonga or artefact material (e.g. pounamu/greenstone artefacts) other than kōiwi tangata is discovered, disturbance of the site shall cease immediately and Southland Museum and Te Ao Marama Inc shall be notified of the discovery by the finder or site archaeologist in accordance with the Protected Objects Act 1975. All taonga tuturu are important for their cultural, historical and technical value and are the property of the Crown until ownership is resolved.

4. *In-situ (natural state) pounamu/greenstone accidental discovery*

Pursuant to the Ngai Tahu (Pounamu Vesting) Act 1997, all natural state pounamu/greenstone in the Ngai Tahu tribal area is owned by Te Runanga o Ngai Tahu. Ngai Tahu Pounamu Management Plans provide for the following measures:

any *in-situ* (natural state) pounamu/greenstone accidentally discovered should be reported to Te Runanga o Ngai Tahu staff as soon as is reasonably practicable. Te Runanga o Ngai Tahu staff will in turn contact the appropriate Kaitiaki Papatipu Runanga;

in the event that the finder considers the pounamu is at immediate risk of loss such as erosion, animal damage to the site or theft, the pounamu/greenstone should be carefully covered over and/or relocated to the nearest safe ground.

The find should then be notified immediately to the Programme Leader – Ohanga, at Te Rūnanga o Ngāi Tahu. Their details are as follows:

Te Rūnanga o Ngāi Tahu, c/o Programme Leader - Ohanga

Te Whare o Te Wai Pounamu

15 Show Place, P O Box 13-046, Otautahi/Christchurch 8021

Phone: (03) 366 4344 Web: www.ngaitahu.iwi.nz

Appendix 4

Contact details for persons identified in Condition 13

The following lists identify the organisations and persons to be invited to the liaison meetings.

The postal and email addresses are based on information in the submissions to the application but could become outdated during the term of the resource consent.

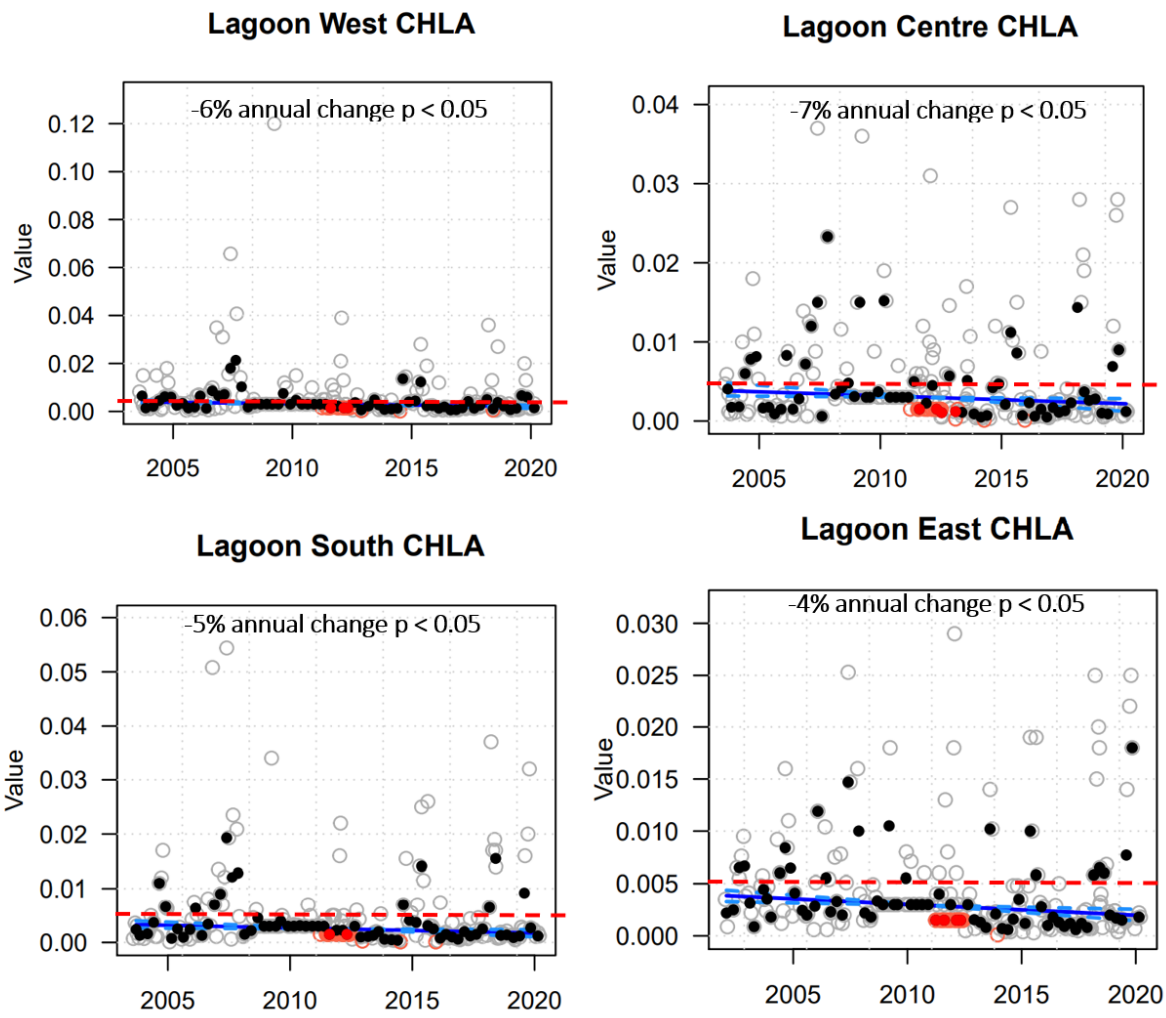
3.1 Organisations:

Note: list of organisation to be reviewed

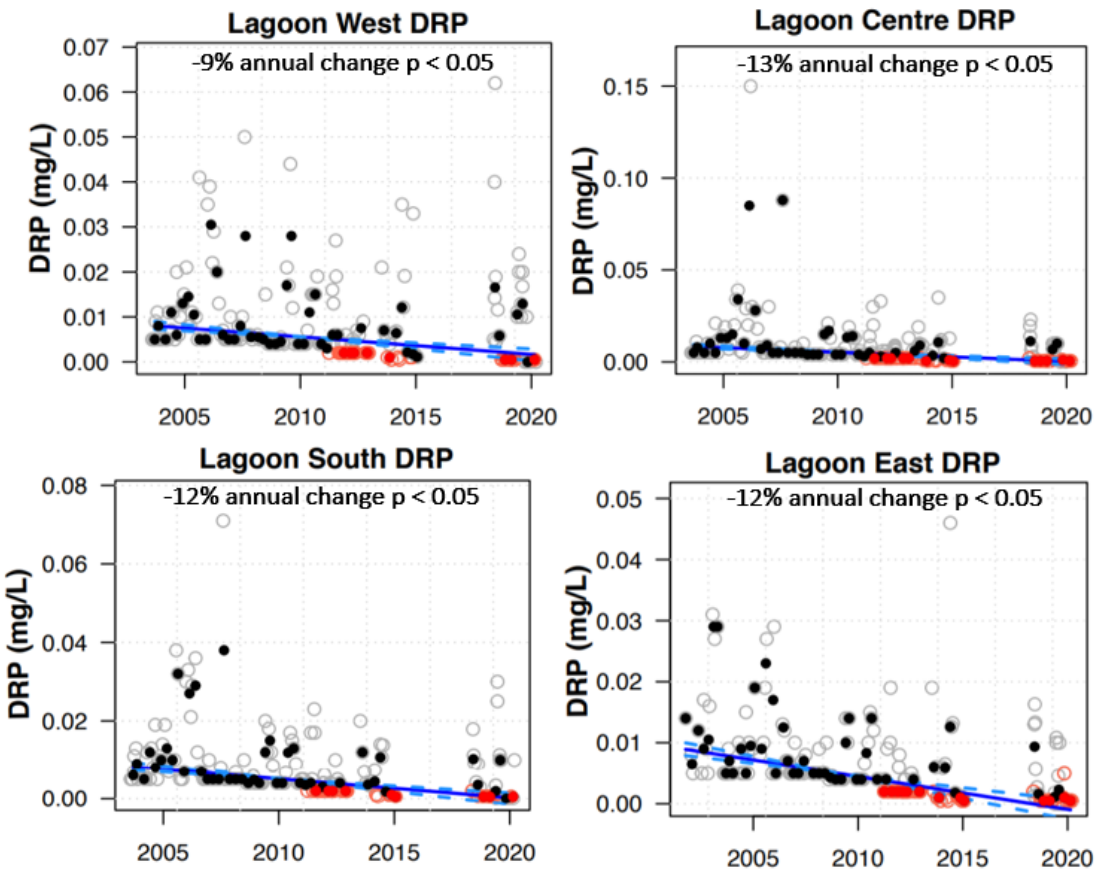
3.2 Individuals, including private landowners adjacent to Waituna Lagoon:

Note: list of individuals to be reviewed

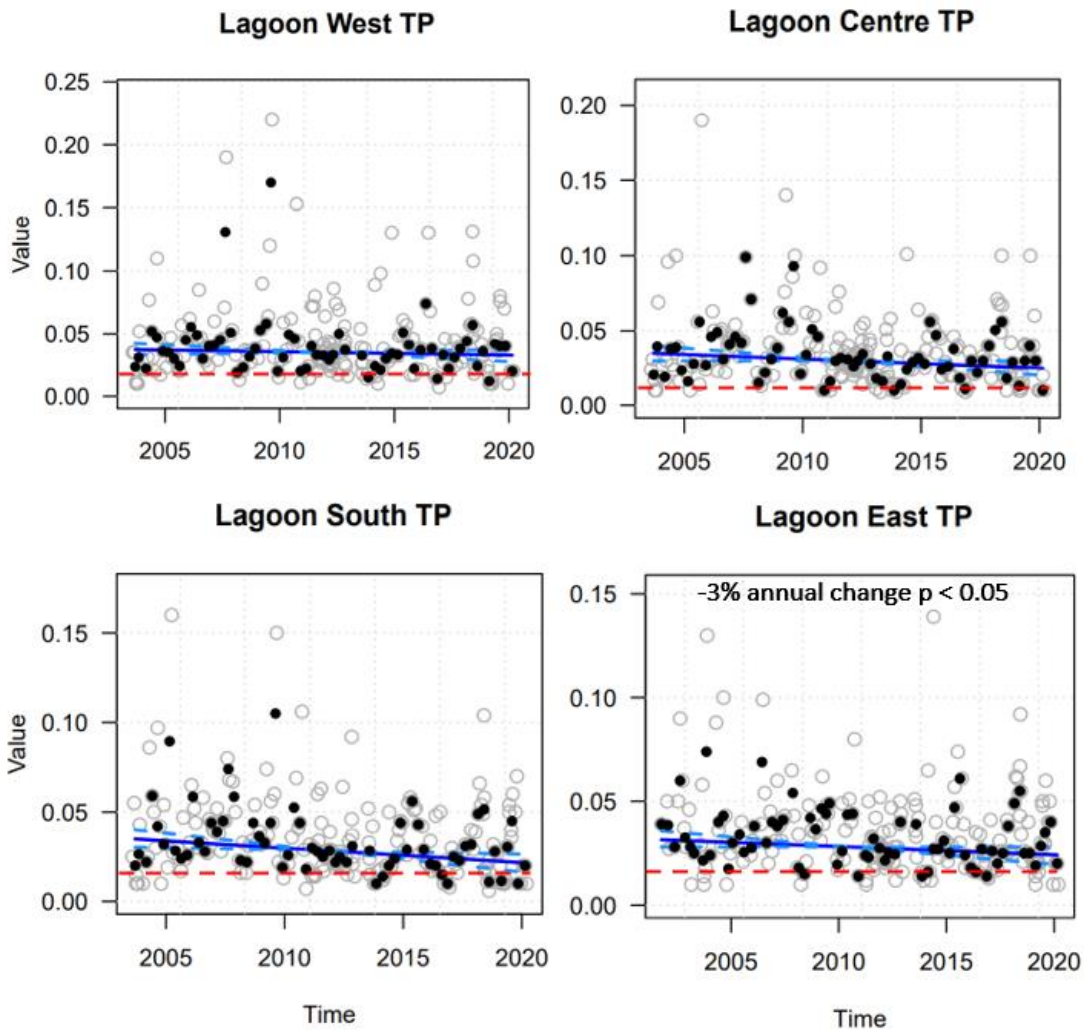
11 Appendix C – Water Quality Trends



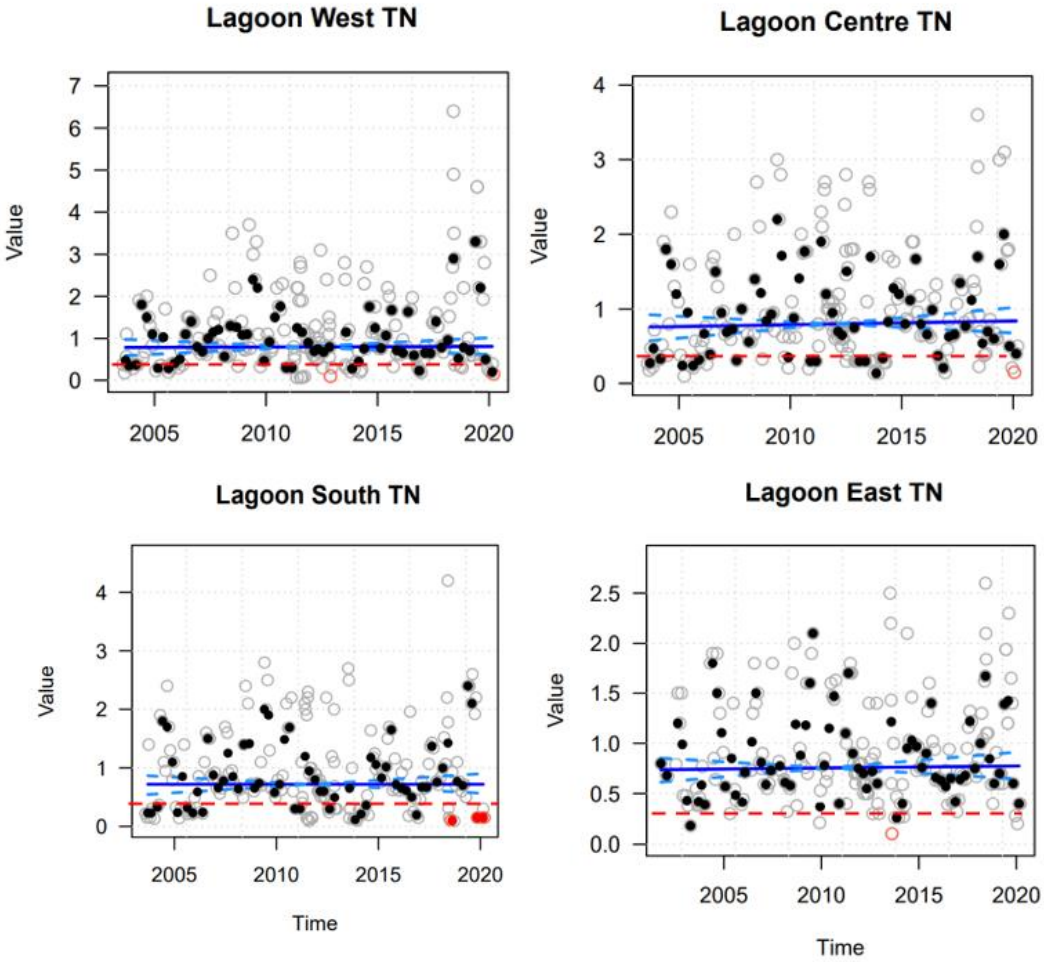
Long-term trends of chlorophyll-a (CHLA, mg/L) concentrations in Waituna Lagoon. All sites displayed a significant decreasing trend in chlorophyll-a concentrations. The LTG 2013 minimum threshold of 0.005 mg/L is noted with the red dashed line. Open circles denote raw data, closed circles denote quarterly medians used in the model, the blue line is the regression line with 95% confidence intervals.



DRP (mg/L) trend analysis results from Waituna Lagoon sites from 2001 to 2020. <u>All sites displayed a significant decreasing trend</u> (blue line). Closed circles represent the quarterly median value used in the trend analysis, open points represent the raw data, and red points represent censored values.



Total Phosphorous (mg/L) trend analysis results from Waituna Lagoon sites from 2001 to 2020. <u>The Lagoon East site displayed a significant decreasing trend</u> (blue line). Closed circles represent the quarterly median value used in the trend analysis, open points represent the raw data, and red points represent censored values. Note that the LTG 2013 guideline for TP is 0.02 mg/L (dashed red line).



Total Nitrogen (mg/L) trend analysis results from Waituna Lagoon sites from 2001 to 2020. No sites displayed a significant decreasing trend (blue line). Closed circles represent the quarterly median value used in the trend analysis, open points represent the raw data, and red points represent censored values. Note that the LTG 2013 guideline for TN is 0.337 mg/L (dashed red line).