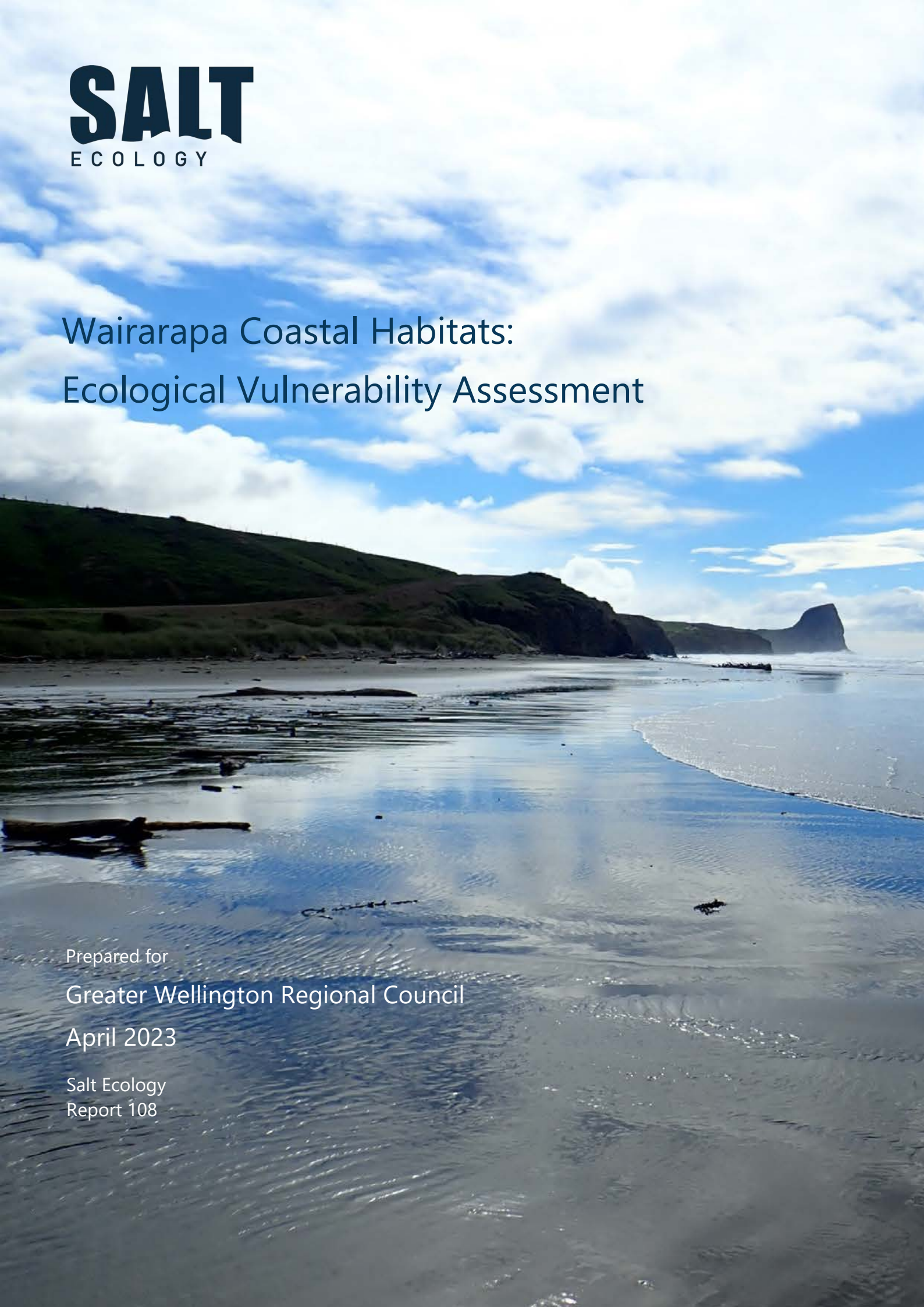
SALT
ECOLOGY

Wairarapa Coastal Habitats: Ecological Vulnerability Assessment



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Cover photo: Humpies Estuary flows onto the beach along the Wairarapa coast (January 2022).

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Wairarapa Coastal Habitats: Ecological Vulnerability Assessment

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April 2023

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GLOSSARY

CLUES	Catchment Land Use for Environmental Sustainability (NIWA model)
CMA	Coastal Marine Area
DO	Dissolved Oxygen
ETI	Estuary Trophic Index
EVA	Ecological Vulnerability Assessment
GIS	Geographic Information System
GPS	Global Positioning System
GWRC	Greater Wellington Regional Council
HEC	High Enrichment Conditions
LCDB	Land Cover Data Base
MHWS	Mean High Water Spring
NEMP	National Estuary Monitoring Protocol
NIWA	National Institute of Water and Atmospheric Research
NPSFM	National Policy Statement for Freshwater Management (2020)
NZCPS	New Zealand Coastal Policy Statement
PNRP	Proposed Natural Resources Plan (Appeals Version 2022)
REA	Rapid Estuary Assessment
RMA	Resource Management Act (1991)
SoE	State of Environment (monitoring)

SPECIES LIST*

Species name	Common name	Common descriptor
Agarophyton spp.	Red macroalgae (seaweed)	Seaweed
Bolboschoenus fluviatilis	*marsh clubrush*	Wetland plant
Ruppia spp.	Horse's mane weed	Aquatic plant (subtidal)
Typha orientalis	raupō (bulrush)	Wetland plant
Ulva spp.	Green macroalgae (seaweed)	Seaweed
Zostera muelleri	Seagrass	Aquatic plant (intertidal or subtidal)

*Salt marsh and terrestrial species are described in text in the format common name (*species name*)

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SUMMARY

In response to the National Policy Statement for Freshwater Management (NPSFM), Greater Wellington Regional Council (GWRC) is implementing the Whaitua Implementation Programme (WIP) in five sub-regions (whaitua) across Greater Wellington. The WIP comprises a non-statutory community-led committee that provides advice and direction to GWRC on how best to manage land and water. The Wairarapa coast region is the final sub-region to form a whaitua committee. The committee will achieve a community vision for water by combining mātauranga Māori, citizen science, community knowledge, and science knowledge. To support the whaitua process, Salt Ecology was commissioned by GWRC to visit (April 2022) and synoptically assess the broad scale condition, pressures and vulnerability of 25 estuaries along the Wairarapa coast. An Ecological Vulnerability Assessment (EVA) was applied to the 25 surveyed estuaries, to explore differences between estuaries and support GWRC in prioritising estuaries for management.

All the estuaries assessed were sub-tidally dominated tidal river estuaries, with many experiencing stratification and periodic entrance restriction and/or closure. Many of the catchments along the Wairarapa coast are modified for pasture, mainly sheep and beef, and are highly erodible leading to high sediment inputs. To a lesser extent, the estuaries also experience moderate water column nutrient concentrations from both elevated catchment loads and restricted flushing. High sediment and moderate nutrient loads, combined with physical susceptibility (e.g. entrance restriction and/or closure), mean the estuaries on the Wairarapa coast are prone to water quality degradation (e.g. poor clarity, phytoplankton blooms and low dissolved oxygen).

Summary of EVA results for the monitored estuaries on the Wairarapa coast, April 2022*.

	Ecological Values	Pressures	Susceptibility	Condition	Final Score
Mātaikona	0.45	0.77	0.80	0.68	**0.67**
Ōkau	0.48	0.88	0.79	0.60	**0.69**
Whakataki	0.48	0.77	0.72	0.67	**0.66**
Castlepoint	0.50	0.59	0.72	0.58	**0.60**
Ngākauau	0.57	0.63	0.66	0.62	**0.62**
Humpies	0.48	0.73	0.72	0.72	**0.66**
Otahome	0.48	0.61	0.69	0.63	**0.60**
Otahome South	0.40	0.70	0.73	0.64	**0.62**
Whareama	0.55	0.70	0.72	0.60	**0.64**
Motuwaireka	0.53	0.71	0.66	0.70	**0.65**
Riversdale North	0.27	0.64	0.67	0.63	**0.55**
Riversdale Central	0.27	0.65	0.62	0.62	**0.54**
Riversdale South	0.51	0.71	0.70	0.71	**0.66**
Waironu	0.65	0.69	0.74	0.60	**0.67**
Patanui	0.43	0.72	0.72	0.72	**0.65**
Waikaraka	0.48	0.72	0.72	0.65	**0.64**
Kaimokopuna	0.21	0.81	0.76	0.67	**0.61**
Kaiwhata River	0.44	0.76	0.66	0.65	**0.63**
Flat Point (Te Unu Unu)	0.24	0.75	0.82	0.75	**0.64**
Pāhāoa River	0.50	0.79	0.73	0.74	**0.69**
Ōterei	0.62	0.79	0.72	0.73	**0.71**
Awhea	0.61	0.73	0.79	0.70	**0.71**
Opouawe	0.45	0.86	0.82	0.67	**0.70**
Whawahui River	0.48	0.82	0.82	0.73	**0.71**
White Rock	0.25	0.77	0.82	0.71	**0.64**

*Green shading indicates estuaries with the highest ecological values. Orange cells indicate estuaries under the greatest pressure, with the highest susceptibility, or in the poorest condition.

The riverine nature of most of the estuaries means salt marsh is relatively uncommon due to both naturally limited available habitat within which it can grow, and due to losses from historical drainage and reclamation. Seagrass (*Zostera muelleri*) was recorded only in Whareama Estuary although *Ruppia* spp. (horse's mane weed) was present in a subset of estuaries where salinity is relatively low for most of the time. Despite the presence of common pressures and the effects of past modification, the estuaries remain important habitats for migratory fish and coastal birds, sediment-dwelling invertebrates and shellfish, as well as supporting amenity values.

Management recommendations:

- The highly erodible catchment and direct sediment inputs from bank erosion and slumping mean sediment loads are high along the Wairarapa coast. A reduction in sediment loads is likely required for most estuaries along the coast, particularly those that retain fine sediments, if ecological quality is to be improved.
- Due to the natural physical susceptibility of the estuaries (i.e. to stratification and entrance restriction and/or closure), naturally occurring phytoplankton and macroalgal blooms may occur under nutrient loads reflective of 'natural state' conditions.
- As current nutrient loads are moderately elevated in most estuaries, and the response to nutrient enrichment can be variable, it is likely management targets will need to be assessed on an estuary-specific basis to reduce the risk of blooms that cause significant and prolonged water quality and sediment degradation.
- In addition to catchment-scale management, estuary-scale management will be required to maintain some ecological values (e.g. habitats). For example, protection, enhancement and/or restoration of salt marsh habitat or the terrestrial margin. It is recommended that GWRC establish priorities for future protection and restoration.
- Stock access to estuaries along the Wairarapa coast is common. To protect salt marsh habitat and reduce bank erosion, stock should be prevented from accessing estuaries.
- Where fish passage has been identified as an issue, further investigation is required to remove barriers and ensure suitable levels of habitat protection.

Knowledge gaps:

- Otahome, Humpies, Waikaraka and Whawahui estuaries have high value salt marsh habitat but are not currently protected. These sites are also information deficient for some key metrics and the ecological EVA ratings of these sites are expected to increase substantially following more detailed site assessments, including habitat, fish and bird surveys.
- Water quality information (e.g. phytoplankton, dissolved oxygen and faecal loads) is very limited in all estuaries, except Whareama.
- Information on sediment related impacts including deposition and habitat loss is very limited in all estuaries, except Whareama.
- More understanding of how coastal hazards (e.g. coastal erosion) will impact estuaries and dune systems is needed. Several estuaries have already experienced large changes over the last two decades due to coastal erosion for example, Riversdale North and Central, Okau, Patanui and Homewood Estuaries.
- Improved understanding of the impacts of climate change including sea level rise (i.e. salt water intrusion) and climatic conditions (e.g. river flow, storm frequency and intensity) will be needed to better understand susceptibility (i.e. entrance closures, stratification, deposition events).

Monitoring

- To maintain a high-level overview of estuary condition and change it is recommended that synoptic surveys (e.g., rapid estuary assessments and/or water quality and habitat and substrate mapping) of estuary condition and risk be repeated at 10-yearly intervals.
- Specific recommendations for targeted monitoring in Whareama Estuary are presented in Forrest et al. (2022).
- GWRC should consider synoptic estuary water quality monitoring (e.g., one-off survey using handheld water quality meters) during periods of prolonged entrance restriction or closure to provide further insight into the extent of water quality degradation under these conditions (e.g. phytoplankton blooms, low dissolved oxygen).

1. INTRODUCTION

In response to the National Policy Statement for Freshwater Management (NPSFM), Greater Wellington Regional Council (GWRC) is implementing the Whaitua Implementation Programme (WIP) in five sub-regions (whaitua) across Greater Wellington (see Fig. 1). The WIP comprises a non-statutory community-led committee that provides advice and direction to GWRC on how best to manage land and water. The Wairarapa coast region is the final sub-region to form a whaitua committee. The committee will achieve a community vision for water by combining mātauranga Māori, citizen science, community knowledge, and expert information (www.gw.govt.nz).

To support the Whaitua process, Salt Ecology was commissioned by GWRC to visit and synoptically assess the broad scale condition, pressures and vulnerability of 26 estuaries along the Wairarapa coast (see Fig. 2). Synoptic field assessments, undertaken in April 2022, assessed the current ecological state of each estuary and were used to update broad scale maps of substrate, macroalgae, seagrass and salt marsh, and to collect point-in-time water quality (e.g. chl-a, dissolved oxygen) and sediment data to support the assessment of condition.

These results were used alongside previous coastal assessments undertaken in the whaitua (Robertson & Stevens 2007a; Todd et al. 2016), more recent catchment information provided by GWRC, and detailed state of the environment (SOE) monitoring results for Whareama Estuary (e.g. (Robertson & Stevens 2016; Forrest et al. 2022). Information on the beaches and rocky shores of the wider coastline, collected from previous studies, are summarised in Appendix 2. These data were not reassessed as part of the current report.

To assess the susceptibility of each estuary to pressures, we drew extensively from the information described above to undertake an Ecological Vulnerability Assessment (EVA). EVA frameworks have been used previously in New Zealand for this purpose, (Robertson et al. 2002a; Robertson & Stevens 2007b, a; Stevens & Robertson 2017; Stevens 2018), with iterative improvements made over time. In this report we apply an EVA framework recently updated and applied in

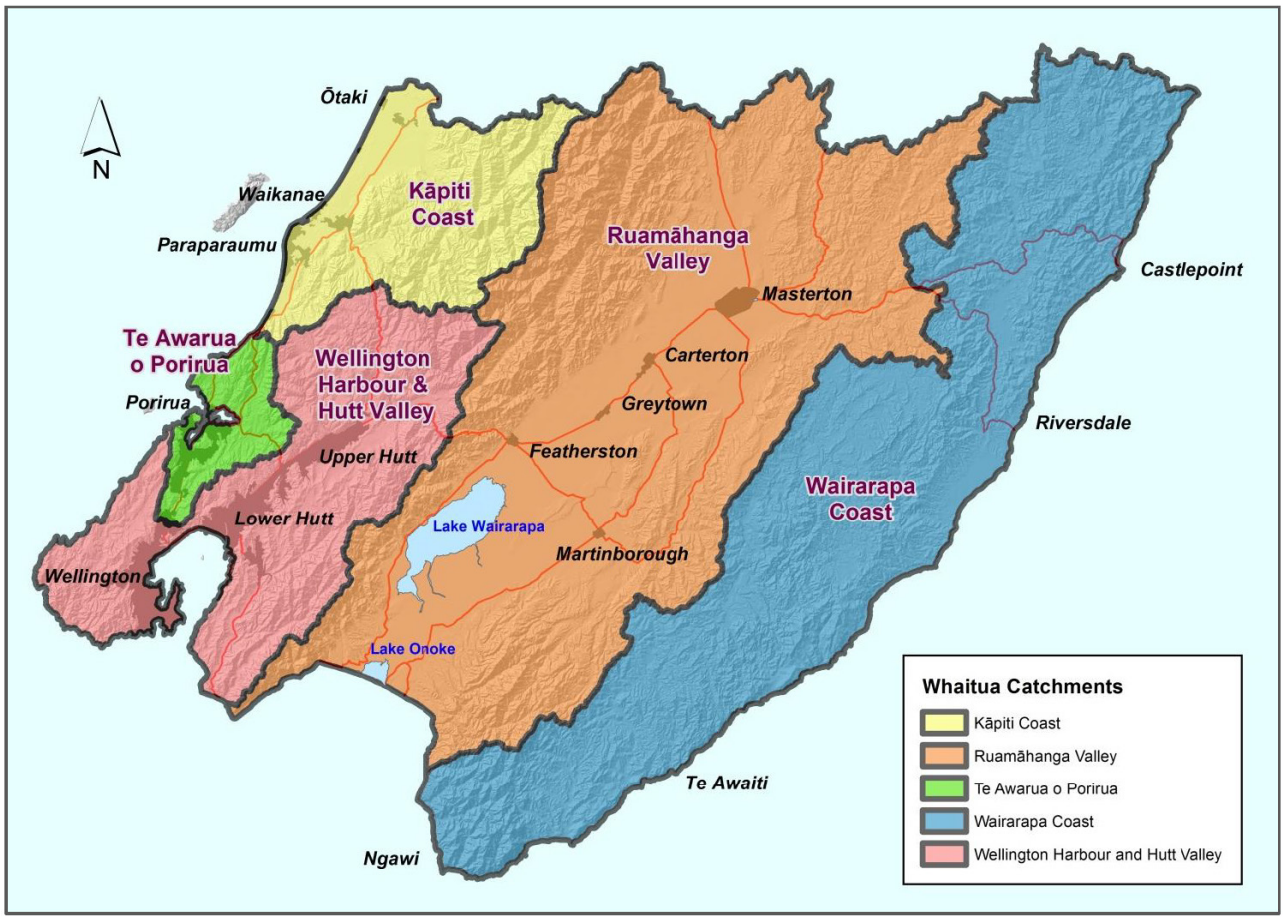

Fig. 1. Whaitua catchments for the Greater Wellington Region (source: GWRC, 2016)

Marlborough to prioritise sites for long-term monitoring (Roberts et al. 2022b).

The EVA approach applied is based on the key characteristics (and their interactions) that affect the priority of an estuary for management, which can be partitioned into four categories as follows:

- Ecological Values: Habitat types, species of conservation significance and habitat intactness.
- Pressures: Natural and anthropogenic pressures on the ecological values.
- Susceptibility: Vulnerability to future changes in state.
- Condition: Current estuary condition with respect to qualitative or quantitative indicators of health.

The EVA is intended to enable different estuaries to be compared in a consistent manner, and to identify ecological values and the main pressures impacting the habitat features present. While there are still some limitations to the approach (e.g. data availability, data quality, thresholds under development) the EVA provides a coarse screening tool to highlight susceptibility and key pressures, and to set priorities for future monitoring and management.

2. SYNOPSIS OF ESTUARIES ON THE WAIRARAPA COAST

The Wairarapa coast has many small river mouth lagoon type estuaries and one large tidal river estuary (Whareama). Because of the exposure to high seas, the majority of the smaller estuaries become restricted or close completely on occasion, making them more susceptible to water and sediment quality issues. In general, the uplifted nature of the Wairarapa coastline means saltwater intrusion, in the smaller estuaries, extends only a few 100 metres upstream or not at all (Robertson & Stevens 2007a). Further, because the estuaries are river dominated, the tidal flats are small and available intertidal habitat for salt marsh is limited.

The Wairarapa coastal catchments are dominated by agricultural land uses including, dairying, drystock farming, orchards and vineyards. The soils of the Wairarapa sub-region, particularly in the eastern hill country, are prone to erosion. The combination of land use activities, that are known sources of sediment (e.g., pastoral farming, exotic forest harvest), and erosion-prone soils, leads to high sediment loads in freshwater inputs. As a result, sedimentation and high suspended sediment yields are a significant issue in the estuaries along the Wairarapa coast (Robertson & Stevens 2007a).

While sediment inputs from periodic storms and episodic disturbances have likely always occurred on the Wairarapa coast, the amount of sediment transported to the coast has increased (~1.4 times on average) compared to natural vegetation cover (Hicks et al. 2019; Oldman 2022). Acknowledging this in 2009, GWRC implemented the Wellington Regional Erosion Control Initiative (WRECI). The programme initially focused on the catchments with the highest rates of sediment discharge and a high proportion of erosion prone land (i.e. Awhea, Opouawe, Upper Taueru, and Whareama catchments, the coastal area around Flatpoint). However, in 2016 the programme was expanded to the wider Wellington region. The initiative supports landowners to produce farm plans and provides funding for erosion control works (e.g. planting, sediment traps, bank erosion control and slump drainage) in the catchment.

Bank slumping after heavy rainfall in Whareama Estuary

Turbid water column and eroding cliff edge, Patanui Estuary

Other issues, that affect estuaries on the Wairarapa coast include:

- Water quality: Like many estuaries in New Zealand, estuaries on the Wairarapa coast are prone to nutrient and sediment run-off from modified catchments (e.g. farming and agriculture). During periods of entrance restriction and/or closure, susceptibility to nutrient driven water quality problems increases (e.g. phytoplankton blooms). Pathogens, microorganisms that can cause diseases in people and animals, are also a potential issue with sources including farm runoff and septic tank systems.
- Hydrology: Hydrological changes generally occur via water abstraction (i.e. lower freshwater flow), channel straightening, barriers to salt water intrusion (e.g. flap gates or raised culverts), reclamation and margin and/or entrance hardening. While some or all of these occur in one or more estuaries on the Wairarapa coast, their impact is site-specific.
- Habitat Loss: The most significant areas of habitat loss occur where an estuary has been modified. On the Wairarapa coast the most significant losses of habitat occur where the margin has been hardened or there is a barrier to saltwater intrusion.

Castlepoint Stream Estuary, road bridge and channelised entrance

Barrier to salt water intrusion and fish passage in Ngakauau Estuary

- Introduced species: Because many areas along the Wairarapa coast have been modified (e.g., farming, agriculture, small areas of housing), there is a high potential for exotic plant and/or animal introductions that displace natives. For example, introduced grasses, such as tall fescue or pampas grass, and common weed species such as gorse and blackberry, growing within salt marsh habitat.
- Coastal erosion: The Wairarapa coast is a high energy environment prone to erosion leading to losses of beach, dune and cliff habitat. These changes can alter the opening status of an estuary (i.e. entrance restricted or closed) and coastal sediment transport and supply.
- Climate change: Changes in weather patterns, erosion, sea surface temperature, ocean acidification and sea level rise could lead to loss of habitat and biodiversity. The Wairarapa coast is predicted to be subject to higher temperatures and less rainfall and subsequent lower mean river flows. Combined with sea level rise this will likely increase the extent of seawater intrusion.
- Recreation: While many of the estuaries on the Wairarapa coast are on private land in remote areas, others are accessible for recreational use including boating, shore diving, vehicle use and walking access. These activities can lead to physical damage to habitats (e.g. salt marsh) and introduction of plant and animal species to the area.

The estuaries along the Wairarapa coast, while relatively small in size, retain high ecological, cultural and social values. For each of the estuaries shown in Fig. 2, a 3-page summary of key estuary features is presented in Appendix 1.

Ōkau Stream Estuary with a dune system on the beach

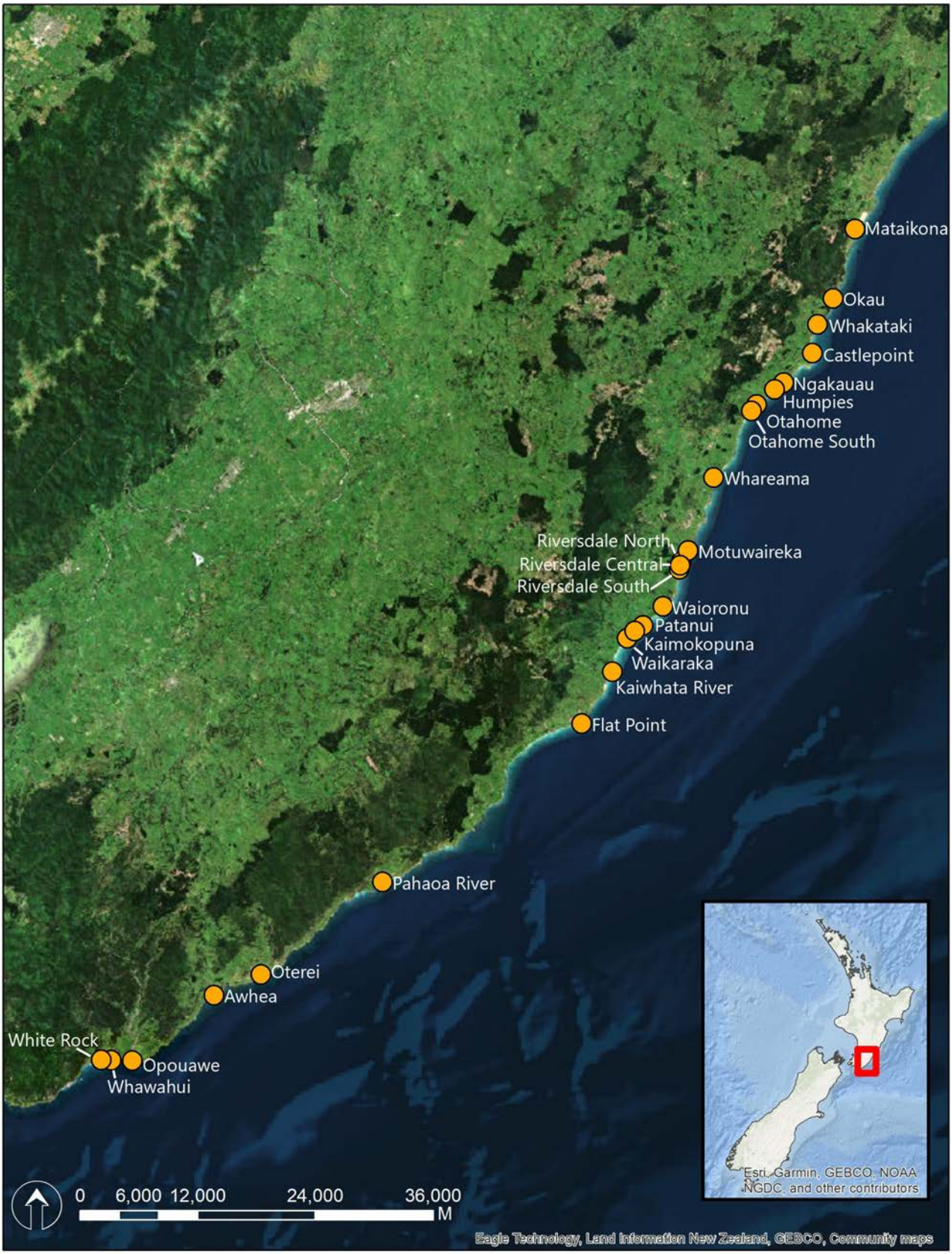

Fig. 2. Map of estuaries included in the current report.

3. METHODS

3.1 ESTUARY FIELD ASSESSMENTS

The primary aim of the field visits was to re-visit estuaries originally mapped as part of the 2007 coastal habitat risk assessment (Robertson & Stevens 2007a) in order to update broad scale maps of substrate, macroalgae, seagrass and salt marsh, and to collect point-in-time water quality data (e.g. chl-a measures). During the field visits we applied a rapid estuary assessment method (Roberts et al. 2022b) to collect additional information on estuary pressures (see 3.1.7).

3.1.1 Overview of broad scale mapping methods

Broad scale mapping methods have been described in previous reports (Robertson & Stevens 2007a; Stevens 2019; Stevens & Forrest 2019; Roberts et al. 2022a) and are summarised here.

NEMP methods (Appendix 3) were used to map and categorise intertidal estuary substrate and vegetation (e.g. Robertson et al. 2002a, b, c; Roberts et al. 2022b; Stevens et al. 2023). The mapping procedure combines aerial photography, detailed ground-truthing, and digital mapping using Geographic Information System (GIS) technology. In 2022, imagery was supplied by GWRC (0.3m/pixel colour aerial imagery captured in February 2021). Ground-truthing using broad-scale monitoring methods (e.g. Stevens et al. 2023; Appendix 3) was undertaken between 29 March 2022 and 7 April 2022 by experienced scientists who assessed each estuary on foot to map the spatial extent of dominant vegetation and substrate. Background information on the key vegetation features and their ecological significance is provided in Table 1.

In the field, features were drawn directly onto 1:3000 scale laminated aerial photographs. The broad scale features were subsequently digitised into ArcMap 10.8 shapefiles using a Huion Kamvas 22 drawing tablet and combined with field notes and georeferenced photographs. In-house scripting tools were used to check for duplicated or overlapping GIS polygons, validate typology (field codes) and calculate areas and percentages used in summary tables. From this information, habitat maps were produced showing the dominant estuary features, e.g. salt marsh, and its underlying substrate type.

For broad scale mapping purposes, an estuary is defined as a partly enclosed body of water, where freshwater inputs (i.e. rivers, streams) mix with seawater. The estuary entrance (i.e seaward boundary) was defined as a straight line between the seaward-most points of land that enclose the estuary, and the upper estuary boundary (i.e. riverine boundary) was based on the estimated upper extent of saline intrusion (i.e. where ocean derived salts during average annual low flow are <0.5ppt). For further detail see FGDC (2012).

Table 1. Overview of the ecological significance of various vegetation types.

Habitat	Description
Terrestrial margin vegetation	A densely vegetated terrestrial margin filters and assimilates sediment and nutrients, acts as an important buffer that protects against introduced grasses and weeds, is an important food source and habitat for a variety of species and, in waterway riparian zones, provides shade to help moderate stream temperature fluctuations, and improves estuary biodiversity.
Salt marsh	Salt marsh (vegetation able to tolerate saline conditions where terrestrial plants are unable to survive) is important in estuaries as it is highly productive, naturally filters and assimilates sediment and nutrients, acts as a buffer that protects against introduced grasses and weeds, minimises band erosion and provides an important habitat for a variety of species including fish and birds.
Seagrass	Seagrass (*Zostera muelleri*) beds are important ecologically because they enhance primary production and nutrient cycling, stabilise sediments, elevate biodiversity, and provide nursery and feeding grounds for a range of invertebrates and fish. Although tolerant of a wide range of conditions, seagrass is vulnerable to fine sediments in the water column (reducing light), sediment smothering (burial), excessive nutrients (secondary impacts from macroalgal smothering), and sediment quality (e.g., low oxygen).
Opportunistic macroalgae	Although sometimes naturally present in estuaries in low biomass, opportunistic macroalgae are a primary symptom of estuary eutrophication (nutrient enrichment). They are highly effective at utilising excess nitrogen, enabling them to out-compete other seaweed species and, at nuisance levels, can form mats on the estuary surface that adversely impact underlying sediments and fauna, other algae, fish, birds, seagrass, and salt marsh. Die-off and accumulation of drift algae can also lead to degraded sediment conditions (e.g., low oxygen sediments).

3.1.2 Substrate classification

Substrate classification in the NEMP is based on the dominant surface features present, e.g. rock, boulder, cobble, gravel, sand, mud. Salt Ecology has revised (e.g. Stevens & Forrest 2020; Stevens et al. 2023) the NEMP substrate classifications for sand and mud (summarised in Appendix 3) and has also extended the NEMP methodology to record the substrate present beneath vegetation. In subtidal areas substrates were classified after taking a grab sample using a modified hoe (see photo).

Sediment sample collected using modified hoe

3.1.3 Macroalgae, seagrass and macrophytes

For mapping purposes, the occurrence of nuisance macroalgae species (i.e. mainly *Agarophyton* and *Ulva* spp.), intertidal seagrass (*Zostera muelleri*) and macrophytes (aquatic plants; e.g. *Ruppia* spp.), where present, were mapped to the nearest 10% using a 6-category rating scale as a guide to describe percentage cover (Fig. 3). Subtidal macrophytes were assessed by taking a grab sample using a modified hoe (Forrest & Stevens 2019; Roberts et al. 2021; Fig. 3)

Macroalgae biomass and growth form (extent of entrainment into the soft sediment matrix) was estimated based on methods in Stevens et al. (2022). To determine an overall rating for macroalgae, results were input into the Opportunistic Macroalgal Blooming Tool (OMBT; WFD-UKTAG 2014) and an overall Ecological Quality Rating (EQR) was calculated using the improvements described in Stevens et al. (2022).

Seagrass in Whareama Estuary

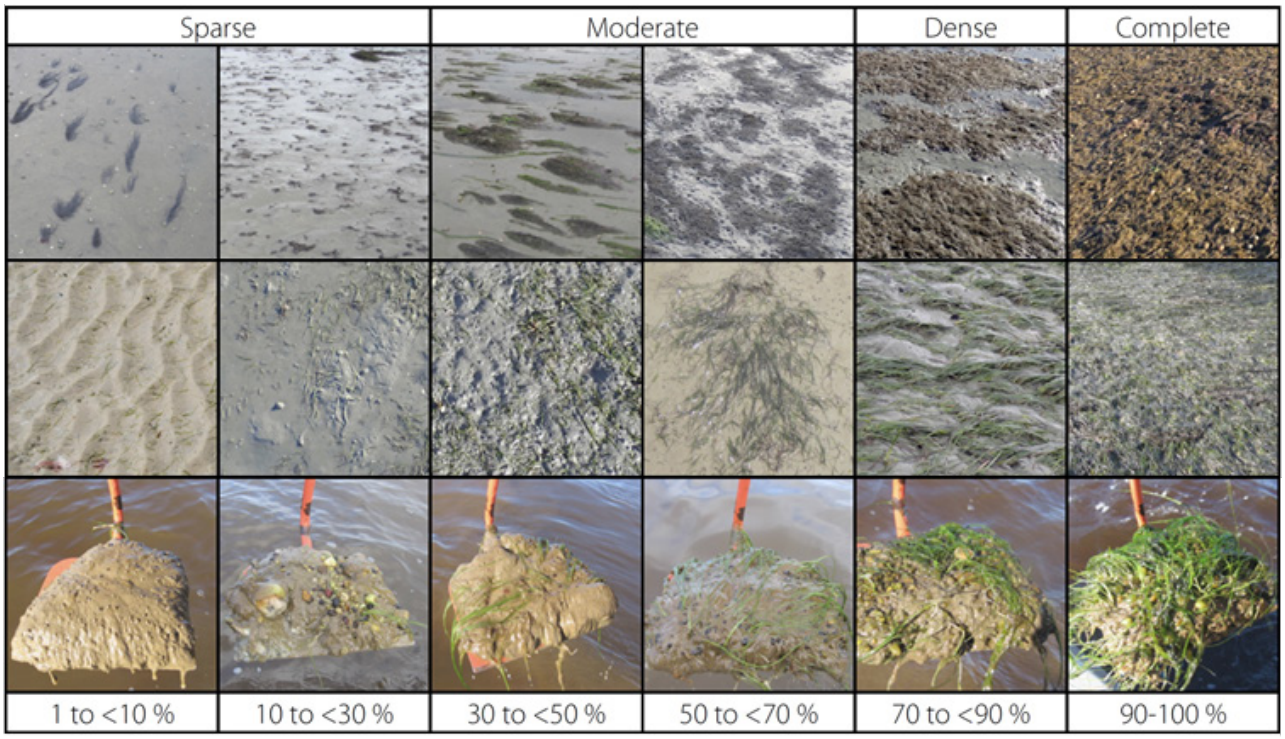

Fig. 3. Visual rating scale for percentage cover estimates. Macroalgae (top), seagrass (middle) and macrophyte (bottom). Modified from FGDC (2012).

3.1.4 Salt marsh

NEMP methods (Robertson et al. 2002a, b, c) were used to map and categorise salt marsh, with dominant estuarine plant species used to define broad structural classes (e.g. rush, sedge, herb, grass, reed, tussock; Appendix 3). Two measures were used to assess salt marsh condition: i) intertidal extent (percent cover) and ii) current extent compared to estimated historical extent.

Herbfield and rushland in Oterei Estuary

3.1.5 Terrestrial margin

Broad scale NEMP methods were used to map and categorise the 200m terrestrial margin using the dominant land cover classification codes described in the Landcare Research Land Cover Data Base (LCDB) detailed in Appendix 3.

Pasture on the terrestrial margin with dairy cows able to access the river in the background

3.1.6 Water quality

At each estuary, water quality measures were taken from ~20cm below the water surface and 5cm from the bottom to assess whether there was any salinity or temperature stratification. Water column measures of pH, salinity, dissolved oxygen (DO), temperature and chlorophyll-a (as an indicator of phytoplankton presence) were made using a YSI Pro10 meter and a Delrin Cyclops-7F fluorometer with chlorophyll optics and Databank datalogger. Care was taken not to disturb bottom sediments before sampling. Stratification, where present, was recorded along with water depth and clarity (Secchi depth). The number of water quality sites was determined by the size of the estuary and whether any stratification was observed.

Point measurements of water quality data and supporting measures of sediment texture and sediment type (Appendix 3) were recorded in electronic templates custom-built using Fulcrum app software (www.fulcrumapp.com). Pre-specified constraints on data entry (e.g. with respect to data type, minimum or maximum values) ensured that the risk of erroneous data recording was minimised. Each sampling record created in Fulcrum generated a GPS position, which was exported to ArcMAP.

Measuring water quality from the upstream bridge at Waironu Estuary

3.1.7 Rapid Estuary Assessment (REA)

The Rapid Estuary Assessment (REA) approach was developed as a high-level screening tool to identify key habitats and pressures, and support council decision making, e.g. site prioritisation (Roberts et al. 2022b). The REA is intended to take <1hr of field time for intertidal estuaries <20ha, with a greater effort likely required for larger systems. The REA focuses on ecological values (i.e. estuary habitats and habitat intactness; Appendix 4) and current condition. It combines aerial photography and high-level ground-truthing, with NEMP methods (see sections 3.1.1 to 3.1.6) used to map and categorise intertidal estuary substrate and vegetation. Further, the REA captures information on pressures and values, information that is not traditionally collected in NEMP surveys. This information was used to support the EVA (see section 3.2).

3.2 ECOLOGICAL VULNERABILITY ASSESSMENT (EVA)

Each of the four main categories of the EVA framework described in Section 1.1 were partitioned into the detailed attributes shown in Table 3, with a five-point rating scale for each attribute based on qualitative, semi-quantitative or fully quantitative descriptors (Roberts et al. 2022b). Using this approach, each attribute was scored out of five, with five being the highest possible score. Since Roberts et al. (2022b), minor improvements to descriptors and two additional attributes (i.e. dissolved oxygen and water clarity) have been added to the EVA framework to improve its application in estuaries where the subtidal area is a large portion of the estuary area.

Where data were unavailable (e.g. sedimentation rate, shellfish, biogenic reef, and site-level climate change attributes), the attribute was excluded for all estuaries, and has been highlighted to GWRC as a knowledge gap.

To emphasise attributes deemed by the authors to have a greater relative importance, a five-point weighting (in even increments from 0.2 to 1.0) was applied, with 1.0 being the highest weight. For example, often marine contaminants represent a localised issue (weighting 0.2) while catchment land uses such as exotic forestry and intense agriculture can cause widespread problems (weighting 1.0).

While weightings can be assigned with a site-specific or a regional focus, in the current study each attribute was weighted in the broader context of New Zealand estuaries as described in Roberts et al. (2022b). However, to apply the framework to subtidal estuaries some minor changes to the weightings have been made since Roberts et al. (2022b) and are outlined in Appendix 5. While the weightings for each attribute varied, the same weighting for a given attribute was applied consistently across each of the 25 Wairarapa estuaries to allow their direct comparison. Weightings were applied following:

$$\text{Final attribute score} = \text{raw score} \times \text{weighting}$$

To calculate a score for each of the four main categories of estuary characteristics (i.e. ecological values, pressures, condition and susceptibility) the final attribute scores were averaged and standardised to 1.0 using the maximum possible score (i.e. average of final attribute scores, assuming all raw scores were 5) for each category following:

$$\text{Final category score} = \frac{\text{Average(final attribute scores for category)}}{\text{Average (maximum possible attribute scores for category)}}$$

To calculate an overall EVA score, the four final category scores were averaged to give a final score out of 1. However, while an overall EVA score is useful, the final scores for each of the four main categories are also important, as they enable closer interrogation of the EVA data. For example, the category scores can distinguish estuaries that have high ecological values and are at high-risk of future degradation (e.g. significant pressures and high susceptibility). Conversely, the category scores can be used to identify estuaries with high ecological values in good condition with minimal pressures.

Table 2. Rating colour scheme used to aid visual interpretation of summary scores for each category within each estuary.

Category	Rating & Score				
	5	4	3	2	1
Values	VG	G	F	P	VP
Pressures	VL	L	M	H	VH
Susceptibility	VL	L	M	H	VH
Condition	VG	G	F	P	VP

VG = very good; G = good; F = fair; P = poor; VP = very poor

VH = very high; H = high, M = moderate; L = low; VL = very low

A high rating score represents an estuary with high values, in good condition combined with low pressures and susceptibility. A low rating score represents low values, poor condition and high pressures and susceptibility.

Riversdale South Estuary, discharging on to the beach

Table 3. Ecological Vulnerability Assessment – Ecological Values.

	Very Good (5)	Good (4)	Fair (3)	Poor (2)	Very Poor (1)
Ecological Values					
Area of estuary (ha) Value of the estuary increases with the area of the resource	>50ha	>20-50ha	>5-20	0.5-5ha	<0.5ha
Habitat Intactness (%) A subjective appraisal of the overall intactness and health of the site relative to estimated natural state.	>80 to 100% of the site is considered healthy and intact	>60 to 80% of the site is considered healthy and intact	>40 to 60% of the site is considered healthy and intact	>20 to 40% of the site is considered healthy and intact	>0 to 20% of the site is considered healthy and intact
Seagrass (extent; % of intertidal area) Provides erosion control, nutrient uptake, sediment deposition and wave dissipation, shelter and nursery for fish and other biota and carbon sequestration.	>20%	>10 to 20%	>5 to 10%	>0 to 5%	0
Salt marsh (extent; % of intertidal area) Provides erosion control, nutrient uptake, sediment deposition and wave dissipation, habitat, shelter and nursery for fish, roosting area for birds, and carbon sequestration.	>20%	>10-20%	>5-10%	>0-5%	0
Mangroves (extent; % of intertidal area) Provides erosion control, nutrient uptake, sediment deposition, wave dissipation, shelter and habitat and nursery for fish and other biota and carbon sequestration.	>20%	>10-20%	>5-10%	>0-5%	0
Intertidal shellfish beds (indigenous) Filter feeders improve water clarity, filter sediment and microphytobenthos	Common ≥10% across estuary including high density areas ≥10 individuals per $1m^2$	Frequent ≥5 to <10% across estuary or ≥10 - <100 individuals per $10m^2$	Occasional ≥1 to <5% across estuary or 1 - <10 individuals per $10m^2$	Rare <1% across estuary or <1 individual per $10m^2$	Absent No visible individuals
Biogenic reef (% across estuary) Increases habitat complexity, nursery for juvenile fish. e.g. tube worms, bryozoans, mussel beds, oyster reefs, sponges	Common ≥10%	Frequent ≥5 to <10%	Occasional ≥1 to <5%	Rare <1%	Absent 0%
Species of conservation significance Threatened or at-risk species e.g. birds: Caspian tern, banded rail e.g. diadromous fish: giant kokopu, lamprey, koaro, longfin eel	Supports nationally endangered or vulnerable species which are not commonly found in other countries.	Supports nationally endangered or vulnerable species or part of known range for nationally critical species.	Supports species in serious or gradual decline or known habitats for endangered or vulnerable species.	Supports endemic and non-threatened species or known habitats for at risk or endemic species.	Supports only non-threatened or migrant species
Protected status (within or adjacent to estuary i.e. terrestrial or marine) e.g. significant marine area, regionally significant wetland (inc. salt marsh), conservation areas, parks or reserves.	Designated Significant Marine Sites or regionally significant wetland within the estuary margin.		Designated Protected Area adjacent to the estuary margin.		None

Table 3. continued. Ecological Vulnerability Assessment – Pressures.

	Very low (5)	Low (4)	Moderate (3)	High (2)	Very High (1)
Pressures					
Catchment					
Indigenous Vegetation Cover (% catchment) Indigenous vegetation types generally release less sediment and nutrients and provide connective habitat for indigenous species.	≥ 80 to 100	≥ 50 to 80	≥ 25 to 50	≥ 10 to 25	< 10
Exotic Forest (% catchment) During establishment and harvest this land use can lead to excess sediment run-off compared to natural land cover.	< 10	≥ 10 to 25	≥ 25 to 50	≥ 50 to 80	≥ 80 to 100
High producing grassland (% catchment) Land use results in higher levels of sediment and nutrient run-off compared to natural land cover.	< 10	≥ 10 to 25	≥ 25 to 50	≥ 50 to 80	≥ 80 to 100
Urban & industrial development (% catchment) Results in more impervious surfaces that promote run-off of stormwater. Increased probability of wastewater and industrial discharges (i.e. increased nutrients, heavy metals, bacteria, viruses).	0 No industrial or urban development.	>0 to 5 Low urban or industrial development	5 to 10 Moderate urban or industrial development.	10 to 15 High urban or industrial development.	>15 Extensive urban or industrial development.
Horticulture (% catchment) Land use generally leads to higher use of pesticides and trace elements to promote crop growth.	0 No horticulture present.	>0 to 5 Low horticultural development.	5 to 10 Moderate horticultural development.	10 to 15 High horticultural development.	>15 Extensive horticultural development.
Nutrient Load Thresholds for symptoms of eutrophication (e.g. macroalgae growth)	Very low (<5 mg/m^2/d)	Low (>5 to ≤10 mg/m^2/d)	Moderate (>10 to ≤50 mg/m^2/d)	High (>50 to ≤250 mg/m^2/d)	Very High (>250mg/m^2/d)
Sedimentation rate (CSR:NSR ratio*) *CSR = Current sedimentation rate, NSR = natural sedimentation rate	CSR 1 to 1.1 x NSR	CSR 1.1 to 2 x NSR	CSR >2 to 5 x NSR	CSR >5 to 10 x NSR	CSR >10 x NSR
Grazing animals in estuary and on margin Grazing animals can lead to direct destruction of high value habitat and increase bank erosion.	Very Low No access to estuary by farmed animals. No known signs of wild animal activity.	Low No access to estuary by farmed animals. Signs (e.g. browsing, pugging, rooting) of wild animal activity (e.g. deer, pigs)	Moderate Potential access for farmed animals i.e. farming on margin and possibility animals could break through fence on occasion.	High Unrestricted access for farmed animals i.e. no fencing and open access to the estuary.	Very High Unrestricted access for farmed animals (i.e. no fencing and open access to the estuary) and evidence of damage to the margin.
Altered Hydrology Modification of freshwater input or tidal flow (e.g. flap gates, culvert, channelised watercourse, high water abstraction etc).	Very low No modification, natural hydrology.		Moderate Localised modification of hydrology.		Very high Extensively modified hydrology

Table 3. continued. Ecological Vulnerability Assessment – Pressures continued.

	Very low	Low	Moderate	High	Very High
Pressures					
Contaminants (chemical & biological)					
Chemical contaminants - marine e.g. Trace metals, SVOCs, emerging contaminants	Little or no connectivity Remote location with little or no vessel activity. No marine structures or known anchorages within 500m.	Low connectivity Anchorage or 1 to 5 private berths/ moorings but no other marine structures within 500m.	Moderate connectivity Moderate density (>5-20) private berths/ moorings or other marine structures within 500m.	High connectivity High density (>20-50) private berths/ moorings or other marine structures within 500m, or commercial vessel route within 500m.	Very high connectivity Very high density (>50) private berths/ moorings or other marine structures within 500m, or commercial vessel route or port/ marina within 500m.
Chemical contaminants - terrestrial e.g. Trace metals, SVOCs, emerging contaminants	Very Low Unmodified catchment. No contaminant inputs.	Low	Moderate Moderate contaminant inputs (e.g. moderate urban, industrial or horticultural development in catchment)	High	Very High Likely significant contaminant inputs (e.g. stormwater, wastewater, horticulture etc)
Marine oil spill risk Proximity of shipping/vessel activity or port to intertidal estuary	Little or no connectivity Remote location with little or no vessel activity. No marine structures or known anchorages within 5km.	Low connectivity Anchorage or 1 to 5 private berths/moorings but no other marine structures within 5km.	Moderate connectivity Moderate density (>5-20) private berths/moorings or other marine structures within 5km.	High connectivity High density (>20-50) private berths/ moorings or other marine structures within 5km, or commercial vessel route within 5km.	Very high connectivity Very high density (>50) private berths/ moorings or other marine structures within 5km, or commercial vessel route or port/ marina within 5km.
Introduced marine species Connectedness to main source populations of estuarine non-indigenous species. Pathways include vessels, structures or proximity to known populations.	Little or no connectivity Remote location with little or no vessel activity. No marine structures or known anchorages within 5km.	Low connectivity Anchorage or 1 to 5 private berths/moorings but no other marine structures within 5km.	Moderate connectivity Moderate density (>5-20) private berths/moorings or other marine structures within 5km.	High connectivity High density (>20-50) private berths/ moorings or other marine structures within 5km, or commercial vessel route within 5km.	Very high connectivity Very high density (>50) private berths/ moorings or other marine structures within 5km, or commercial shipping route or port/ marina within 5km.

Table 3. continued. Ecological Vulnerability Assessment – Pressures continued.

	Very low (5)	Low (4)	Moderate (3)	High (2)	Very High (1)
Pressures					
Contaminants (chemical & biological)					
Phytoplankton algal blooms Phytoplankton blooms reduce water clarity, can lead to low oxygen conditions upon breakdown and can be harmful to shellfish/ fish.	No previous blooms		Occasional blooms		Re-occurring blooms (e.g. annual)
Pathogens Risk to ecology if exotic or indigenous pathogens are introduced (e.g. shellfish/fish) or emerge due to environmental pressures.	Very low pressures or little or no connectivity to likely terrestrial or marine (see biosecurity) sources.	Low pressures or low connectivity to likely terrestrial or marine (see biosecurity) sources.	Moderate pressures or moderate connectivity to likely terrestrial or marine (see biosecurity) sources.	High pressures or high connectivity to likely terrestrial or marine (see biosecurity) sources.	Very high pressures or very high connectivity to likely terrestrial or marine (see biosecurity) sources.
Human use					
Direct Human use Non-commercial use (e.g. recreation)	Very low Little or no use	Low Occasional use	Moderate Seasonal use	High High year-round use	Very High Very High year-round use
Direct Human use Commercial marine species harvest or aquaculture within estuary (e.g. shellfish harvest or marine farms)	Very low None	Low Occasional harvest, no permanent aquaculture structures	Moderate Seasonal harvest, no permanent aquaculture structures	High Year-round harvest, no permanent aquaculture structures	Very High Year-round harvest and/or permanent aquaculture structures
Disturbance of wildlife Direct human access - level of protection.	Restricted e.g. fence around important habitat or breeding area.		Limited e.g. signage to prevent dog access		Unrestricted
Habitats					
Salt Marsh pressures (number of recorded pressures) Pressures include grazing/ vehicle damage, reclamation, drainage, erosion, weeds and other	≤1	2	3	4	≥5
Seagrass pressures (number of recorded pressures) Pressures include macroalgal smothering, epiphytic growth on leaves, sediment smothering, leaf die-off, physical erosion and grazing or other	≤1	2	3	4	≥5
Fish passage Many of New Zealand's fish species migrate between freshwater and marine environments as part of their lifecycles. Infrastructure can inhibit the natural connectivity reducing the abundance of these species.	Very Low No barriers to fish passage		Moderate Partial barrier to fish passage (i.e. not all access is restricted)		Very High Complete barrier to fish passage (i.e. all access is restricted)

Table 3. continued. Ecological Vulnerability Assessment – Susceptibility.

	Very low (5)	Low (4)	Moderate (3)	High (2)	Very High (1)
Susceptibility					
Current physical susceptibility to eutrophication					
Estimated Physical Susceptibility Overall susceptibility of an estuary is, in part, dependent on dilution and flushing (see Robertson et al. 2016a)	High export Low susceptibility		Moderate export Moderate susceptibility		Low export High Susceptibility
Mixing status (i.e. well mixed, partially mixed, stratified) i.e. Stratification can influence dissolved oxygen concentration and phytoplankton growth.	Unlikely to stratify		Potential to stratify for short periods (<1 week)		Likely to stratify (>1week)
Extent of increase in pressures in <10 years					
Catchment pressures (e.g. forestry harvest, farming intensification, land disturbance)	Low		Moderate		High
Contaminants (chemical & biological) (e.g. increase in vessel numbers, marine structures, development)	Low		Moderate		High
Human Use (e.g. aquaculture expansion or intensification, population increase, increased accessibility to estuary)	Low		Moderate		High
Extent of increase in pressures in >10 y					
Catchment pressures (e.g. forestry harvest, farming intensification, land disturbance)	Low		Moderate		High
Contaminants (chemical & biological) (e.g. increase in vessel numbers, marine structures, development)	Low		Moderate		High
Human Use (e.g. aquaculture expansion or intensification, population increase, increased accessibility to estuary)	Low		Moderate		High
Adaptive capacity of estuary to sea level rise Ability of estuary to migrate landward with sea level rise (e.g. physical barriers to migration artificial or natural)	Very high No barriers to landward migration.	High Few barriers to landward migration, e.g. low intensity land use and/or low gradient coastal plain (slow inundation).	Moderate Some barriers to landward migration, e.g. high intensity land use and/or moderate gradient coastal plain.	Low Many barriers to landward migration, e.g. armouring, infrastructure, steep gradient coastal plain (rapid inundation).	Very low No meaningful capacity for landward migration (e.g. steep margin, rock, cliff)
Climate change adaptation and resilience (e.g. to rising sea temperatures, marine heat waves, ocean acidification, increased storm frequency etc)	Needs further development The criteria should consider exposure, sensitivity, and adaptive capacity. However, high resolution data at a regional scale is required to make a meaningful assessment.				

Table 3. continued. Ecological Vulnerability Assessment – Condition.

	Very Good (5)	Good (4)	Moderate (3)	Poor (2)	Very Poor (1)
Condition					
Habitat					
Estimated historical salt marsh extent (% of historic salt marsh remaining) **estimated from known data sources or historic imagery*	≥ 80 to 100	≥ 60 to <80	≥ 40 to <60	≥20 to <40	< 20
Proportion (%) of current salt marsh degraded *Pressures include grazing/ vehicle damage, reclamation, drainage, erosion, weeds and other	< 20	≥20 to 40	≥ 40 to 60	≥ 60 to 80	≥ 80 to 100
% Seagrass decline from estimated baseline **estimated from known data sources or historic imagery*	<5	≥ 5 to 10	≥ 10 to 15	≥ 15 to 20	≥ 20
Proportion (%) of current seagrass degraded *Pressures include macroalgal smothering, epiphytic growth on leaves, sediment smothering, leaf die-off, physical erosion, grazing etc.	< 20	≥20 to 40	≥ 40 to 60	≥ 60 to 80	≥ 80 to 100
Substrate					
Diversity of substrate types * Based on REA criteria.	≥5	4	3	2	1
Predicted sedimentation rate (mm/y)	0	>0 to <0.5	≥0.5 to <1	≥1 to <2	≥2
Mud extent (% intertidal)	<1%	1 to 5%	>5 to 15%	>15 to 50%	>50%
Eutrophication					
Opportunistic macroalgae extent (% intertidal)	0 to 5%	>5 to 15%	>15 to 25%	>25 to 75%	>75 to 100%
Phytoplankton (µg/L) **Categories dependent on salinity (ppt)**	<3µg/L (>30ppt) <5µg/L (≤30ppt)	>3 to 8µg/L (>30ppt) <5 to 10µg/L (≤30ppt)	>8 to 12µg/L (>30ppt) >10 to 16µg/L (≤30ppt)	>12 to 16µg/L (>30ppt) >16 to 32 µg/L (≤30ppt)	>16µg/L (>30ppt) >32µg/L (≤30ppt)
Dissolved oxygen (mg/L) **1-day minimum**	≥5.5mg/L	≥5 to <5.5mg/L	≥4.5 to <5mg/L	≥4 to <4.5mg/L	<4mg/L
Water clarity i.e. light penetration into the water controls the available light in which plants can grow. Light penetration can be limited by the amount of suspended sediments in the water column, chlorophyll-a or tannins.	Water clarity to 100% of bottom depth	≥75 to <100% of bottom depth	≥ 50 to <75% of bottom depth	≥ 25 to <50% of bottom depth	<25% of bottom depth
High Enrichment Conditions (Ha or % intertidal area)	0ha OR 0%	>0-0.5ha OR >0-1%	0.5-5ha OR 1-5%	>5-20ha or >5-10%	>20ha or >10%

Table 3. continued. Ecological Vulnerability Assessment – Current State.

	Very Good (5)	Good (4)	Moderate (3)	Poor (2)	Very Poor (1)
Current State					
Invasive Species					
Existing presence of invasive species in the estuary (e.g. *Spartina* sp., pacific oysters, *Undaria* sp.)	Absent No visible individuals	Rare <1 individual per 10m^2 or <1% across estuary	Occasional 1 - <10 indiv. per 10m^2 or ≥1 to <5% across estuary	Frequent ≥10 - <100 indiv. per 10m^2 or ≥5 to <10% across estuary	Common ≥10% across estuary with high density areas ≥10 individuals per 1m^2
Modification					
Reclamation and/or drainage of habitat (% area affected)	<1%	1-5%	5-10%	>10 to 25%	>25%
Shoreline length modified/ disturbed (% shoreline modified) (e.g. grassland, infrastructure, exotic bush etc)	< 20	≥ 40 to 20	≥ 40 to 60	≥ 60 to 80	≥ 80 to 100
Hardening of estuary margin (% hardened) (e.g. artificial rock wall, earth bund, reinforcement armouring)	< 20	≥ 40 to 20	≥ 40 to 60	≥ 60 to 80	≥ 80 to 100
200m terrestrial margin (% densely vegetated) (LCDB classes 45-71)	≥ 80 to 100	≥ 50 to <80	≥ 25 to <50	≥10 to >25	<10

Maitakona Estuary entrance

4. EVA RESULTS & DISCUSSION

A summary of EVA scores for each of the estuaries assessed is presented in Table 4, with detail on each presented in Appendix 1. The EVA scores are most useful in highlighting individual differences between estuaries regionally and for grouping subsets of estuaries based on their ecological values, or the pressures, susceptibility or condition they are in. A final combined score has also been calculated, which is the average of the four individual scores (see Section 4). An estuary scores highest when it has 'very good' ecological values and condition combined with 'very low' pressures and susceptibility.

Overall, all the estuaries assessed were sub-tidally dominated tidal river estuaries, with many experiencing stratification and periodic entrance restriction and/or closure. Further, many of the catchments along the Wairarapa coast are modified for pasture, mainly sheep and beef, and are highly erodible leading to high sediment inputs. To a lesser extent, the estuaries along the coast also experience moderate water column nutrient concentrations from a combination of elevated catchment loads and restricted flushing. High sediment and moderate nutrient loads, combined with physical susceptibility (e.g. entrance restriction and/or closure), mean these estuaries are prone to water quality degradation (e.g. poor clarity, phytoplankton blooms and low dissolved oxygen).

Table 4. Summary of EVA results for the monitored estuaries on the Wairarapa coast, April 2022*.

	Ecological Values	Pressures	Susceptibility	Condition	Final Score
Mātaikona	0.45	0.77	0.80	0.68	**0.67**
Ōkau	0.48	0.88	0.79	0.60	**0.69**
Whakataki	0.48	0.77	0.72	0.67	**0.66**
Castlepoint	0.50	0.59	0.72	0.58	**0.60**
Ngākauau	0.57	0.63	0.66	0.62	**0.62**
Humpies	0.48	0.73	0.72	0.72	**0.66**
Otahome	0.48	0.61	0.69	0.63	**0.60**
Otahome South	0.40	0.70	0.73	0.64	**0.62**
Whareama	0.55	0.70	0.72	0.60	**0.64**
Motuwaireka	0.53	0.71	0.66	0.70	**0.65**
Riversdale North	0.27	0.64	0.67	0.63	**0.55**
Riversdale Central	0.27	0.65	0.62	0.62	**0.54**
Riversdale South	0.51	0.71	0.70	0.71	**0.66**
Wironu	0.65	0.69	0.74	0.60	**0.67**
Patanui	0.43	0.72	0.72	0.72	**0.65**
Waikaraka	0.48	0.72	0.72	0.65	**0.64**
Kaimokopuna	0.21	0.81	0.76	0.67	**0.61**
Kaiwhata River	0.44	0.76	0.66	0.65	**0.63**
Flat Point (Te Unu Unu)	0.24	0.75	0.82	0.75	**0.64**
Pāhāoa River	0.50	0.79	0.73	0.74	**0.69**
Ōterei	0.62	0.79	0.72	0.73	**0.71**
Awhea	0.61	0.73	0.79	0.70	**0.71**
Opouawe	0.45	0.86	0.82	0.67	**0.70**
Whawahui River	0.48	0.82	0.82	0.73	**0.71**
White Rock	0.25	0.77	0.82	0.71	**0.64**

*Green shading indicates estuaries with the highest ecological values. Orange cells indicate estuaries under the greatest pressure, with the highest susceptibility, or in the poorest condition.

The riverine nature of most of the estuaries means salt marsh is relatively uncommon due to both limited available habitat within which it can grow, and due to losses from historical drainage and reclamation. Seagrass (*Zostera muelleri*) was recorded only in Whareama Estuary although *Ruppia* spp. (horse's mane weed) was present in a subset of estuaries where salinity is relatively low for most of the time. Despite the presence of common pressures and the effects of past modification, the estuaries remain important habitats for migratory fish and coastal birds, sediment-dwelling invertebrates and shellfish, as well as supporting amenity values.

Using the EVA criteria described in this report, Table 4 shows the estuaries with the highest ecological values (shaded green cells) were Ngākauau, Wironu, Ōterei and Āwhea. These ratings were primarily driven by the relatively high percentage of salt marsh habitat, the presence of significant species (e.g. threatened or endangered species) and/or their current level of estuary protection (i.e. significant wetland or protection under the PNRP Appeals Version 2022). Whareama Estuary also scored highly for ecological values due its size, the presence of both seagrass and salt marsh, and its conservation values. Despite having proportionately large areas of salt marsh habitat, Otahome, Humpies, Waikaraka and Whawahui estuaries scored lower than other estuaries. This was due to these sites having limited information on bird and fish species, or the sites not being currently designated for protection (i.e. not a significant wetland or protected under the PNRP Appeals Version 2022; Appendix 1). Due to the presence of high value salt marsh habitat, and the fact that this is relatively rare along the Wairarapa coast, these estuaries may require more extensive consideration to determine whether they require protection in future planning iterations.

Concerningly, three of the estuaries with the highest ecological values (Ngākauau, Whareama and Wironu) were also ranked in the poorest condition (Table 4). Ngākauau and Whareama had pasture-dominated margins, poor water clarity, muddy sediments and a high proportion of salt marsh under pressure (Appendix 1). Wironu had elevated phytoplankton (i.e. chlorophyll-a) and low oxygen conditions that appear to have been persistent given widespread oxygen depletion in the sediments (A14 in Appendix 1). Interestingly, *Ruppia* spp. were still growing in the anoxic soft sandy muds.

Ngākauau Estuary with pasture on the margin and eroding banks

Whareama Estuary with cattle grazing down to the margin and turbid water column

Wironu Estuary with extensive salt marsh along the margins

Other estuaries in relatively poor condition included Okau, Castlepoint, Otahome, Riversdale North and Riversdale Central. Okau, Castlepoint, Riversdale North and Riversdale Central (see Appendix 1) are all small estuaries that have been highly modified, with partly hardened margins, and the latter three are located within residential areas. Otahome is similar to Ngākauau in that it has a pastoral margin, poor water clarity, muddy sediments and a high proportion of salt marsh under pressure.

Castlepoint drains onto the beach through box culverts, an orange sign warns against recreational use due to pollutant levels

Riversdale North (top) eroding dune and houses adjacent to the stream, and Riversdale Central (bottom) with housing on the margin and margin hardening

Pugging of salt marsh and intertidal mud habitats in Otahome Estuary

Raised culverts on Ngākauau Stream preventing fish passage

The EVA pressure scores provide further insight into potential drivers of current state. The most significant pressures are listed for each individual estuary in Appendix 1.The most common pressures across all estuaries were:

- High sediment inputs from steep, highly erodible catchments that are dominated by pasture.
- Localised sediment inputs from bank erosion and slumping.
- Moderate nutrient inputs from modified catchments.
- Stock grazing within the estuary margin.
- Modified hydrology (e.g. channel straightening, culverts, margin hardening).
- Weed incursions in the terrestrial estuary margin.
- Phytoplankton growth, particularly a risk when estuary entrances are restricted and/or closed.
- Human use and discharges in residential areas.

Because many of the pressures are consistent across all estuaries there was not a large range in the EVA pressure scores (i.e. 0.59 to 0.88; Table 4). The estuaries that scored lowest (i.e. had the highest pressure) were Castlepoint, Riversdale North, Riversdale Central, Ngākauau and Otahome (see Appendix 1). As discussed previously, the first three are small highly modified estuaries in residential areas with upstream catchments dominated by pasture, modified hydrology (e.g. culverts) and are also subject to higher human use and wastewater inputs through direct discharges (Castlepoint), or potential septic tank leakage. The Ngākauau and Otahome estuaries, while also historically modified (see photo), are most under pressure from impacts associated with their pasture-dominated catchments and from grazing animals which have direct access to the estuaries (with damage to salt marsh evident).

Bank erosion and a sheep on the margin, Whareama Estuary

Cattle grazing upstream of the estuary entrance, Ōpouawe River

Gorse dominates the upstream margin of Ōkau stream

Many of the estuaries along the Wairarapa coast have similar physical susceptibilities (i.e. are prone to stratification and/or mouth restriction or closure) and are remote and therefore have limited human use. As a result, there was not a large range in the EVA susceptibility scores (i.e. 0.62 to 0.82). The estuaries with the highest susceptibility included those in residential areas such as Motuwaireka, Riversdale North and Riversdale Central due to moderate human use and physical susceptibility. Other estuaries with high susceptibility included Ngākauau, Otahome and Kaiwhata because of their physical characteristics (e.g. susceptibility for stratification and low flushing), and an elevated likelihood of disturbance in the catchment (e.g. >20% of the catchment is due for exotic forest harvest).

In comparison with an earlier assessment by Robertson and Stevens (2007a), the updated EVA results described in the current report found the key pressures and susceptibility have remained relatively consistent since 2007. These are detailed in Appendix 1 and are briefly outlined in Section 5. The updated EVA framework has however provided further insight into the differences between individual estuaries, which can be used to better prioritise estuaries for management.

The protection and management of estuaries on the Wairarapa coast requires both a catchment-scale and an estuary-scale perspective. Sediment, nutrient and contaminant loads need to be managed at a catchment-scale and will be explored further with the implementation of the NPSFM and whaitua process. However, there are also benefits to estuary-scale management to protect estuarine habitat types and their values. For example, estuarine habitats such as salt marsh or the immediate terrestrial margin can be relatively easily protected through the exclusion of stock from the estuary margin and control of weeds. Active management might include native plantings to enhance or restore habitat or mitigate local scale sediment or nutrient impacts. There are several examples where estuary-scale management is already occurring in estuaries along the Wairarapa coast;

- Ōkau – native plantings on the terrestrial margin and adjacent dune.
- Humpies – native plantings of both terrestrial and salt marsh species, planted in the 1990's, are now well-established.
- Pāhāoa – native plantings on the estuary margin and fencing to protect bird nesting habitat.
- Waiohuru – native plantings on the estuary margin and fencing.

In addition to these, there are several other protection, enhancement and restoration opportunities along the Wairarapa coast. The EVA has highlighted some estuaries where active management to maintain salt marsh (e.g. Otahome, Humpies, Ngākauau, Waikaraka and Whawahui) is recommended, while Todd et al. (2016) also discuss potential conservation management opportunities for many of the estuaries reported here.

While estuary-scale management does not negate the need for catchment-scale management, when implemented alongside catchment-scale efforts it can improve estuary resilience and benefit the animals (e.g. fish, birds, invertebrates) that rely on these systems.

Established native plantings, Humpies Estuary

5. CONCLUSIONS & RECOMMENDATIONS

General conclusions, knowledge gaps and recommendations from the EVA and summary information presented in Appendix 1 are summarised below:

Management:

- The highly erodible catchment and direct sediment inputs from bank erosion and slumping mean sediment loads are high along the Wairarapa coast. As such, a reduction in sediment loads is likely required for most estuaries along the coast, particularly those that retain fine sediments, if ecological quality is to be improved.
- Due to the natural physical susceptibility of the estuaries (i.e. to stratification and entrance restriction and/or closure), phytoplankton and macroalgal blooms may occur under nutrient loads reflective of 'natural state' conditions.
- As current nutrient loads are moderately elevated in most estuaries, and the response to nutrient enrichment can be variable, it is likely management targets will need to be assessed on an estuary-specific basis to reduce the risk of blooms that cause significant and prolonged water quality and sediment degradation.
- In addition to catchment-scale management, estuary-scale management will be required to maintain some ecological values (e.g. habitats). For example, protection, enhancement and/or restoration of salt marsh habitat or the terrestrial margin. It is recommended that GWRC establish priorities for future protection and restoration.
- Stock access to estuaries along the Wairarapa coast is common. To protect salt marsh habitat and reduce bank erosion, stock should be prevented from directly accessing estuaries.
- Where fish passage has been identified as a potential issue, further investigation is required to remove potential barriers and ensure suitable levels of habitat protection.

Knowledge gaps:

- Otahome, Humpies, Waikaraka and Whawahui estuaries have high value salt marsh habitat but are not currently protected. These sites are also information deficient for some key metrics and the ecological EVA ratings of these sites are expected to increase substantially following more detailed site assessments, including habitat, fish and bird surveys.
- Water quality information (e.g. phytoplankton, dissolved oxygen and faecal loads) is very limited
- Information on sediment related impacts including deposition and habitat loss is very limited.
- More understanding of how coastal hazards (e.g. coastal erosion) will impact estuaries and dune systems is needed. Several estuaries have already experienced large changes over the last two decades due to coastal erosion for example, Riversdale North and Central, Ōkau, Patanui and Homewood Estuaries.
- Improved understanding of the impacts of climate change including sea level rise (i.e. salt water intrusion) and climatic conditions (e.g. river flow, storm frequency and intensity) will be needed to better understand susceptibility (i.e. entrance closures, stratification, deposition events).

Monitoring

- To maintain a high-level overview of estuary condition and change it is recommended that synoptic surveys of estuary condition and risk be repeated at 10-yearly intervals.
- Specific recommendations for targeted monitoring in Whareama Estuary are presented in Forrest et al. (2022).
- GWRC should consider synoptic estuary water quality monitoring (e.g., one-off survey using handheld water quality meters that measure oxygen, salinity, temperature, chlorophyll-a and turbidity) during periods of prolonged entrance restriction or closure to provide further insight into the extent of water quality degradation under these conditions (e.g. phytoplankton blooms, low dissolved oxygen).

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APPENDIX 1: ESTUARY SUMMARIES

The following appendix presents a summary for each individual estuary. For clarity, each estuary is labelled with a unique identifier (see Estuary Inventory Index in Table A1), with a letter denoting the sub-region and a number denoting the individual estuary. The estuary summaries distil the information captured in the EVA into a more user-friendly format. Each estuary summary is presented over three pages as follows:

Page 1: provides a written summary and two summary tables that include general information on the estuary and catchment and the results of the EVA.

EVA results are colour-coded as a general guide to assist with interpretation of estuary health status. The bandings have been derived from the EVA results for estuaries presented in this report and represent a relative comparison across the Wairarapa coast. Bandings for each colour were derived from the minimum and maximum scores in each category and the range split into 5 even bands. The EVA is colour coded as follows:

Category	Rating & Score				
	Very Poor	Poor	Fair	Good	Very Good
Values	≤0.30	>0.30 to 0.39	>0.39 to 0.48	>0.48 to 0.57	>0.57
Condition	≤0.62	>0.62 to 0.65	>0.65 to 0.68	>0.68 to 0.72	>0.72
	Very High	High	Moderate	Low	Very Low
Pressures	≤0.65	>0.65 to 0.71	>0.71 to 0.77	>0.77 to 0.83	>0.83
Susceptibility	≤0.66	>0.66 to 0.70	>0.70 to 0.74	>0.74 to 0.78	>0.78

The highest overall score (i.e. when averaged across categories) for an estuary reflects 'very good' values and condition combined with 'very low' pressures and susceptibility.

Page 2: presents two figures, the first a land use catchment map (catchment boundaries provided by GWRC or derived from NIWA's CLUES model), and the second is an aerial photo of the estuary with key habitat features (e.g. salt marsh, seagrass, macroalgae and substrate) highlighted.

Page 3: presents a series of photos illustrating the estuary's main habitat types and key pressures.

Table A1. Inventory of estuaries on the Wairarapa Coast, including unique ID and summary of EVA results for each estuary. Estuaries designated by GWRC as a significant wetland or an area of significant indigenous biodiversity in the proposed Natural Resource Plan are shown.

ID	Estuary Name	Ecological Values	Pressures	Susceptibility	Condition	Final Score	PNRP Schedule F4	Significant Wetland	Bird records	Fish records
A1	Mātaikona	0.45	0.77	0.80	0.68	0.67	✓	✓	✓	✓
A2	Ōkau	0.48	0.88	0.79	0.60	0.69	✓		✓	✓
A3	Whakataki	0.48	0.77	0.72	0.67	0.66	✓	✓	✓	✓
A4	Castlepoint	0.50	0.59	0.72	0.58	0.60	-	-	-	✓
A5	Ngākauau	0.57	0.63	0.66	0.62	0.62	✓	-	✓	✓
A6	Humpies	0.48	0.73	0.72	0.72	0.66	-	-	✓	-
A7	Otahome	0.48	0.61	0.69	0.63	0.60	-	-	✓	-
A8	Otahome South	0.40	0.70	0.73	0.64	0.62	-	-	-	-
A9	Whareama	0.55	0.70	0.72	0.60	0.64	✓	-	✓	✓
A10	Motuwaireka	0.53	0.71	0.66	0.70	0.65	✓	-	✓	✓
A11	Riversdale North	0.27	0.64	0.67	0.63	0.55	-	-	-	-
A12	Riversdale Central	0.27	0.65	0.62	0.62	0.54	-	-	-	-
A13	Riversdale South	0.51	0.71	0.70	0.71	0.66	-	-	-	-
A14	Waironu	0.65	0.69	0.74	0.60	0.67	-	✓	✓	-
A15	Patanui	0.43	0.72	0.72	0.72	0.65	-	-	✓	-
A16	Waikaraka	0.48	0.72	0.72	0.65	0.64	-	-	✓	-
A17	Kaimokopuna	0.21	0.81	0.76	0.67	0.61	-	-	-	-
A18	Homewood	-	-	-	-	-	-	-	-	-
A19	Kaiwhata	0.44	0.76	0.66	0.65	0.63	✓	-	✓	-
A20	Flat Point	0.24	0.75	0.82	0.75	0.64	-	-	-	-
A21	Pāhāoa	0.50	0.79	0.73	0.74	0.69	✓	-	✓	✓
A22	Rerewhakaaitu	-	-	-	-	-	-	-	-	-
A23	Ōterei	0.62	0.79	0.72	0.73	0.71	✓	✓	✓	✓
A24	Āwhea	0.61	0.73	0.79	0.70	0.71	✓	-	✓	✓
A25	Āwheaiti	-	-	-	-	-	-	-	-	-
A26	Ōpouawe	0.45	0.86	0.82	0.67	0.70	✓	✓	✓	✓
A27	Whawahui	0.48	0.82	0.82	0.73	0.71	-	-	-	✓
A28	White Rock	0.25	0.77	0.82	0.71	0.64	-	-	-	-
A29	Cape Palliser	-	-	-	-	-	-	-	-	-

A1. MĀTAIKONA RIVER ESTUARY

Mātaikona River Estuary is a moderate (~12ha) sized river mouth lagoon that drains through a narrow opening. The entrance can become restricted and occasionally blocks when high seas cause gravels and sand to build up across the entrance. During times of restricted flushing, the estuary is particularly prone to nutrient, sediment and pathogen issues. While the tidal influence can extend up to 2km upstream from the estuary mouth, Mātaikona Estuary is largely freshwater dominated (Robertson & Stevens 2007a; Todd et al. 2016).

In a site visit on 5th April 2022 the estuary was open to the sea, well mixed and freshwater dominated. A large saline (23.9ppt) backwater, toward the north of the entrance was disconnected from the estuary. While the main river channel was dominated by gravels, in the backwater pool fine sediments had deposited over marine sands and, in parts, benthic mats of algae were growing on the sediment surface, suggesting water and sediment condition quickly deteriorate when flushing is restricted. In the main river channel water clarity was poor, and the water column turbid (21-34FNU). Woody debris builds-up at the entrance and around the disconnected pool. Two previous site visits reported the estuary in similar condition, however the entrance position and/or backwater were in a different location (Robertson & Stevens 2007a; Todd et al. 2016).

As reported previously, there is very limited available habitat for salt marsh owing to the small intertidal area, mobile substrate and steep banks. While *Ruppia* spp. was recorded in the pooled subtidal area in 2016 (Todd et al. 2016), it was not observed in 2022.

Several bird species, including but not limited to black shag, pied stilt, Caspian tern, variable oystercatcher and white face heron have been sighted at Mātaikona Estuary (Todd et al. 2016). Eight migratory fish have also been identified including "At Risk: Declining" (longfin eel, inanga, kōaro, redfin bully and torrentfish) species and marine species (Todd et al. 2016).

The most significant pressure to Mātaikona Estuary is the high sediment and nutrient loads from highly modified, erodible catchment (pasture and forestry). Frequent restriction or closure of the estuary entrance also leads to increased susceptibility to nutrient, sediment and pathogen issues, with nutrient enrichment issues already observed in the pooled area to the northeast. Other direct pressures include moderate recreational use (e.g., fishing, swimming, white baiting, bird watching), weed incursions and forestry on the margin.

Table A1.1 Summary information for Mātaikona Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	12.5	-
Intertidal Area (Ha; % Estuary)[1]	8.4	67.8
Dominant Estuary Substrate[1]	Gravel	
Mud extent (>50% mud content)	0.2	2.1
Macroalgae (Ha; cover >50%)[1]	0.1	0.8
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	-	-
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	17,791	
Dominant Catchment Land Cover[2]	High producing grassland	
% Catchment indigenous vegetation[2]	38.1	
% Catchment exotic forest[2]	18.3	
% Producing grassland[2]	43.1	
Mean Freshwater Flow (m^3/s)[3]	4.4	
Catchment Nitrogen Load (T/y)[3]	92.3	
Catchment Phosphorus Load (T/y)[3]	42.3	
Catchment Sediment Load (KT/y)[3]	156.4	
Catchment Geology	Mudstone (Upper) Argillite (Mid-lower)	
Biodiversity		
Significant Site [5]	Y	
Birds[5]	Black shag, pied stilt, Caspian tern, pied shag, red-billed gull, pied stilt	
Fish[5]	Longfin eel, inanga, kōaro, redfin bully, torrentfish	
Shellfish	nd	
Pressures		
High nutrient and sediment inputs from the modified (exotic forestry and farming), erodible catchment. Frequent restriction or closure of the estuary entrance. Bank Erosion. Public access to the estuary from the road edge. Weeds and grasses common on margin.		

[1]Field visit 5th April 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers, [5]Todd et al. (2016)

Table A1.2. Ecological Vulnerability Assessment, Mātaikona Estuary.

Category	Score
Values	0.45
Pressures	0.77
Susceptibility	0.80
Condition	0.68
Average Score	**0.67**

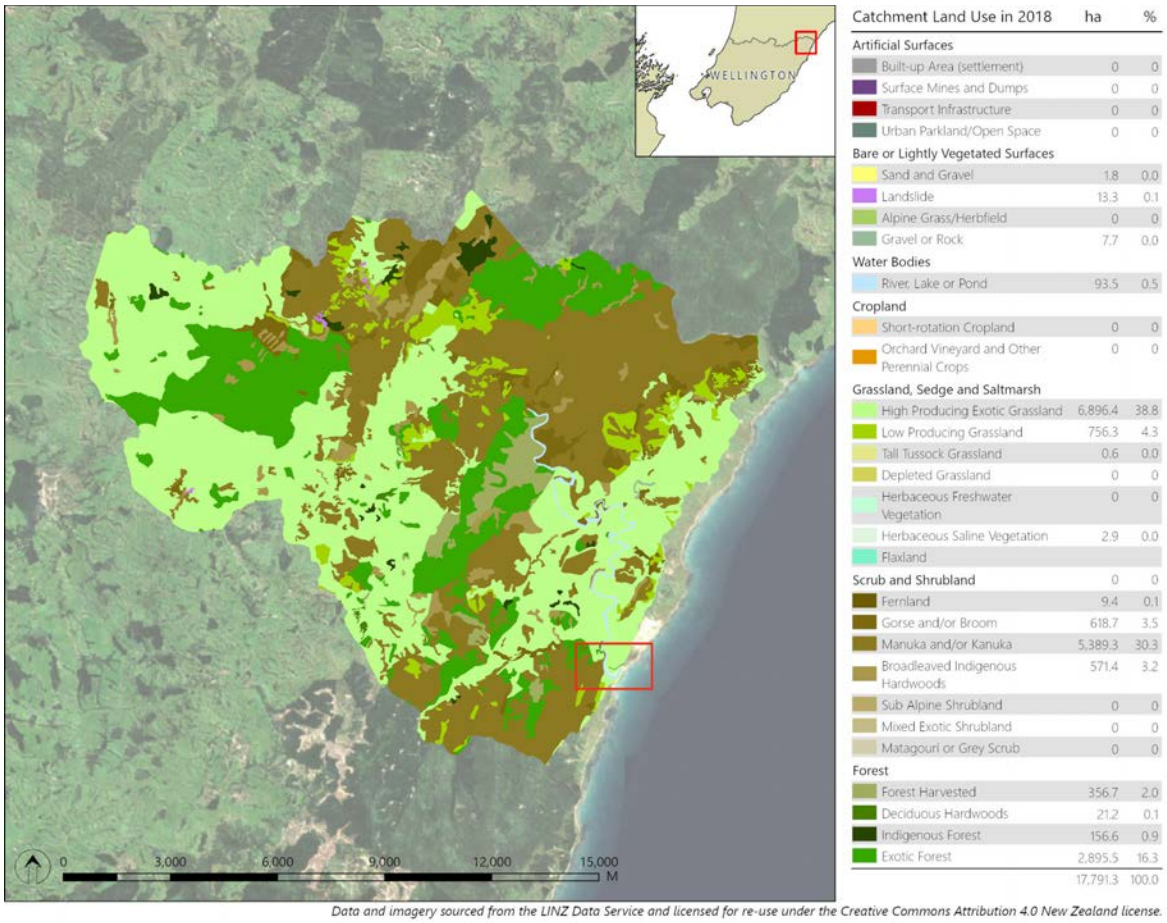


Fig. A1.1. Mātaikona Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

Fig. A1.2. Mātaikona Estuary dominant vegetation and substrate features. In this instance the red area represents thick beds of benthic algae.

Mātaikona Estuary entrance, backwater in background

Steep eroding margin, limited habitat for salt marsh

Backwater disconnected from the estuary and woody debris

Turbid water column and steep margin with mixed exotic forest

Very shallow mudflats of the backwater growing benthic algal mats on the sediment surface

Upper riverine section of the estuary with a narrow channel on the true right bank and gravel field on the true left

Benthic algae growing on the surface of the sediment in mats in the shallow part of the backwater pool to the north

Wetland-like area on the north-west side of the entrance, with giant umbrella sedge in the foreground

A2. ŌKAU STREAM ESTUARY

Ōkau Stream Estuary is a small-sized (1.0ha) riverine estuary draining a small (1263ha) catchment dominated by indigenous vegetation cover. Tidal ingress is dependent on the dynamic entrance which commonly restricts and/or closes (Todd et al. 2016; Robertson & Stevens 2007a). During a site visit on 5th April 2022 the estuary was open to the sea, however, it was still dominated by freshwater (salinity 0.3‰). While no water quality or macroalgal issues were recorded, during times of restricted flushing, the estuary is particularly prone to nutrient, sediment and pathogen issues.

Since 2006, sediments in the stream channel have transitioned from clean sand and silt to mud deposited over sands. Unlike 2006, significant bank slumping and erosion was observed, likely contributing to the muddy substrate in the mid estuary (see photos). Artificial rock wall remains on the true right bank of the lower estuary margin to prevent erosion near the road edge. Further, a large area of salt marsh (i.e. three-square) has been lost since 2006. This is likely owing to bank erosion, as the area where three-square was recorded previously on the lower true left bank is now a steep (0.5m high) eroding bank (see photo).

The estuary is a site of significant indigenous biodiversity in the Proposed Natural Resources Plan (Schedule F4) owing to its high macroinvertebrate community health (PNRP Appeals Version 2022). Several bird species, including but not limited to, black shag, banded dotterel, Caspian tern, pied stilt and red-billed gull have been sighted at Ōkau Stream Estuary (Todd et al. 2016 and references therein). Five migratory fish have also been identified including "At Risk: Declining" species (longfin eel, inanga and redfin bully; Todd et al. 2016 and references therein). Restoration plantings undertaken by GWRC are establishing on the estuary margin and on the foredune, however grasses remain a dominant feature of the immediate terrestrial margin (see photos).

The catchment is mainly in indigenous vegetation cover with pasture in the lower catchment. As such, nutrient loads are low. However, the soft rock catchment is highly erodible and therefore sediment inputs from modified land and bank erosion are a current and potential future pressure if the catchment is modified further. Frequent restriction or closure of the estuary entrance also leads to increased susceptibility to nutrient, sediment and pathogen issues. Other direct pressures include low level recreational use and weed incursions on the margin (e.g. gorse).

Table A2.1 Summary information for Ōkau Stream Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	1.0	-
Intertidal Area (Ha; % Estuary)[1]	0.8	76.7
Dominant Estuary Substrate[1]	Firm sand (mud in mid estuary)	
Mud extent (>50% mud content)	-	-
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	0.01	1.4
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	1263	
Dominant Catchment Land Cover[2]	Mānuka and/or Kānuka	
% Catchment indigenous vegetation[2]	82.6	
% Catchment exotic forest[2]	7.4	
% Producing grassland[2]	6.3	
Mean Freshwater Flow (m^3/s)[3]	0.2	
Catchment Nitrogen Load (T/y)[3]	3.5	
Catchment Phosphorus Load (T/y)[3]	1.1	
Catchment Sediment Load (KT/y)[3]	2.4	
Catchment Geology[4]	Argillite	
Biodiversity		
Significant Site[4]	Y	
Birds[5]	Banded dotterel, Caspian tern, reef heron, pied stilt, red-billed gull	
Fish[5]	longfin eel, inanga and redfin bully	
Shellfish	nd	
Pressures		
Erodible catchment leading to higher sediment inputs. Bank slumping and erosion in the mid estuary. Frequent restriction or closure of the estuary entrance. Exotic forestry. Public access to the estuary from the road edge. Records of stock access to the estuary in 2009. Weeds and grasses common on margin.		

[1]Field visit 5th April 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers, [5]Todd et al. (2016)

Table A2.2. Ecological Vulnerability Assessment, Ōkau Stream Estuary.

Category	Score
Values	0.48
Pressures	0.88
Susceptibility	0.79
Condition	0.60
Average Score	**0.69**

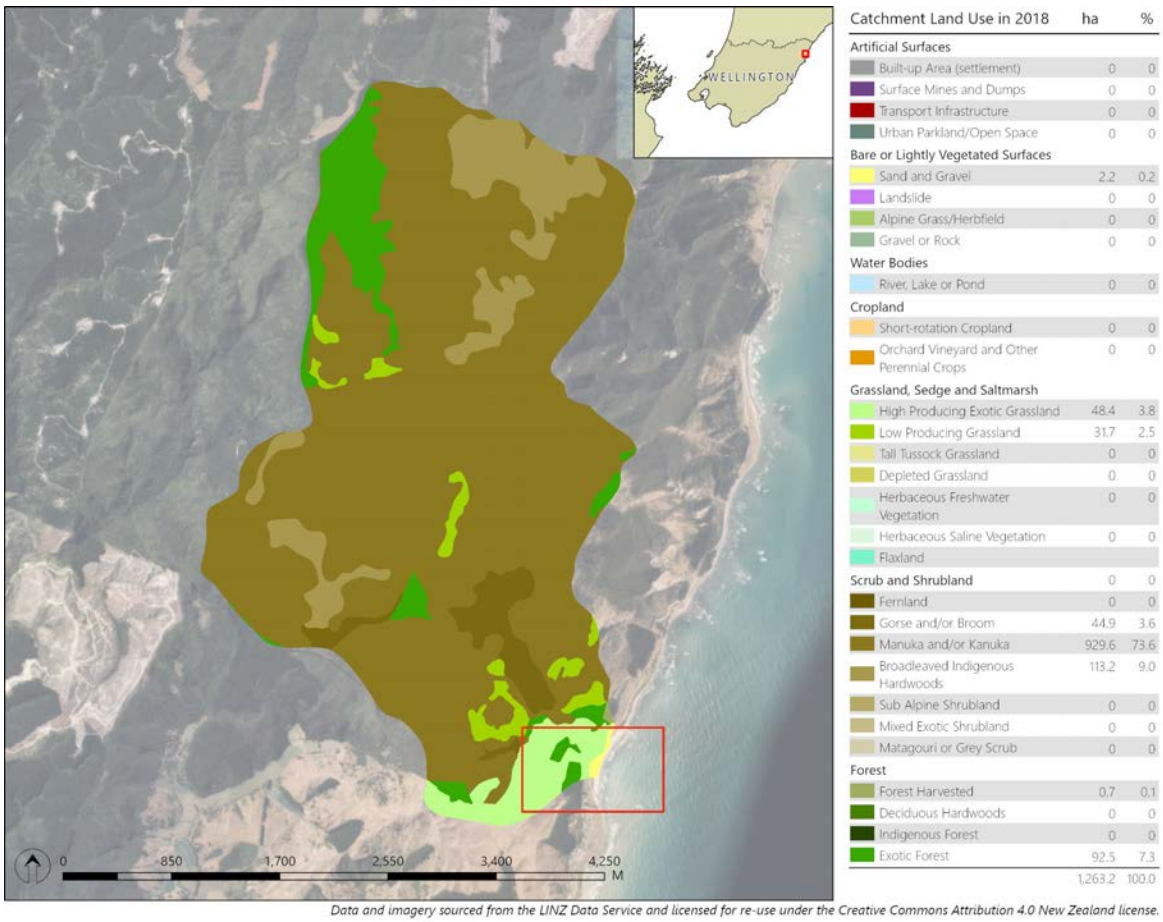


Fig. A2.1. Ōkau Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

Fig. A2.2. Ōkau Estuary dominant vegetation and substrate features.

Ōkau Stream Estuary looking downstream toward the entrance (top) and looking upstream from the road edge, three-square on the true left bank near eroding edge (bottom)

Bank erosion (top) and slumping banks with pine forestry in the background (bottom) of Ōkau Stream Estuary

Mixed gorse and grass margin growing over eroding banks

Restoration plantings on the estuary margin

Ōkau Stream Estuary with the entrance open and draining to the sea and large dune area on the seaward edge

A3. WHAKATAKI RIVER ESTUARY

Whakataki River Estuary is a small-sized (3.9ha) river mouth lagoon draining a moderate-sized (4229ha) catchment dominated by exotic forestry and high producing grassland. The entrance to the estuary is dynamic and periodically restricts and/or closes, on occasion the lagoon is mechanically opened (Todd et al. 2016; Robertson & Stevens 2007a). On 5th April 2022 the estuary was open to the sea, although still dominated by freshwater (salinity 0.3‰). Previous studies have recorded tidal influence up to 600m upstream of the entrance. While no water quality or macroalgal issues were recorded in 2022, decaying blooms of macroalgae and high turbidity were recorded in 2006. During times of restricted flushing, the estuary is particularly prone to nutrient, sediment and pathogen issues.

The dominant substrate in the Whakataki River is gravel transitioning to sand near the entrance. Soft sandy mud was recorded on the subtidal river margins near salt marsh, likely from bank erosion. Artificial rock wall on the true left bank in the mid estuary protects private land from eroding. Three-square, salt marsh rush and herbfield are present in a narrow band on the estuary margin, and transition to wetland vegetation and terrestrial tussockland (Todd et al. 2016).

The estuary is a site of significant indigenous biodiversity in the Proposed Natural Resources Plan (Schedule F4) because it is an important habitat for migratory indigenous fish species and is an important inanga spawning habitat (PNRP Appeals Version 2022). The lower estuary oxbow wetland is classified as a significant wetland due to its high level of plant diversity. Several bird species, including but not limited to black shag, banded dotterel, Caspian tern, pied stilt and red-billed gull have been sighted at Whakataki River Estuary (Todd et al. 2016 and references therein). Five migratory fish have also been identified including "At Risk: Declining" species (longfin eel, inanga, kōaro, redfin bully, torrentfish; Todd et al. 2016 and references therein).

The most significant pressures to Whakataki River Estuary are nutrient and sediment inputs from the catchment, of which their impacts are exacerbated when the estuary entrance restricts or closes. Further, other pressures include, localised bank erosion, moderate recreational use (e.g. swimming, fishing, whitebaiting) and weed incursions, particularly in the adjacent wetland area and dune.

Table A3.1 Summary information for Whakataki River Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	3.9	-
Intertidal Area (Ha; % Estuary)[1]	2.0	52.5
Dominant Estuary Substrate[1]	Gravel	
Mud extent (>50% mud content)	0.02	1.0
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	0.05	2.5
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	4229	
Dominant Catchment Land Cover[2]	Exotic forestry	
% Catchment indigenous vegetation[2]	31.1	
% Catchment exotic forest[2]	43.2	
% Producing grassland[2]	22.5	
Mean Freshwater Flow (m^3/s)[3]	0.7	
Catchment Nitrogen Load (T/y)[3]	13.5	
Catchment Phosphorus Load (T/y)[3]	3.6	
Catchment Sediment Load (KT/y)[3]	11.7	
Catchment Geology[4]	Argillite (Mid-upper) Mudstone (Lower)	
Biodiversity		
Significant Site[4]	Y	
Birds[5]	Banded dotterel, Caspian tern, New Zealand pipit, pied stilt, red-billed gull	
Fish[5]	Longfin eel, inanga, kōaro, redfin bully, torrentfish	
Shellfish	nd	
Pressures		
High nutrient and sediment inputs from the modified (exotic forestry and farming), erodible catchment. Frequent restriction or closure of the estuary entrance. Bank erosion. Public access to the estuary. Weeds and grasses common.		

[1]Field visit 5th April 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers, [5]Todd et al. (2016)

Table A3.2. Ecological Vulnerability Assessment, Whakataki River Estuary.

Category	Score
Values	0.48
Pressures	0.77
Susceptibility	0.72
Condition	0.67
Average Score	**0.66**

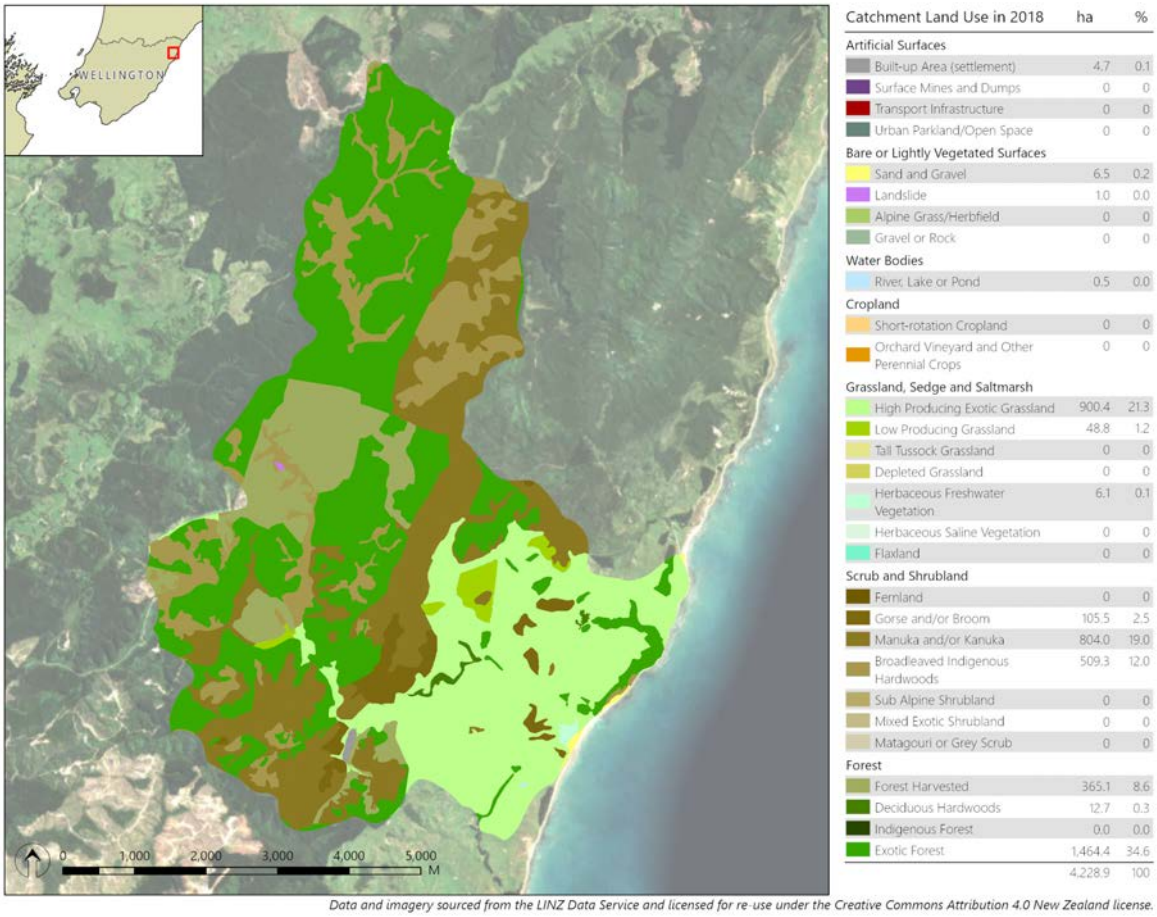


Fig. A3.1. Whakataki Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

Fig. A3.2. Whakataki Estuary dominant vegetation and substrate features.

Whakataki River Estuary entrance (top) and upstream from the beach with rock armouring on the the true left bank and salt marsh mixed with grass on the true right bank (bottom)

Freshwater input at the southern end of the beach and salt marsh within the significant wetland area (top) and a narrow band of three-square toward the north end (bottom)

Narrow bank of salt marsh rush on the true left bank

Dune north of the Whakataki River mouth

Whakataki River Estuary, dune in foreground and entrance at the southern end of the beach

A4. CASTLEPOINT STREAM ESTUARY

Castlepoint Stream Estuary is a very small-sized (0.2ha) riverine estuary draining a small (1247ha) catchment dominated by high producing grassland (sheep and beef). The estuary entrance is permanently open owing to a concrete bridge and box culverts, however there is the potential for restriction when sand builds up within the culverts (see photo). In a site on the 5th April 2022 the estuary upstream of the bridge was freshwater dominated (salinity 0.3‰). Raupō, a predominantly freshwater species, was recorded ~130m upstream of the bridge suggesting tidal influence is limited. Salt marsh species were present on the true left bank, including three-square and marsh clubrush, while the true right bank was raised and eroding. The subtidal substrate was dominated by firm sand and cobble, with a thin layer of fine sediment deposited on the surface in the mid estuary.

While no water quality or macroalgal issues were recorded during the site visit a no swim warning sign (see photo) indicated stream pollution has been an issue previously. In addition, to nutrients and pathogens from catchment land use (sheep and beef), stormwater from the settlement and treated wastewater from the Castlepoint wastewater treatment plant discharges directly into Castlepoint Stream.

While the estuary itself is not protected, upstream of the estuarine area Castlepoint Stream is a site of significant indigenous biodiversity in the Proposed Natural Resources Plan (Schedule F1) because it is an important habitat for migratory and non-migratory indigenous fish species (PNRP Appeals Version 2022). Fish species recorded include "At Risk: Declining" species (longfin eel, inanga, kōaro and redfin bully) and the common bully, black flounder and banded kokopu (PNRP Appeals Version 2022). There are no estuary specific data on birds for Castlepoint Stream Estuary, however several bird species have been observed on the Castlepoint foreshore including a breeding population of red-billed gulls and white fronted terns (PNRP Appeals Version 2022).

The most significant pressures to Castlepoint Estuary include nutrient and pathogen inputs including stormwater, treated wastewater and catchment run off. Further, other pressures include, the modified entrance, localised bank erosion, public access, and weed incursions.

Table A4.1 Summary information for Castlepoint Stream Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	0.2	-
Intertidal Area (Ha; % Estuary)[1]	0.05	32.2
Dominant Estuary Substrate[1]	Sand	
Mud extent (>50% mud content)	-	-
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	0.01	27.8
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	1247	
Dominant Catchment Land Cover[2]	High producing grassland	
% Catchment indigenous vegetation[2]	7.6	
% Catchment exotic forest[2]	23.3	
% Producing grassland[2]	65.3	
Mean Freshwater Flow (m^3/s)[3]	0.2	
Catchment Nitrogen Load (T/y)[3]	6.2	
Catchment Phosphorus Load (T/y)[3]	1.4	
Catchment Sediment Load (KT/y)[3]	5.8	
Catchment Geology[4]	Argillite (Upper) Mudstone (Lower)	
Biodiversity		
Significant Site[4]	N	
Birds[5]	nd	
Fish[5]	Longfin eel, inanga, kōaro and redfin bully, black flounder, banded kokopu	
Shellfish	nd	
Pressures		
High nutrient and pathogen inputs from the modified catchment and stormwater and wastewater discharges. Potential restriction of entrance with sand build-up in the box culverts. Bank erosion. Public access to the estuary. Weeds and grasses common.		

[1]Field visit 5th April 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers, [5]PNRP Appeals Version (2022)

Table A4.2. Ecological Vulnerability Assessment, Castlepoint Stream.

Category	Score
Values	0.50
Pressures	0.59
Susceptibility	0.72
Condition	0.58
Average Score	0.60

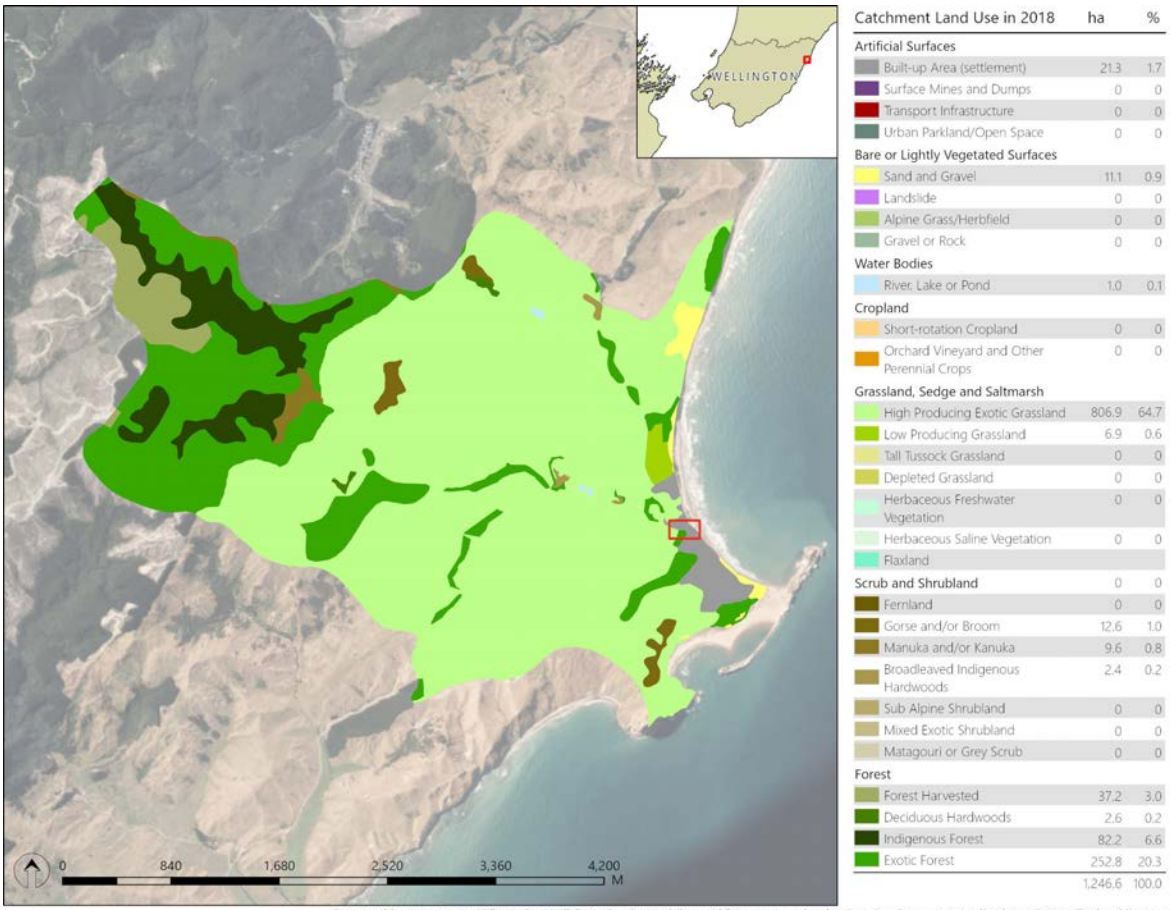


Fig. A4.1. Castlepoint Stream Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

Fig. A4.2. Castlepoint Stream Estuary dominant vegetation and substrate features.

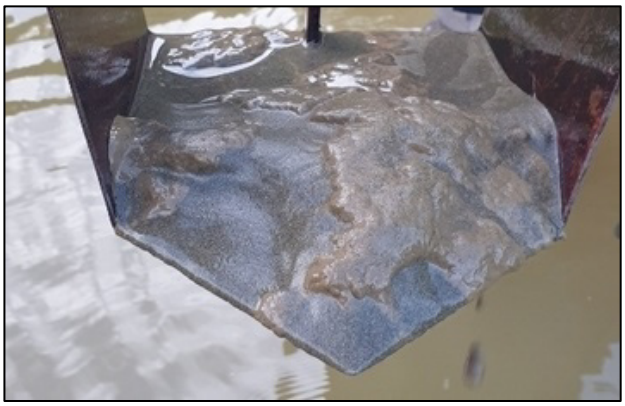
Castelpoint Stream Estuary flows under a concrete road bridge with box culverts, sand build-up narrows the entrance (top) and there is heavy rock armouring on the beach side (bottom)

Three-square near the road bridge (top) and narrow strip of marsh clubrush in the mid estuary (bottom)

Sand and cobble dominated lower estuary

Stream pollution warning sign for Castlepoint Stream

Raupō ~130m upstream of the road bridge



Fine sediments deposited over firm sands in the mid estuary

A5. NGĀKAUAU STREAM ESTUARY

Ngākauau Stream Estuary is a small-sized (4.3ha) river mouth lagoon that receives inputs from two streams Ngākauau Stream and a smaller unnamed stream to the north. Low flows and the dynamic movement of the sandbar cause the entrance to restrict and/or close on occasion (Todd et al. 2016; Robertson & Stevens 2007a). Water quality measurements taken on the 6th April 2022, when the entrance was open, showed the estuary was turbid and prone to stratification. While no other water quality issues were recorded at the time of sampling, prolonged periods of stratification upon restriction of the entrance and/or reduced flushing can lead to low oxygen conditions in the bottom waters and/or phytoplankton blooms.

No macroalgal issues were recorded in 2022, however in 2006 decaying macroalgae and enriched sediments were recorded in the estuary. In 2022, enriched (low oxygen) sandy muds were still present in the stream channels transitioning to sands toward the entrance. Very low cover of *Ruppia* sp. (horses mane weed) was recorded growing in soft sandy muds, however due to the high turbidity of the water column these areas could not be mapped accurately. Salt marsh comprised a narrow strip of rushland and herbfield on the stream margin, and there was evidence of salt marsh erosion in the upper reaches of Ngākauau Stream (see photo). Bank erosion was also common. Sheep have unrestricted access to the stream channel and a fence prevents access to the beach.

The estuary is site of significant indigenous biodiversity in the Proposed Natural Resources Plan (Schedule F4) because it provides habitat for threatened indigenous fish species (PNRP Appeals Version 2022). Four migratory fish have also been identified including "At Risk: Declining" species (longfin eel and inanga; Todd et al. 2016 and references therein). Several bird species, including but not limited to black shag, pied stilt, red-billed gull and variable oystercatcher have been sighted at Ngākauau Stream Estuary (Todd et al. 2016 and references therein).

The most significant pressures to Ngākauau Stream Estuary are nutrient and sediment inputs from the catchment, which are exacerbated by stratification and/or the entrance restriction or closure. Todd et al. (2016) noted a history of chemical contamination from the direct discharge of sheep drench up to the 1980's. The legacy of contamination in the soils persists today. Further, upstream hydrology of Ngākauau Stream has been historically altered with raised culverts at the road crossing preventing fish passage and tidal influence further upstream.

Table A5.1 Summary information for Ngākauau Stream Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	4.3	-
Intertidal Area (Ha; % Estuary)[1]	2.8	65.3
Dominant Estuary Substrate[1]	Sandy mud (subtidal)	
Mud extent (>50% mud content)	0.04	1.4
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	0.3	11.8
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	1707	
Dominant Catchment Land Cover[2]	High producing grassland	
% Catchment indigenous vegetation[2]	18.9	
% Catchment exotic forest[2]	37.9	
% Producing grassland[2]	42.9	
Mean Freshwater Flow (m^3/s)[3]	0.2	
Catchment Nitrogen Load (T/y)[3]	6.6	
Catchment Phosphorus Load (T/y)[3]	1.2	
Catchment Sediment Load (KT/y)[3]	3.5	
Catchment Geology[4]	Argillite (Upper) Sandstone & mudstone (Lower)	
Biodiversity		
Significant Site[4]	Y	
Birds[5]	Black shag, pied stilt, variable oystercatcher, red-billed gull	
Fish[5]	Common bully, short & longfin eel, inanga	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment. Erodible catchment, bank erosion. Restriction or closure of the estuary entrance. Stratification of the water column. Sheep access to streams. Historic chemical contamination from sheep drenching. Upstream culverts preventing fish passage.		

[1]Field visit 6th April 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers, [5]Todd et al. (2016)

Table A5.2. Ecological Vulnerability Assessment, Ngākauau Stream Estuary.

Category	Score
Values	0.57
Pressures	0.63
Susceptibility	0.66
Condition	0.62
Average Score	**0.62**

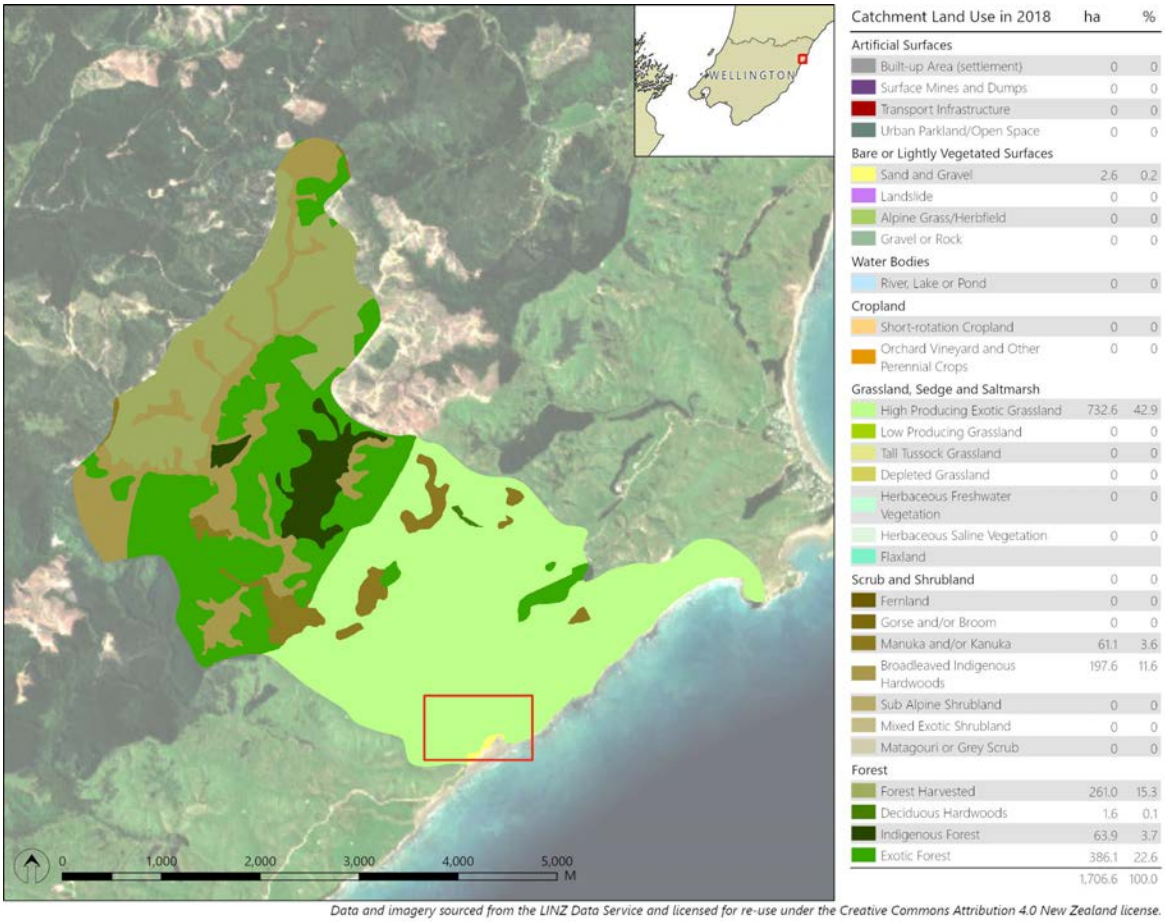


Fig. A5.1. Ngākauau Stream Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

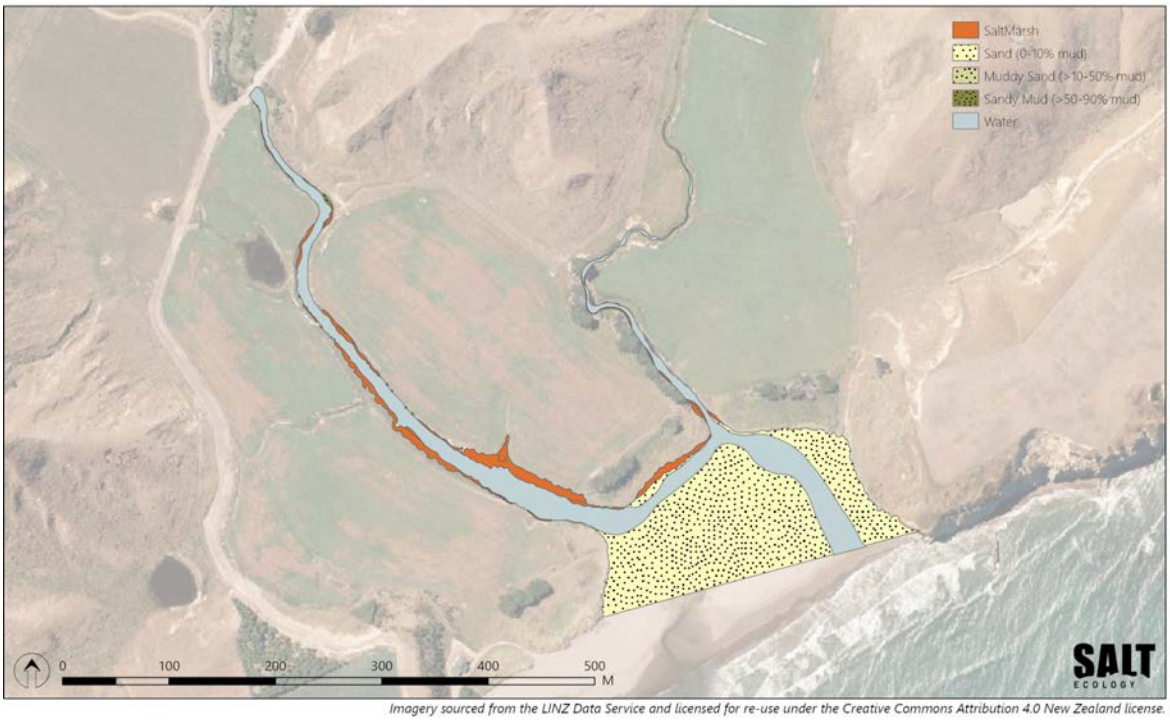


Fig. A5.2. Ngākauau Stream Estuary dominant vegetation and substrate features.

Unamed stream flowing into the lagoon toward the estuary entrance at the northern end of the beach (top) and the Ngākauau Stream outflow to the south connected to the lagoon (bottom)

Unamed stream with marsh clubrush on the margin (top) and Ngākauau Stream channel straightened with salt marsh rush on the margin and open access to animals (bottom)

Raised culverts on Ngākauau Stream preventing fish passage

Unfenced sheep grazing up to the estuary margin

Enriched soft sandy mud with fresh mud deposited on the surface (left) and sand deposited on anoxic soft sandy mud (right)

Eroding banks with salt marsh plants falling into the stream and unfenced crop on the margin

A6. HUMPIES STREAM ESTUARY

Humpies Stream Estuary is a small-sized (1.0ha) riverine river mouth lagoon estuary draining a small (440ha) catchment dominated by high producing grassland (sheep and beef). Tidal ingress is dependent on the dynamic entrance which commonly restricts and/or closes (Todd et al. 2016; Robertson & Stevens 2007a). In a site visit on 6th April 2022 the estuary was open to the sea, however, was still dominated by freshwater (salinity 0.3‰). Water quality measurements taken on the 6th April 2022, when the entrance was open, showed the estuary was turbid and potentially prone to stratification. While no other water quality issues were recorded at the time of sampling, prolonged periods of stratification upon restriction of the entrance and/or reduced flushing can lead to low oxygen conditions in the bottom waters and/or phytoplankton blooms. During times of restricted flushing, the estuary is particularly prone to nutrient, sediment and pathogen issues.

No macroalgal issues were recorded in 2022, however in 2006 decaying macroalgae and enriched sediments were recorded in the estuary. In 2022, soft sandy muds remain in the main channel but were well oxygenated and transitioned to sand dominated sediments toward the entrance. Very low cover of *Ruppia* sp. (horses mane weed) was recorded growing in soft sandy muds, however due to the high turbidity of the water column these areas could not be mapped accurately.

While the stream and estuary are not classified as significant the landowner has invested substantial effort planting and maintaining riparian vegetation since the 1990's which has led to well established native trees and a strip of salt marsh on the channel margin that includes salt marsh ribbonwood, searush and three-square. Birds frequent the estuary, including, but not limited to, pied stilt, variable oystercatcher, red-billed gull and the southern black-backed gull. While there are no fish records migratory fish likely enter the pool when the entrance is open to the sea, this was confirmed with an eel sighted during the April 2022 site visit however, the species was not confirmed.

The most significant pressures to Humpies Stream Estuary are nutrient and sediment inputs from the catchment, which are exacerbated when the entrance restricts or closes. Further, other pressures include, localised bank erosion, altered hydrology with a small culvert under the road and the presence of weeds and grasses.

Table A6.1 Summary information for Humpies Stream Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	1.0	-
Intertidal Area (Ha; % Estuary)[1]	0.8	79.4
Dominant Estuary Substrate[1]	Sand	
Mud extent (>50% mud content)	0.08	9.3
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	0.09	10.8
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	440	
Dominant Catchment Land Cover[2]	High producing grassland	
% Catchment indigenous vegetation[2]	11.1	
% Catchment exotic forest[2]	28.7	
% Producing grassland[2]	59.9	
Mean Freshwater Flow (m^3/s)[3]	0.1	
Catchment Nitrogen Load (T/y)[3]	2.3	
Catchment Phosphorus Load (T/y)[3]	0.6	
Catchment Sediment Load (KT/y)[3]	1.1	
Catchment Geology[4]	Argillite (Upper) Mudstone (Lower)	
Biodiversity		
Significant Site[4]	N	
Birds[5]	Pied stilt, variable oystercatcher, red-billed gull, southern black-backed gull	
Fish	nd	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment.		
Erodible catchment, bank erosion.		
Restriction or closure of the estuary entrance.		
Potential stratification of the water column.		
Weeds and grasses growing throughout plantings.		

[1]Field visit 6th April 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers, [5]Todd et al. (2016)

Table A6.2. Ecological Vulnerability Assessment, Humpies Stream Estuary.

Category	Score
Values	0.48
Pressures	0.73
Susceptibility	0.72
Condition	0.72
Average Score	**0.66**

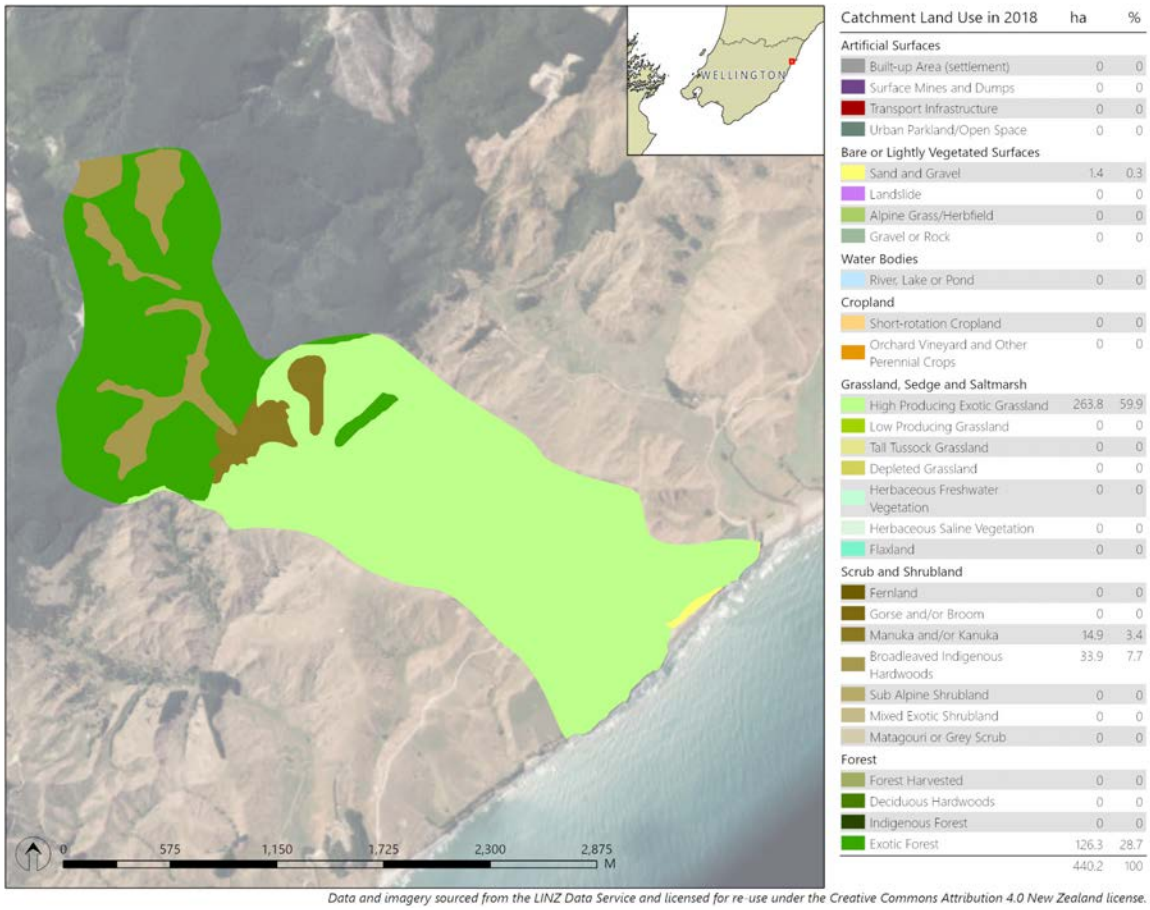


Fig. A6.1. Humpies Stream Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

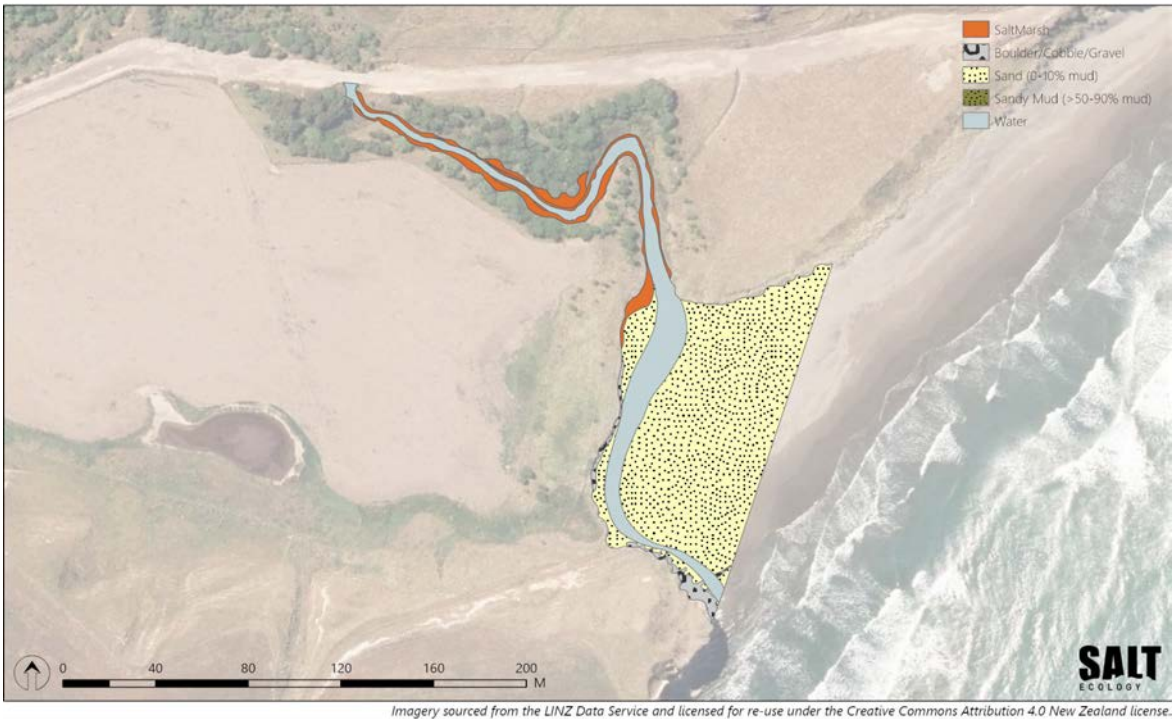


Fig. A6.2. Humpies Stream Estuary dominant vegetation and substrate features.

Humpies Stream Estuary flowing out to sea at the southern end of the beach (top) and the shallow narrow channel running along the margin with woody debris deposited on three-square (bottom)

Narrow band of marsh clubrush and salt marsh rush on the estuary margin (top) and native terrestrial plantings that have significantly grown since 2006 and are now well established (bottom)

Road crossing Humpies Stream ~300m from the estuary entrance, recent flooding exceed the height of the road (see flax on poles)

Salt marsh and established native bush plantings (planted in the 1990's) on the margin

Humpies Stream Estuary flowing onto the beach, marram dominated dunes in the background

A7. OTAHOME STREAM ESTUARY

Otahome Stream Estuary is a small-sized (1.9ha) river mouth lagoon that receives inputs from both Otahome Stream and a smaller unnamed stream to the south. Low flows and the dynamic movement of the sandbar cause the entrance to restrict and/or close on occasion (Todd et al. 2016; Robertson & Stevens 2007a). Water quality measurements taken on the 6th April 2022, when the entrance was open, showed the estuary was turbid and prone to stratification. While no other water quality issues were recorded at the time of sampling, prolonged periods of stratification upon restriction of the entrance and/or reduced flushing can lead to low oxygen conditions in the bottom waters and/or phytoplankton blooms.

No macroalgal issues were recorded in 2022, however in 2006 decaying macroalgae and enriched sediments were recorded in the estuary. In 2022, enriched (low oxygen) sandy muds were still present in the stream channels transitioning to sands toward the entrance. *Ruppia* spp. (horses mane weed) was recorded growing in soft sandy muds, along the channel margin and within the channel of the unnamed stream. Pugging damage was significant on the unnamed stream bed (see photo). No *Ruppia* spp. was recorded in the grab samples taken from the Otahome Stream. Because the sampling was not comprehensive it does not preclude its presence however, high water column turbidity likely limits its growth.

Historic straightening of the streams entering Otahome Estuary means that only a narrow strip of rushland and estuarine shrub remains, with steep banks on Otahome Stream restricting the area for potential salt marsh growth. However, unrestricted stock access (cattle) to both areas has left signs of visible salt marsh damage through pugging and grazing (see photo). While the Otahome Stream mouth is classified as a natural wetland, the stream and estuary are not classified as significant and there are no records of fish, however birds frequent the estuary. Bird species include, but are not limited to, New Zealand pipit, pied stilt, red-billed gull and the variable oystercatcher. It is likely that migratory fish enter the pool when the entrance is open to the sea.

The most significant pressures to Otahome Stream Estuary are nutrient and sediment inputs from the catchment, which are exacerbated by stratification and/or the entrance restriction or closure. Further, upstream hydrology of Otahome Stream has been historically altered, weeds and grasses are common and stock have unrestricted access to the streams with pugging observed, however the beach area is fenced.

Table A7.1 Summary information for Otahome Stream Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	1.9	-
Intertidal Area (Ha; % Estuary)[1]	1.5	77.2
Dominant Estuary Substrate[1]	Soft sandy mud	
Mud extent (>50% mud content)	0.4	29.2
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	0.4	28.0
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	685.9	
Dominant Catchment Land Cover[2]	High producing grassland	
% Catchment indigenous vegetation[2]	12.6	
% Catchment exotic forest[2]	20.8	
% Producing grassland[2]	65.9	
Mean Freshwater Flow (m^3/s)[3]	0.1	
Catchment Nitrogen Load (T/y)[3]	3.6	
Catchment Phosphorus Load (T/y)[3]	0.9	
Catchment Sediment Load (KT/y)[3]	2.4	
Catchment Geology[4]	Argillite (Upper) Mudstone (Lower)	
Biodiversity		
Significant Site[4]	N	
Birds[5]	Pied stilt, red-billed gull, New Zealand pipit, variable oystercatcher	
Fish	nd	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment.		
Erodible catchment, bank erosion.		
Restriction or closure of the estuary entrance.		
Stratification of the water column.		
Cattle access to streams.		
Historic channelisation of the stream.		
Weeds and grasses common on margin.		

[1]Field visit 6th April 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers, [5]Todd et al. (2016)

Table A7.2. Ecological Vulnerability Assessment, Otahome Stream Estuary.

Category	Score
Values	0.48
Pressures	0.61
Susceptibility	0.69
Condition	0.63
Average Score	0.60

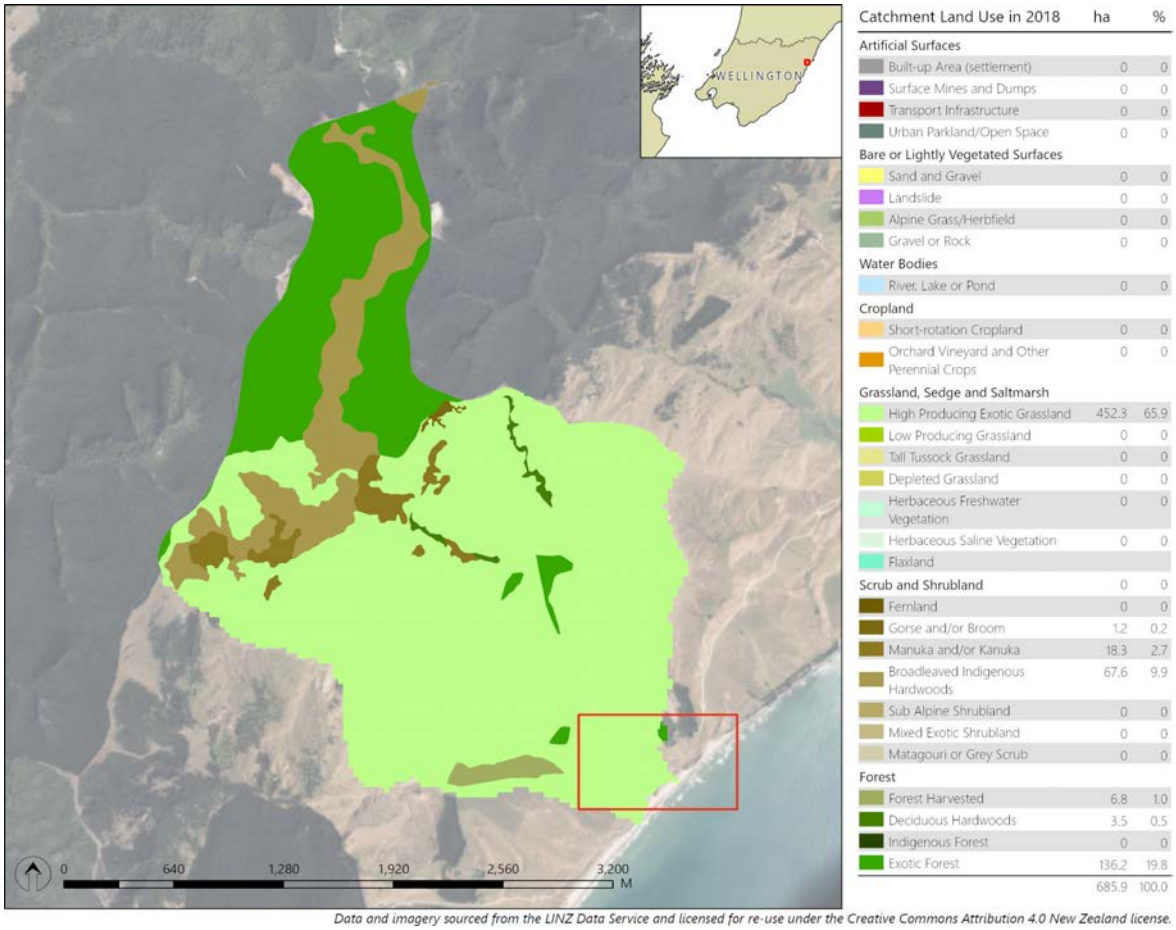


Fig. A7.1. Otahome Stream Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

Fig. A7.2. Otahome Stream Estuary dominant vegetation and substrate features.

Entrance of Otahome Stream Estuary (top) and view of Otahome Stream Estuary showing the two stream inputs (bottom)

Three-square at the entrance of the stream (top) and a narrow strip of marsh clubrush, rushland and estuarine shrub (bottom)

Soft sandy mud and *Ruppia* spp. within the straightened unamed small stream. Note significant pugging damage in foreground

Salt marsh, rushland and herbfield, and *Ruppia* spp. growing in pooled areas

Culverts on Otahome Stream under the road

Cattle grazing in the unfenced pasture next to the estuary

A8. OTAHOME STREAM SOUTH ESTUARY

Otahome Stream South Estuary is a very small-sized (0.2ha) riverine estuary draining a small (1263ha) catchment dominated by pasture. Tidal ingress is dependent on the dynamic entrance which commonly restricts and/or closes. During times of restricted flushing, the estuary is particularly prone to nutrient, sediment and pathogen issues.

In a site visit on 6th April 2022 the estuary was open to the sea, although the estuary remained freshwater dominated (salinity 0.3‰). Water clarity was poor, however there were no obvious signs of algal blooms or macroalgal growth. Soft sandy mud was common on the margin and freshly deposited in the mid-estuary over gravels. The substrate transitioned to sand moving toward the entrance. Relative to the size of the estuary, salt marsh was extensive with large areas of three-square and, upstream, the herb Bachelor's button. Stock can access the stream upstream of the road bridge and pugging damage on the stream bank and in the herbfield was recorded. *Ruppia* spp. was recorded upstream of the bridge in a strongly flowing section of the stream, and while it was not recorded downstream it may still be present. Some erosion of the spinifex foredune was observed (see photo).

Erosion of foredune, Otahome Stream South Estuary

The stream or estuary are not classified as significant and there are no records of birds or fish for the site. However, birds likely frequent the salt marsh and the dunes provide an important habitat for nesting birds. It is possible that migratory fish enter the estuary when the entrance is open to the sea.

The most significant pressures to Otahome Stream South Estuary are nutrient and sediment inputs from the catchment, which are exacerbated when the entrance restricts or closes. Other pressures include weeds and grasses, bank erosion, vehicle use on the beach and unrestricted stock access upstream of the road bridge with the beach area fenced.

Table A8.1 Summary information for Otahome Stream South Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	0.2	-
Intertidal Area (Ha; % Estuary)[1]	0.1	77.2
Dominant Estuary Substrate[1]	Soft sandy mud	
Mud extent (>50% mud content)	0.4	29.2
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	0.4	28.0
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	361	
Dominant Catchment Land Cover[2]	High producing grassland	
% Catchment indigenous vegetation[2]	22.3	
% Catchment exotic forest[2]	22.0	
% Producing grassland[2]	53.8	
Mean Freshwater Flow (m^3/s)[3]	0.1	
Catchment Nitrogen Load (T/y)[3]	1.7	
Catchment Phosphorus Load (T/y)[3]	0.5	
Catchment Sediment Load (KT/y)[3]	1.1	
Catchment Geology[4]	Argillite (Upper) Mudstone (Lower)	
Biodiversity		
Significant Site[4]	N	
Birds	nd	
Fish	nd	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment.		
Erodible catchment, bank erosion.		
Restriction or closure of the estuary entrance.		
Stock access upstream of bridge.		
Vehicle use on the beach.		
Weeds and grasses common on margin.		

[1]Field visit 6th April 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers

Table A8.2. Ecological Vulnerability Assessment, Otahome Stream South Estuary.

Category	Score
Values	0.40
Pressures	0.70
Susceptibility	0.73
Condition	0.64
Average Score	**0.62**

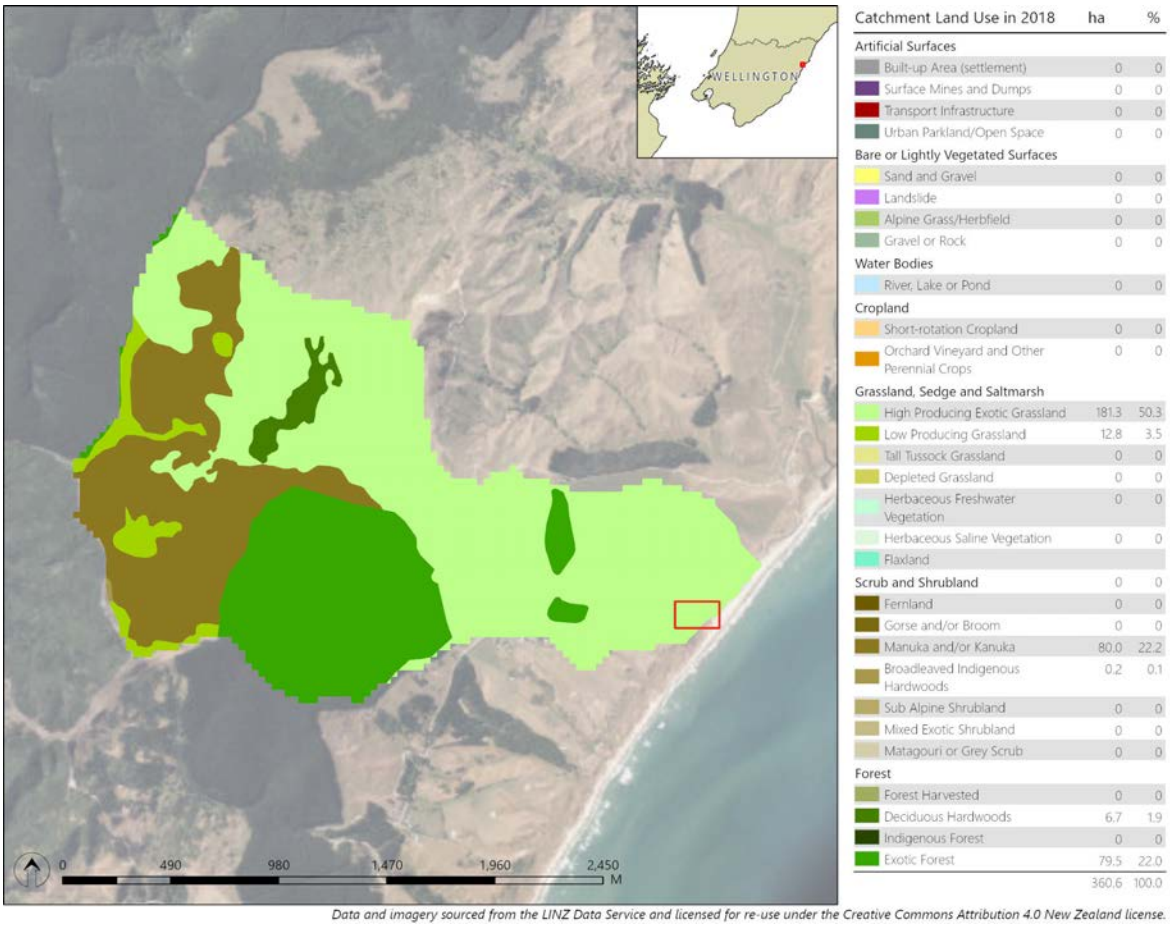


Fig. A8.1. Otahome Stream South Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

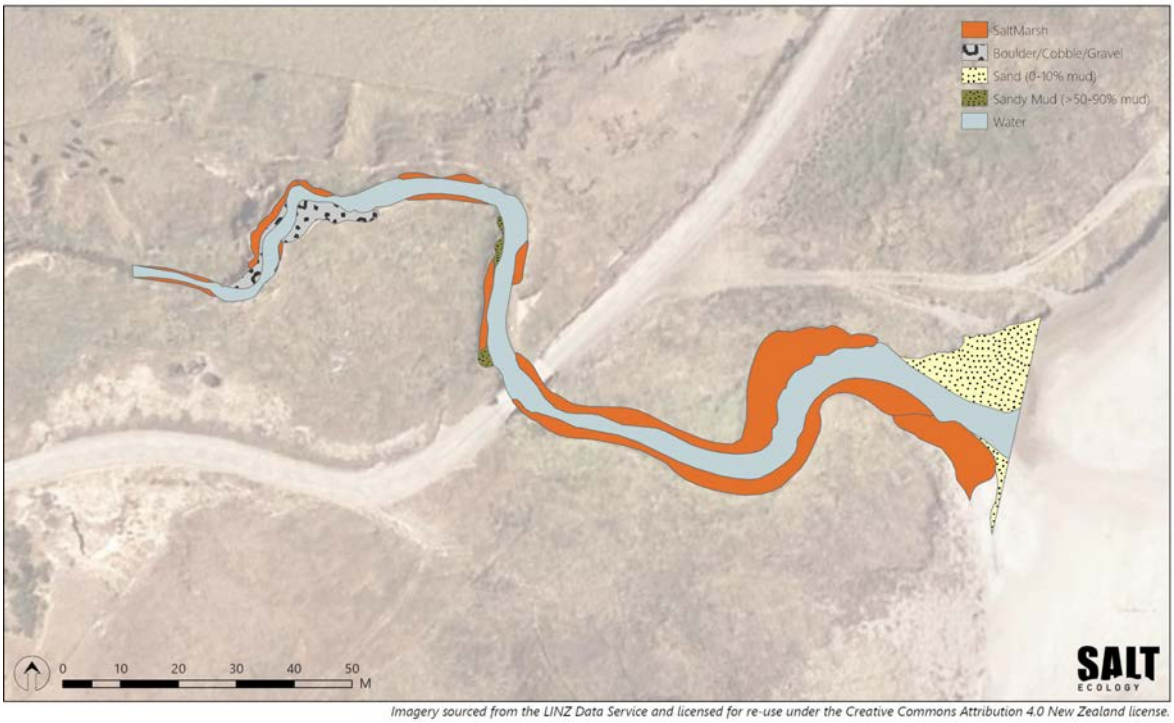


Fig. A8.2. Otahome Stream South Estuary dominant vegetation and substrate features.

Entrance of Otahome Stream South Estuary (top) and looking down across the entrance (bottom)

Both images show a narrow strip of three-square along the stream edge and unfenced grassland (top) and fenced grassland (bottom)

Three-square near the estuary entrance flattened and dying back at the end of summer

Ruppia spp. growing upstream of the bridge, likely maximum extent of saline intrusion

Stock access and pugging in herbfield upstream of the bridge

Vehicle access on the beach near the estuary entrance

A9. WHAREAMA RIVER ESTUARY

Whareama Estuary is a large tidal river estuary draining a large (52,249ha) catchment dominated by high producing pasture (sheep and beef). The entrance is permanently open to the sea. While the estuary is river-dominated and, during periods of low-flow, salt water intrudes up to 17km upstream from the mouth (Robertson & Stevens 2007a). Under low-flow conditions the estuary is commonly stratified, with fresh surface water overlying denser (heavier) seawater. This creates the potential for oxygen to become depleted in the bottom waters, nutrients to be released from the sediment (e.g. phosphorus release in the absence of oxygen), and phytoplankton blooms to develop if conditions (e.g. temperature and light availability) are suitable. In previous surveys, moderate macroalgal growth and high phytoplankton (i.e. green colour of water column) have been observed at times (Robertson & Stevens 2016). However, frequent periods of flushing (i.e. high river flows) have likely prevented these problems from persisting (Robertson & Stevens 2016).

The catchment is steep and susceptible to erosion, which is reflected in the estuary with high sediment muddiness and low water clarity due to suspended solids (Robertson & Stevens 2007a). Bank erosion and grazing along the estuary margin are also common (see photos). Because most of the immediate estuary margin is steep and dominated by grassland, pine and/or gorse, there is limited available habitat for salt marsh. Only small areas of rushland have been observed on the lower estuary margin and around small stream inputs with intertidal areas. A small area of seagrass has been observed in the mid-estuary, growing in very soft sandy muds. Despite the muddy, turbid conditions, shellfish appear abundant in the estuary, with mussels growing on hard rock substrate and cockles observed in soft-sediment areas (see photos). Sediment dwelling animals are mainly hardy species tolerant to high mud levels (Forrest et al. 2022)

The estuary is a site of significant indigenous biodiversity in the Proposed Natural Resources Plan (Schedule F4) because it provides habitat for threatened indigenous fish species (PNRP Appeals Version 2022). Important bird and fish species recorded in the estuary are listed in Table A9.1 (Todd et al. 2016).

The most significant pressures in Whareama River Estuary are nutrient and sediment inputs from the catchment, which are exacerbated by stratification and reduced flushing. Other pressures are listed in Table A9.1.

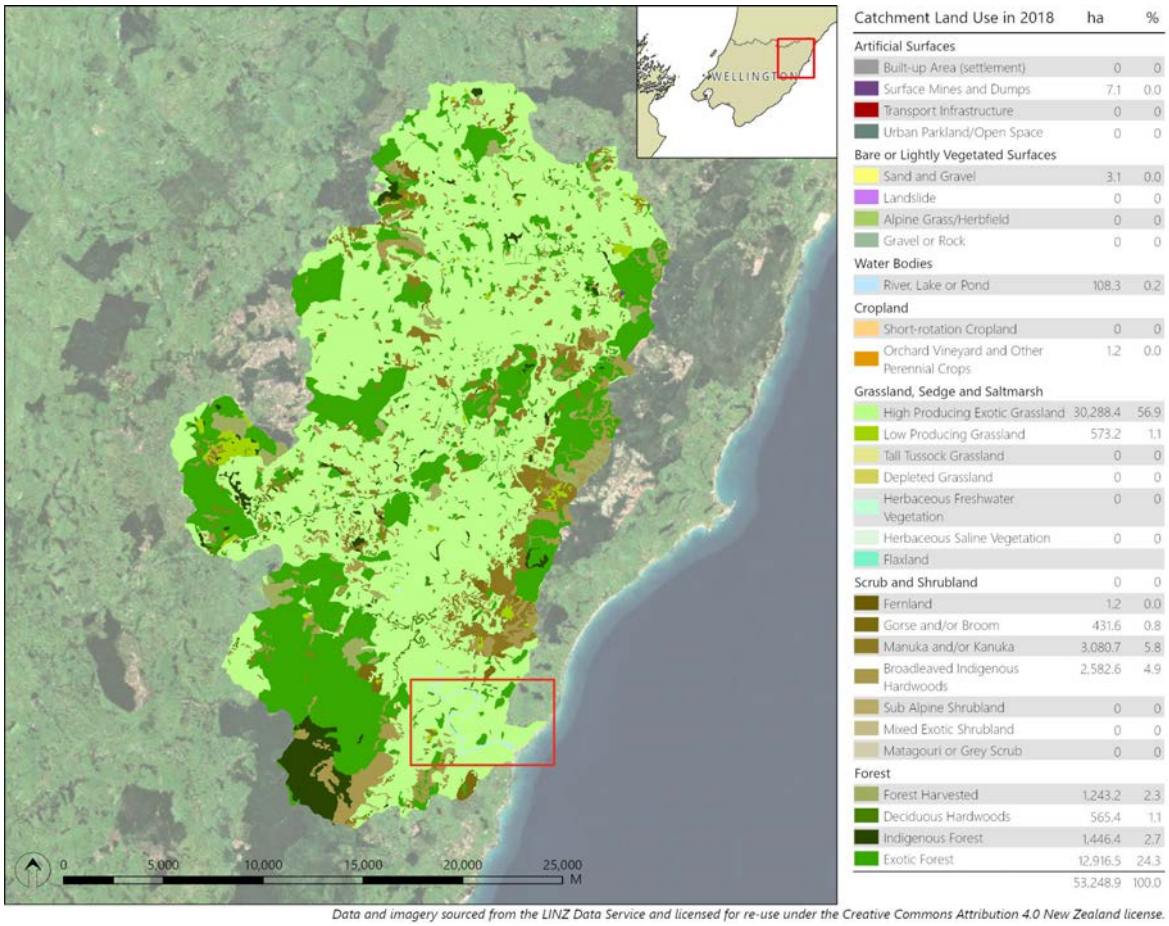
Table A9.1 Summary information for Whareama River Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	74.4*	-
Intertidal Area (Ha; % Estuary)[1]	20.1	26.9
Dominant Estuary Substrate[1]	Soft sandy mud	
Mud extent (>50% mud content)	10.7	53.0
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	0.02	0.10
Salt Marsh (Ha; % intertidal)[1]	0.2	1.0
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	53,249	
Dominant Catchment Land Cover[2]	High producing grassland	
% Catchment indigenous vegetation[2]	13.4	
% Catchment exotic forest[2]	26.6	
% Producing grassland[2]	58.0	
Mean Freshwater Flow (m^3/s)[3]	8.4	
Catchment Nitrogen Load (T/y)[3]	269.8	
Catchment Phosphorus Load (T/y)[3]	124.8	
Catchment Sediment Load (KT/y)[3]	217.9	
Catchment Geology[4]	Mostly Argillite, sandstone, mudstone & greywacke present	
Biodiversity		
Significant Site[4]	Y	
Birds[5]	Banded dotterel, Caspian tern, reef heron, red-billed gull, pied stilt	
Fish[5]	Longfin eel, giant kōkopu, inanga, lamprey	
Shellfish	Cockles	
Pressures		
Sediment and nutrient loads from modified catchment. Erodible catchment, bank erosion and slumping. Stratification of the water column. Reduced flushing under low flow conditions. Pine forestry on margin, stock access to the river. Recreational use (boats) and vehicle use in lower estuary. Weeds and grasses common on margin.		

[1]Field visit 31st March 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers, [5]Todd et al. (2016), *Mapped extent in March 2022, 113ha previously reported.

Table A9.2. Ecological Vulnerability Assessment, Whareama River Estuary.

Category	Score
Values	0.55
Pressures	0.70
Susceptibility	0.72
Condition	0.60
Average Score	0.64



Catchment Land Use in 2018	ha	%
Artificial Surfaces		
Built-up Area (settlement)	0	0
Surface Mines and Dumps	7.1	0.0
Transport Infrastructure	0	0
Urban Parkland/Open Space	0	0
Bare or Lightly Vegetated Surfaces		
Sand and Gravel	3.1	0.0
Landslide	0	0
Alpine Grass/Herbfield	0	0
Gravel or Rock	0	0
Water Bodies		
River, Lake or Pond	108.3	0.2
Cropland		
Short-rotation Cropland	0	0
Orchard Vineyard and Other Perennial Crops	1.2	0.0
Grassland, Sedge and Saltmarsh		
High Producing Exotic Grassland	30,288.4	56.9
Low Producing Grassland	573.2	1.1
Tall Tussock Grassland	0	0
Depleted Grassland	0	0
Herbaceous Freshwater Vegetation	0	0
Herbaceous Saline Vegetation	0	0
Flaxland		
Scrub and Shrubland	0	0
Fernland	1.2	0.0
Gorse and/or Broom	431.6	0.8
Manuka and/or Kanuka	3,080.7	5.8
Broadleaved Indigenous Hardwoods	2,582.6	4.9
Sub Alpine Shrubland	0	0
Mixed Exotic Shrubland	0	0
Matagouri or Grey Scrub	0	0
Forest		
Forest Harvested	1,243.2	2.3
Deciduous Hardwoods	565.4	1.1
Indigenous Forest	1,446.4	2.7
Exotic Forest	12,916.5	24.3
	53,248.9	100.0

Fig. A9.1. Whareama River Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

Fig. A9.2. Whareama River Estuary dominant vegetation and substrate features.

Seawater mixing with freshwater near the entrance (top) and the entrance of Whareama River Estuary with woody debris (bottom)

Small patch of seagrass growing in soft sandy mud (top) and cockles in soft sandy mud (bottom)

Vehicle tracks on the tidal flats of the lower estuary, gorse and pine on the margin

Cattle and sheep can access the estuary margin freely and bank slumping is common

Turbid surface water and three-square growing in a narrow strip of the upper intertidal area bordered by pasture

A slip directly depositing sediment and pine slash into the estuary

A10. MOTUWAIREKA STREAM ESTUARY

Motuwaireka Stream Estuary at Riversdale is a small (6.5ha) narrow river mouth lagoon that drains a moderate-sized (3353ha) catchment dominated by high producing grassland (sheep and beef). Low flows and the dynamic movement of the sandbar cause the entrance to restrict and/or close on occasion (Todd et al. 2016; Robertson & Stevens 2007a). Water quality deteriorates when the lagoon is isolated from the sea and flushing is limited. As such, on occasion, the mouth is manually opened to improve water quality outcomes. Since the mid-1990's water quality has deteriorated likely owing to the change in catchment land use and inefficiencies in local waste disposal (Stansfield 2000; Robertson & Stevens 2007a). While there were no obvious signs of phytoplankton blooms or macroalgal growth during the site visit on the 29th March 2022, sediments were highly enriched with black sulfidic anoxic mud below a fresh layer of sandy mud. In the early 2000's polluted sediments were excavated from the estuary to try and improve the deteriorating condition of the lagoon.

Tidal influence extends only a few hundred metres upstream from the lagoon area, with a dominance of freshwater vegetation (raupō) near the unnamed stream input. There is limited available habitat for salt marsh owing to the steep true right bank with only a narrow strip of salt marsh on the true left bank. *Ruppia* spp. (Horse's mane weed) has been reported previously (Todd et al. 2016).

The estuary is a site of significant indigenous biodiversity in the Proposed Natural Resources Plan (Schedule F4) because it is the only site in the Wellington region that supports a population of breeding New Zealand dotterels and is habitat for other threatened bird species (PNRP Appeals Version 2022). Several bird species, including but not limited to, New Zealand dotterel banded dotterel, black-billed gull, Caspian tern, pied shag, and red-billed gull have been sighted at Motuwaireka Stream Estuary with a comprehensive list in Todd et al. (2016). Eight migratory fish have also been identified including "At Risk: Declining" species (longfin eel, kōaro, redfin bully and inanga; Todd et al. 2016 and references therein).

The most significant pressures to Motuwaireka Stream Estuary are nutrient, pathogen and sediment inputs from the catchment including the adjacent township. Water quality and sediment issues are exacerbated when the entrance is restricted and/or closes. Other pressures include, public access, vehicle use, grazing near the margin, localised erosion and the presence of weeds and grasses.

Table A10.1 Summary information for Motuwaireka Stream Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	6.5	-
Intertidal Area (Ha; % Estuary)[1]	3.8	58.5
Dominant Estuary Substrate[1]	Soft sandy mud	
Mud extent (>50% mud content)	0.1	3.1
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	-	-
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	3,353	
Dominant Catchment Land Cover[2]	High producing grassland	
% Catchment indigenous vegetation[2]	24.0	
% Catchment exotic forest[2]	16.9	
% Producing grassland[2]	54.9	
Mean Freshwater Flow (m^3/s)[3]	0.6	
Catchment Nitrogen Load (T/y)[3]	17.2	
Catchment Phosphorus Load (T/y)[3]	4.4	
Catchment Sediment Load (KT/y)[3]	10.2	
Catchment Geology[4]	Argillite (Upper) Sandstone & mudstone (Lower)	
Biodiversity		
Significant Site[4]	N	
Birds[5]	New Zealand dotterel, banded dotterel, Caspian tern, pied shag	
Fish[5]	longfin eel, giant kōkopu, inanga, kōaro, redfin bully	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment.		
Pathogen loads from catchment and township.		
Entrance restriction or closure, mechanical openings.		
Poor water quality & enriched sediments.		
Grazing near the margin.		
High recreational use including vehicle access.		
Weeds and grasses common on margin.		

[1]Field visit 29th March 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers, [5]Todd et al. (2016)

Table A10.2. Ecological Vulnerability Assessment, Motuwaireka Stream Estuary.

Category	Score
Values	0.53
Pressures	0.71
Susceptibility	0.66
Condition	0.70
Average Score	0.65

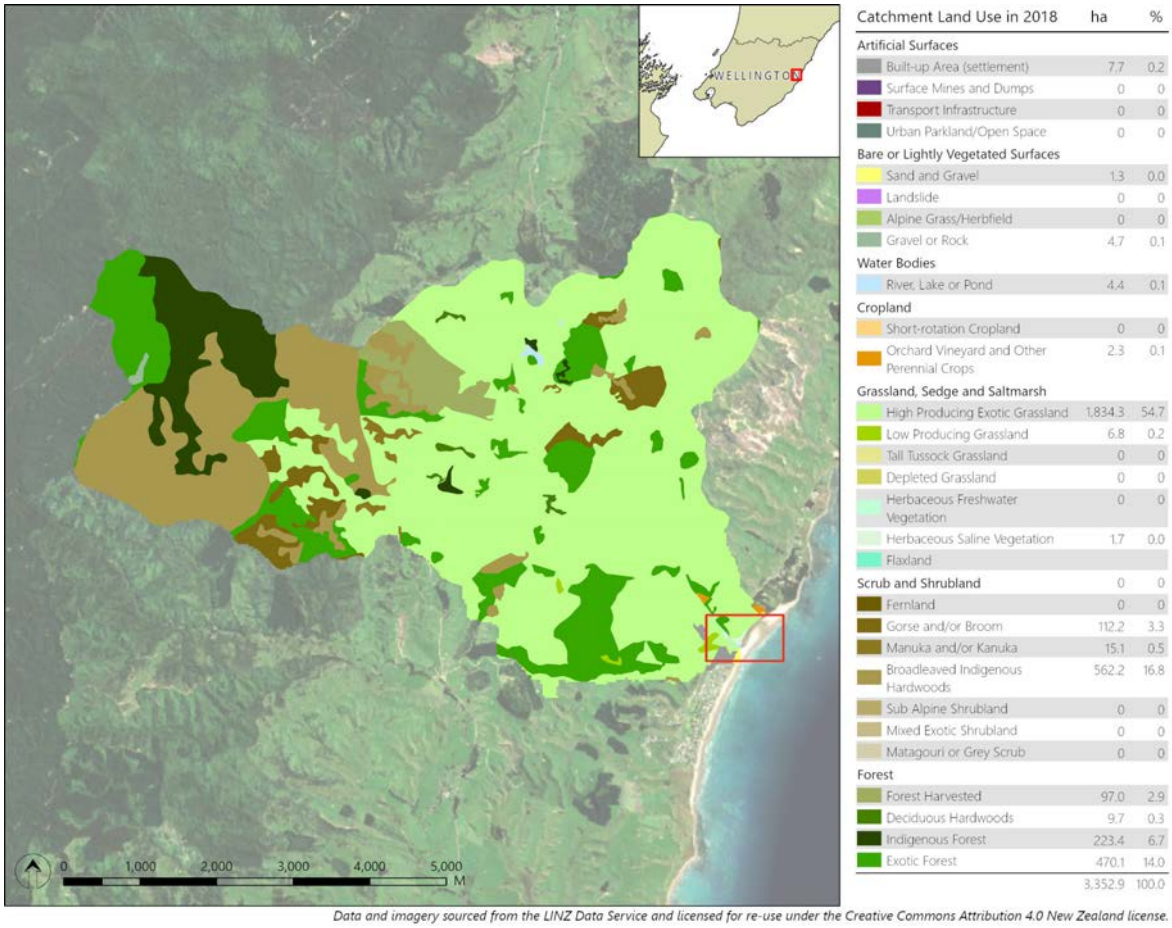


Fig. A10.1. Motuwaireka Stream Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

Fig. A10.2. Motuwaireka Stream Estuary dominant vegetation and substrate features.

Entrance of Motuwaireka Stream Estuary and eroding dune (top) and looking toward the entrance from upstream (bottom)

Raupō near the unamed stream input on the true left bank (top) and looking upstream across the grass dominated margin (bottom)

Narrow strip of three-square on the estuary on the margin toward the estuary entrance

Freshly deposited soft muds over organically enriched black anoxic sediments

Vehicle tracks on the beach area which is an important breeding area for New Zealand dotterels

Layer of compacted mud on the surface of clean sands, near the beach bend

A11. RIVERSDALE NORTH ESTUARY

Riversdale North Stream is a very small-sized (0.1ha) riverine estuary draining a very small (51ha) catchment dominated by high producing grassland. Low flows and the dynamic movement of the sandbar cause the entrance to restrict and/or close frequently, particularly in summer. In a site visit on the 29th March 2022, woody debris had accumulated in the narrow channel and was also deposited on the beach. There was also significant erosion of the marram dunes at the estuary entrance.

Riversdale North Stream is highly modified with the channel straightened, several culverts and underpasses and a grass dominated margin. The substrate is sand dominated, with no significant signs of enrichment. The stream flows through the golf course and township meaning nutrient and pathogen inputs are potentially high at times. Chlorophyll-*a*, a proxy for phytoplankton growth, was elevated in March 2022, however no macroalgal issues were recorded. Further, green algal mats were observed upstream of the road bridge suggesting nutrient inputs are high enough to support excess growth. During periods of low flow, restricted flushing and entrance closure the estuary is particularly prone to nutrient, sediment and pathogen issues. Additionally, when the stream mouth closes it presents a potential flooding risk upstream which could affect properties and the nearby golf course (PNRP Appeals Version 2022).

The stream or estuary are not classified as significant and there are no specific records of birds or fish for the site. However, Riversdale Beach supports a population of breeding New Zealand dotterels, banded dotterels, variable oystercatchers and pied stilt and is an important habitat for other birds. It is possible that migratory fish enter the estuary when the entrance is open to the sea.

The most significant pressures to Riversdale North Stream are nutrient and pathogen inputs from the catchment including the adjacent township and golf course. Water quality and pathogen issues are exacerbated when the entrance is restricted and/or closes. Other pressures include, public access, dune erosion, flooding when closed and the presence of weeds and grasses.

Table A11.1 Summary information for Riversdale North Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	0.06	-
Intertidal Area (Ha; % Estuary)[1]	0.05	74.9
Dominant Estuary Substrate[1]	Sand	
Mud extent (>50% mud content)	-	-
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	-	-
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	51	
Dominant Catchment Land Cover[2]	High producing grassland	
% Catchment indigenous vegetation[2]	10.2	
% Catchment exotic forest[2]	5.0	
% Producing grassland[2]	69.3	
Mean Freshwater Flow (m^3/s)[3]	0.01	
Catchment Nitrogen Load (T/y)[3]	0.3	
Catchment Phosphorus Load (T/y)[3]	0.03	
Catchment Sediment Load (KT/y)[3]	0.05	
Catchment Geology[4]	Gravels (Upper) Mudstone (Mid) Dune sands (Lower)	
Biodiversity		
Significant Site[4]	N	
Birds	nd	
Fish	nd	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment. Pathogen loads from catchment and township. Restriction or closure of the estuary entrance leading to water quality problems and potential flooding. Public access to the estuary. Dune erosion Build-up of woody debris. Weeds and grasses common on margin.		

[1]Field visit 29th March 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers

Table A11.2. Ecological Vulnerability Assessment, Riversdale North Estuary.

Category	Score
Values	0.27
Pressures	0.64
Susceptibility	0.67
Condition	0.63
Average Score	0.55

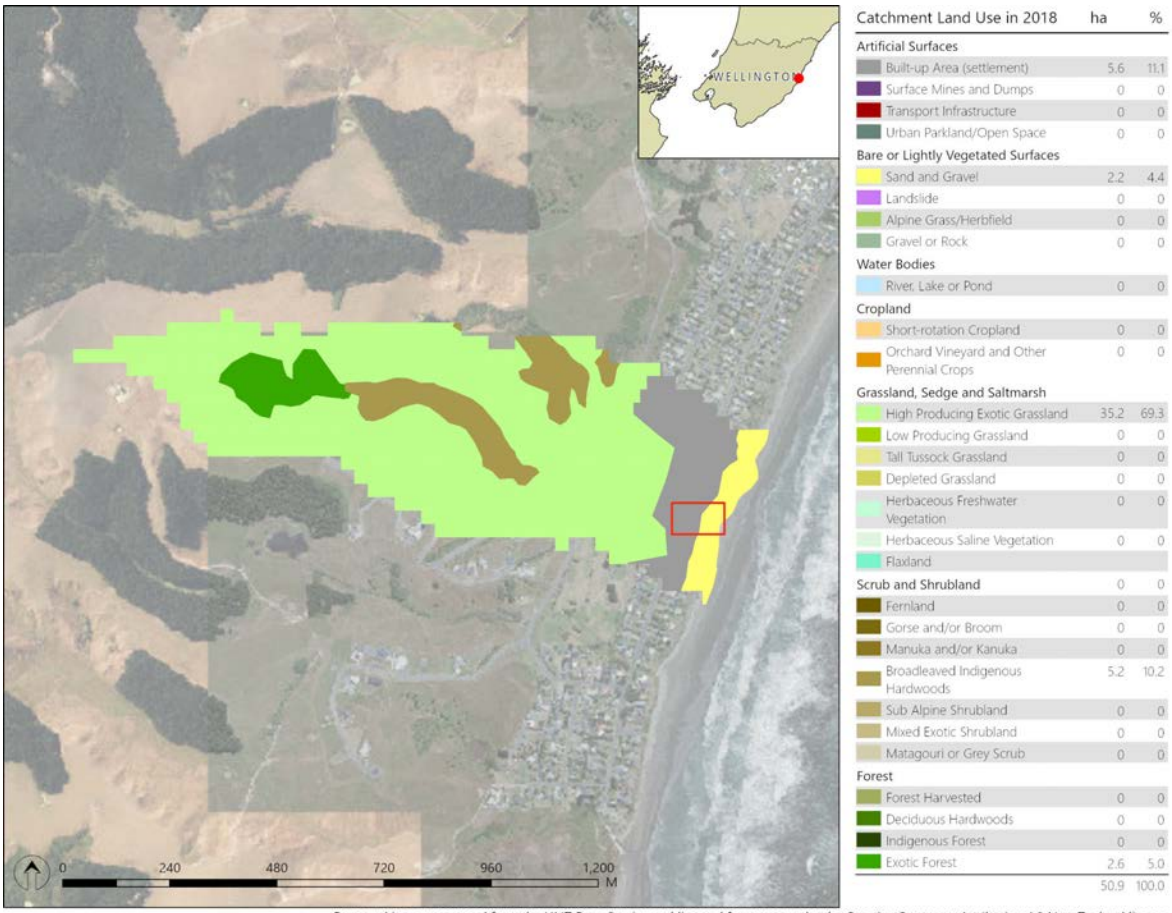


Fig. A11.1. Riversdale North Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

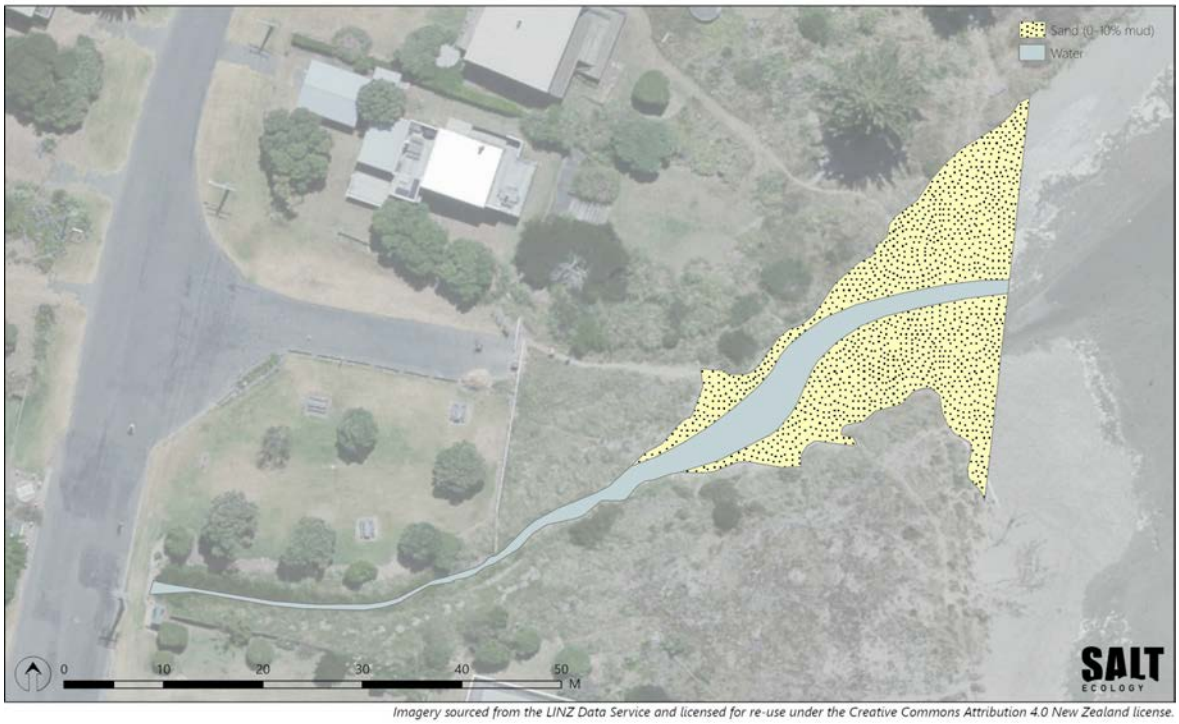


Fig. A11.2. Riversdale North Estuary dominant vegetation and substrate features.

Entrance of Riversdale North Stream and eroding dune (top) and looking upstream, significant flood debris in channel (bottom)

View upstream to road (top) and downstream from the road (bottom) with significant woody debris built up in the channel

Eroding dunes near the entrance of the stream and properties adjacent to the stream

Highly modified Riversdale North stream running through golf course upstream of the road, algal growths in shallow channel

Dune erosion and flood debris deposited on the beach at the entrance

Firm sand substrate in Riversdale North Stream

A12. RIVERSDALE CENTRE STREAM

Riversdale Centre Stream is a very small-sized (0.04ha) riverine estuary draining a very small (85ha) catchment dominated by high producing grassland. Low flows and the dynamic movement of the sandbar cause the entrance to restrict and/or close frequently, particularly in summer. In a site visit on the 29th March 2022, there was some woody debris in the channel and on the beach. Where the stream meets the beach there are artificial boulders on both banks, presumably installed as rock armouring to prevent erosion of the dunes. However, it does not appear to be successful with erosion commonly observed behind the boulders.

Riversdale Centre Stream is highly modified with the channel straightened, several culverts and underpasses and a grass dominated margin. The substrate is sand dominated, with no significant signs of enrichment. The stream flows through the golf course and township meaning nutrient and pathogen inputs are potentially high at times. Chlorophyll-*a*, a proxy for phytoplankton growth, was elevated in March 2022, however no macroalgal issues were recorded. During periods of low flow, restricted flushing, and entrance closure the estuary is particularly prone to nutrient, sediment and pathogen issues. Additionally, when the stream mouth closes it presents a potential flooding risk upstream which could affect properties and the nearby golf course (PNRP Appeals Version 2022).

The stream or estuary are not classified as significant and there are no specific records of birds or fish for the site. However, Riversdale Beach supports a population of breeding New Zealand dotterels, banded dotterels, variable oystercatchers and pied stilt and is an important habitat for other birds. It is possible that migratory fish enter the estuary when the entrance is open to the sea.

The most significant pressures to Riversdale Centre Stream are nutrient and pathogen inputs from the catchment including the adjacent township and golf course. Water quality and pathogen issues are exacerbated when the entrance is restricted and/or closes. Other pressures include, public access, dune erosion, flooding when closed and the presence of weeds and grasses.

Table A12.1 Summary information for Riversdale Centre Stream.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	0.04	-
Intertidal Area (Ha; % Estuary)[1]	0.03	69.3
Dominant Estuary Substrate[1]	Sand	
Mud extent (>50% mud content)	-	-
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	-	-
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	85	
Dominant Catchment Land Cover[2]	High producing grassland	
% Catchment indigenous vegetation[2]	0.0	
% Catchment exotic forest[2]	15.0	
% Producing grassland[2]	74.5	
Mean Freshwater Flow (m^3/s)[3]	0.01	
Catchment Nitrogen Load (T/y)[3]	0.5	
Catchment Phosphorus Load (T/y)[3]	0.03	
Catchment Sediment Load (KT/y)[3]	0.06	
Catchment Geology[4]	Gravels (Upper) Mudstone (Mid) Dune sands (Lower)	
Biodiversity		
Significant Site[4]	N	
Birds	nd	
Fish	nd	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment. Pathogen loads from catchment and township. Restriction or closure of the estuary entrance leading to water quality problems and potential flooding. Public access to the estuary. Dune erosion. Weeds and grasses common on margin.		

[1]Field visit 29th March 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers

Table A12.2. Ecological Vulnerability Assessment, Riversdale Centre Stream.

Category	Score
Values	0.27
Pressures	0.65
Susceptibility	0.62
Condition	0.62
Average Score	**0.54**

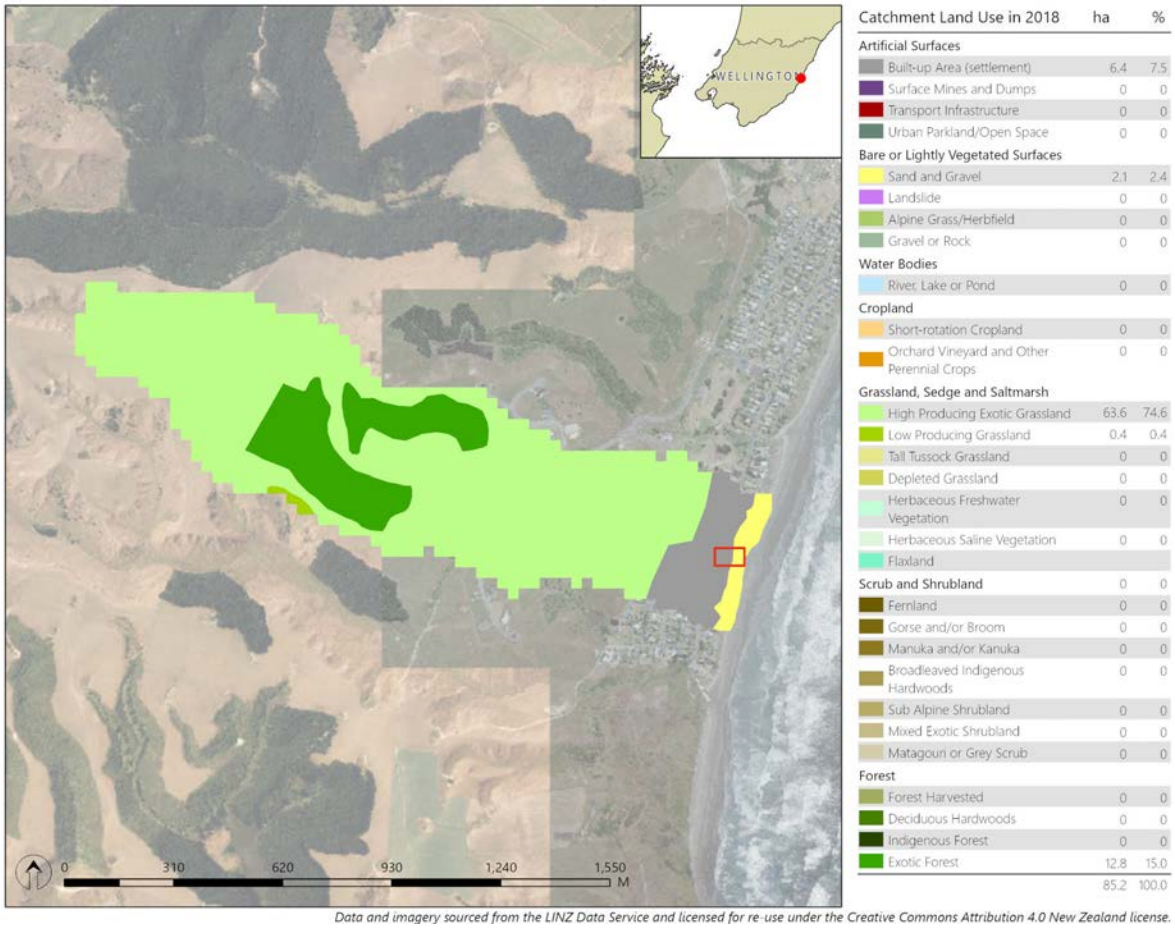


Fig. A12.1. Riversdale Centre Stream catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

Fig. A12.2. Riversdale Centre Stream dominant vegetation and substrate features.

Entrance of Riversdale Centre Stream (top) and looking upstream (bottom) artificial boulders on both banks to limit erosion

Looking downstream from bridge (top) and upstream from beach (bottom), woody debris in channel and grasses on margin

Artificial boulder field and eroding dune at the entrance of the Riversdale Centre Stream

Significant build up of woody debris at the road culvert, pooled water has poor water clarity

Looking downstream to the artificial boulder field on the true right bank

Firm sand substrate in Riversdale Centre Stream

A13. RIVERSDALE SOUTH STREAM

Riversdale South Stream is a very small-sized (0.1ha) riverine estuary draining a very small (168ha) catchment dominated by high producing grassland. Low flows and the dynamic movement of the sandbar cause the entrance to restrict and/or close frequently, particularly in summer. In a site visit on the 29th March 2022, there was some woody debris in the channel and on the beach. There was also significant erosion of the marram dunes at the estuary entrance.

In Riversdale South Stream the substrate is sand dominated, with no significant signs of enrichment. While the stream is on the edge of the township within the 100m margin there are houses, a walkway and public toilets meaning nutrient and pathogen inputs are potentially high at times. Chlorophyll-*a*, a proxy for phytoplankton growth, was elevated in March 2022, however no macroalgal issues were recorded. During periods of low flow, restricted flushing, and entrance closure the estuary is particularly prone to nutrient, sediment and pathogen issues. Additionally, when the stream mouth closes it presents a potential flooding risk upstream which could affect nearby properties (PRNP Appeals Version 2022).

Unlike the two streams further north, Riversdale South Stream has some small patches of marsh clubrush and three-square. The dunes flanking the estuary are marram dominated, with other species including spinifex, knobby clubrush and flax, although weeds are common. Upstream the margin is dominated by a mix of native plants and grasses, with adjacent wetland habitat present.

The stream or estuary are not classified as significant and there are no specific records of birds or fish for the site. However, Riversdale Beach supports a population of breeding New Zealand dotterels, banded dotterels, variable oystercatchers and pied stilt and is an important habitat for other birds. It is possible that migratory fish enter the estuary when the entrance is open to the sea.

The most significant pressures to Riversdale South Stream are nutrient and pathogen inputs from the catchment including the adjacent township. Water quality and pathogen issues are exacerbated when the entrance is restricted and/or closes. Other pressures include, public access, dune erosion, flooding when closed and the presence of weeds and grasses.

Table A13.1 Summary information for Riversdale South Stream.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	0.11	-
Intertidal Area (Ha; % Estuary)[1]	0.06	52.8
Dominant Estuary Substrate[1]	Sand	
Mud extent (>50% mud content)	-	-
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	0.01	12.3
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	168	
Dominant Catchment Land Cover[2]	High producing grassland	
% Catchment indigenous vegetation[2]	0.0	
% Catchment exotic forest[2]	11.7	
% Producing grassland[2]	79.1	
Mean Freshwater Flow (m^3/s)[3]	0.03	
Catchment Nitrogen Load (T/y)[3]	1.0	
Catchment Phosphorus Load (T/y)[3]	0.2	
Catchment Sediment Load (KT/y)[3]	0.3	
Catchment Geology[4]	Gravels (Upper) Mudstone (Mid) Dune sands (Lower)	
Biodiversity		
Significant Site[4]	N	
Birds	nd	
Fish	nd	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment. Pathogen loads from catchment and township. Restriction or closure of the estuary entrance leading to water quality problems and potential flooding. Public access to the estuary. Dune erosion. Weeds and grasses common on margin.		

[1]Field visit 6th April 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers

Table A13.2. Ecological Vulnerability Assessment, Riversdale South Stream.

Category	Score
Values	0.51
Pressures	0.71
Susceptibility	0.70
Condition	0.71
Average Score	**0.66**

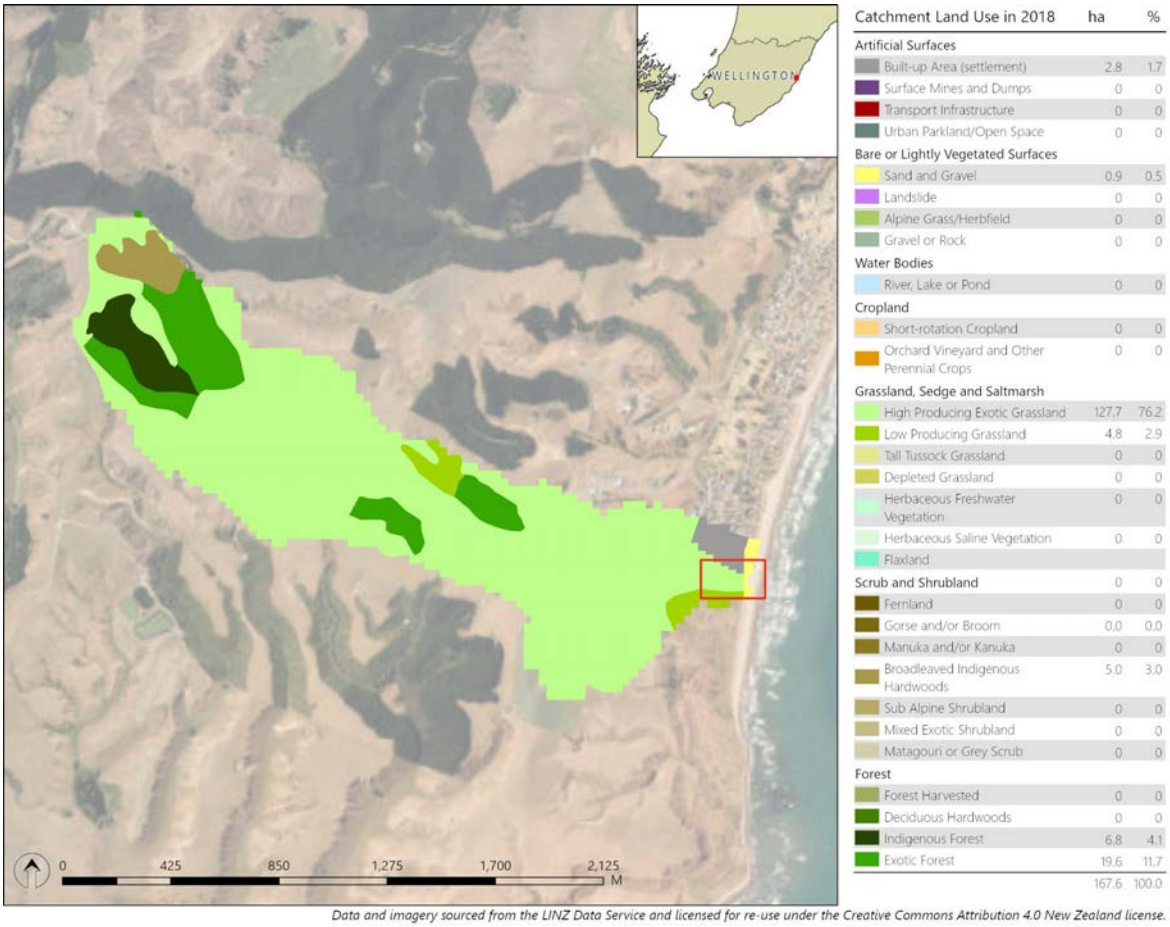


Fig. A13.1. Riversdale South Stream catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

Fig. A13.2. Riversdale South Stream dominant vegetation and substrate features.

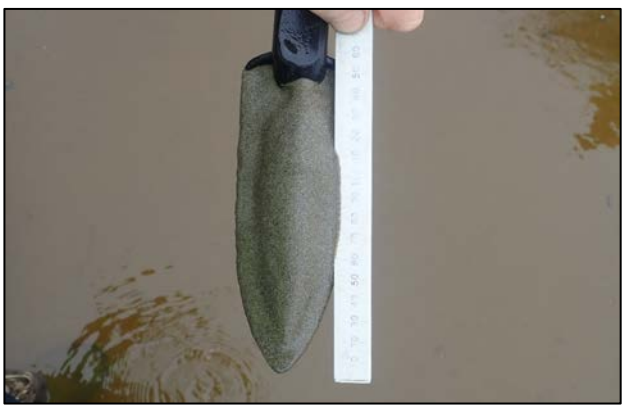
Entrance of Riversdale South Stream with eroding dunes on the margin (top), and view upstream from beach (bottom)

Views upstream to the walking bridge showing marsh clubrush and grasses on margin (top) and woody debris in channel (bottom)

Looking downstream from the walking bridge, marsh clubrush on the true right bank

Looking upstream from the walking bridge, grasses dominate the margin with some native species present

Three-square on the intertidal margin and public toilets in the background



Firm sand substrate in Riverdale South Stream

A14. WAIORONU STREAM ESTUARY

Waioronu Stream Estuary is a small-sized (1.4ha) river mouth lagoon draining a small (944ha) catchment dominated by high producing grassland. Commonly a large sand bar blocks the estuary entrance, with tidal flushing restricted other than when the entrance is open, i.e., after a large flood (Todd et al. 2016). The entrance generally closes rapidly (~3 days) as freshwater inputs recede. Saline extent reaches ~300m upstream, with the upper limit of saline intrusion restricted by a culvert (Todd et al. 2016). On occasion the lagoon is mechanically opened during winter to minimise flooding on adjacent land. In general, the waters in the lagoon are brackish and during periods of restricted flushing and closure, the estuary is particularly prone to nutrient, sediment and pathogen issues.

On 1st April 2022 the estuary was open to the sea, with freshwater on the surface and brackish waters on the bottom. The estuary was stratified at the road bridge. Oxygen was depleted in both the sediments (black anoxic muds) and the water column, ranging from 6-10% in the bottom waters and ~30% dissolved oxygen saturation in the surface waters. Low oxygen conditions can result from high organic matter loading (e.g. catchment inputs or breakdown of algal/ plant material) and/or prolonged periods of low flushing. Low oxygen events can significantly alter biogeochemical processes (e.g. release of sediment-bound phosphorus) and inhibit or reduce the migration success of native fish species moving through the estuary.

The Waioronu Stream Wetland is classified as significant and comprises the salt marsh around the lagoon. Salt marsh species include marsh clubrush, salt marsh ribbonwood, three-square, searush and herbfield (see photos). *Ruppia* spp. (Horses mane weed) was also present in the main lagoon. The salt marsh and tidal flats support several bird species, including, but not limited to, banded dotterel, Caspian tern, pied stilt and the red-billed gull (Todd et al. 2016 and references therein). While there are no fish records for the site it is possible that migratory fish enter the estuary when the entrance is open to the sea.

The most significant pressures to Waioronu Stream Estuary include sediment and nutrient loads from the modified catchment (pasture), and restriction of the estuary entrance increasing the susceptibility of the estuary to water quality deterioration (e.g. phytoplankton blooms and/ or low oxygen). Other pressures include channelisation upstream of the estuarine area, adjacent pasture, and weeds and grasses common on the margin.

Table A14.1 Summary information for Waioronu Stream Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	1.4	-
Intertidal Area (Ha; % Estuary)[1]	0.6	41.7
Dominant Estuary Substrate[1]	Soft sandy mud	
Mud extent (>50% mud content)	-	-
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	0.4	-
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	944	
Dominant Catchment Land Cover[2]	High producing grassland	
% Catchment indigenous vegetation[2]	0.8	
% Catchment exotic forest[2]	5.2	
% Producing grassland[2]	86.6	
Mean Freshwater Flow (m^3/s)[3]	0.1	
Catchment Nitrogen Load (T/y)[3]	6.3	
Catchment Phosphorus Load (T/y)[3]	0.3	
Catchment Sediment Load (KT/y)[3]	0.5	
Catchment Geology[4]	Gravels (Upper) Mudstone (Mid) Dune sands (Lower)	
Biodiversity		
Significant Site[4]	Y	
Birds[5]	Banded dotterel, Caspian tern, pied stilt, red-billed gull	
Fish	nd	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment. Erodible catchment. Poor water quality in periods of closure/ restriction. Low oxygen conditions in water column and sediment. Weeds and grasses common on margin.		

[1]Field visit 1st April 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers, [5]Todd et al. (2016)

Table A14.2. Ecological Vulnerability Assessment, Waioronu Stream Estuary.

Category	Score
Values	0.65
Pressures	0.69
Susceptibility	0.74
Condition	0.60
Average Score	0.67

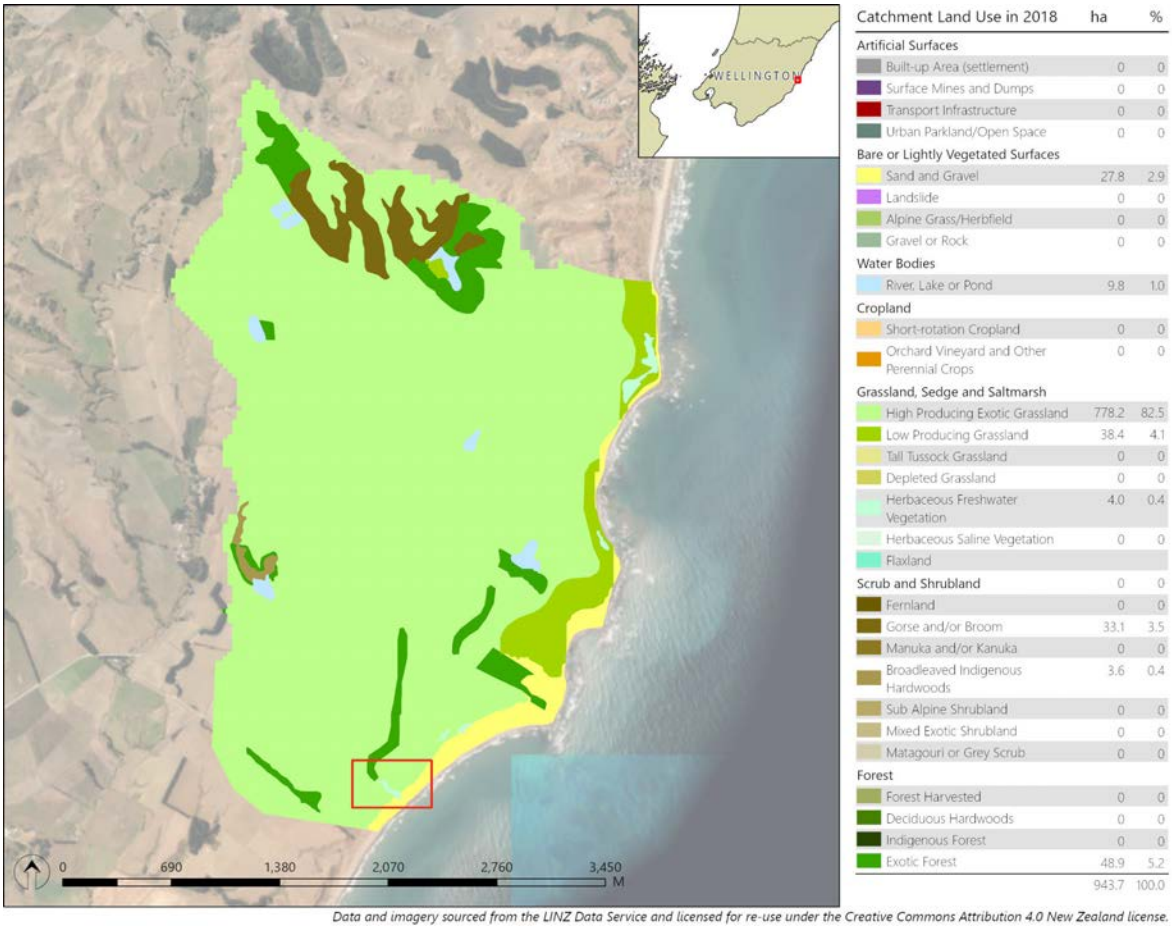


Fig. A14.1. Waioronu Stream Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

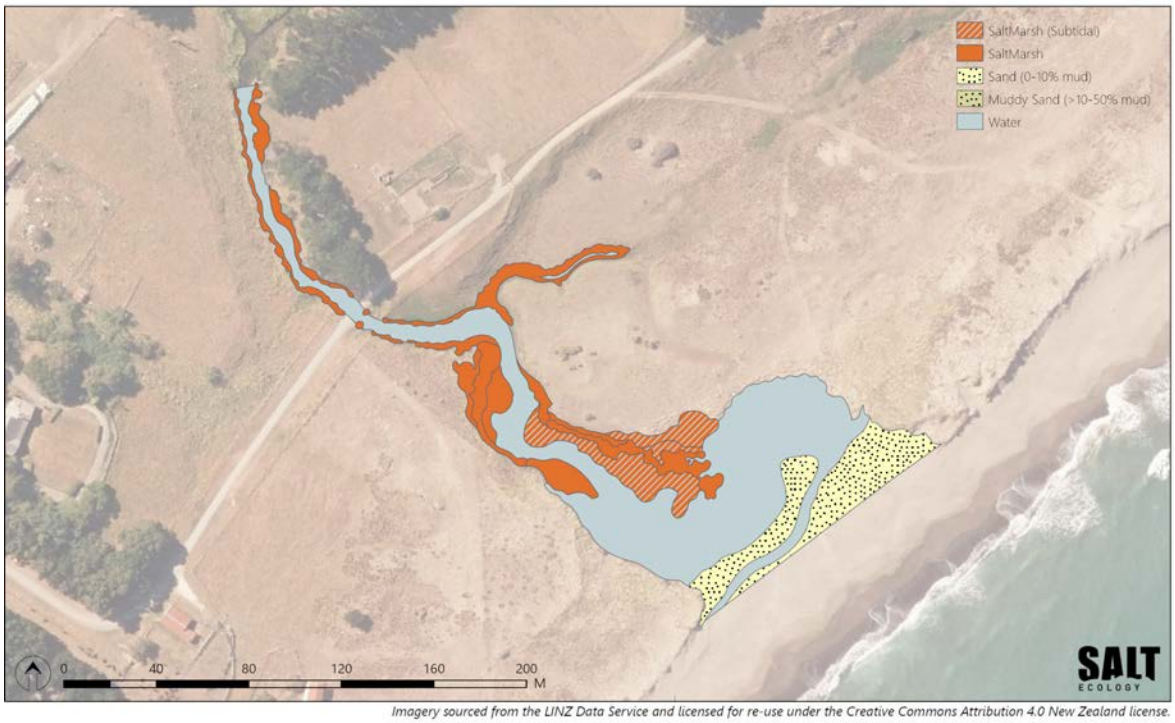


Fig. A14.2. Waioronu Stream Estuary dominant vegetation and substrate features. Note subtidal salt marsh would normally be intertidal under base flow conditions (the survey followed a high rainfall event).

Outflow to the lagoon meandering around a narrow sandbar (top) and entrance of Waioronu Stream along the dune (bottom)

Narrow band of salt marsh on margin of Waioronu Stream (top) and high water level at the time of sampling (bottom)

Looking downstream from the road bridge, tannin rich waters

High water level inundating herbfield and rushland

Soft, anoxic sandy mud with dense growth of *Ruppia* spp.

A15. PATANUI STREAM ESTUARY

Patanui River Estuary is a small-sized (1.0ha) river mouth estuary with lagoon draining a moderate-sized (3483ha) catchment dominated by high producing grassland with some exotic forestry in the upper catchment. The entrance to the estuary is dynamic and periodically restricts and/or closes. During times of restricted flushing, the estuary is particularly prone to nutrient, sediment and pathogen issues.

The lower estuary has changed dramatically since previous surveys (pre-2010). Where Patanui Stream used to flow southwest and form a lagoon behind a large sandpit, today the stream flows directly onto the beach, is disconnected from the lagoon, and the sandspit has almost completely eroded away (see photo and Fig. A15.2). Erosion is ongoing and to the northeast of the channel there are now steep eroding cliffs. Within the stream, bank slumping and erosion is common.

On 30th March 2022 the estuary was open to the sea, although still dominated by freshwater (salinity 0.2‰). Previous studies have recorded tidal influence up to 3km upstream of the entrance (Todd et al. 2016). In the stream chlorophyll-*a*, a proxy for phytoplankton was slightly elevated and high in the neighbouring lagoon. Aerial imagery confirms the lagoon is prone to phytoplankton blooms. Sediments were sand and gravel dominated with some recent fine sediment deposition on the surface. Sediments in the lagoon were low in oxygen, while sediments in the stream were well oxygenated.

There is limited salt marsh in Patanaui Stream due to the steep nature of the banks, however there are salt marsh plants around the lagoon, and between the stream and lagoon there is a wetland area dominated by umbrella sedge, knobby clubrush and swamp sedge. While the Patanui Stream mouth is classified as a natural wetland, the stream and estuary are not classified as significant and there are no records of fish. However, birds frequent the estuary including, but not limited to, red-billed gull, royal spoonbill, variable oystercatcher and southern black-backed gull. It is likely that migratory fish enter the lagoon and stream when open to the sea.

The most significant pressures to Patanui Stream Estuary include sediment and nutrient loads from the modified catchment (pasture), and restriction of the estuary entrance increasing the susceptibility of the estuary to water quality deterioration. Other pressures include accelerated coastal erosion, bank slumping and erosion, weeds and grasses common on the margin.

Table A15.1 Summary information for Patanui Stream Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	1.0	-
Intertidal Area (Ha; % Estuary)[1]	0.1	12.2
Dominant Estuary Substrate[1]	Sand/gravel	
Mud extent (>50% mud content)	-	-
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	0.01	10.8
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	3483	
Dominant Catchment Land Cover[2]	High producing grassland	
% Catchment indigenous vegetation[2]	26.2	
% Catchment exotic forest[2]	11.3	
% Producing grassland[2]	54.3	
Mean Freshwater Flow (m^3/s)[3]	0.7	
Catchment Nitrogen Load (T/y)[3]	18.6	
Catchment Phosphorus Load (T/y)[3]	3.5	
Catchment Sediment Load (KT/y)[3]	7.3	
Catchment Geology	Argillite & mudstone (Upper) Alluvium & gravels (Mid) Dune sands (Lower)	
Biodiversity		
Significant Site[4]	N	
Birds[5]	Red-billed gull, royal spoonbill, variable oystercatcher, southern black-backed gull	
Fish	nd	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment. Erodible catchment, bank erosion, rapid coastal erosion. Poor water quality in periods of closure/ restriction. Poor sediment and water quality in the adjacent lagoon. Private recreational use by landowner. Weeds and grasses common on margin.		

[1]Field visit 30th March 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers, [5]Todd et al. (2016)

Table A15.2. Ecological Vulnerability Assessment, Patanui Stream Estuary.

Category	Score
Values	0.43
Pressures	0.72
Susceptibility	0.72
Condition	0.72
Average Score	0.65

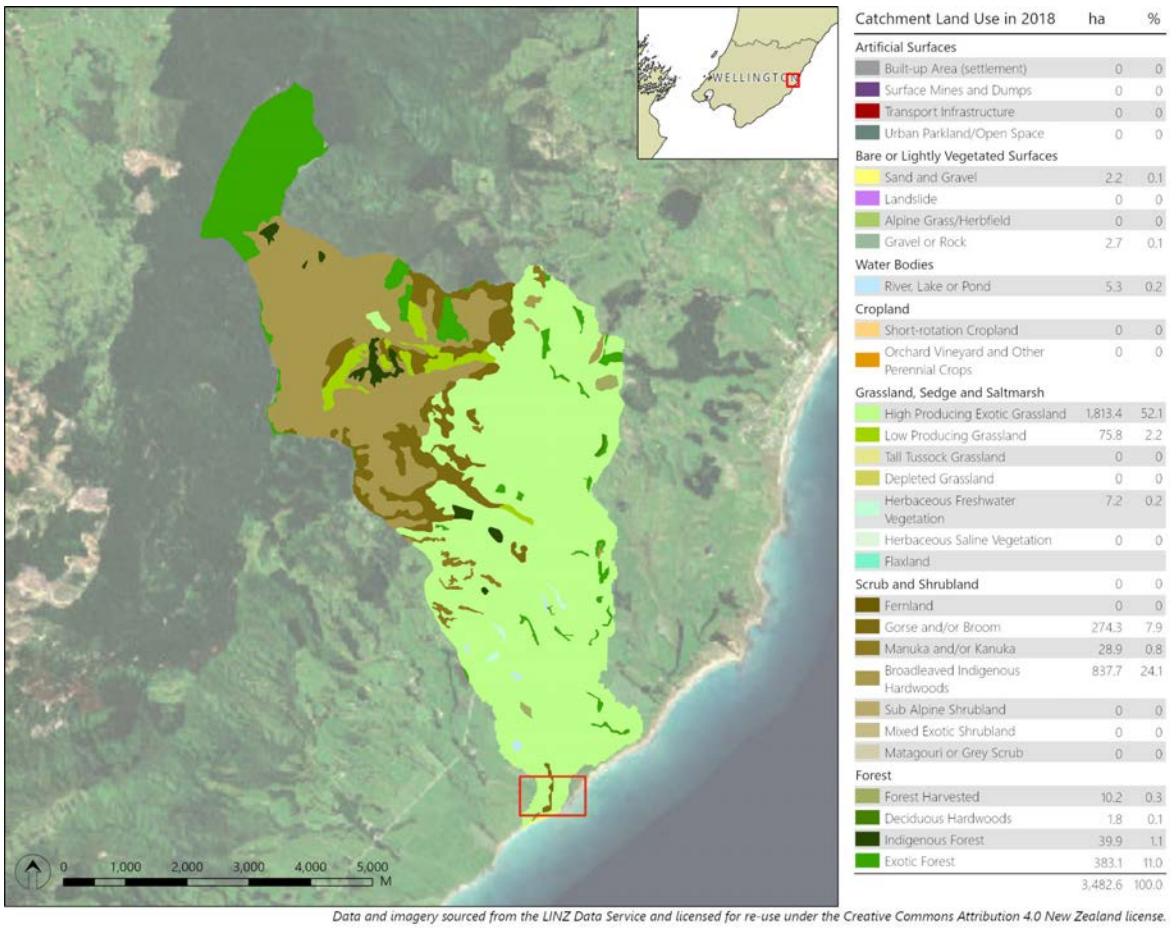


Fig. A15.1. Patanui Stream Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

Fig. A15.2. Patanui Stream Estuary dominant vegetation and substrate features.

Outflow to Patanui Stream (top) and view looking upstream from beach with a steep eroding cliff on the true left bank (bottom)

Erosion of dune and wetland vegetation (top) and wetland area between the lagoon and stream (bottom)

Looking downstream toward the estuary entrance

True left bank slumping, erosion observed on both banks

Patanui Lagoon, south of Patanui Stream. The estuary previously discharged to the coast via the lagoon (see photo opposite) but now drains directly to the sea with the lagoon now disconnected

Patanui Stream Estuary in 2006 (image source: Google Earth). The present day lagoon is cut off from the main stream and much of the coastal dune has eroded away (see Fig. A15.2 for 2022 status)

A16. WAIKARAKA STREAM ESTUARY

Waikaraka Stream Estuary is a small-sized (1.0ha) river mouth lagoon draining a moderate-sized (1631ha) catchment dominated by high producing grassland (sheep and beef). The entrance to the estuary is dynamic and frequently restricts and/or closes (Todd et al. 2016). Previous studies have recorded tidal influence up to 2km upstream when the entrance is open (Todd et al. 2016). However, during times of restricted flushing, the estuary is particularly prone to nutrient, sediment and pathogen issues. Waikaraka Stream has been heavily modified, with a tributary toward the southwest now disconnected from the main stream, and other parts of the main channel straightened.

On 30th March 2022 the estuary was open to the sea, although still dominated by freshwater (salinity 0.3‰). While there were no water quality or macroalgal issues at the time of sampling, the subtidal substrate was soft sandy mud and it was highly enriched with a very fine layer of freshly deposited oxygenated sediment on top of anoxic muds. *Ruppia* spp. was growing in the subtidal area (see photo). While algae were not elevated in the Waikaraka Stream, it was observed growing in the disconnected tributary to the southwest that overflows into the Waikaraka Stream after high rainfall. This suggests that nutrient inputs are high enough to support excess algal growth, a potential problem when the entrance is closed.

Marsh clubrush was growing in thick strips along the estuary margin and raupō was growing in the disconnected tributary to the southwest. While the Waikaraka Stream mouth is classified as a natural wetland, the stream and estuary are not classified as significant and there are no records of fish. However, birds frequent the estuary including, but not limited to, red-billed gull, pied stilt, southern black-backed gull and variable oystercatcher. It is likely that migratory fish enter the lagoon and stream when the entrance is open to the sea.

The most significant pressures to Waikaraka Stream Estuary include sediment and nutrient loads from the modified catchment (pasture), and restriction of the estuary entrance increasing the susceptibility to water quality deterioration. Other pressures include significant historic modification of the channel and tributary margins, with introduced weeds and grasses also common.

Table A16.1 Summary information for Waikaraka Stream Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	1.3	-
Intertidal Area (Ha; % Estuary)[1]	0.4	32.4
Dominant Estuary Substrate[1]	Soft sandy mud	
Mud extent (>50% mud content)	0.3	61.3
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	0.3	61.6
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	1631	
Dominant Catchment Land Cover[2]	High producing grassland	
% Catchment indigenous vegetation[2]	18.1	
% Catchment exotic forest[2]	11.8	
% Producing grassland[2]	66.5	
Mean Freshwater Flow (m^3/s)[3]	0.3	
Catchment Nitrogen Load (T/y)[3]	10.8	
Catchment Phosphorus Load (T/y)[3]	1.2	
Catchment Sediment Load (KT/y)[3]	2.3	
Catchment Geology[4]	Argillite (Upper) Mudstone (Mid) Alluvium & gravels (Lower)	
Biodiversity		
Significant Site[4]	N	
Birds[5]	Red-billed gull, pied stilt, southern black-backed gull, variable oystercatcher	
Fish	nd	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment. Erodible catchment. Poor water quality in periods of closure/ restriction. Historic modification of estuary and tributaries. Private recreational use by landowner. Weeds and grasses common on margin.		

[1]Field visit 30th March 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers, [5]Todd et al. (2016)

Table A16.2. Ecological Vulnerability Assessment, Waikaraka Stream Estuary.

Category	Score
Values	0.48
Pressures	0.72
Susceptibility	0.72
Condition	0.65
Average Score	0.64

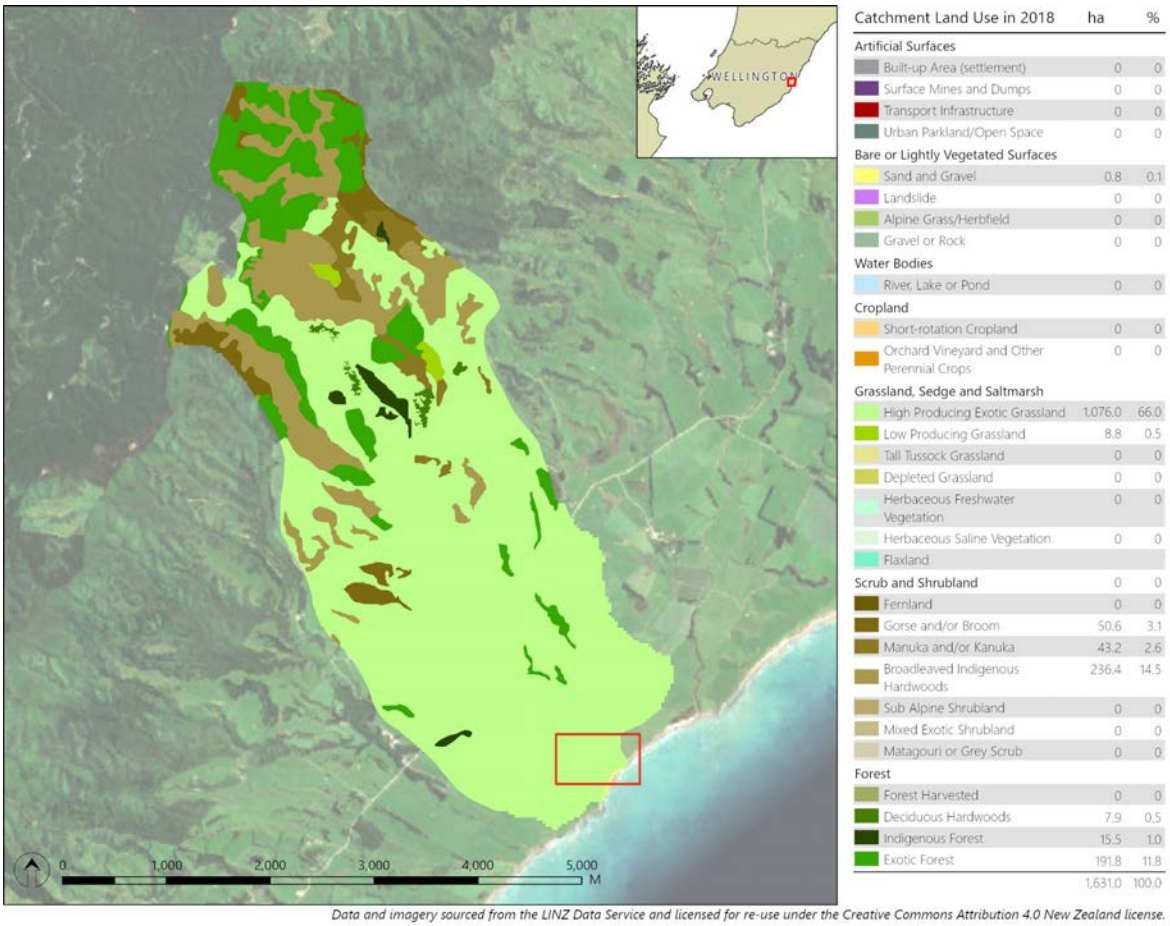


Fig. A16.1. Waikaraka Stream Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

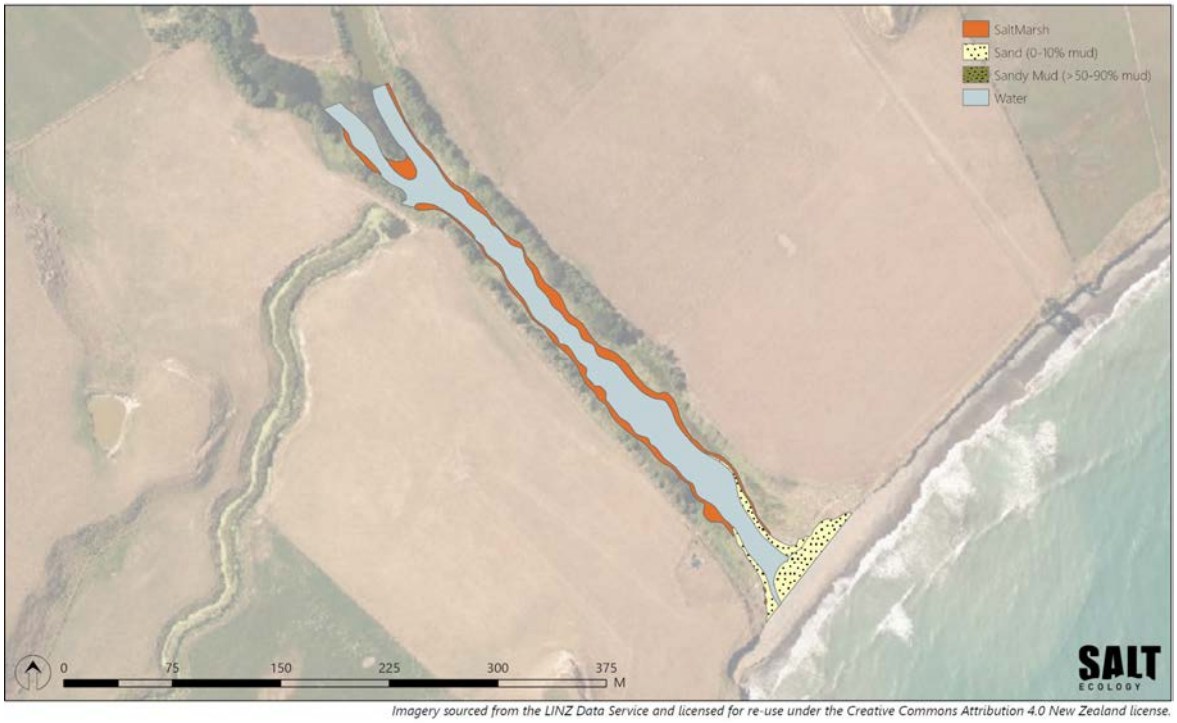


Fig. A16.2. Waikaraka Stream Estuary dominant vegetation and substrate features.

Outflow to Waikaraka Stream (top) and looking downstream toward the entrance, woody debris on true right bank (bottom)

Looking over Waikaraka Stream toward entrance (top) and downstream with marsh clubrush on the margin (bottom)

Ruppia spp. growing in the subtidal channel, mid estuary

Low levels of oxygen in soft sandy muds with *Ruppia* spp.

High rainfall led to run-off from the disconnected tributary (now a freshwater backwater), across the farm road and into the Waikaraka Stream

Raupō growing in the disconnected tributary (now a freshwater backwater), which would have historically been connected to Waikaraka Stream

A17. KAIMOKOPUNA STREAM ESTUARY

Kaimokopuna Stream Estuary is a small-sized (1.6ha) river mouth lagoon draining a moderate-sized (1004ha) catchment dominated by broad leaved indigenous hardwoods in the upper catchment, and high producing grassland (sheep and beef) in the lower catchment. The entrance to the estuary frequently restricts and/or closes during low flow events or when there is movement of the sand across the entrance. The extent of tidal influence is uncertain however, at high tide waves wash into the stream and erosion on the cliffs highlight the high energy nature of the waves in big seas. When the entrance is restricted or closed, flushing is reduced, and the estuary is particularly prone to nutrient, sediment and pathogen issues.

Kaimokopuna Stream has been heavily modified with the tributary toward the west disconnected from the main channel and dammed, and other parts of the main channel straightened. A second similarly modified small un-named stream is present ~150m to the southwest. Both channels are deeply incised into the land with steep grassed banks that are prone to slumping and erosion, compounded by coastal erosion near the entrances where steep cliffs are present. The steep and eroding banks, and dynamic entrance, mean there is limited available intertidal habitat for salt marsh growth.

On 30th March 2022 the estuary was open to the sea, but was freshwater dominated (salinity 0.2‰). There were no water quality or macroalgal issues, and the subtidal substrate was sand and gravel dominated toward the entrance, with soft sandy mud on the mid estuary margins and likely in the subtidal channel. While algae were not elevated in the Kaimokopuna Stream it was observed growing in the disconnected tributary to the southwest that overflows into the Kaimokopuna Stream after high rainfall. This suggests that nutrient inputs are high enough to support excess algal growth, a potential problem when the entrance is closed.

While the Kaimokopuna Stream mouth is not classified as significant, Kaimokopuna Stream is a site of significant indigenous biodiversity in the Proposed Natural Resources Plan (Schedule F1) because it has high macroinvertebrate community health (PNRP Appeals Version 2022). There are no records of fish or birds for the estuary, although migratory fish likely enter the stream when the entrance is open to the sea.

The most significant pressures to Kaimokopuna Stream Estuary are nutrient, pathogen and sediment inputs from the catchment. The water quality issue is exacerbated when the entrance is restricted and/or closes. See Table A17.1 for other pressures.

Table A17.1 Summary information for Kaimokopuna Stream Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	1.6	-
Intertidal Area (Ha; % Estuary)[1]	1.0	60.8
Dominant Estuary Substrate[1]	Sand (lower) Soft sandy mud	
Mud extent (>50% mud content)	0.1	7.6
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	-	-
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	1004	
Dominant Catchment Land Cover[2]	Broadleaved Indigenous Hardwoods	
% Catchment indigenous vegetation[2]	54.3	
% Catchment exotic forest[2]	0.5	
% Producing grassland[2]	27.5	
Mean Freshwater Flow (m^3/s)[3]	0.2	
Catchment Nitrogen Load (T/y)[3]	4.5	
Catchment Phosphorus Load (T/y)[3]	0.5	
Catchment Sediment Load (KT/y)[3]	1.2	
Catchment Geology[4]	Argillite (Upper), Mudstone (Mid) Alluvium & gravels (Lower)	
Biodiversity		
Significant Site[4]	N	
Birds	nd	
Fish	nd	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment. Bank slumping and erosion, coastal erosion. Potential for poor water quality during closure/ restriction. Historic modification of estuary and tributaries. Farming adjacent to stream, although fenced. Private recreational use by landowner. Grasses and some weeds dominate the margin.		

[1]Field visit 30th March 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers

Table A17.2. Ecological Vulnerability Assessment, Kaimokopuna Stream Estuary.

Category	Score
Values	0.21
Pressures	0.81
Susceptibility	0.76
Condition	0.67
Average Score	**0.61**

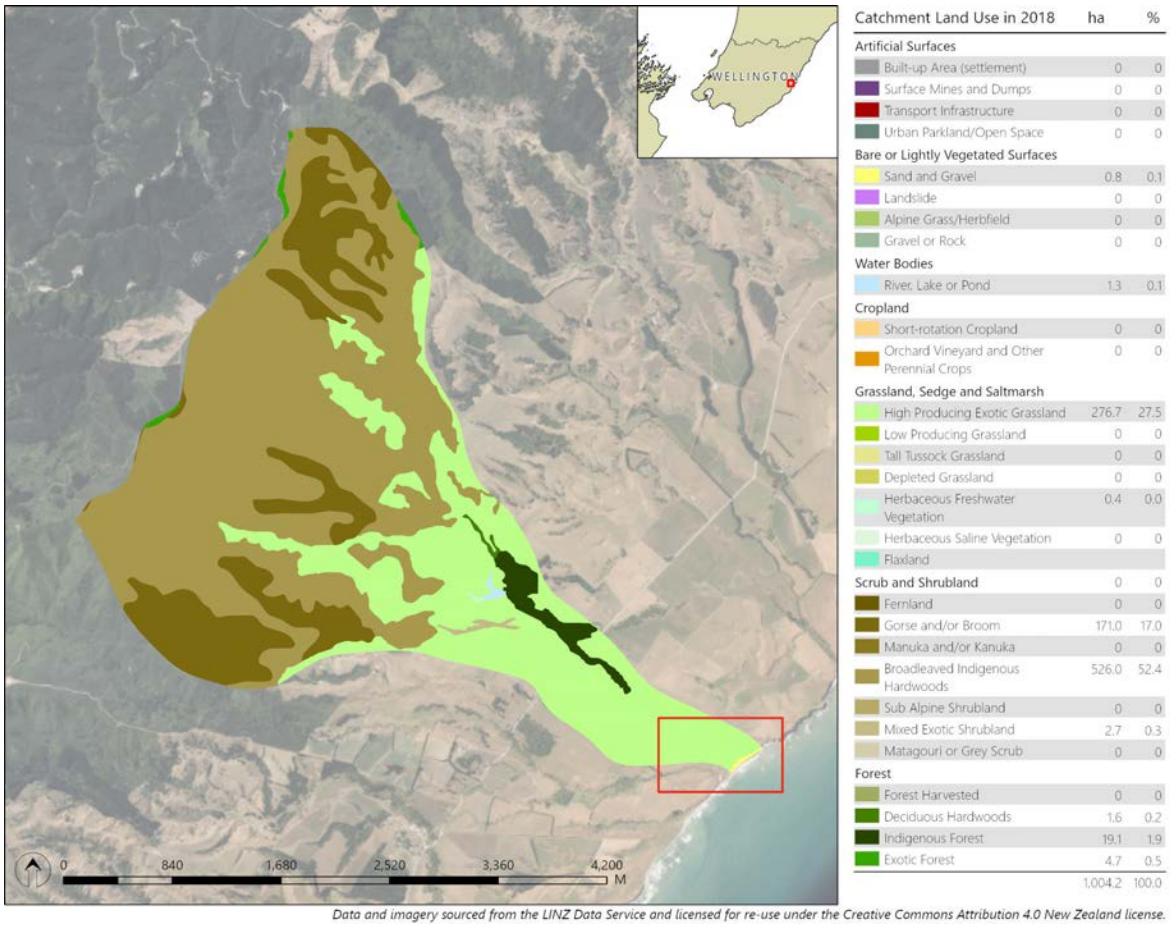


Fig. A17.1. Kaimokopuna Stream Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

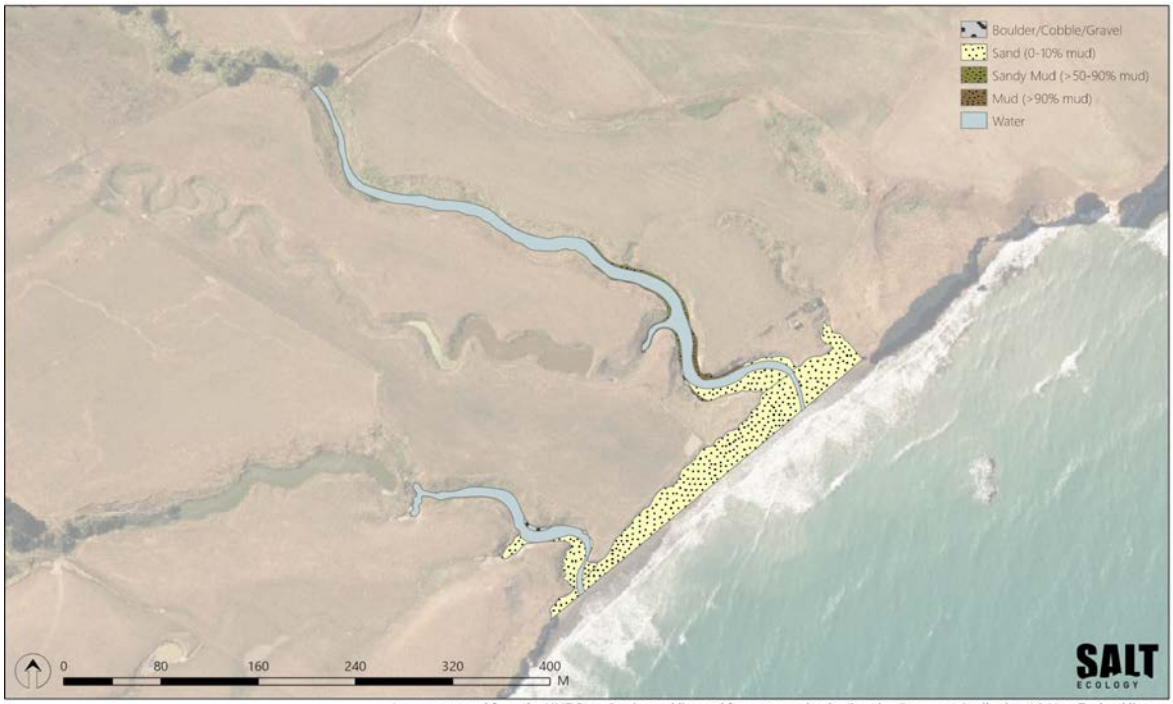


Fig. A17.2. Kaimokopuna Stream Estuary dominant vegetation and substrate features.

Outflow of northern Kaimokopuna Stream (top) and looking downstream toward the entrance, woody debris on true right bank (bottom)

Upstream Kaimokopuna Stream, channel to the left used to be connected to a tributary that is now dammed (top) and bank slumping and sheep access on true right bank (bottom)

Steep eroding cliffs, sand and cobble substrate with woody debris deposited on the margins

Soft sandy mud and grasses dominate the steep margin, fencing on the true left bank

Entrance of small unamed stream to the south of Kaimokopuna Stream, steep eroding cliffs

Steep eroding cliffs of the small unamed stream to the south of Kaimokopuna Stream

A18. HOMEWOOD ESTUARIES

There were four small estuaries between Kaimokopuna Estuary and Kaiwhata River Estuary in the area known as Homewood. These estuaries were assessed during the synoptic field survey however, they were not included in the detailed EVA due to their small size. A high-level overview, including photos, is presented below.

"Homewood North": Located ~1.2km south of Kaimokopuna Stream Estuary a small unnamed stream mouth estuary discharges onto the beach. It flows through a cobble field with a large volume of woody debris blocking the upstream channel which has been straightened. The entrance can restrict and/or close at times. Chlorophyll-*a*, a proxy for phytoplankton growth, was elevated, and dissolved oxygen was low (~50% saturation). Depleted oxygen is likely attributed to both the upstream freshwater input (drainage channels) and the movement of water through the cobble field and woody debris limiting exchange with the atmosphere.

Unamed ('Homewood North') stream mouth (top) flowing through cobblefield before entering onto the beach (middle). The upstream channel was clogged by woody debris (bottom)

"Homewood Central": Located ~1.5km south of Kaimokopuna Stream Estuary a second small unnamed stream mouth estuary discharges onto the beach. It flows through a deeply incised channel with a clay base, and bank erosion and slumping are present (see photo). The upstream channel has been straightened and the entrance, at times, can restrict and/or close.A large volume of woody debris clogged the channel and was also built up on the beach during the site visit (30th March 2022). Historically the stream flowed along the coast and entered onto the beach via "Homewood North", however ~25m of coastal erosion between 2013 and 2018 has led to the stream being disconnected from "Homewood North" and discharging directly onto the beach.

Unamed stream (Homewood Central) clogged with woody debris (top), looking downstream (middle) and upstream (bottom) with both bank erosion and slumping present

"Waiohuru": Waiohuru Stream mouth is a small-sized (<0.3ha) estuary ~2.2km south of Kaimokopuna Stream Estuary. The estuary drains a catchment dominated by high producing grassland. The entrance is flanked by a steep eroding cliff to the north and raised banks to the south. The estuary frequently restricts and/or closes during low flow events or when there is movement of the sand across the entrance. During a site visit on the 30th March 2022, the estuary was open to the sea, and had been recently overtopped by waves. At the time of sampling, it remained freshwater dominated and there were no eutrophication symptoms (e.g. phytoplankton or macroalgal issues). However, closure of the entrance and poor flushing make the estuary particularly prone to nutrient and pathogen issues. Further the deposition of organic debris (e.g. marine seaweeds; see photo) in the lagoon could fuel low oxygen conditions.

Available habitat for salt marsh was limited with only a small area of three-square present. While the margins were grass-dominated, there are riparian plantings of flax and other natives. A recent landslide into the lagoon on the north bank (see bottom photo) had deposited a large amount of fine sediment, and the water column was turbid from both this and a recent rain event.

Waiohuru Estuary discharges along the southern (true right) side, with debris (mainly seaweed) deposited at the entrance (top). A lagoon is present behind the entrance sand bar, with native plantings on the margin (bottom). Note recent slip in foreground.

"Homewood South": Located ~2.5km south of Kaimokopuna Stream Estuary, this very small estuary drains a catchment dominated by high producing grassland. The stream flows through a deeply incised channel, with bank erosion and bank slumping observed in the site visit on the 30th March 2022 (see photo). The steep nature of the catchment means salt water is unlikely to intrude upstream more than 100m. The upstream channel has been dammed which controls to flow of water downstream, with flow likely restricted under low rainfall conditions.

"Homewood South" Estuary ~2.5km south of Kamokopuna Stream (top), and looking upstream from the beach (bottom) with both bank erosion and slumping present

Homewood Estuaries Summary

The four small stream mouth estuaries are not classified as significant, and there are no specific records of birds or fish for the sites. The greatest pressures are nutrient, pathogen and sediment inputs from the high producing grassland catchments, effects of which are exacerbated when the entrances are restricted and/or close. There is limited public access as the estuaries drain private land, with the only access by boat. Other pressures include the deposition of woody debris and seaweed. Owing to the high energy coastline, coastal erosion is also common.

Fig A18.1. Aerial photo of the four estuaries between Kaimokopuna and Kaiwhata near Homewood.

A19. KAIWHATA RIVER ESTUARY

Kaiwhata River Estuary is a small-sized (4.1ha) river mouth lagoon draining a large (10,135ha) catchment dominated by exotic forestry and high producing grassland (sheep and beef). The entrance to the estuary is dynamic and frequently restricts and/or closes forming a lagoon behind the sandbar (Todd et al. 2016). During times of restricted flushing, the estuary is particularly prone to nutrient, sediment and pathogen issues.

On 30th March 2022 the estuary was open to the sea, although still dominated by freshwater (salinity 0.2‰). Water clarity was poor (i.e. secchi depth <20cm), and the turbidity very high (>150FNU). While at the time of sampling there were no signs of eutrophication symptoms (e.g. phytoplankton or macroalgal issues), regular restriction of the entrance and poor flushing make the estuary particularly prone to phytoplankton blooms in summer. Further, aerial imagery shows macroalgae, likely *Ulva* spp., has grown on the shallow subtidal flats when the entrance has been restricted. This suggests that nutrient inputs are high enough to support excess algal growth. The substrate was a mix of sand and gravel in the lower estuary and cobble field in the mid to upper estuary, with no signs of sediment enrichment (e.g. low oxygenation) present.

The true left bank has been stabilised and grazed since the late 1800's and is dominated by grassland, and the true right bank consists of steep erosion prone cliffs (Todd et al. 2016). There is a small wetland area below the terrace on the true left bank but no areas of salt marsh habitat.

The estuary is a site of significant indigenous biodiversity in the Proposed Natural Resources Plan (Schedule F4) because it provides seasonal or core habitat for indigenous migratory fish species (i.e. longfin eel, inanga and redfin bully; PNRP Appeals Version 2022). Several bird species, including but not limited to, black shag, Caspian tern, pied stilt, red-billed gull and little shag have been sighted at Kaiwhata Stream Estuary, with a comprehensive list in Todd et al. (2016). Further the Kaiwhata River mouth is a nationally significant geological feature because subfossil totara stumps (~8000yrs old) are present ~40m offshore and are exposed at low tide (PNRP Appeals Version 2022).

The most significant pressures to Kaiwhata River Estuary are nutrient, pathogen and sediment inputs from the catchment, effects of which are exacerbated when the entrance is restricted and/or closes. See Table A19.1 for other pressures.

Table A19.1 Summary information for Kaiwhata River Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	4.1	-
Intertidal Area (Ha; % Estuary)[1]	2.1	50.6
Dominant Estuary Substrate[1]	Gravel/cobble	
Mud extent (>50% mud content)	-	-
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	-	-
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	10,135	
Dominant Catchment Land Cover[2]	Exotic forestry	
% Catchment indigenous vegetation[2]	19.6	
% Catchment exotic forest[2]	49.3	
% Producing grassland[2]	26.5	
Mean Freshwater Flow (m^3/s)[3]	2.5	
Catchment Nitrogen Load (T/y)[3]	38.1	
Catchment Phosphorus Load (T/y)[3]	16.2	
Catchment Sediment Load (KT/y)[3]	66.3	
Catchment Geology	Argillite (Mid-upper) Mudstone (Lower)	
Biodiversity		
Significant Site[5]	Y	
Birds[6]	Black shag, Caspian tern, pied stilt, red-billed gull, little shag	
Fish[7]	Longfin eel, inanga and redfin bully	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment. Erodible catchment, steep eroding cliffs and bank erosion. Poor water quality in periods of closure/ restriction. Private recreational use, including vehicles. Weeds and grasses common on margin.		

[1]Field visit 30th March 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers, [6]Todd et al. (2016), [7]PNRP Appeals Version 2022

Table A19.2. Ecological Vulnerability Assessment, Kaiwhata River Estuary.

Category	Score
Values	0.44
Pressures	0.76
Susceptibility	0.66
Condition	0.65
Average Score	0.63

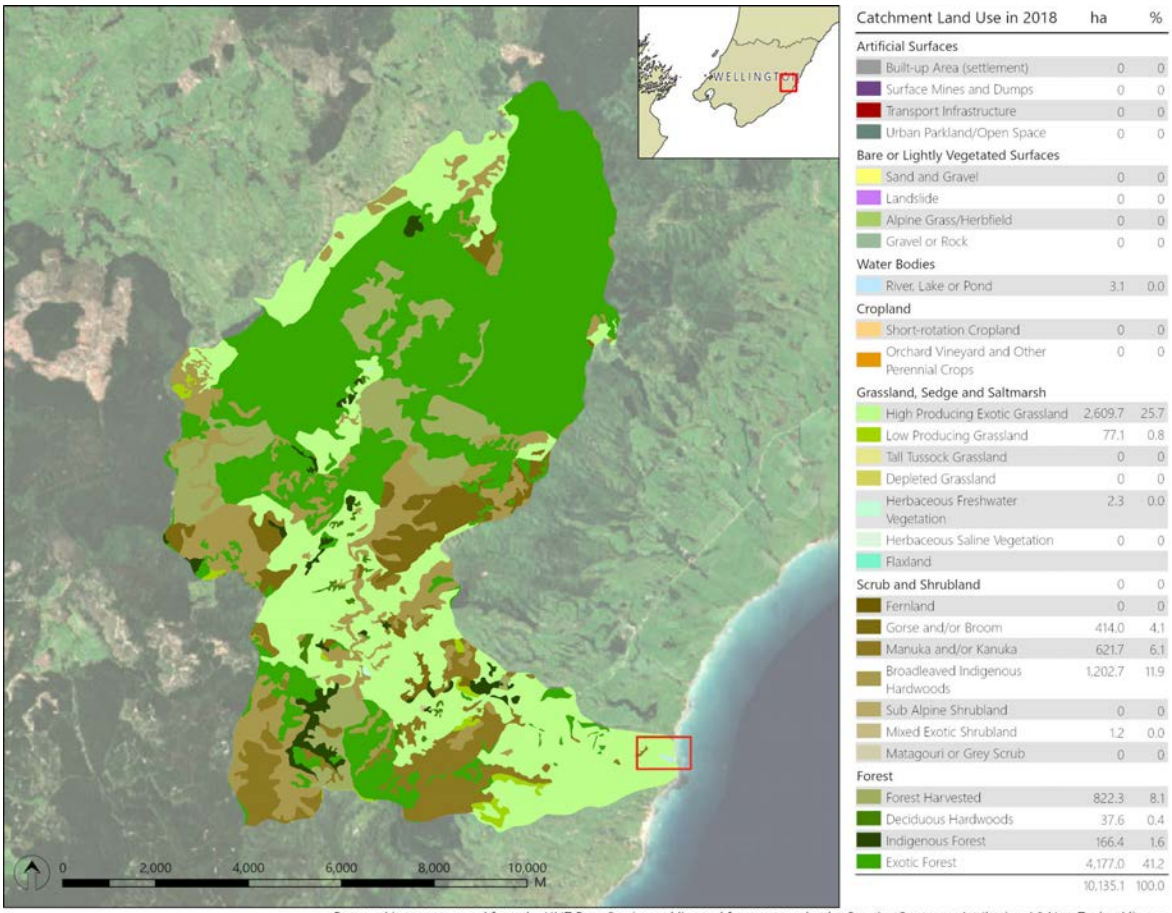


Fig. A19.1. Kaiwhata River Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

Fig. A19.2. Kaiwhata River Estuary dominant vegetation and substrate features.

Entrance of Kaiwhata River Estuary (top) and looking upstream from the entrance (bottom) with steep eroding cliffs on the true right bank

View toward the upper estuary with a mix of gravel and cobble field (top). Mid-estuary sands and gravels with a very thin layer of fine sediment deposition from a recent event (bottom)

Exotic vegetation growing on steep cliffs, very high turbidity water and gravel substrate on the bottom

Wetland area on the lower terrace of the true left bank, knobby clubrush growing among grasses

Grazed, fenced pasture on the true right bank, grasses and exotic vegetation dominating the immediate margin

Steep eroding cliffs with pines planted along the margin, and turbid water column

A20. TE UNU UNU (FLAT POINT) ESTUARY

Te Unu Unu (Flat Point) Stream Estuary is a very small-sized (0.4ha) river mouth lagoon draining a moderate-sized (1467ha) catchment dominated by high producing grassland (sheep and beef). The entrance to the estuary is dynamic and frequently restricts and/or closes forming a lagoon behind the sandbar. During times of restricted flushing, the estuary is particularly prone to nutrient, sediment and pathogen issues.

On 1st April 2022 the estuary was open to the sea, although still dominated by freshwater (salinity 0.2‰). While at the time of sampling there were no signs of eutrophication symptoms (e.g. phytoplankton or macroalgal issues), closure of the entrance and poor flushing make the estuary particularly prone to phytoplankton blooms in summer. The substrate is a mix of sand and cobble at the entrance, and firm muddy sand in the mid estuary. There was evidence of recent sediment deposition in the mid estuary following a large recent rainfall event. The banks of the stream are dominated by grasses and prone to erosion. Archaeological sites have been exposed by erosion on the true left bank of Te Unu Unu stream, including ovens and shell middens (McFadgen 2003).

Neither the stream or estuary are classified as significant and there are no specific records of birds or fish for the site. However, the Flat Point coastline supports habitat for threatened or at-risk species of birds including the banded dotterel, variable oystercatcher, pied stilt, white-fronted tern, black shag and New Zealand pipit. It is possible that migratory fish enter the estuary when the entrance is open to the sea.

The most significant pressures to Te Unu Unu Stream Estuary include sediment and nutrient loads from the modified catchment (pasture), with restriction of the estuary entrance increasing susceptibility to water quality deterioration. Other pressures include public access to the stream, bank erosion, and pasture, weeds, gorse and grasses common on the margin.

Grass dominated margin

Table A20.1 Summary information for Te Unu Unu (Flat Point) Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	0.4	-
Intertidal Area (Ha; % Estuary)[1]	0.2	54.4
Dominant Estuary Substrate[1]	Sand	
Mud extent (>50% mud content)	-	-
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	0.002	1.0
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	1467	
Dominant Catchment Land Cover[2]	High producing grassland	
% Catchment indigenous vegetation[2]	31.6	
% Catchment exotic forest[2]	3.2	
% Producing grassland[2]	63.1	
Mean Freshwater Flow (m^3/s)[3]	0.2	
Catchment Nitrogen Load (T/y)[3]	5.1	
Catchment Phosphorus Load (T/y)[3]	1.6	
Catchment Sediment Load (KT/y)[3]	5.2	
Catchment Geology	Argillite (Upper) Mudstone (Mid) Dune sands (Lower)	
Biodiversity		
Significant Site[5]	N	
Birds	nd	
Fish	nd	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment. Erodible catchment, steep eroding cliffs and bank erosion. Poor water quality in periods of closure/ restriction. Public walking access. Weeds and grasses common on margin.		

[1]Field visit 1st April 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers

Table A20.2. Ecological Vulnerability Assessment, Te Unu Unu (Flat Point) Estuary.

Category	Score
Values	0.24
Pressures	0.75
Susceptibility	0.82
Condition	0.75
Average Score	**0.64**

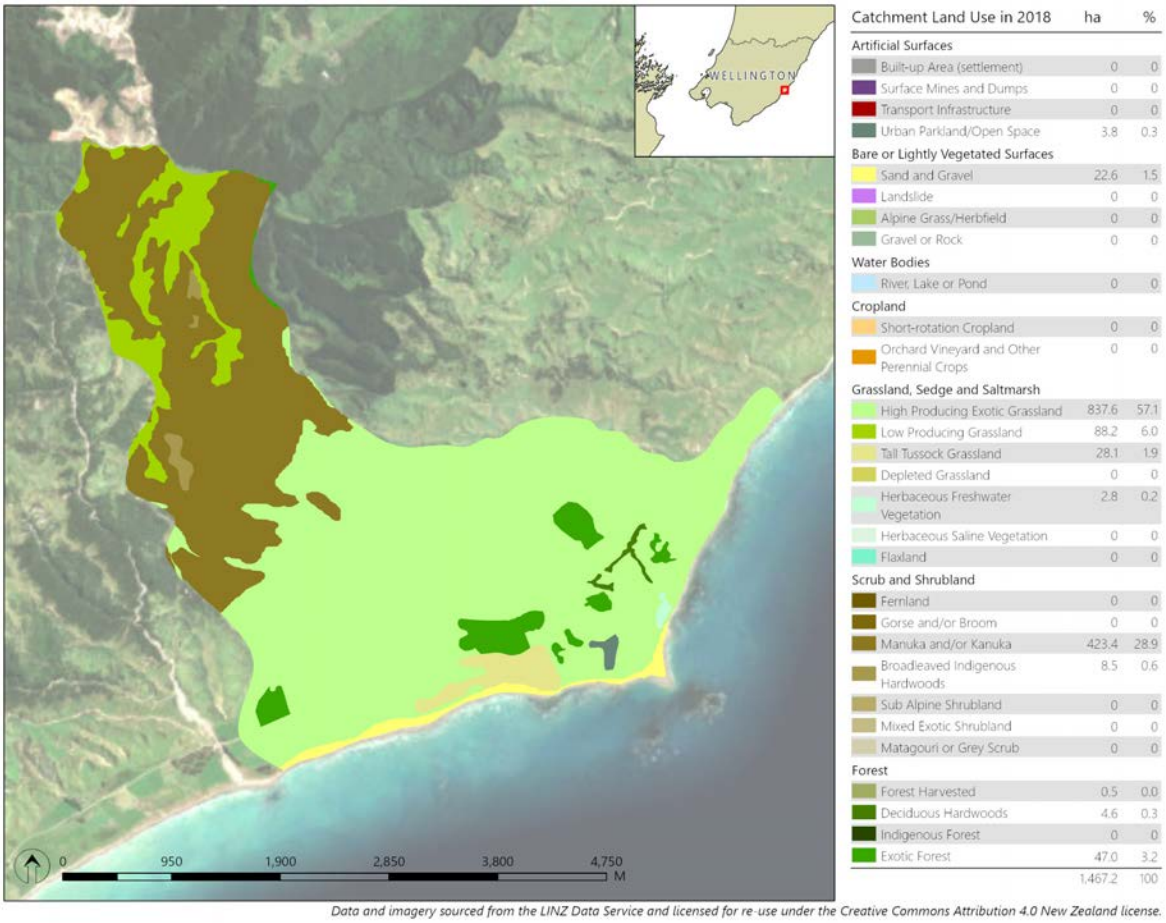


Fig. A20.1. Te Unu Unu (Flat Point) Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary supplied by GWRC.

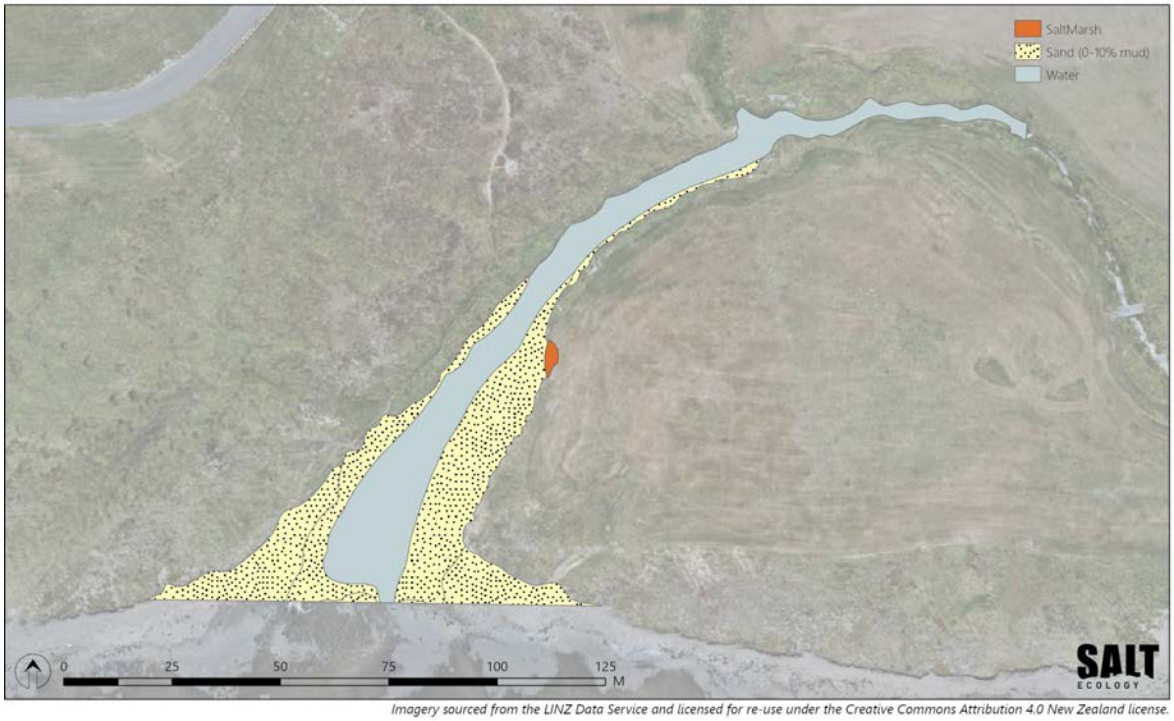


Fig. A20.2. Te Unu Unu (Flat Point) Estuary dominant vegetation and substrate features.

Te Unu Unu Stream entrance was dominated by sands and gravels with woody debris deposited on the beach (top). Grass dominated eroding banks on the estuary margin (bottom)

Te Unu Unu Stream looking upstream: cobbles in the main channel and sands deposited on the edges near the entrance (top), and small area of three-square growing in firm muddy sand (bottom)

Wetland plants (i.e. knobby clubrush) and marram dune vegetation on the upper stream channel margins

Firm muddy sand deposited on top of sands in the mid estuary channel

Grasses dominate most of the margin and the stream channel is shallow when the estuary is open to the sea

Knobby clubrush and other dune vegetation are present on the true right bank, and there is a walkway to the estuary

A21. PĀHĀOA RIVER ESTUARY

Pāhāoa River Estuary is a large-sized river system with a moderate-sized (24.5ha) river mouth lagoon estuary that drains through a narrow opening to the southwest. The entrance is dynamic and commonly restricts and closes, particularly during summer (Todd et al. 2016; Robertson & Stevens 2007a). The entrance is constrained by a sand spit and limestone outcrop to the northeast. When the entrance is open the river is tidally influenced 1-3km upstream of the estuary entrance (Todd et al. 2016; Robertson & Stevens 2007a). Two previous site visits have reported similar entrance conditions (Robertson & Stevens 2007a; Todd et al. 2016). During times of restricted flushing (i.e. entrance closure), the estuary is particularly prone to nutrient, sediment and pathogen issues. This has been evident in previous years, where prolonged closures led to an algal bloom and fish kills (pers. comm. landowner), likely due to low oxygen levels proceeding algal dieback.

In a site visit on 6th April 2022 the estuary was open to the sea toward the southwest with a tidal influence observed in the lower estuary toward the entrance. However, the main lagoon was freshwater dominated. Water clarity was good (i.e. secchi depth to the bottom), and the turbidity low (<7FNU). The substrate in the lagoon and on the tidal flats was dominated by gravel and sands. There were a few patches of intertidal salt marsh, mainly three-square, on the true right bank. Restoration plantings are establishing, and the margin is fenced to protect bird habitat. While *Ruppia* spp. was recorded in the subtidal area in 2016 (Todd et al. 2016) it was not observed in 2022, acknowledging that it may still be present and simply has not been captured in the synoptic field survey.

The estuary is site of significant indigenous biodiversity in the Proposed Natural Resources Plan (Schedule F4) because it provides habitat for threatened indigenous fish species (PNRP Appeals Version 2022). Eight migratory fish have been identified including "At Risk: Declining" species (longfin eel, kōaro, inanga; Todd et al. 2016 and references therein). Several bird species have been sighted at Pāhāoa River Estuary, including, but not limited to, banded dotterel, Caspian tern, red-billed gull, black shag and New Zealand pipit (Todd et al. 2016 and references therein).

The most significant pressures to Pāhāoa River Estuary include very high sediment and nutrient loads from the modified catchment (pasture and forestry), and restriction of the estuary entrance increasing the susceptibility of the estuary to water quality deterioration.

Table A21.1 Summary information for Pāhāoa River Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	24.5	-
Intertidal Area (Ha; % Estuary)[1]	10.6	43.3
Dominant Estuary Substrate[1]	Gravel	
Mud extent (>50% mud content)	0.10	0.9
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	0.07	0.7
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	65,024	
Dominant Catchment Land Cover[2]	High producing grassland	
% Catchment indigenous vegetation[2]	23.1	
% Catchment exotic forest[2]	23.0	
% Producing grassland[2]	51.9	
Mean Freshwater Flow (m^3/s)[3]	12.6	
Catchment Nitrogen Load (T/y)[3]	293.9	
Catchment Phosphorus Load (T/y)[3]	110.9	
Catchment Sediment Load (KT/y)[3]	321.9	
Catchment Geology[4]	Mixed Greywacke, Mudstone & Argillite	
Biodiversity		
Significant Site[4]	Y	
Birds[5]	Banded dotterel, Caspian tern, red-billed gull, black shag and New Zealand pipit	
Fish[5]	Longfin eel, kōaro, inanga	
Shellfish	Cockles & pipi	
Pressures		
Sediment and nutrient loads from modified catchment. Erodible catchment. Restriction or closure of the estuary entrance. Algal blooms and water quality deterioration. In 2016 grazing on the true left bank up to high tide mark, true right bank fenced to stop vehicle and animal access. Weeds and grasses common on margin.		

[1]Field visit 6th April 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers, [6]Todd et al. (2016)

Table A21.2. Ecological Vulnerability Assessment, Pāhāoa River Estuary.

Category	Score
Values	0.50
Pressures	0.79
Susceptibility	0.73
Condition	0.74
Average Score	**0.69**

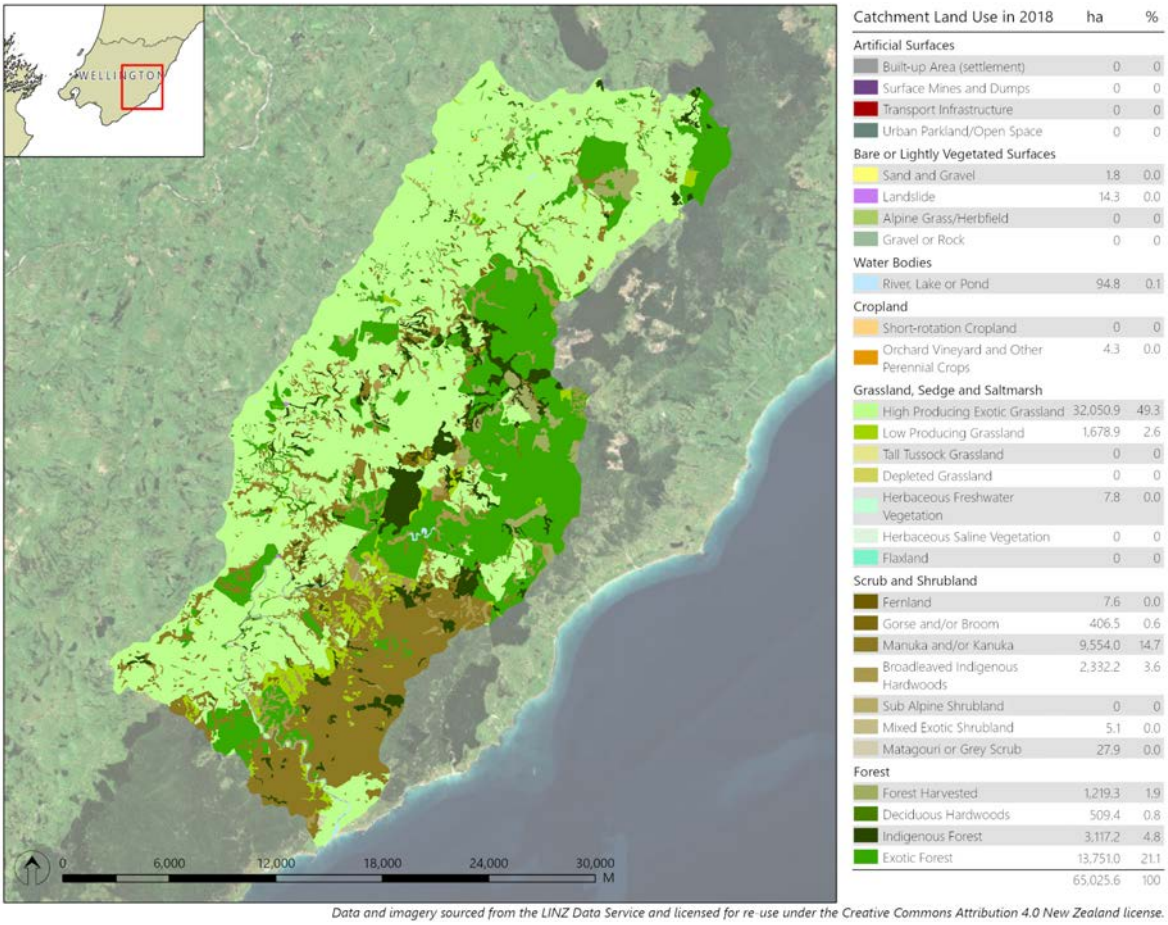


Fig. A21.1. Pāhāoa River Estuary catchment land use classifications from LCDB5 (2017/2018)

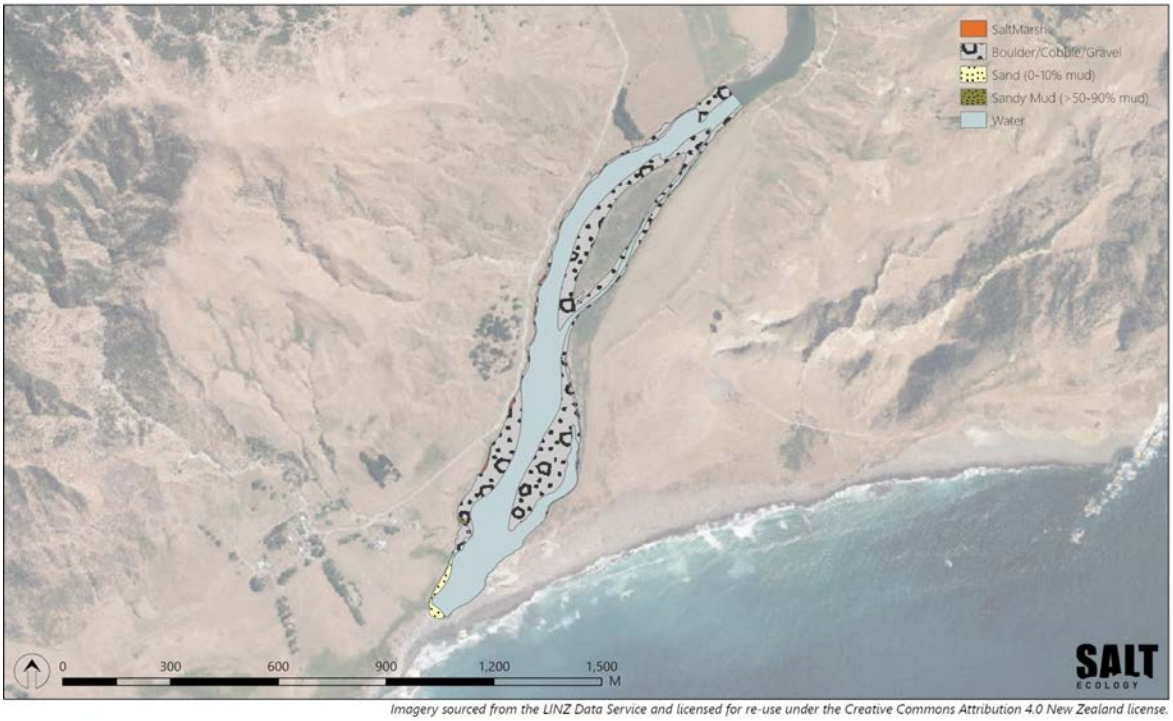


Fig. A21.2. Pāhāoa River Estuary dominant vegetation and substrate features.

Pāhāoa River Estuary entrance (top) and lagoon (bottom) showing hilly catchment

Salt marsh (three-square - *Schoenoplectus pungens*) in the mid (top) to lower (bottom) estuary

Looking upstream across the vegetated island

Gravel substrate in the main lagoon

Lower tidal flats and entrance of the Pāhāoa River Estuary

A22. REREWHAKAAITU RIVER ESTUARY

Rerewhakaaitu River Estuary is a large-sized river system with a small-sized (~5ha) river mouth lagoon estuary. The estuary was not visited in April 2022 and therefore the summary below is based on previous reports by Robertson & Stevens (2007a) and Todd et al. (2016), in addition to the best available desktop information. The site is summarised below for completeness but because it was not visited in 2022, it was not included in the EVA.

The entrance is dynamic and commonly restricts and closes, particularly during summer when freshwater inputs are low (Todd et al. 2016; Robertson & Stevens 2007a). When the entrance is closed, a brackish lake forms behind the sandbar at the base of a steep rocky valley. During times of restricted flushing (i.e. entrance closure), the estuary is particularly prone to nutrient, sediment and pathogen issues. Robertson & Stevens (2007a) highlighted the potential for phytoplankton blooms after prolonged periods of closure, with the risk increasing if there were any significant changes in the catchment.

The catchment is predominantly native scrub with pasture in the lower third of the catchment. Todd et al. (2016) noted the area was partially fenced on the south side of the mouth, however stock had full access to the stream on the north bank with pasture continuing up to the high tide mark in most places. The steep rock slopes limit the available habitat for salt marsh with only small patches of knobby clubrush and searush noted where the slope was gentler and the water shallower (Todd et al. 2016). Todd et al. (2016) also recorded salt marsh ribbonwood, flax and giant umbrella sedge on the margin.

The Rerewhakaaitu River Estuary is not classified as significant and there are no specific records of fish at the site. However, several bird species been sighted at Rerewhakaaitu River Estuary, including, but not limited to, banded dotterel, black shag, pied stilt, variable oystercatcher and New Zealand pipit have (Todd et al. 2016 and references therein).

Due to the remote nature of Rerewhakaaitu River Estuary and the mostly native scrub (manuka and/or kanuka) catchment, sediment and nutrient loads are relatively low. However, the steep nature of the catchment makes it prone to erosion. The most significant pressure to Rerewhakaaitu River Estuary is the natural cycle of entrance closure that increases the susceptibility of the estuary to water quality deterioration, in addition to grazing and weeds on the margin.

Table A22.1 Summary information for Rerewhakaaitu River Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	5.0	-
Intertidal Area (Ha; % Estuary)[1]	nd	-
Dominant Estuary Substrate[1]	Gravel/sand	
Mud extent (>50% mud content)	-	-
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	<0.1	-
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	4686	
Dominant Catchment Land Cover[2]	Manuka and/or kanuka	
% Catchment indigenous vegetation[2]	77.1	
% Catchment exotic forest[2]	5.7	
% Producing grassland[2]	17.0	
Mean Freshwater Flow (m^3/s)[3]	1.0	
Catchment Nitrogen Load (T/y)[3]	14.4	
Catchment Phosphorus Load (T/y)[3]	4.6	
Catchment Sediment Load (KT/y)[3]	13.1	
Catchment Geology[4]	Mudstone (Upper) Argillite & Greywacke (Lower)	
Biodiversity		
Significant Site[4]	N	
Birds[1]	Banded dotterel, black shag, pied stilt, variable oystercatcher and New Zealand pipit	
Fish	nd	
Shellfish	nd	
Pressures		
Low catchment nutrient and sediment loads. Steep erodible catchment. Restriction or closure of the estuary entrance. Low level recreational use. Grazing up to the margin on the true left bank. Weeds and grasses common on margin.		

[1]Todd et al. (2016); [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers

Closed entrance in December 2006 (photo: Robertson & Stevens 2007)

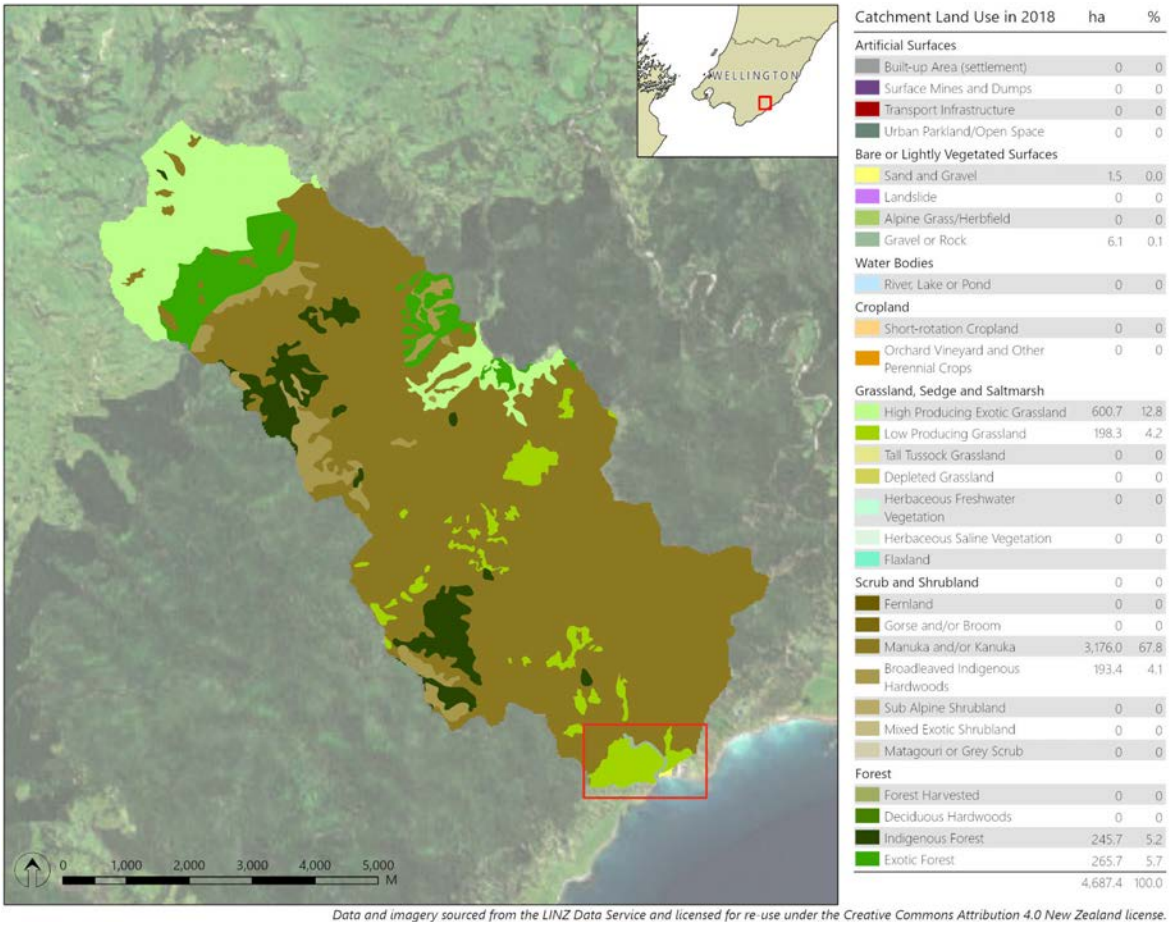


Fig. A22.1. Rerewhakaaitu River Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary derived from CLUES 10.8.

Fig. A22.2. Aerial image of Rerewhakaaitu River Estuary.

Rerewhakaaitu River looking upstream (top) and the estuary entrance (bottom) in December 2006, the entrance is closed and a lagoon has formed behind the sand/gravel bar that is flanked by very steep cliffs (photos sourced from Robertson & Stevens 2007)

A23. ŌTEREI RIVER ESTUARY

Ōterei River is a medium-sized river system with a small (6.2ha) river mouth lagoon estuary that drains through a narrow opening to the southwest. The entrance is dynamic and commonly restricts and closes, particularly during summer (Todd et al. 2016; Robertson & Stevens 2007a) forming a brackish lagoon behind a semi-permanent sand bar. Two previous site visits reported the estuary in a similar condition (Robertson & Stevens 2007a; Todd et al. 2016). During times of restricted flushing, the estuary is particularly prone to nutrient, sediment and pathogen issues.

In a site visit on 7th April 2022 the estuary was open to the sea toward the southwest, and the lagoon was brackish (6ppt). Water clarity was poor, and the water column turbid (22-25FNU). The brackish lagoon was shallow (<1m), except for a deeper channel on the true left bank, and comprised soft sandy mud. Mud-dominated substrate was also common on the channel margins upstream of the road bridge. Drift macroalgae was observed in the lagoon and growing on woody debris. No persistent macroalgal growths were observed.

The estuary is a site of significant indigenous biodiversity in the Proposed Natural Resources Plan (Schedule F4) because it provides habitat for threatened indigenous fish species (PNRP Appeals Version 2022). Nine migratory fish have also been identified including "At Risk: Declining" species (longfin eel, giant kōkopu, shortjaw kōkopu, kōaro, inanga and redfin bully; Todd et al. 2016 and references therein). The intertidal salt marsh is classified as a significant wetland and comprises both herbfield and rushland with a strip of umbrella sedge on along the upper margin. In 2022, vehicle damage was observed in the herbfield. Several bird species, including, but not limited to, banded dotterel, Caspian tern, red-billed gull, black shag and variable oystercatcher have been sighted at Ōterei River Estuary (Todd et al. 2016 and references therein).

The most significant pressures to Ōterei River Estuary include sediment and nutrient loads from the partially modified catchment, and restriction of the estuary entrance increasing the susceptibility of the estuary to water quality deterioration. Other direct pressures include recreational use (swimming, fishing, coastal walkers), vehicle damage and weed incursions on the margin (e.g. gorse, tree lupin).

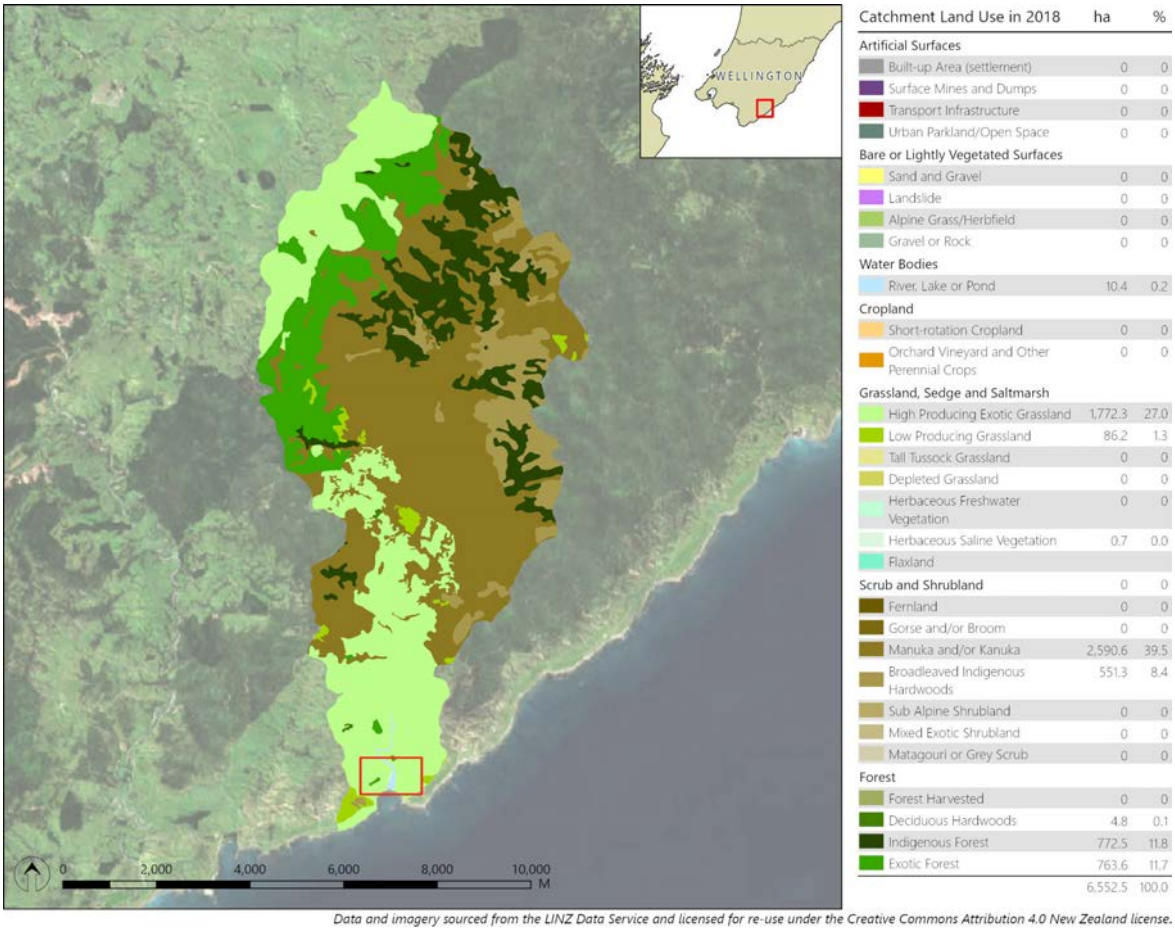
Table A23.1 Summary information for Ōterei River Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	6.2	
Intertidal Area (Ha; % Estuary)[1]	1.1	17.2
Dominant Estuary Substrate[1*]	gf/fs (intertidal) sms (subtidal)	
Mud extent (>50% mud content)	0.03	2.6
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	0.3	29.1
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	6,553	
Dominant Catchment Land Cover[2]	Manuka and/or Kanuka	
% Catchment indigenous vegetation[2]	59.7	
% Catchment exotic forest[2]	11.7	
% Producing grassland[2]	28.3	
Mean Freshwater Flow (m^3/s)[3]	1.3	
Catchment Nitrogen Load (T/y)[3]	23.1	
Catchment Phosphorus Load (T/y)[3]	7.3	
Catchment Sediment Load (KT/y)[3]	17.0	
Catchment Geology[4]	Mudstone (Upper) Argillite & Greywacke (Lower)	
Biodiversity		
Significant Site[4]	Y	
Birds[5]	Banded dotterel, Caspian tern, red-billed gull, black shag	
Fish[5]	Longfin eel, giant kōkopu, shortjaw kōkopu, kōaro, inanga and redfin bully	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment.		
Erodible catchment, bank erosion.		
Poor water quality in periods of closure/ restriction.		
Moderate recreational use.		
Vehicle damage of salt marsh.		
Weeds and grasses common on margin.		

[1]Field visit 7th April 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers, [5]Todd et al. (2016), *gf = gravel field, fs = firm sand, sms = soft sandy mud

Table A23.2. Ecological Vulnerability Assessment, Ōterei River Estuary.

Category	Score
Values	0.62
Pressures	0.79
Susceptibility	0.72
Condition	0.73
Average Score	**0.71**



Catchment Land Use in 2018	ha	%
Artificial Surfaces		
Built-up Area (settlement)	0	0
Surface Mines and Dumps	0	0
Transport Infrastructure	0	0
Urban Parkland/Open Space	0	0
Bare or Lightly Vegetated Surfaces		
Sand and Gravel	0	0
Landslide	0	0
Alpine Grass/Herbfield	0	0
Gravel or Rock	0	0
Water Bodies		
River, Lake or Pond	10.4	0.2
Cropland		
Short-rotation Cropland	0	0
Orchard Vineyard and Other Perennial Crops	0	0
Grassland, Sedge and Saltmarsh		
High Producing Exotic Grassland	1,772.3	27.0
Low Producing Grassland	86.2	1.3
Tall Tussock Grassland	0	0
Depleted Grassland	0	0
Herbaceous Freshwater Vegetation	0	0
Herbaceous Saline Vegetation	0.7	0.0
Flaxland		
Scrub and Shrubland	0	0
Fernland	0	0
Gorse and/or Broom	0	0
Manuka and/or Kanuka	2,590.6	39.5
Broadleaved Indigenous Hardwoods	551.3	8.4
Sub Alpine Shrubland	0	0
Mixed Exotic Shrubland	0	0
Matagouri or Grey Scrub	0	0
Forest		
Forest Harvested	0	0
Deciduous Hardwoods	4.8	0.1
Indigenous Forest	772.5	11.8
Exotic Forest	763.6	11.7
	6,552.5	100.0

Fig. A23.1. Ōterei River Estuary catchment land use classifications from LCDB5 (2017/2018)

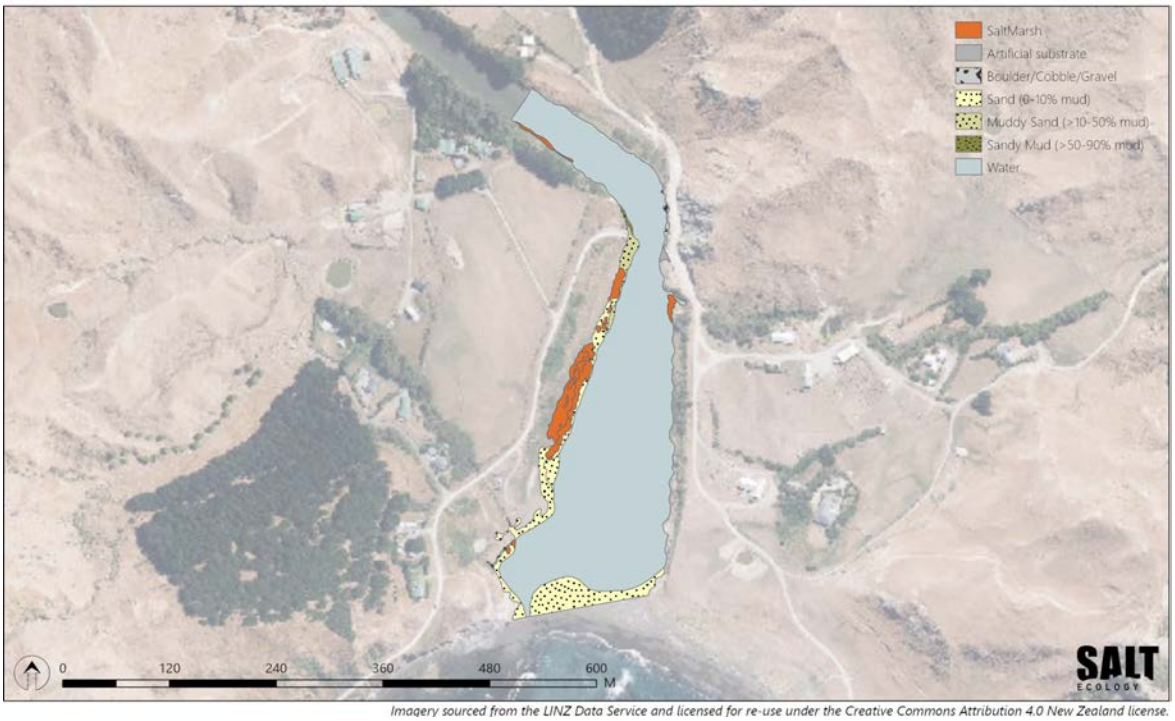
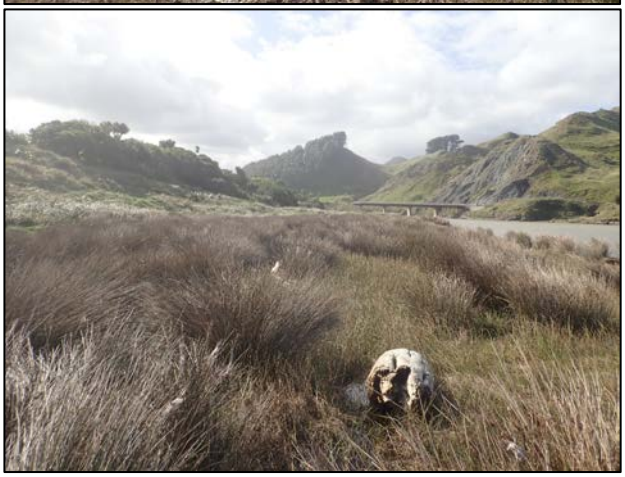


Fig. A23.2. Ōterei River Estuary dominant vegetation and substrate features.

Ōterei River Estuary entrance (top) and lagoon (bottom) showing the steep true left bank and salt marsh on the true right bank



Vehicle tracks in salt marsh herbfield (top). Rushland on the true right bank (bottom)

Stormwater drain running into the estuary

Soft sandy mud in the channel near the steep true left bank

Lagoon behind the coastal sandspit of Ōterei River Estuary. Entrance in central right of photo

A24. ĀWHEA RIVER ESTUARY

Āwhea River is a medium-sized braided river system with a small (4.0ha) 'river mouth lagoon' estuary that drains through a narrow opening. The entrance is dynamic and, during summer, commonly restricts and/or closes (Todd et al. 2016; Robertson & Stevens 2007a). When the entrance restricts the brackish lagoon backs up water in the river and tidal influence is negligible (Todd et al. 2016). During times of restricted flushing, the estuary is particularly prone to nutrient, sediment and pathogen issues.

In a site visit on 7th April 2022 the estuary was open to the sea, and the lagoon was freshwater dominated. Water clarity was poor, and the water column turbid (~200FNU). The lagoon promotes settling of fine sediments, confirmed by the soft sandy muds observed deposited over sand. Water quality at the Tora Rd Bridge is consistently rated 'fair' to 'good' with high levels of periphyton recorded in the river under low flow conditions (Todd et al. 2016 and references therein). A narrow strip of marsh clubrush (*Bolboschoenus fluviatilis*) was recorded on the water's edge extending just beyond the bridge. Two previous site visits reported the estuary in a similar condition (Robertson & Stevens 2007; Todd et al. 2016).

The estuary is a site of significant indigenous biodiversity in the Proposed Natural Resources Plan (Schedule F4) because it provides habitat for threatened indigenous fish species (PNRP Appeals Version 2022). Six migratory fish have also been identified including "At Risk: Declining" species (longfin eel, inanga and redfin bully; Todd et al. 2016 and references therein). A wetland area on the true left bank is dominated by ruatahi (cutty grass/*Carex geminata*). Several bird species, including but not limited to, Black shag, banded dotterel, Caspian tern, reef heron, pied shag and red-billed gull have been sighted at Āwhea River Estuary (Todd et al. 2016 and references therein). Six migratory fish have also been identified including "At Risk: Declining" species (longfin eel, inanga and redfin bully; Todd et al. 2016 and references therein).

The most significant pressures to Āwhea River Estuary are the very high sediment and nutrient loads from the modified catchment (pasture and forestry). Further, restriction of the estuary entrance increases the susceptibility of the estuary to water quality deterioration and algal blooms. Other direct pressures include moderate recreational use (swimming, fishing, walking, camping) and vehicle damage and weed incursions on the margin.

Table A24.1 Summary information for Āwhea River Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	4.0	-
Intertidal Area (Ha; % Estuary)[1]	0.3	7.3
Dominant Estuary Substrate[1]	Soft sandy mud	
Mud extent (>50% mud content)	0.06	21.7
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	0.06	21.9
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	15,224	
Dominant Catchment Land Cover[2]	High producing grassland	
% Catchment indigenous vegetation[2]	27.0	
% Catchment exotic forest[2]	14.5	
% Producing grassland[2]	56.8	
Mean Freshwater Flow (m^3/s)[3]	3.4	
Catchment Nitrogen Load (T/y)[3]	80.0	
Catchment Phosphorus Load (T/y)[3]	27.5	
Catchment Sediment Load (KT/y)[3]	576.1	
Catchment Geology[4]	Mudstone (Upper) Argillite (Mid) Mudstone & Greywacke (Lower)	
Biodiversity		
Significant Site[4]	Y	
Birds[5]	Banded dotterel, Caspian tern, reef heron, pied shag, red-billed gull	
Fish[5]	Longfin eel, inanga, redfin bully, common smelt, shortfin eel	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment. Erodible catchment, bank erosion. Poor water quality in periods of closure/ restriction. Moderate recreational use. Vehicle damage on the true right bank near campsite. Weeds and grasses common on margin.		

[1]Field visit 7th April 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers, [5]Todd et al. (2016)

Table A24.2. Ecological Vulnerability Assessment, Āwhea River Estuary.

Category	Score
Values	0.61
Pressures	0.73
Susceptibility	0.79
Condition	0.70
Average Score	0.71

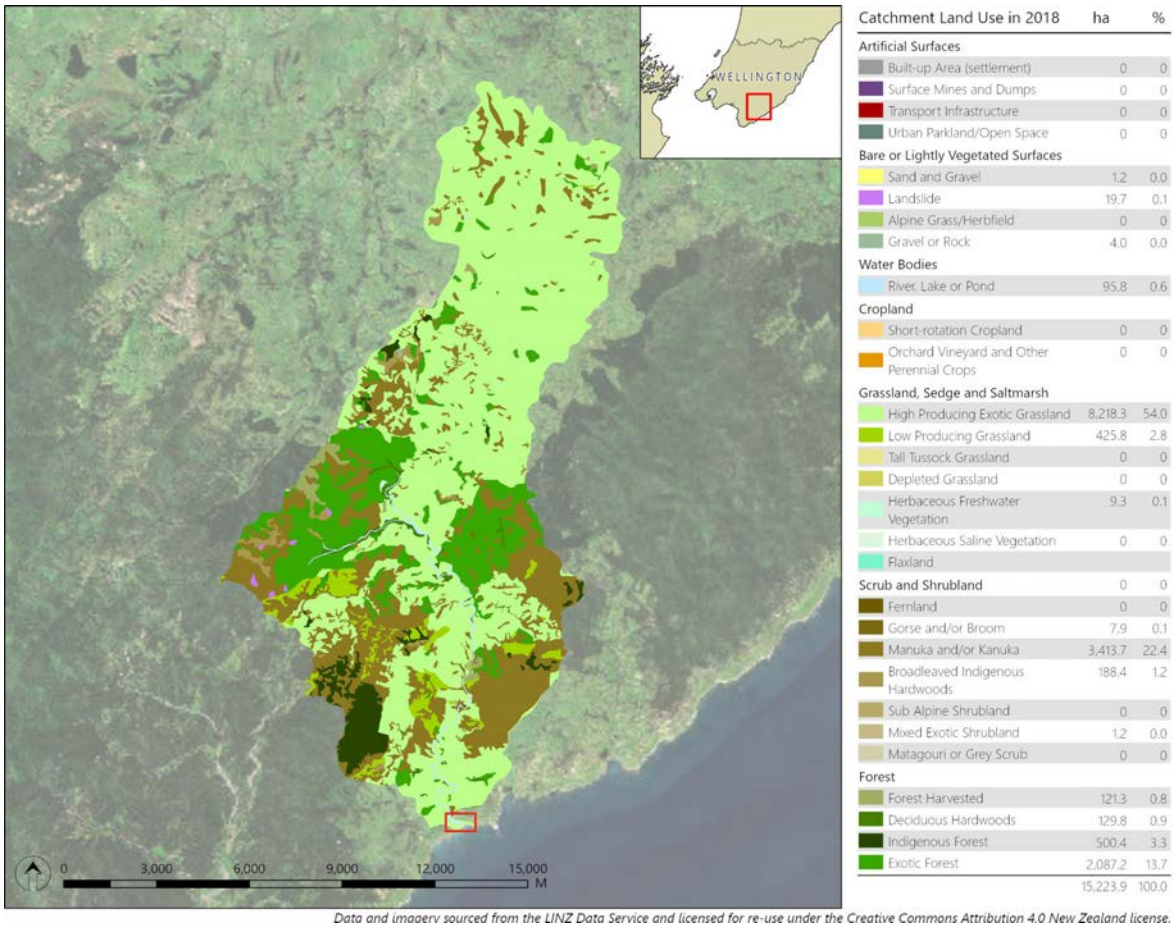


Fig. A24.1. Āwhea River Estuary catchment land use classifications from LCDB5 (2017/2018).

Fig. A24.2. Āwhea River Estuary dominant vegetation and substrate features.

Āwhea River Estuary entrance: small outflow to the sea (top) and the narrowing of the outflow from the lagoon (bottom)

Cutty grass and marsh clubrush wetland at the waters edge (top). Extensive lagoon waters above the narrow outflow (bottom)

Lagoon, with areas of wetland and narrow strip of marsh clubrush

Bottom substrate of the lagoon, soft sandy mud on top of sand

Āwhea River Estuary entrance

A25. ĀWHEAITI STREAM ESTUARY

Āwheaiti Stream Estuary is a small-sized (~1ha) river mouth lagoon within a steep sided and confined river channel. The estuary was not visited in April 2022 and therefore the summary below is based on a previous report by Todd et al. (2016) in addition to the best available desktop information. While the site is summarised below for completeness, because the site was not visited in 2022, it was not included in the EVA.

The entrance is dynamic and commonly restricts and closes, particularly during summer when freshwater inputs are low (Todd et al. 2016; Google Earth historic imagery). When the entrance is closed, a small brackish lagoon forms behind the sandbar and backs up along the river channel. During times of restricted flushing (i.e. entrance closure), the estuary is particularly prone to nutrient, sediment and pathogen issues.

The headwaters of the stream lie in the Tora Bush Scenic Reserve. Most of the mid-lower catchment has been modified for pasture (sheep and beef) for over a century and pasture also dominates the margin (Todd et al. 2016; LCDB5). Runoff from the catchment combined with prolonged periods of lagoon closure mean there is the potential for phytoplankton blooms to develop in Āwheaiti Stream Estuary. Further, Todd et al. (2016) noted sheep and cattle have full access to the stream margins damaging terrestrial vegetation and promoting bank erosion. Only a few small areas of knobby clubrush and giant umbrella sedge are present on the stream banks (Todd et al. 2016).

The Āwheaiti Stream Estuary is not classified as significant and there is only one fish record for the site, the common bully. Several bird species, including, but not limited to, banded dotterel, pied stilt, variable oystercatcher, red-billed gull and New Zealand pipit have been sighted at Āwheaiti Stream Estuary (Todd et al. 2016 and references therein).

The most significant pressure to Āwheaiti Stream Estuary is sediment and nutrient loads from the modified catchment (pasture). Further, restriction of the estuary entrance increases the susceptibility of the estuary to water quality deterioration and algal blooms. Other direct pressures include moderate recreational use (swimming, fishing, walking, camping), open access for grazing and weed incursions on the margin.

Table A25.1 Summary information for Āwheaiti Stream Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	~1.0	-
Intertidal Area (Ha; % Estuary)[1]	nd	-
Dominant Estuary Substrate[1]	Gravel/sand	
Mud extent (>50% mud content)	-	-
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	<0.1	-
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	803	
Dominant Catchment Land Cover[2]	High producing grassland	
% Catchment indigenous vegetation[2]	41.9	
% Catchment exotic forest[2]	1.3	
% Producing grassland[2]	52.9	
Mean Freshwater Flow (m^3/s)[3]	0.2	
Catchment Nitrogen Load (T/y)[3]	4.3	
Catchment Phosphorus Load (T/y)[3]	1.8	
Catchment Sediment Load (KT/y)[3]	5.1	
Catchment Geology[4]	Greywacke, Argillite (Mid-Upper) Mudstone, Limestone (Lower)	
Biodiversity		
Significant Site[4]	N	
Birds[1]	Banded dotterel, pied stilt, variable oystercatcher, red-billed gull, New Zealand pipit	
Fish[1]	Common bully	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment. Erodible catchment. Restriction or closure of the estuary entrance. Moderate level recreational use. Grazing up to the margin. Weeds and grasses common on margin.		

[1]Todd et al. (2016); [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers

Tora Recreaction Reserve on the southern bank, grazing cattle on the margin (photo: March 2010, Google Maps Street View)

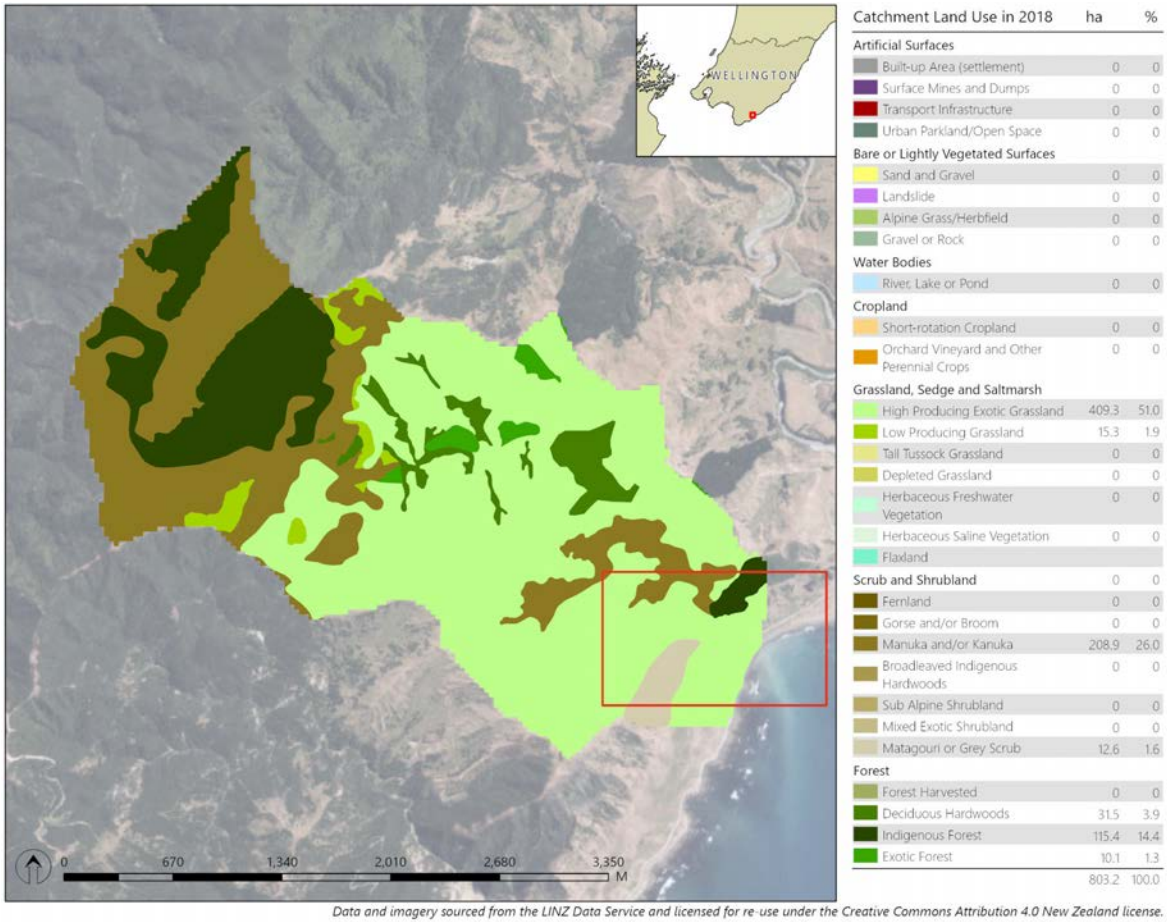


Fig. A25.1. Āwheaiti Stream Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary derived from CLUES 10.8.

Fig. A25.2. Aerial image of Āwheaiti Stream Estuary.

Āwheaiti Stream Estuary looking toward the beach (top) with cattle grazing on the margin of the southern bank and looking upstream (bottom) at Tora Station. Both images show the banks eroding and high turbidity of the water column (photo: March 2010, Google Maps Street View)

A26. ŌPOUAWE RIVER ESTUARY

Ōpouawe River is a medium-sized braided river system with a moderate-sized (12.0ha) 'river mouth lagoon' estuary that drains through a narrow opening. The entrance is dynamic and during summer commonly restricts and/or closes (Todd et al. 2016; Robertson & Stevens 2007a). This estuary lagoon is shallow (<1m) and floods the area behind the beach bar when the entrance is restricted. During times of restricted flushing, the estuary is particularly prone to nutrient, sediment and pathogen issues. Upstream tidal influence is dependent on the size and position of estuary entrance, and on occasion seawater overtops the beach bar into the lagoon (see photo).

In a site visit on 7th April 2022 the estuary was open to the sea through a narrow entrance. While the surface water and riverine sections were freshwater dominated, the bottom waters of the lagoon were partially mixed and saline (16ppt). The braided river channel and the lagoon were dominated by gravels and sand, with some fine sediment deposition observed. However, water clarity was poor, and the water column turbid (~200FNU). Todd et al. (2016) postulated that sediment was deposited before reaching the estuary entrance because the broad, braided riverbed dissipates flood waters allowing settling. No areas of salt marsh have been recorded in the estuary. Because the substrate is mobile, banks are steep and, where vegetation is present, it is dominated by grassland or duneland.

The estuary is a site of significant indigenous biodiversity in the Proposed Natural Resources Plan (Schedule F4) because it provides habitat for threatened indigenous fish species (PNRP Appeals Version 2022). Four migratory fish have also been identified including "At Risk: Declining" species (longfin eel, shortjaw kōkopu, kōaro and redfin bully; Todd et al. 2016 and references therein). The Ōpouawe River mouth is classified as a significant site for breeding birds, including the banded dotterel. Several other bird species, including but not limited to black shag, Caspian tern, variable oystercatcher and pied stilt have also been sighted at Ōpouawe River Estuary (Todd et al. 2016 and references therein).

The most significant pressures to Ōpouawe River Estuary are the very high sediment and nutrient loads from the partly modified catchment (pasture). Further, restriction of the estuary entrance increases the susceptibility of the estuary to water quality deterioration and algal blooms. Other direct pressures include grazing and cattle access to the river, low recreational use (walking, picnickers), vehicle use and weed incursions on the margin.

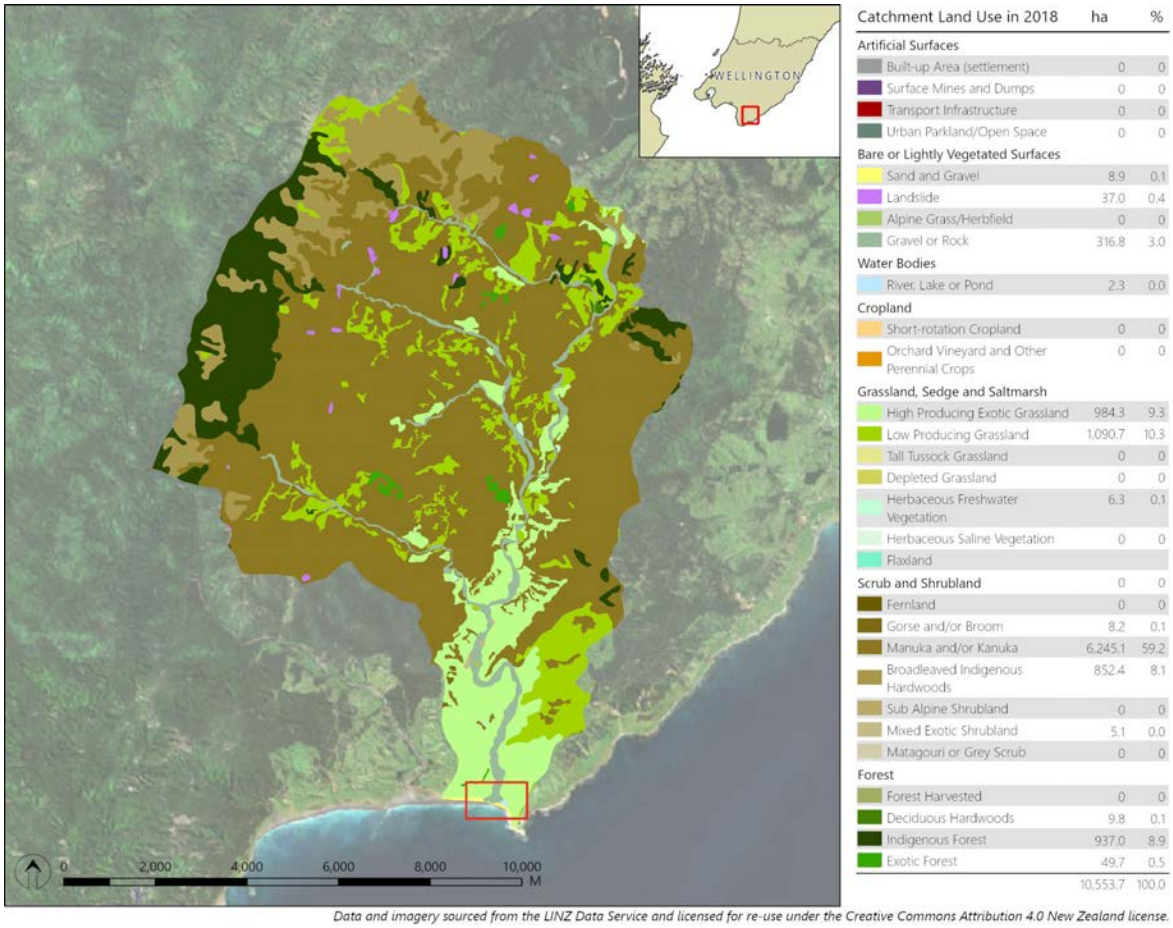
Table A26.1 Summary information for Ōpouawe River Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	12.0	-
Intertidal Area (Ha; % Estuary)[1]	7.6	63.6
Dominant Estuary Substrate[1]	Gravel	
Mud extent (>50% mud content)	-	-
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	-	-
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	10,554	
Dominant Catchment Land Cover[2]	Manuka and/or Kanuka	
% Catchment indigenous vegetation[2]	76.3	
% Catchment exotic forest[2]	0.5	
% Producing grassland[2]	19.6	
Mean Freshwater Flow (m^3/s)[3]	4.2	
Catchment Nitrogen Load (T/y)[3]	41.8	
Catchment Phosphorus Load (T/y)[3]	19.9	
Catchment Sediment Load (KT/y)[3]	785.0	
Catchment Geology[4]	Greywacke (Upper) Sandstone (Mid) Mudstone (Lower)	
Biodiversity		
Significant Site[4]	Y	
Birds[5]	Black shag, banded dotterel, Caspian tern, oystercatchers and pied stilt	
Fish[5]	Longfin eel, shortjaw kōkopu, kōaro and redfin bully	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment		
Erodible catchment, bank erosion		
Poor water quality in periods of closure/ restriction		
Moderate recreational use		
Vehicle damage on the true right bank near camping area		
Weeds and grasses common on margin		

[1]Field visit 7th April 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers, [5]Todd et al. (2016)

Table A26.2. Ecological Vulnerability Assessment, Ōpouawe River Estuary.

Category	Score
Values	0.45
Pressures	0.86
Susceptibility	0.82
Condition	0.67
Average Score	**0.70**



Catchment Land Use in 2018	ha	%
Artificial Surfaces		
Built-up Area (settlement)	0	0
Surface Mines and Dumps	0	0
Transport Infrastructure	0	0
Urban Parkland/Open Space	0	0
Bare or Lightly Vegetated Surfaces		
Sand and Gravel	8.9	0.1
Landslide	37.0	0.4
Alpine Grass/Herbfield	0	0
Gravel or Rock	316.8	3.0
Water Bodies		
River, Lake or Pond	2.3	0.0
Cropland		
Short-rotation Cropland	0	0
Orchard Vineyard and Other Perennial Crops	0	0
Grassland, Sedge and Saltmarsh		
High Producing Exotic Grassland	984.3	9.3
Low Producing Grassland	1,090.7	10.3
Tall Tussock Grassland	0	0
Depleted Grassland	0	0
Herbaceous Freshwater Vegetation	6.3	0.1
Herbaceous Saline Vegetation	0	0
Flaxland		
Scrub and Shrubland	0	0
Fernland	0	0
Gorse and/or Broom	8.2	0.1
Manuka and/or Kanuka	6,245.1	59.2
Broadleaved Indigenous Hardwoods	852.4	8.1
Sub Alpine Shrubland	0	0
Mixed Exotic Shrubland	5.1	0.0
Matagouri or Grey Scrub	0	0
Forest		
Forest Harvested	0	0
Deciduous Hardwoods	9.8	0.1
Indigenous Forest	937.0	8.9
Exotic Forest	49.7	0.5
	10,553.7	100.0

Fig. A26.1. Ōpouawe River Estuary catchment land use classifications from LCDB5 (2017/2018).

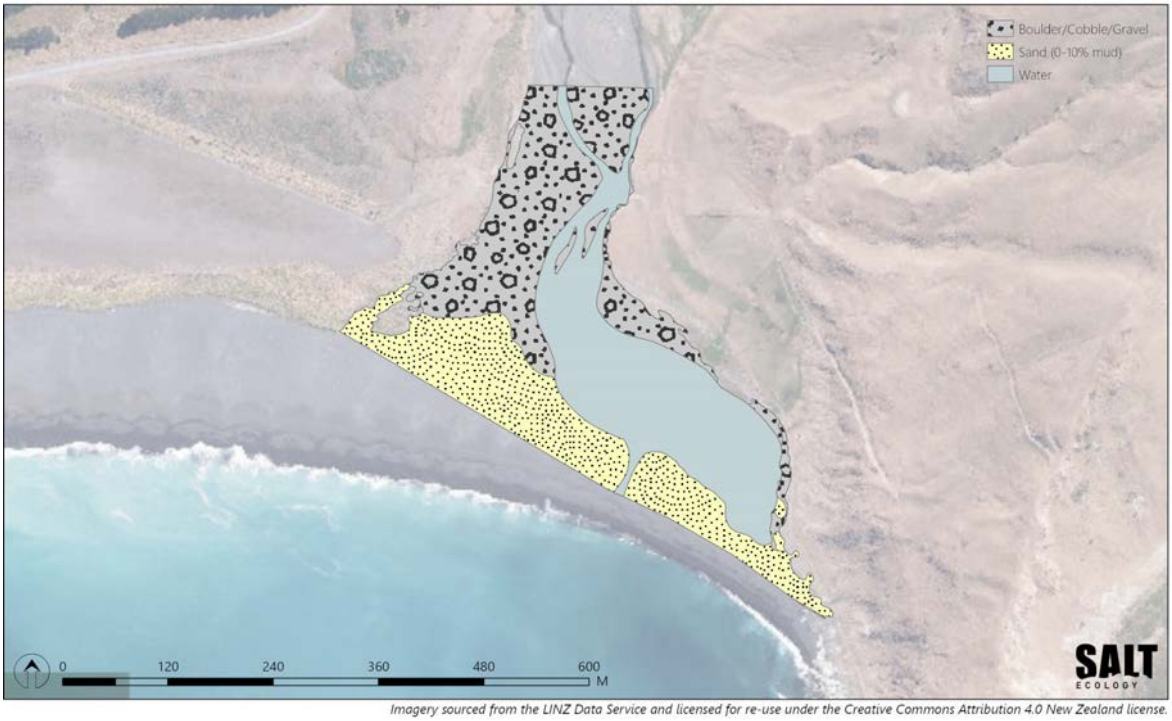


Fig. A26.2. Ōpouawe River Estuary dominant vegetation and substrate features.

Ōpouawe River Estuary entrance, small outflow to the sea (top) and waves overtopping the beach into the lagoon area (bottom)

Lagoon behind the beach bar (top) and the restricted estuary entrance, with steep sand banks on the side of the lagoon (bottom)

Vehicle tracks on the river flats upstream of the estuary entrance

Fence across Ōpouawe River upstream of the entrance, cattle grazing in the river

Ōpouawe River Estuary

A27. WHAWANUI RIVER ESTUARY

Whawanui River is a small-sized river system with a small (~3ha) 'river mouth lagoon' estuary that drains through a narrow opening. The entrance is dynamic and during summer commonly restricts and/or closes. Sampling in April 2022 followed a large rainfall event and a shallow lagoon had formed behind the sandbar extending east toward the marram dunes. Upstream tidal influence is dependent on the size and position of estuary entrance. Aerial imagery shows, the lagoon is not always present and commonly the estuary drains straight to the beach or is closed. During times of restricted flushing, the estuary is particularly prone to nutrient, sediment and pathogen issues.

In a site visit on 7th April 2022 the estuary was open to the sea, a lagoon was formed by the sand bar and large waves regularly overtopped the sand bar flushing seawater into the lagoon. In the lagoon area, a thin layer of mud had deposited on the surface of firm sands. The river channel was dominated by gravels and the lagoon and entrance comprised coarse sand. Water clarity was poor, and the water column turbid. Bank erosion was evident with large clumps falling into the river and fencing undercut by bank erosion. Salt marsh comprised 14.3% of the intertidal habitat and was a mix of rushland and sedgeland including three-square, jointed wire rush, knobby clubrush and herbfield species.

While the estuary itself is not protected upstream of the estuarine area, Whawanui River is a site of significant indigenous biodiversity in the Proposed Natural Resources Plan (Schedule F1) because it is an important habitat for migratory and non-migratory indigenous fish species and has high freshwater macroinvertebrate community health (PNRP Appeals Version 2022). While not classified as significant wetland, to the west of the estuary lagoon, salt marsh transitions into a fenced freshwater wetland dominated by raupō. This area provides important habitat for birds.

The most significant pressures to Whawanui River Estuary are high sediment and nutrient loads from the partly modified catchment (pasture). Further, restriction of the estuary entrance increases the susceptibility of the estuary to water quality deterioration, although it appears to drain through the sand bar when closed because a permanent lagoon is uncommon. Other direct pressures include potential for stock access, low recreational use (walking) and weed incursions on the margin.

Table A27.1 Summary information for Whawanui River Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	8.4	
Intertidal Area (Ha; % Estuary)[1]	6.3	74.9
Dominant Estuary Substrate[1]	Gravel/sand	
Mud extent (>50% mud content)	-	-
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	0.9	14.3
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	2749	
Dominant Catchment Land Cover[2]	Mānuka and/or Kānuka	
% Catchment indigenous vegetation[2]	81.3	
% Catchment exotic forest[2]	0.2	
% Producing grassland[2]	17.4	
Mean Freshwater Flow (m^3/s)[3]	1.2	
Catchment Nitrogen Load (T/y)[3]	11.1	
Catchment Phosphorus Load (T/y)[3]	3.5	
Catchment Sediment Load (KT/y)[3]	46.1	
Catchment Geology[4]	Greywacke (Upper) Sandstone (Mid) Mudstone (Lower)	
Biodiversity		
Significant[4]	N	
Birds	nd	
Fish[5]	Longfin eel, shortjaw kōkopu, kōaro and redfin bully	
Shellfish	nd	
Pressures		
Sediment and nutrient loads from modified catchment. Erodible catchment, bank erosion. Entrance closure or restriction. Potential access to the estuary by grazing animals. Weeds and grasses common on margin.		

[1]Field visit 7th April 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers, [5]Todd et al. (2016)

Table A27.2. Ecological Vulnerability Assessment, Whawanui River Estuary.

Category	Score
Values	0.48
Pressures	0.82
Susceptibility	0.82
Condition	0.73
Average Score	**0.71**

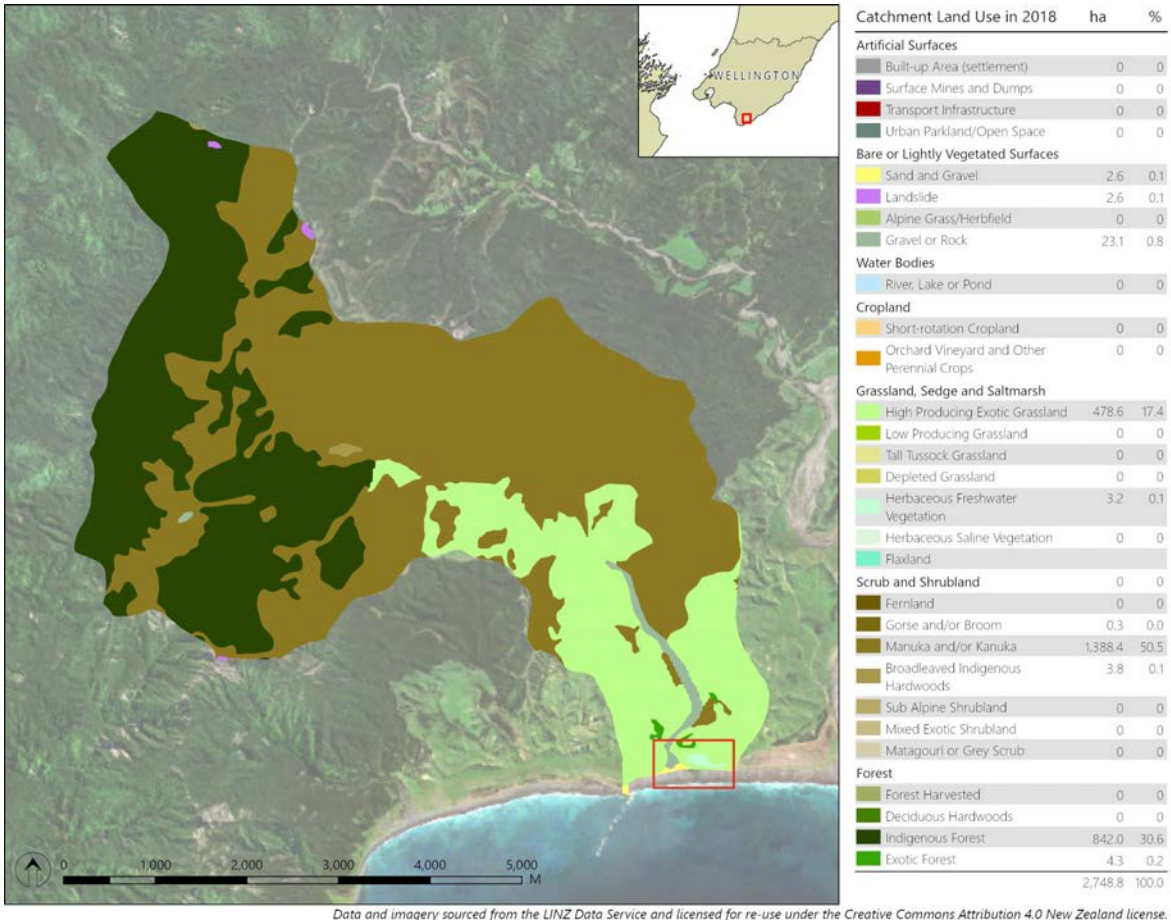


Fig. A27.1. Whawanui River Estuary catchment land use classifications from LCDB5 (2017/2018).

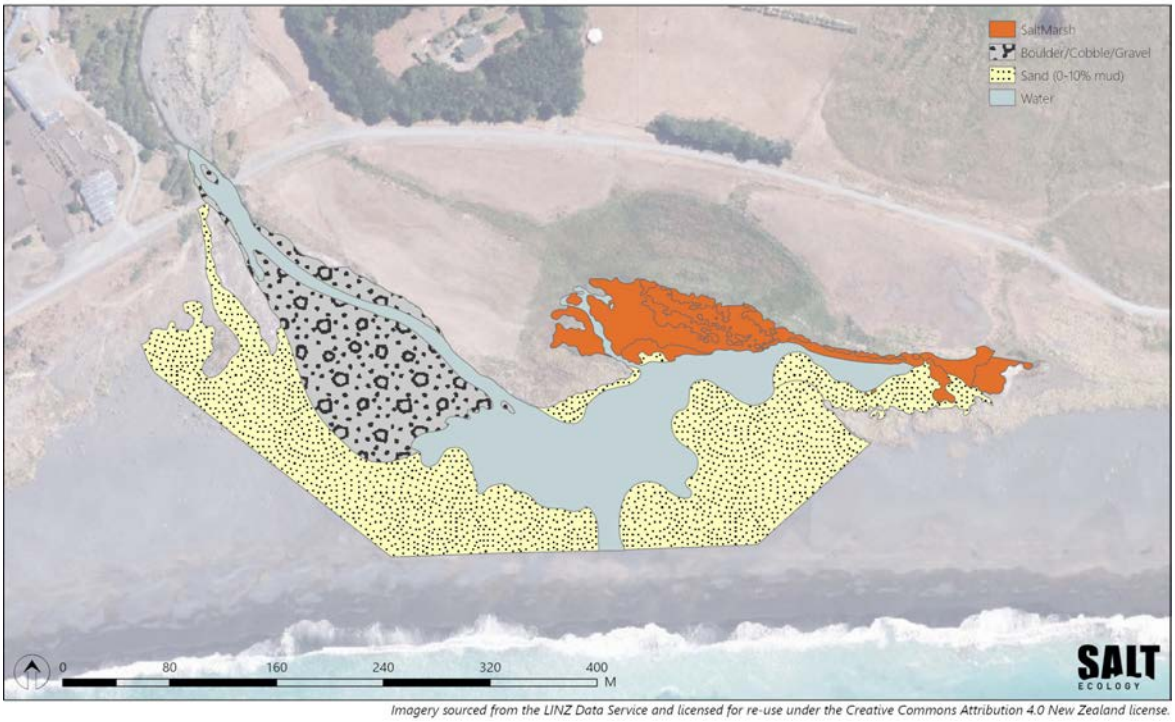


Fig. A27.2. Whawanui River Estuary dominant vegetation and substrate features.

Whawanui River Estuary entrance, small outflow with waves regularly overtopping the sand bar (top) and the lagoon (bottom)

Transition of salt marsh to reedland (top) and extensive salt marsh on the lagoon edge (bottom)

Whawanui River flowing into the lagoon with bank erosion along the margin

February 2021, the river flow is low and the entrance closed (source: Google Earth Maps)

Whawanui River Estuary, looking over the wetland and salt marsh to the lagoon and entrance

A28. WHITE ROCK ESTUARY

White Rock Estuary is a small stream that flows onto the beach forming a small (6.4ha) intermittent riverine estuary that drains through a narrow opening. Unlike other estuaries on the coast the small unnamed stream that feeds the estuary is intermittent and flow ceases after long periods of dry weather. As the stream flow diminishes the entrance closes and water is retained in a pooled area to the west. Aerial imagery shows the lagoon also dries and commonly the estuary drains straight to the beach or is closed. Sampling in April 2022 followed a large rainfall event and the stream meandered through the marram dunes, and the entrance was to the east while a lagoon had formed to the west. The beach is steep and therefore upstream tidal influence is limited. While some fine sediments were freshly deposited in the stream channel at the time of sampling, no ongoing issues from nutrients and sediments were recorded, likely owing to the intermittent nature of the stream input.

In a site visit on 7th April 2022 the estuary was open to the sea, and the estuary freshwater dominated. Water clarity was poor, and the water column turbid (>60FNU). No salt marsh was recorded, however the estuary flowed through a freshwater wetland to the northwest and marram dune system to the east. The lack of salt marsh is likely owing to intermittent inundation and dominance of freshwater in the system.

The stream and intermittent estuary are not classified as significant and there are no records of birds or fish for the site. However, birds likely frequent the wetland and dunes provide an important habitat for nesting birds. Because the stream input is intermittent, it is uncertain whether the system supports migratory fish species.

The catchment is mostly mānuka and/or kānuka with pasture on steep hill country in the lower catchment. However, freshwater inputs are minimal and nutrient loads and sediment inputs are low, there were no obvious signs of eutrophication. Due to the shallow nature of the lagoon area, there is a potential for phytoplankton blooms in summer during periods of poor flushing. A road passes over the stream and cattle were grazing in the dunes and adjacent wetland area with unrestricted access to the beach. Recreational use is likely limited given the remote location, and weeds and grasses were common on the northern margin.

Table A28.1 Summary information for White Rock Estuary.

Summary Information		
Estuary	**Ha**	**%**
Estuary Area[1]	6.4	
Intertidal Area (Ha; % Estuary)[1]	5.1	79.3
Dominant Estuary Substrate[1]	Gravel	
Mud extent (>50% mud content)	-	-
Macroalgae (Ha; cover >50%)[1]	-	-
Seagrass (Ha; cover >50%)[1]	-	-
Salt Marsh (Ha; % intertidal)[1]	-	-
High Enrichment Conditions (HEC)[1]	-	-
Catchment		
Catchment Area (Ha)[2]	262.3	
Dominant Catchment Land Cover[2]	Mānuka and/or Kānuka	
% Catchment indigenous vegetation[2]	81.5	
% Catchment exotic forest[2]	0.0	
% Producing grassland[2]	18.3	
Mean Freshwater Flow (m^3/s)[3]	0.10	
Catchment Nitrogen Load (T/y)[3]	1.07	
Catchment Phosphorus Load (T/y)[3]	0.31	
Catchment Sediment Load (KT/y)[3]	1.07	
Catchment Geology[4]	Greywacke (Upper) Sandstone (Lower)	
Biodiversity		
Significant Site[4]	N	
Birds	nd	
Fish	nd	
Shellfish	nd	
Pressures		
Low sediment and nutrient loads from catchment. Erodible catchment. Intermittent stream input. If the shallow lagoon is isolated there is a potential for phytoplankton blooms. Access to the estuary by grazing animals. Weeds and grasses common on margin.		

[1]Field visit 7th April 2022; [2]GWRC catchment clip of LCDB5; [3]CLUES; [4]GWRC GIS layers

Table A28.2. Ecological Vulnerability Assessment, White Rock Estuary.

Category	Score
Values	0.25
Pressures	0.77
Susceptibility	0.82
Condition	0.71
Average Score	**0.64**

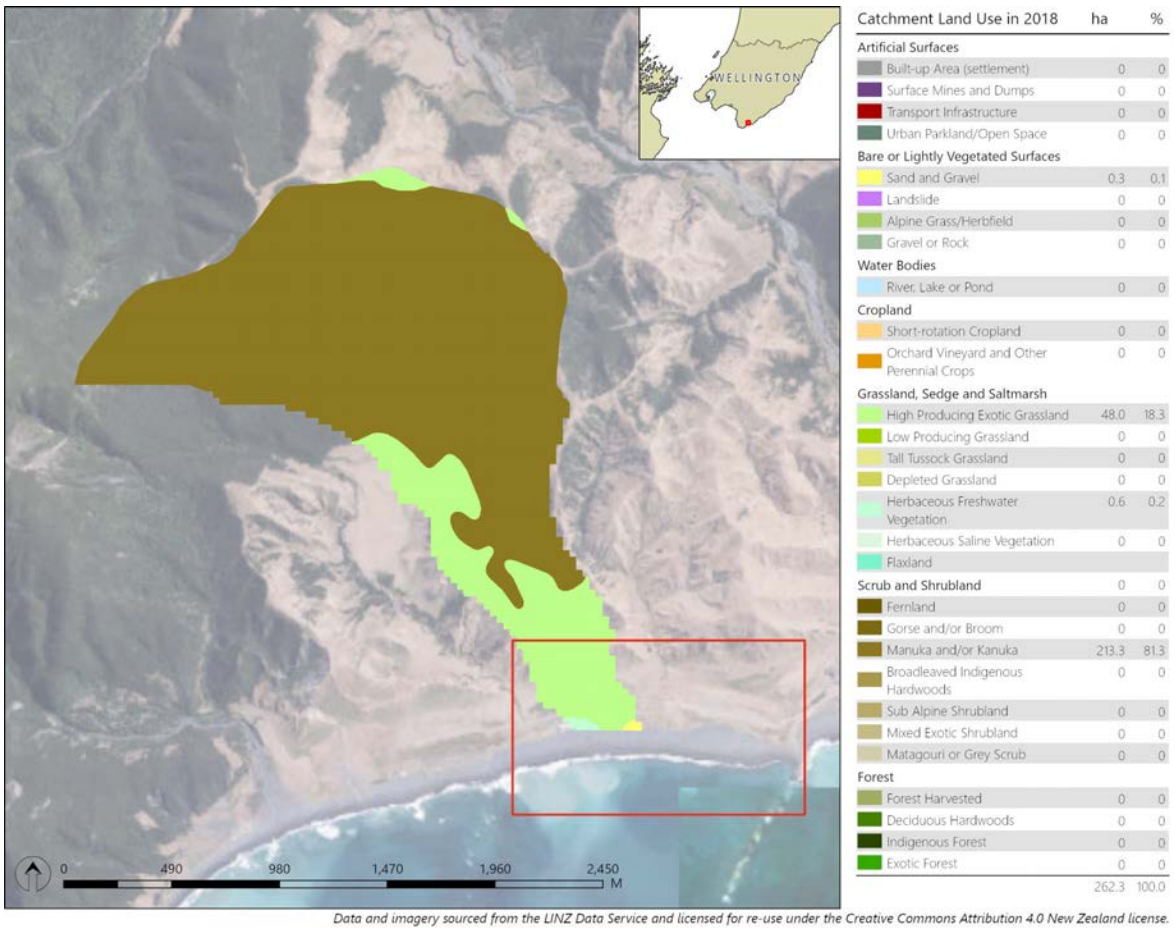


Fig. A28.1. White Rock Estuary catchment land use classifications from LCDB5 (2017/2018). Catchment boundary derived from CLUES 10.8.

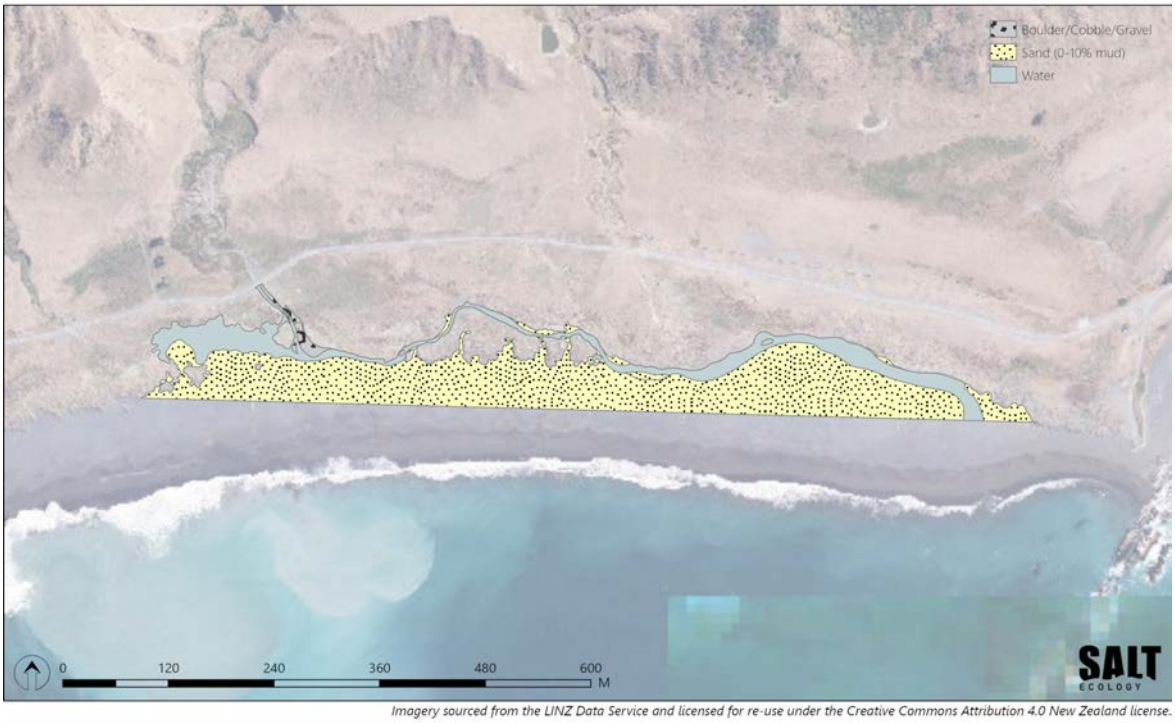


Fig. A28.2. White Rock Estuary dominant vegetation and substrate features.

White Rock Estuary entrance, small outflow to the sea showing tidal influence (top) and waves washing over the beach bar (bottom)

Shallow lagoon near input to the west (top) and stream meandering through dunes to the estuary entrance toward the east (bottom)

Cattle grazing in the dunes and adjacent wetland

Stream meandering through the dunes and wetland

White Rock Estuary, White Rock in the background

A29. CAPE PALLISER ESTUARIES

There are a number of small streams drain to the coast at Cape Palliser (Matakitakiakupe) southwest of White Rock. Three of the main streams (Mākotukutuku, Pararaki and Ōtakaha) have been surveyed previously by Todd et al. (2016). These estuaries were not visited in April 2022 and therefore the summary below is based on a previous report by Todd et al. (2016) in addition to the best available desktop information. While the sites are summarised below for completeness because the site was not visited in 2022, it was not included in the EVA.

The three main streams (Mākotukutuku, Pararaki and Ōtakaha) drain into Palliser Bay to the west of Cape Palliser. The streams are gravel dominated and the entrances are dynamic and restrict and/or close on occasion (Todd et al. 2016; Google Earth historic imagery). When the entrances are closed, a small brackish lagoon can form behind the gravel bar (Todd et al. 2016; Google Earth Historic Imagery). During times of restricted flushing (i.e. entrance closure) the estuaries are prone to nutrient, sediment and pathogen issues, although issues are likely short-lived as these systems are highly dynamic and the entrance condition changes regularly. Further, as new gravels are constantly being deposited as the course of the stream meanders back and forth, vegetation is limited or absent in the riverbed due its instability (Todd et al. 2016).

While the Cape Palliser stream estuaries (Mākotukutuku, Pararaki and Ōtakaha) are not classified as significant, the freshwater streams are classified as sites of significant indigenous biodiversity in the Proposed Natural Resources Plan (Schedule F1) because they provide habitat for high macroinvertebrate community health and threatened or at-risk species of fish (PNRP Appeals Version 2022). Eight migratory fish have been identified including "At Risk: Declining" species (longfin eel, giant kōkopu, shortjaw kōkopu, kōaro and redfin bully; Todd et al. 2016 and references therein). Further several bird species, including but not limited to black shag, banded dotterel, Caspian tern, pied stilt, red-billed gull and the variable oystercatcher have been sighted at the stream mouths (Todd et al. 2016 and references therein).

The mid-upper catchments are dominated by indigenous forest and mānuka and/or kānuka, while a mix of low and high producing grassland is present in the lower catchments. The main pressure to the Cape Palliser stream estuaries is the naturally dynamic nature of the stream beds preventing establishment of intertidal vegetation and sediment and nutrient inputs from the lower modified catchment. When the entrances close, a shallow lagoon forms. Under these conditions there is the potential for phytoplankton blooms during periods of extended poor flushing, however the entrances appear to change regularly. A road bridge passes over each of the streams and sheep have full access to the stream beds promoting bank erosion in parts (Todd et al. 2016). Further, recreational use is limited given the remote location and access via private land and weeds and grasses were common on the margins.

Mākotukutuku Stream entrance looking downstream from the road bridge (photo: November 2013, Google Maps Street View)

Pararaki Stream entrance looking downstream from the road bridge (photo: November 2013, Google Maps Street View)

Ōtakaha Stream entrance looking downstream from the road bridge (photo: November 2013, Google Maps Street View)

APPENDIX 2. COAST SUMMARIES

The following appendix presents a summary for coastal habitats other than estuaries and includes beaches, rocky shores, dunes and gravel berms. Visiting these coastal areas in April 2022 was outside the scope of the current report however summaries are paraphrased from Robertson & Stevens (2007a) and updated, where applicable, with the best available desktop information. The coastal habitats are separated into six sub-regions:

B1. Owahanga Estuary to Castlepoint

B2. Castlepoint to Whareama River

B3. Whareama River to Flat Point

B4. Flat Point to Pāhāoa River

B5. Pāhāoa River to Cape Palliser

B6. Cape Palliser to Whatarangi River

B1. OWĀHANGA ESTUARY TO CASTLEPOINT

This section of the Wairarapa coastline is relatively secluded and situated between the Owāhanga Estuary to the north and Castlepoint, which is 25km south. The area below high water is typically comprised of a narrow strip of firm sand that transitions into wide, flat platforms of soft sedimentary rock and boulders that become exposed at low tide.

Flat rock platforms north of Mātaikona River (photo: December 2006, Wriggle Coastal Management)

The terrestrial margin located beyond the high-water mark is mainly comprised of a narrow stretch of dune-land that is dominated by the introduced marram grass (*Ammophila arenaria*) and the native knobby clubrush (*Ficinia nodosa*). A larger and steeper section of duneland is situated just north of Mātaikona River (see photo). The vegetation immediately beyond the dune area is typically grassland, utilised for low density sheep and beef grazing. The dune and beach areas are generally not fenced.

Rocky platform in foreground and steep marram dominated dune north of Mātaikona River (photo: December 2006, Wriggle Coastal Management)

Looking down on Whakataki Estuary and duneland dominated by marram on the foredune and knobby clubrush on the backdune (photo: April 2022)

While rocky reef platforms are common along this stretch of the Wairarapa coastline, intertidal seagrass beds are less common. South of Mātaikona River is a rocky intertidal platform that supports extensive areas of healthy seagrass growing in rock depressions where sand has been deposited (see photos).

Seagrass beds south of Mātaikona River growing on the rocky reef platform in sands deposited in depressions between rocks (photo: April 2022)

At certain spots, such as the beach at Castlepoint, the rock platforms are absent or only partially visible, resulting in a wider expanse of sandy beach. The beaches in these areas are categorised as "dissipative," meaning it is generally flat and fronted by a wide surf zone that dissipates wave energy. However, Castlepoint deviates from the typical dissipative beach type due to the prevalence of intertidal rocky reef platforms, particularly toward the southern end of the beach. The beach is highly exposed to wave and wind activity. Artificial seawalls stretch along the beach to protect the road and township from coastal erosion. Stormwater and treated sewage (via Castlepoint stream) are discharged onto the beach, with poor water quality recorded regularly in the stream.

Castlepoint beach with rock armouring to protect against coastal erosion and Castlepoint lighthouse in the background (photo: April 2022)

At the southern end of the Castlepoint township there is a lagoon and sand beach enclosed within a limestone reef system. The reef, lagoon, sand dunes, and Castle Rock are all part of Castlepoint Scenic Reserve. As well as protecting outstanding landforms, the reserve is the only location in the world where the Castlepoint daisy (*Brachyglottis compactus*) grows on the crumbled limestone of the reef and Castle Rock. Commercial fishing boats are launched at the south end of the beach through the "Gap" between Castle Rock and the Castlepoint Reef.

Castlepoint lighthouse looking down at the southern end of Castlepoint beach where commercial vessels are launched to the south (photo: April 2022)

To the north of Mātaikona River there is no direct road access with the land privately owned, therefore recreational use is low. However, further south near Castlepoint the area has moderate seasonal use with surfing, recreational fishing, swimming, walking and quad-biking common during the holiday season. Commercial fishing from Castlepoint and farming (sheep and beef) along the whole coastline are also common.

In general, along this section of the Wairarapa coastline the coastal rock types are soft sandstones and mudstones which are easily eroded in the high energy wave environment of the Wairarapa coast. Consequently, some of the land margin is eroding, and the sea discoloured to a light milky brown colour with low clarity, particularly after rainfall. A number of small to moderately sized rivers and streams discharge to this section of the coast (see A1 to A4 in Appendix 1). They undergo a natural pattern of mouth opening and closure, and generally experience poor water quality when the mouth is closed or restricted. The Owāhanga (Manawatu-Wanganui region) and Mātaikona rivers are the largest and drain erosion-prone catchments. Therefore, sediment loads are elevated, and turbid waters often bathe this section of the coast.

Sediment transport north along the Wairarapa coast following cyclone Gabrielle in February 2023 (image source; Cawthron Eye taken 18 February 2023)

B2. CASTLEPOINT TO WHAREAMA RIVER

This isolated stretch of coast, located between Castlepoint in the north and Whareama Estuary 20km south, is characterised by eroding cliffs and shallow rock reefs comprised of soft sandstone. The largest rocky reef platforms are located between Castle Rock and Ngākauau Stream, between Humpies Stream and Otahome Beach and between Otahome Beach and Whareama Estuary. Each of these areas are flanked by steep eroding cliffs. There is also a small rocky platform reef between Ngākauau Stream and Humpies Stream.

Steep eroding cliffs looking north to Castle Rock (top) and south of Ngākauau Stream (bottom; photo: December 2006, Wriggle Coastal Management)

Further south in gentler sloping areas, sandy beaches occur, for example near Otahome. These beaches are generally intermediate type beaches meaning they are characterised by plunging and spilling breakers and are steeper than dissipative beaches, with mobile sediments and rip currents common. A narrow strip of duneland, covered mainly by introduced marram grass (*Ammophila arenaria*) and the native knobby clubrush (*Ficinia nodosa*) is typically found on this stretch of coastline. Marram dunes are also present on the beaches adjacent to the Whareama Estuary. The vegetation beyond the dune area is mostly grassland used for extensive sheep and beef grazing.

Shallow rock reefs north of Otahome Stream mouth (photo: December 2006, Wriggle Coastal Management)

Marram and knobby clubrush dominated duneland near Otahome Stream mouth (photo: April 2022)

Beach south of Otahome Stream mouth (top; December 2006, Wriggle Coastal Management)

Except for Whareama River, only small streams discharge to the coast (see A5 to A8 in Appendix 1). However, as discussed in more detail in A9 (Appendix 1), the Whareama River is a large river system that drains a pasture dominated catchment significantly prone to erosion with high suspended sediment loads transported to the coast in addition to localised, land slips, bank erosion and slumping in the estuary. In addition to coastal currents transporting sediment northward (see photo in B1), riverine inputs mean suspended sediments are elevated and turbid waters often bathe this section of the coast.

Whareama Estuary entrance with bank slumping and erosion on the steep hillside and marram dominated dunes on the seaward edge (top) and Whareama River with high suspended sediment loads (bottom; photo: April 2022)

This stretch of coastline is mostly privately owned combined with large stretches of steep eroding cliffs that limit access, recreational use is low. Sheep and beef grazing is the most common land use type nearest to the coast. With these areas generally unfenced.

Shallow rocky reef platforms north of Whareama Estuary (December 2006, Wriggle Coastal Management)

Cattle pasture along the coastline (December 2006, Wriggle Coastal Management)

B3. WHAREAMA RIVER TO FLAT POINT

This isolated shoreline between Whareama Estuary to the north and Flat Point 31km to the south includes the holiday town of Riversdale and is dominated by narrow, steepening sand or cobble beaches and shallow rock platform reefs exposed at low tide. For example, south of Whareama River to Motuwaireka Stream there is a large rocky reef platform (see photo). The rocks along the coast from Whareama River to Flat Point are, almost without exception, soft (easily eroded) sandstones and mudstones.

South of Whareama River rocky reef platform (December 2006; Wriggle Coastal Management)

The township of Riversdale has a number of small stream inputs discussed in more detail in Appendix 1 (see A11 to A13). Narrow marram dunes are eroding along this section of beach, with some areas of artificial rock wall crudely installed to prevent erosion. In the last 20 years at least 1m of dune erosion has been observed in this area (Google Earth Historic Imagery). Houses back the narrow dunes (<20m from beach) and will likely be prone to more coastal hazards as sea levels rise.

Artificial boulder field installed at Riversdale Central to minimise erosion of the dune (A12; Appendix 1; photo: April 2022)

Eroding foredune on Riversdale beach with houses <20m from the foreshore (photo: April 2022)

From Whareama River to Uruti Point, just south of Riversdale, a sandy beach is present. The beach is comprised of fine and hard sand to the south and coarse very soft sand to the north. Above high water, there are extensive areas of duneland whose vegetation is dominated by introduced marram grass (*Ammophila arenaria*) near the beach, and the native knobby clubrush (*Ficinia nodosa*) and harestail (*Lagurus ovata*) further inland. Freshwater seeps are common, and in these areas raupō (*Typha orientalis*), flax (*Phormium tenax*), and giant umbrella sedge (*Cyperus ustulatus*) and various rushes dominate the vegetation.

Marram foredune and narrow beach with rock showing at low tide (top) and a freshwater seep dominated by raupō (bottom; photo: December 2006, Wriggle Coastal Management)

Vegetation immediately inland of the dune area is primarily grassland used for extensive sheep and beef grazing. The dune and beach areas are generally not fenced. The dune complex (which includes ridges and sand plains) at Uruti Point is the largest such system in the eastern Wairarapa, extending up to 300m inland. Vegetation is dominated by marram grass and knobby clubrush (see photo). Uruti Point is also well-known for its extensive areas of broad terraces extending inland from the Point and its exposed sandstone and mudstone beds on the beach (see photo).

Marram dominated foredune and knobby club rush in the back dune (photo: December 2006; Wriggle Coastal Management)

Exposed sandstone and mudstone beds on the beaches at Uruti Point (photo: December 2006; Coastal Wriggle Management)

Between Uruti Point and the Kaiwhata River mouth the shoreline is dominated by eroding cliffs, long expanses of steepening sandy beaches and rocky areas, which border onto dune areas. Rocky reef platforms are also common off the points and at the lower tidal extent of some beach areas. There has been significant erosion of this coastline in the last 20 years with up to 25m lost in some areas (see 'A18. Homewood Estuaries'; Appendix 1).

Steep beaches and eroding cliffs between Uruti Point and Kaiwhata River (photo: April 2022)

Steep rocky cliffs and rocky reef platform between Uruti Point and Kaiwhata River (photo: April 2022)

Between Kaiwhata River mouth and Flat Point (~5km south), the coastline is mainly a steep beach of boulders with the base of the hills extending to the edge of the beach. Dune features are absent, and hills are primarily grassed and used for extensive sheep and cattle grazing.

Human use is moderate, particularly around the township of Riversdale where walking, quad-biking, surfing, diving, scientific interest and inshore fishing is seasonal. Public access is good at the Riversdale end but limited south of Uruti Point as most of the land is privately owned (the public road re-enters at Flat Point). Commercial fishing boats are launched off the beach at Uruti Point. Several small streams and rivers discharge to this section of the high energy coastline with suspended sediments high in this area due to the highly erodible catchments (see A10 to A19; Appendix 1).

B4. FLAT POINT TO PĀHĀOA RIVER

The shoreline between Flat Point and the Pāhāoa River (26 km to the south) is varied. The first section, between Flat Point and the Waikekino Stream (north of Horewai Point) consists of a relatively wide Holocene marine terrace separated from the sea by an extensive intermediate type (i.e. beach characterised by plunging and spilling breakers that is steeper than a dissipative beach with mobile sediments and rip currents common), sandy and at times smooth pebble beach for ~11km. The beach is backed by a marram grass (*Ammophila arenaria*) dominated dune.

Beach shoreline towards Flat Point (photo: December 2006; Wriggle Coastal Management)

Marram dominated dune south of Flat Point (photo: December 2006; Wriggle Coastal Management)

Between Waikekino Stream and Horewai Point, on the seaward edge of the Holocene marine terrace is an extensive rocky reef with large boulders and cobbles on top of bedrock (see photo). Dune vegetation is absent in these areas with low and high producing grassland up to the high water mark, erosion of the lands edge is common in this area.

Beach shoreline looking south toward Waikekino Stream (top) and rocky reef south of Waikekino Stream at the end of the Halocene marine terrace (photo: December 2006; Wriggle Coastal Management)

Between Horewai Point and Pāhāoa River, the coastal plain becomes gradually narrower, and the shoreline rockier (boulders, cobbles and rock features). Although there are some sandy beach areas within this stretch of coast, they are all small and restricted to embayments (see photo).

Rock reef with small beach area in embayment near Horewai Point (photo: December 2006; Wriggle Coastal Management)

Duneland is generally absent from this section, except at Flat Point, and near Arawhata, Waihingaia and Pāhāoa River mouths. Instead, the landward margin of the shore is predominantly grassland used for extensive sheep and cattle grazing (see photo below), except for a small area of native bush north of the Pāhāoa River mouth. Limestone outcrops, like that at Pāhāoa River mouth, are not uncommon on this stretch of coast (see photo).

Eroding grassland to the margin and pebble beach with rocks on the low tide margin south of Waikekino Stream (photo: December 2006; Wriggle Coastal Management)

Limestone outcrop at the mouth of the Pāhāoa River (photo: April 2022)

The coastal rock types in the area are generally soft sandstones and mudstones which are easily eroded in the high energy wave environment of the Wairarapa coast. Consequently, much of the land margin is eroding and suspended solids are high along the coast (see photo previous page). Further, a number of small streams draining highly erodible catchments discharge onto the coast, with the Pāhāoa River being the largest (see A21; Appendix 1).

Pāhāoa River (photo: April 2022)

Human use of the beach, dunes and rocky shores in this section of the coast is low. However, landscape appreciation and scientific interest in the geology of the area, particularly Honeycomb Rock, is high. Apart from these uses, the coastline area is valued for walking, quad-biking, surfing, diving, and inshore fishing. The duneland and beach margin areas are generally unfenced and grazed by sheep and cattle. However, since Robertson & Stevens (2007) assessed these areas there has been more effort, particularly around Pāhāoa River, to improve fencing and protect sensitive habitats. Public access is generally good in the beach section near Glenburn but more restricted in the rocky section, further south. There is no public road access along the shoreline past Glenburn Station (just south of the Waikekino Stream). However, public access via Honeycomb rock walkway crosses private land. Holiday housing is sparse with some more recent developments at Flat Point.

Honeycomb Rock (Photo: December 2006; Wriggle Coastal Management)

B5. PĀHĀOA RIVER TO CAPE PALLISER

The shoreline inland of high water between Pāhāoa River mouth to the north and Cape Palliser, 55km to the south, is very remote and exposed. In parts (e.g. Pāhāoa River to Rerewhakaaitu River) the shoreline is dominated by towering greywacke cliffs fringed by a narrow strip of uplifted rock-and-gravel platform (see photo). These areas are prone to land slips and erosion, see example from December 2006 where a large land slip has created a turbidity plume near shore (see photo).

Steep cliffs south of Pāhāoa River to Rerewhakaaitu River (Photo: December 2006; Wriggle Coastal Management)

South of Rerewhakaaitu River there is a Holocene marine terrace along the coast flanked by steep mountains inland (i.e. ~200 to 500m inland). The platform is primarily grassland with various scrub species, particularly tauhinu (cottonwood), gorse and kānuka. Below high water, the shores are exposed gravel, cobble, boulder and rock fields with the occasional shingle fan and longer stretches of steep cliffs. At only a few localities are the younger and softer tertiary rocks present, mainly limestone (e.g. White Rock, at the mouth of the Ōpouawe River, Hangaroa River and Āwhea River).

Limestone outcrop at White Rock (photo: April 2022)

Marine terrace south of Rerewhakaaitu River (photo: December 2006; Wriggle Coastal Management)

Steep to intermediate gravel/sand beaches are present in several areas with the most extensive occurring at White Rock. Dunelands tend to be absent except for a short and relatively narrow strip of marram grass dominated dunes at Tora and a much longer (5km) and wider (up to 1km) area at White Rock. Several patches of lowland swamp were also present on the grassland above the beach at Tora. In these areas raupō (*Typha orientalis*), flax (*Phormium tenax*), and giant umbrella sedge (*Cyperus ustulatus*) and various rushes (*Juncus sarophorus*, *Juncus gregiflorus*) dominate the vegetation.

White Rock beach looking south toward Cape Palliser (photo: December 2006; Wriggle Coastal Management)

Swamp areas near Tora beach (photo: December 2006; Wriggle Coastal Management)

A number of streams and rivers discharge between Pāhāoa River and White Rock, with many of them river mouth lagoons meaning the entrances close or restrict on occasion depending on swell size, direction and river flows (see A21 to A28; Appendix 1). Sediment loads in these areas are expected to be low due to the hard rock nature of the catchment, therefore there are also less inputs onto the coast. In areas that are grazed, nutrient and pathogen loadings could be a potential issue, however, in general, water quality in these estuaries is good.

Āwhea River discharges onto the coast (photo: April 2022)

Ōpouawe River discharges onto the coast (photo: April 2022)

South of White Rock beach toward Cape Palliser access is more limited as the coastline is captured in the Aorangi Forest Park with only off-road access possible, and permission required to cross private land. Cape Palliser lighthouse can be accessed via road from the south. The area comprises steep hard rock (greywacke) mountains covered in native forest. Several streams discharge along this stretch of coastline, however because they drain a predominantly vegetated hard rock catchment, sediment loadings are low relative to other parts of the Wairarapa coast.

Lower hills of Aorangi Forest Park (top), Cape Palliser Lighthouse (middle) and rocky reef flanked by steep mountains north of Cape Palliser Lighthouse (bottom; photo: December 2006; Wriggle Coastal Management)

Human use between Pāhāoa River and Cape Palliser is low given its remoteness. Large areas of the coastline are captured within privately owned land, predominantly sheep and beef stations. Public road access is available at Pāhāoa River, Tora Beach and White Rock. Recreational uses include walking, quad-biking, surfing, diving, scientific interest and inshore fishing.

B6. CAPE PALLISER TO WHATARANGI RIVER

This 22km long section of the coast is very exposed and bathed by relatively clear, clean waters up to Mākotukutuku River, beyond which the catchment transitions to more erosion prone soft rocks toward the Whatarangi River. Below high water, the shores are narrow, steep gravel, cobble beaches or boulder and rock fields with artificial seawalls present in many areas (e.g. Whatarangi along the base of the eroding cliffs). Above high water, a broad uplifted flat coastal plain of mixed alluvial and marine gravels is backed by a series of raised platforms and steep weathered hillsides. The coastal platform narrows in parts (e.g. north of Te Humenga Point) is primarily mixed grassland and scrubland, flanked by steep grassland hillsides.

The foreshore between Cape Palliser to Kupe's Sail (east of Mangotoetoe Stream) is identified by GWRC as an area of important conservation value and on this section of coast, large rocky outcrops dominate with boulder and gravel fields at the top of the beaches. A seal colony is present at Cape Palliser.

Rocky reef east of Kupe's Sail (photo: December 2006; Wriggle Coastal Management)

Seals on the rocky outcrops at Cape Palliser (photo: December 2006; Wriggle Coastal Management)

A small fishing village, Ngawi, lies northwest of Cape Palliser and there is a steep gravel beach in the small embayment that is flanked by rocky reef on either side. Fishing boats are launched and retrieved from the steep gravel beach using bulldozers and heavy machinery. Ngawi is also a popular holiday area and there are several popular surf breaks.

Bulldozers and boats line the beach in front of the Ngawi township (photo: December 2006; Wriggle Coastal Management)

The coastal terrace widens from Te Kawakawa (Black) Rocks (just south of Ngawi) to Te Humenga Point with steep gravel beaches flanked by spinifex dominated dunes and grassland, however marram, an introduced species, was recorded in 2006. The dune area near Te Humenga Point is spinifex dominated and is protected under a DOC land protection covenant. In partnership with the landowner significant effort has been made to fence the area of duneland to protect its conservation values and weed management is ongoing. This area of coast is particularly prone to erosion with artificial seawalls along the coast to protect roading infrastructure just south of Pararaki River.

Spinifex dunes south of Te Humenga Point (photo: December 2006; Wriggle Coastal Management)

Rock armouring to prevent erosion near roading infrastructure (photo: December 2006; Wriggle Coastal Management)

The coastal terrace narrows north of Te Humenga Point up to Mākotukutuku River. The narrow beaches are dominated by gravels with some boulders at low water. Between Cape Palliser and Mākotukutuku River a number of streams and rivers discharge to the coast (e.g. Whawanui, Mākotukutuku, Pararaki and Ōtakaha; see A29, Appendix 1). All drain hard rock-type catchments and consequently they tend to have low sediment loadings and exit the coast across broad shingle and cobble fans. Nutrient and pathogen loadings are expected to be low due to the mostly native bush catchments.

Narrow gravel (top) and sand (bottom) beaches north of Te Humenga Point (photo: December 2006; Wriggle Coastal Management)

The small stretch (~3km) north of Mākotukutuku River through to Whatarangi River is prone to severe erosion where both the road and houses are threatened or have been condemned due to falling cliffs. Large sections of the coast have seawalls along the base of the eroding cliffs and dunes to protect the foreshore.

Rock armouring on the road edge (top) and eroding cliffs threatening houses in 2006 (bottom) note that this erosion is more extensive today (photo: December 2006; Wriggle Coastal Management)

Human use of the area is high and public access along the coastal road is good. Farming is the dominant land use, with walking, surfing, diving, holidaying, scientific interest and inshore fishing all popular. The major ecological risks to this section of the coast are habitat loss from erosion, marram grass invasion of the Te Humenga duneland, and the influence of climate change (e.g. increase in temperature) on high biodiversity rocky reef areas.

APPENDIX 3. BROAD SCALE HABITAT CLASSIFICATION DEFINITIONS

Estuary vegetation was classified using an interpretation of the Atkinson (1985) system described in the NEMP (Robertson et al. 2002) with minor modifications as listed. Revised substrate classes were developed by Salt Ecology to more accurately classify fine unconsolidated substrate. Terrestrial margin vegetation was classified using the field codes included in the Landcare Research Land Cover Database (LCDB5) - see following page.

VEGETATION (mapped separately to the substrates they overlie and ordered where commonly found from the upper to lower tidal range).

Estuarine shrubland: Cover of estuarine shrubs in the canopy is 20-80%. Shrubs are woody plants <10 cm dbh (density at breast height).

Tussockland: Tussock cover is 20-100% and exceeds that of any other growth form or bare ground. Tussock includes all grasses, sedges, rushes, and other herbaceous plants with linear leaves (or linear non-woody stems) that are densely clumped and >100 cm height. Examples occur in all species of *Cortaderia*, *Gahnia*, and *Phormium*, and in some species of *Chionochloa*, *Poa*, *Festuca*, *Rytidosperma*, *Cyperus*, *Carex*, *Uncinia*, *Juncus*, *Astelia*, *Aciphylla*, and *Celmisia*.

Sedgeland: Sedge cover (excluding tussock-sedges and reed-forming sedges) is 20-100% and exceeds that of any other growth form or bare ground. "Sedges have edges". If the stem is clearly triangular, it's a sedge. If the stem is flat or rounded, it's probably a grass or a reed. Sedges include many species of *Carex*, *Uncinia*, and *Scirpus*.

Grassland[1]: Grass cover (excluding tussock-grasses) is 20-100% and exceeds that of any other growth form or bare ground.

Introduced weeds[1]: Introduced weed cover is 20-100% and exceeds that of any other growth form or bare ground.

Reedland: Reed cover is 20-100% and exceeds that of any other growth form or open water. Reeds are herbaceous plants growing in standing or slowly-running water that have tall, slender, erect, unbranched leaves or culms that are either round and hollow – somewhat like a soda straw, or have a very spongy pith. Unlike grasses or sedges, reed flowers will each bear six tiny petal-like structures. Examples include *Typha*, *Bolboschoenus*, *Scirpus lacutris*, *Eleocharis sphacelata*, and *Baumea articulata*.

Lichenfield: Lichen cover is 20-100% and exceeds that of any other growth form or bare ground.

Cushionfield: Cushion plant cover is 20-100% and exceeds that of any other growth form or bare ground. Cushion plants include herbaceous, semi-woody and woody plants with short densely packed branches and closely spaced leaves that together form dense hemispherical cushions.

Rushland: Rush cover (excluding tussock-rushes) is 20-100% and exceeds that of any other growth form or bare ground. A tall, grass-like, often hollow-stemmed plant. Includes some species of *Juncus* and all species of *Apodasmia (Leptocarpus)*.

Herbfield: Herb cover is 20-100% and exceeds that of any other growth form or bare ground. Herbs include all herbaceous and low-growing semi-woody plants that are not separated as ferns, tussocks, grasses, sedges, rushes, reeds, cushion plants, mosses or lichens.

Seagrass meadows: Seagrasses are the sole marine representatives of Angiospermae. Although they may occasionally be exposed to the air, they are predominantly submerged, and their flowers are usually pollinated underwater. A notable feature of all seagrass plants is the extensive underground root/rhizome system which anchors them to their substrate. Seagrasses are commonly found in shallow coastal marine locations, salt-marshes and estuaries and are mapped.

Macroalgal bed: Algae are relatively simple plants that live in freshwater or saltwater environments. In the marine environment, they are often called seaweeds. Although they contain chlorophyll, they differ from many other plants by their lack of vascular tissues (roots, stems, and leaves). Many familiar algae fall into three major divisions: Chlorophyta (green algae), Rhodophyta (red algae), and Phaeophyta (brown algae). Macroalgae are algae observable without using a microscope. Macroalgal density, biomass and entrainment are classified and mapped.

Note NEMP classes of Forest and Scrub are considered terrestrial and have been included in the terrestrial Land Cover Data Base (LCDB) classifications.

SUBSTRATE (physical and zoogenic habitat)

Sediment texture is subjectively classified as: firm if you sink 0-2 cm, soft if you sink 2-5cm, very soft if you sink >5cm, or mobile - characterised by a rippled surface layer.

Artificial substrate: Introduced natural or man-made materials that modify the environment. Includes rip-rap, rock walls, wharf piles, bridge supports, walkways, boat ramps, sand replenishment, groynes, flood control banks, stopgates. Commonly sub-grouped into artificial: substrates (seawalls, bunds etc), boulder, cobble, gravel, or sand.

Rock field: Land in which the area of basement rock exceeds the area covered by any one class of plant growth-form. They are named from the leading plant species when plant cover is ≥1%.

Boulder field: Land in which the area of unconsolidated boulders (>200mm diam.) exceeds the area covered by any one class of plant growth-form. They are named from the leading plant species when plant cover is ≥1%.

Cobble field: Land in which the area of unconsolidated cobbles (>20-200 mm diam.) exceeds the area covered by any one class of plant growth-form. They are named from the leading plant species when plant cover is ≥1%.

Gravel field: Land in which the area of unconsolidated gravel (2-20 mm diameter) exceeds the area covered by any one class of plant growth-form. They are named from the leading plant species when plant cover is ≥1%.

Sand: Granular beach sand with a low mud content 0-10%. No conspicuous fines evident when sediment is disturbed.

Sand/Shell: Granular beach sand and shell with a low mud content 0-10%. No conspicuous fines evident.

Muddy sand (Moderate mud content): Sand/mud mixture dominated by sand, but has an elevated mud fraction (i.e. >10-25%). Granular when rubbed between the fingers, but with a smoother consistency than sand with a low mud fraction. Generally firm to walk on.

Muddy sand (HIgh mud content): Sand/mud mixture dominated by sand, but has an elevated mud fraction (i.e. >25-50%). Granular when rubbed between the fingers, but with a much smoother consistency than muddy sand with a moderate mud fraction. Often soft to walk on.

Sandy mud (Very high mud content): Mud/sand mixture dominated by mud (i.e. >50%-90% mud). Sediment rubbed between the fingers is primarily smooth/silken but retains a granular component. Sediments generally very soft and only firm if dried out or another component, e.g. gravel, prevents sinking.

Mud (>90% mud content): Mud dominated substrate (i.e. >90% mud). Smooth/silken when rubbed between the fingers. Sediments generally only firm if dried out or another component, e.g. gravel, prevents sinking.

Cockle bed /Mussel reef/ Oyster reef: Area that is dominated by both live and dead cockle shells, or one or more mussel or oyster species respectively.

Sabellid field: Area that is dominated by raised beds of sabellid polychaete tubes.

Shell bank: Area that is dominated by dead shells

[1] *Additions to the NEMP classification.*

Table of modified NEMP substrate classes and list of Landcare Land Cover Database (LCDB5) classes.

Consolidated substrate			Code
Bedrock		Rock field "solid bedrock"	RF
Coarse Unconsolidated Substrate (>2mm)			
Boulder/ Cobble/ Gravel	>256mm to 4.1m	Boulder field "bigger than your head"	BF
	64 to <256mm	Cobble field "hand to head sized"	CF
	2 to <64mm	Gravel field "smaller than palm of hand"	GF
	2 to <64mm	Shell "smaller than palm of hand"	Shel
Fine Unconsolidated Substrate (<2mm)			
Sand (S)	Low mud (0-10%)	Mobile sand	mS
		Firm shell/sand	fSS
		Firm sand	fS
		Soft sand	sS
Muddy Sand (MS)	Moderate mud (>10-25%)	Mobile muddy sand	mMS10
		Firm muddy shell/sand	fSS10
		Firm muddy sand	fMS10
		Soft muddy sand	sMS10
	High mud (>25-50%)	Mobile muddy sand	mMS25
		Firm muddy shell/sand	fMSS25
		Firm muddy sand	fMS25
		Soft muddy sand	sMS25
Sandy Mud (SM)	Very high mud (>50-90%)	Firm sandy mud	fSM
		Soft sandy mud	sSM
		Very soft sandy mud	vsSM
Mud (M)	Very high mud (>90%)	Firm mud	fM90
		Soft mud	sM90
		Very soft mud	vsM90
Zootic (living)			
		Cocklebed	CKLE
		Mussel reef	MUSS
		Oyster reef	OYST
		Tubeworm reef	TUBE
Artificial Substrate			
		Substrate (brg, bund, ramp, walk, wall, whf)	aS
		Boulder field	aS BF
		Cobble field	aS CF
		Gravel field	aS GF
		Sand field	aS SF

Artificial Surfaces

1 Built-up Area (settlement)
2 Urban Parkland/Open Space
5 Transport Infrastructure
6 Surface Mines and Dumps

Bare or Lightly Vegetated Surfaces

10 Sand and Gravel
12 Landslide
16 Gravel and Rock

Water Bodies

20 Lake or Pond
21 River

Cropland

30 Short-rotation Cropland
33 Orchard Vineyard & Other Perennial Crops

Grassland, Sedge and Saltmarsh

40 High Producing Exotic Grassland
41 Low Producing Grassland
45 Herbaceous Freshwater Vegetation
46 Herbaceous Saline Vegetation

Scrub and Shrubland

47 Flaxland
50 Fernland
51 Gorse and/or Broom
52 Manuka and/or Kanuka
54 Broadleaved Indigenous Hardwoods
56 Mixed Exotic Shrubland
58 Matagouri or Grey Scrub

Forest

64 Forest - Harvested
68 Deciduous Hardwoods
69 Indigenous Forest
71 Exotic Forest

APPENDIX 4. RAPID ESTUARY ASSESSMENT

Rapid Estuary Assessment

Field based assessment of ecological values and condition

SALT ECOLOGY

Site:

Date/Time:

Tide Time:

Field Observer/s

Weather prior to sampling (i.e. dry, rainfall etc)

Photos of key habitats Y/N

Photos of key pressures Y/N

VALUE - Habitat Intactness							
Method	A subjective appraisal of the overall intactness and health of the site relative to estimated natural state.						
% of the site is considered healthy and intact compared to natural state	>80 to 100% ☐	>60 to ≤80% ☐	>40 to ≤60% ☐	>20 to ≤40% ☐	0 to ≤20% ☐	VALUE SCORE	CONDITION SCORE
SCORE	**5**	**4**	**3**	**2**	**1**		

VALUE - Substrate Habitat Diversity						
Method	The number of different substrate types. Including mud, shell/sand, gravel/cobble recorded if >5% intertidal area and boulder/bedrock, zootic recorded if >1% intertidal area (outside of saltmarsh areas).					
Common substrates present (tick)	Mud-dominated (>5% intertidal area) ☐	Sand/Shell-dominated (>5% intertidal area) ☐	Gravel/cobble (>5% intertidal area) ☐	Boulder/Bedrock (>1% intertidal area) ☐	Zootic (mussel etc) (>1% intertidal area) ☐	Notes:
Approximate % of total substrate (estimate)	_____%	_____%	_____%	_____%	_____%	
Number of substrate types (circle)	≥5	4	3	2	1	VALUE SCORE / CONDITION SCORE
SCORE	**5**	**4**	**3**	**2**	**1**	

CONDITION - Mud Extent							
Method	Estimate or measure extent of intertidal mud-dominated sediments e.g. >50% mud content.						
% Intertidal Area	<1% ☐	1-5% ☐	>5-15% ☐	>15-50% ☐	>50% ☐	VALUE SCORE	CONDITION SCORE
SCORE	**5**	**4**	**3**	**2**	**1**		

VALUE - Salt marsh							
Method	Estimate or measure the area of intertidal salt marsh extent.						
Intertidal salt marsh extent (%) (tick and estimate extent)	>20% ☐ ___%	>10-20% ☐ ___%	>5-10% ☐ ___%	>0-5% ☐ ___%	0% ☐	VALUE SCORE	CONDITION SCORE
SCORE	**5**	**4**	**3**	**2**	**1**		

CONDITION - Salt marsh						
Method	Five common pressures are listed. Two metrics are used. 1) to identify whether salt marsh is under single or multiple pressures; and 2) the percentage of the salt marsh impacted by the pressures present. The attribute with the lowest score determines the final score.					
Common pressures present (tick)	Grazing or Vehicle damage ☐	Reclamation ☐	Drainage ☐	Erosion ☐	Weeds ☐	Notes:
% of salt marsh affected (estimate)	_____%	_____%	_____%	_____%	_____%	
List any additional pressures:						
Total count of pressures (circle)	1	2	3	4	≥5	
Total salt marsh area affected (circle)	0%	>0 to 5%	>5 to 10%	>10 to 20%	>20%	VALUE SCORE / CONDITION SCORE
SCORE	**5**	**4**	**3**	**2**	**1**	

VALUE - Seagrass							
Method	Estimate or measure extent of intertidal seagrass.						
Intertidal seagrass extent (%) (tick and estimate extent)	>20% ☐ ___%	>10-20% ☐ ___%	>5-10% ☐ ___%	>0-5% ☐ ___%	0% ☐	VALUE SCORE	CONDITION SCORE
SCORE	**5**	**4**	**3**	**2**	**1**		

CONDITION - Seagrass							
Method	Five common pressures are listed. Two metrics are used. 1) to identify whether seagrass is under single or multiple pressures; and 2) the percentage of the seagrass impacted by the pressures present. The attribute with the lowest score determines the final score. NA, where no seagrass is present.						
Common pressures present (tick)	Macroalgae smothering ☐	Epiphytic growth ☐	Sediment smothering ☐	Leaf die-off/discolouration ☐	Physical erosion or grazing (e.g. swans) ☐	Notes:	
% of seagrass affected (estimate)	_____%	_____%	_____%	_____%	_____%		
Total count of pressures (circle)	1	2	3	4	≥5		
Total seagrass area affected (circle)	0	>0-5%	>5-10%	>10-20%	>20%	VALUE SCORE	CONDITION SCORE
SCORE	**5**	**4**	**3**	**2**	**1**		

CONDITION - Macroalgae (growths of opportunistic macroalgae)							
Method	% cover of the intertidal area with >5% opportunistic nuisance macroalgae cover (e.g. *Ulva* spp., *Agarophyton* spp. or other known bloom forming species in the region).						
% of intertidal area with >5% macroalgae cover	0 to ≤5 ☐	>5 to ≤15 ☐	>15 to ≤25 ☐	>25 to ≤75 ☐	>75 to 100% ☐	VALUE SCORE	CONDITION SCORE
SCORE	**5**	**4**	**3**	**2**	**1**		

CONDITION - High Enrichment Conditions (HECs)							
Method	Estimate the intertidal area expressing High Enrichment Conditions (>50% macroalgae, low sediment oxygen (i.e. shallow aRPD), mud>25% or anoxic muds devoid of life). These areas are usually relatively small and located in deposition areas where fine muds accumulate.						
% of intertidal area with HECs	0ha or 0% ☐	>0-0.5ha or >0-1% ☐	0.5-5ha or 1-5% ☐	>5-20ha or >5-10% ☐	>20ha or >10% ☐	VALUE SCORE	CONDITION SCORE
SCORE	**5**	**4**	**3**	**2**	**1**		

CONDITION - Estuary margin hardening (e.g. reclamation or artificial rock wall)							
Method	Percent of the estuary margin (high tide line) that has been reclaimed or hardened, compromising the natural connectivity of the estuary to the surrounding terrestrial areas. e.g. seawalls, reclamation, roading						
% of high tide line modified	0 to ≤20% ☐	>20 to ≤40% ☐	>40 to ≤60% ☐	>60 to ≤80% ☐	>80 to 100% ☐	VALUE SCORE	CONDITION SCORE
SCORE	**5**	**4**	**3**	**2**	**1**		

CONDITION - Invasive species							
Method	Record the presence of invasive species and their level of establishment. e.g. Pacific oyster, *Undaria* sp. and *Spartina* sp.						
Existing presence of invasive species (individual per area or % across estuary)	Absent No visible individuals ☐	Rare <1 indiv./ 10m^2 or <1% across estuary ☐	Occasional 1 to <10 indiv./ 10m^2 or ≥1 to <5% across estuary ☐	Frequent ≥10 to <100 indiv./10m^2 or ≥5 to <10% across estuary ☐	Common ≥10% across estuary including high density areas ≥10 indiv./1m^2 ☐		
List any invasive species seen or recorded from the site:						VALUE SCORE	CONDITION SCORE
SCORE	**5**	**4**	**3**	**2**	**1**		

CONDITION - Toxicants							
Method	Five common sources are listed to indicate whether inputs are likely from single or multiple pressures. List any other potential toxicant sources.						
Common pressures present (tick)	Urban stormwater ☐	Industrial discharges ☐	Sewage discharges (e.g. outfalls, septic tanks) ☐	Landfills ☐	Catchment viticulture, horticulture, cropping ☐	*List other pressures:*	
Total count of pressures (circle)	1	2	3	4	≥5	VALUE SCORE	CONDITION SCORE
SCORE	**5**	**4**	**3**	**2**	**1**		

CONDITION - Pathogens							
Method	Five common sources are listed to indicate whether inputs are likely from single or multiple pressures. List any other potential pathogen sources						
Common pressures present (tick)	Urban stormwater ☐	Dairy shed or other industrial discharges ☐	Sewage discharges (e.g. outfalls, septic tanks) ☐	Large waterfowl populations ☐	Catchment intensive agriculture (e.g. sheep, dairy, cattle, deer) ☐	*List other pressures:*	
Total count of pressures (circle)	1	2	3	4	≥5	VALUE SCORE	CONDITION SCORE
SCORE	**5**	**4**	**3**	**2**	**1**		

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VALUE SCORE	0	/20
CONDITION SCORE	0	/45

Sub-scores for the rapid estuary assessment

	Estuary Name	Date	Substrate diversity	Habitat Intactness	Salt marsh (extent)	Salt marsh (condition)	Seagrass (extent)	Seagrass (condition)	Mud (extent)	Macroalgae (extent)	HEC (extent)	Margin hardening	Invasive Species	Toxicants	Pathogens	**Values /15***	**Condition /40***	**Overall score /55**
A1	Maitikona	5/04/22	3	1	2	1	na	na	3	5	5	5	3	5	4	6	31	**37**
A2	Okau	5/04/22	4	1	2	1	na	na	3	5	5	2	5	5	4	7	30	**37**
A3	Whakataki	5/04/22	4	2	3	1	na	na	4	5	5	5	5	5	4	9	34	**43**
A4	Castlepoint	5/04/22	2	1	2	1	na	na	5	5	5	1	3	4	3	5	27	**32**
A5	Ngakauau	6/04/22	2	1	2	2	na	na	2	5	5	5	3	5	5	5	32	**37**
A6	Humpies	6/04/22	2	3	3	4	na	na	2	5	5	5	3	5	5	8	34	**42**
A7	Otahome	6/04/22	2	1	3	2	na	na	1	5	3	5	3	5	5	6	29	**35**
A8	Otahome South	6/04/22	3	2	2	2	na	na	2	5	5	5	3	5	5	7	32	**39**
A9	Whareama	31/03/22	3	1	2	1	2	1	1	5	5	5	3	5	5	8	31	**39**
A10	Motuwaireka	29/03/22	2	2	3	1	na	na	2	5	4	5	5	4	4	7	30	**37**
A11	Riversdale North	29/03/22	1	1	1	na (1)	na	na	5	5	5	5	3	4	4	3	32	**35**
A12	Riversdale Centre	29/03/22	1	1	1	na (1)	na	na	5	5	5	4	3	4	4	3	31	**34**
A13	Riversdale South	29/03/22	1	4	5	5	na	na	5	5	5	5	3	4	4	10	36	**46**
A14	Waironu	1/04/22	2	3	3	1	na	na	3	5	1	5	3	5	5	8	28	**36**
A15	Patanui	30/03/22	3	2	2	1	na	na	5	5	5	5	3	5	4	7	33	**40**
A16	Waikaraka	30/03/22	2	2	2	1	na	na	5	5	5	5	3	5	5	6	34	**40**
A17	Kaimokopuna	30/03/22	3	1	1	na (1)	na	na	5	5	5	5	3	5	5	5	34	**39**
A19	Kaiwhata	30/03/22	2	2	2	4	na	na	5	5	5	5	5	5	5	6	39	**45**
A20	Flat Point	1/04/22	2	1	2	2	na	na	5	5	5	5	3	5	4	5	34	**39**
A21	Pahaoa	6/04/22	3	2	2	3	na	na	4	5	5	5	3	5	5	7	35	**42**
A23	Oterei	7/04/22	4	1	2	3	na	na	2	5	2	5	3	5	5	7	30	**37**
A24	Awhea	7/04/22	3	1	2	2	na	na	1	5	5	5	3	5	5	6	31	**37**
A26	Opouawe	7/04/22	2	1	1	na (1)	na	na	5	5	5	5	3	5	5	4	34	**38**
A27	Whawahui	7/04/22	2	1	3	3	na	na	5	5	5	5	3	5	5	6	36	**42**
A28	White Rock (South)	7/04/22	2	1	2	2	na	na	5	5	5	5	3	5	5	5	35	**40**

Excludes seagrass because it was only recorded in one estuary.

APPENDIX 5. EVA DATA SOURCES & WEIGHTINGS

Table Appendix 4-1: EVA Data Sources.

Ecological Values	
Area of estuary (ha) ** Area of intertidal	April 2022 broad scale mapping survey
Habitat Intactness	April 2022 broad scale mapping survey
Seagrass (extent; % of intertidal area)	April 2022 broad scale mapping survey
Salt marsh (extent; % of intertidal area)	April 2022 broad scale mapping survey
Mangroves (extent; % of intertidal area)	Not applicable
Intertidal shellfish beds (indigenous)	No data
Biogenic reef	No data
Species of conservation significance	Todd et al. (2016) or Proposed Natural Resources Plan Appeals Version (2022)
Protected status (within or adjacent to estuary i.e. terrestrial or marine)	Proposed Natural Resources Plan Appeals Version (2022) GIS layer; GWRC Significant Wetland (2022) GIS Layer; DOC Maps (https://www.doc.govt.nz/map/index.html)
Pressures	
Catchment Land Use - % Indigenous Vegetation Cover	LCDB5 (Catchment Clip supplied by GWRC or CLUES)
Catchment Land Use - % Exotic Forest	LCDB5 (Catchment Clip supplied by GWRC or CLUES)
Catchment Land Use - % High producing grassland	LCDB5 (Catchment Clip supplied by GWRC or CLUES)
Catchment Land Use - % Urban & industrial development	LCDB5 (Catchment Clip supplied by GWRC or CLUES)
Catchment Land Use - % Horticulture	LCDB5 (Catchment Clip supplied by GWRC or CLUES)
Nutrient Load Thresholds (macroalgae)	CLUES Estuaries (Clues_TasREc2_10.3 software version CLUES 10.8) Run date 01/02/2023
Sedimentation rate (CSR:NSR ratio*) *CSR = Current, NSR = natural sedimentation rate	Coastal Sediment Source Portal (Oldman 2022; prepared for the Department of Conservation)
Grazing animals in estuary and margin	Aerial imagery, previous reports (Robertson & Stevens 2007a; Todd et al. 2016) and site visit
Altered Hydrology	Aerial imagery, previous reports (Robertson & Stevens 2007a; Todd et al. 2016) and site visit
Fish passage	Aerial imagery, previous reports (Robertson & Stevens 2007a; Todd et al. 2016) and site visit
Chemical contaminants - marine	Aerial imagery, previous reports (Robertson & Stevens 2007a)
Chemical contaminants - terrestrial	GIS layers: discharge consents, Land Use, previous reports (Robertson & Stevens 2007; Todd et al. 2016)
Marine oil spill risk	Aerial imagery, shipping & boating information
Introduced marine species	Aerial imagery (e.g. jetties, ports, marina, moorings)
Phytoplankton blooms	Previous reports (Robertson & Stevens 2007a; Todd et al. 2016), water quality data, site visits, anecdotal reports
Pathogens	Monitoring reports and/or rapid estuary assessments, GWRC GIS layers: resource consents, land use, aerial imagery
Direct Human use - Non-commercial use	Previous reports (Robertson & Stevens 2007a; Todd et al. 2016) and site visits
Direct Human use - Commercial marine species harvest/aquaculture	GWRC GIS layers: resource consents
Direct human access - Level of protection to prevent disturbance of wildlife.	Site visits, photos and aerial imagery
Salt Marsh pressures (Number of recorded pressures)	April 2022 broadscale mapping and rapid estuary assessments
Seagrass pressures (Number of recorded pressures)	April 2022 broadscale mapping and rapid estuary assessments

Table Appendix 4-1: EVA Data Sources continued.

Susceptibility	
Estimated Physical Susceptibility	Based on principles in ETI Tool 1, expert assessment
Mixing status (i.e. well mixed, partially mixed, stratified)	Based on principles in ETI Tool 1, expert assessment
Likelihood catchment pressures within <10 years	GWRC GIS layers: resource consents, forestry blocks, LCDB5
Likelihood contaminants (chemical & biological) within < 10 years	GWRC GIS layers: resource consents; Previous reports (Robertson & Stevens 2007a; Todd et al. 2016)
Likelihood human use pressures increase within < 10 years	GWRC GIS layers: resource consents; previous reports (Robertson & Stevens 2007a; Todd et al. 2016). Population expected to increase by ~6% by 2033, however, most likely to be in the main town centres (Stats NZ).
Likelihood catchment pressures within >10 years	GWRC GIS layers: resource consents, forestry blocks, LCDB5
Likelihood contaminants (chemical & biological) within >10 years	Based on the assumption of no change, this can be updated when information becomes available.
Likelihood human use pressures increase within >10 years	Previous reports (Robertson & Stevens 2007a; Todd et al. 2016). Population expected to increase by ~10% by 2048, however, most likely to be in the main town centres (Stats NZ).
Adaptive capacity of estuary to sea level rise	Site visits and photos
Coastal vulnerability Index - Coastal erosion and sea level rise	No data
Climate adaptation and resilience	Under development
Condition	
Estimated historical salt marsh extent (% of historical remaining)	April 2022 broadscale mapping and rapid estuary assessments Retrolens.co.nz to assess historic imagery
Proportion (%) of current salt marsh degraded	April 2022 broadscale mapping and rapid estuary assessments
% Seagrass decline from estimated baseline	No data
Proportion (%) of current seagrass degraded	April 2022 broadscale mapping and rapid estuary assessments
Substrate	April 2022 broadscale mapping and rapid estuary assessments
Diversity of substrate types	April 2022 broadscale mapping and rapid estuary assessments
Predicted sedimentation rate (mm/y)	No data
Mud extent (% intertidal)	April 2022 broadscale mapping and rapid estuary assessments
Opportunistic macroalgae extent (% intertidal)	April 2022 broadscale mapping and rapid estuary assessments
Phytoplankton (ug/L)	One-off water quality measurements April 2022, chl-a was estimated for 9 estuaries because the meter was not working.
Dissolved oxygen (mg/L)	One-off water quality measurements April 2022
Water Clarity	One-off water quality measurements April 2022
High Enrichment Conditions (Ha or % intertidal area)	April 2022 broadscale mapping and rapid estuary assessments
Existing presence of invasive species in the estuary	April 2022 broadscale mapping and rapid estuary assessments
Reclamation and/or drainage (% of area affected)	April 2022 broadscale mapping and rapid estuary assessments Retrolens.co.nz to assess historic imagery
Shoreline length modified/ disturbed	Estimated from aerial imagery and site photos
Hardening of estuary margin	April 2022 broadscale mapping and rapid estuary assessments
200m terrestrial margin (Densely vegetated)	LCDB5 and rapid estuary assessments

Table Appendix 4-2: EVA Weightings derived from Roberts et al. (2022b) and modified to suite subtidal estuaries. Weightings highlighted in yellow have been updated to suit the current study.

Category	Weighting Roberts et al. (2022b)	Weighting in current report
Ecological Values		
Area of estuary (ha) ** Area of intertidal	0.2	0.2
Habitat Intactness	1.0	1.0
Seagrass (extent; % of intertidal area)	1.0	1.0
Salt marsh (extent; % of intertidal area)	1.0	1.0
Mangroves (extent; % of intertidal area)	1.0	1.0
Intertidal shellfish beds (indigenous)	1.0	1.0
Biogenic reef	1.0	1.0
Species of conservation significance	0.8	0.8
Protected status (within or adjacent to estuary i.e. terrestrial or marine)	0.8	0.8
Pressures		
Catchment Land Use - % Indigenous Vegetation Cover	1.0	1.0
Catchment Land Use - % Exotic Forest	1.0	1.0
Catchment Land Use - % High producing grassland	1.0	1.0
Catchment Land Use - % Urban & industrial development	0.6	0.6
Catchment Land Use - % Horticulture	0.6	0.6
Nutrient Load Thresholds (macroalgae)	1.0	1.0
Sedimentation rate (CSR:NSR ratio)	1.0	1.0
Grazing animals in estuary and margin	0.8	0.8
Altered Hydrology	0.8	0.8
Fish passage	0.8	0.8
Chemical contaminants - marine	0.6	0.2
Chemical contaminants - terrestrial	0.4	0.6
Marine oil spill risk	0.8	0.2
Introduced marine species	0.4	0.2
Phytoplankton blooms	0.2	0.8
Pathogens	0.2	0.2
Direct Human use - Non-commercial use	0.6	0.6
Direct Human use - Commercial marine species harvest/aquaculture	0.4	0.4
Direct human access - Level of protection to prevent disturbance of wildlife.	0.6	0.6
Salt Marsh pressures (Number of recorded pressures)	1.0	1.0
Seagrass pressures (Number of recorded pressures)	1.0	1.0

Table Appendix 4-2: EVA Weightings derived from Roberts et al. (2022b) continued.

Category	Weighting Roberts et al. (2022b)	Weighting in current report
Susceptibility		
Estimated Physical Susceptibility	1.0	1.0
Mixing status (i.e. well mixed, partially mixed, stratified)	0.8	0.8
Likelihood catchment pressures within <10 years	1.0	1.0
Likelihood contaminants (chemical & biological) within < 10 years	0.6	0.6
Likelihood human use pressures increase within < 10 years	1.0	1.0
Likelihood catchment pressures within >10 years	0.8	0.8
Likelihood contaminants (chemical & biological) within >10 years	0.4	0.4
Likelihood human use pressures increase within >10 years	0.6	0.6
Adaptive capacity of estuary to sea level rise	1.0	1.0
Coastal vulnerability Index - Coastal erosion and sea level rise	0.8	0.8
Climate adaptation and resilience	na	na
Condition		
Estimated historical salt marsh extent (% of historical remaining)	0.8	0.8
Proportion (%) of current salt marsh degraded	1.0	1.0
% Seagrass decline from estimated baseline	0.8	0.8
Proportion (%) of current seagrass degraded	1.0	1.0
Diversity of substrate types	0.6	0.6
Predicted sedimentation rate (mm/y)	0.8	0.8
Mud extent (% intertidal)	1.0	0.2
Opportunistic macroalgae extent (% intertidal)	1.0	0.2
Phytoplankton (ug/L)	0.6	1.0
Dissolved oxygen (mg/L)	na	1.0
Water Clarity (%)	na	1.0
High Enrichment Conditions (Ha or % intertidal area)	1.0	1.0
Existing presence of invasive species in the estuary	0.8	0.8
Reclamation and/or drainage (Percentage of area affected)	0.8	0.8
Shoreline length modified/ disturbed	0.8	0.8
Hardening of estuary margin (e.g. artificial rock wall, earth bund)	0.8	0.8
200m terrestrial margin (Densely vegetated)	0.4	0.4

APPENDIX 6. SEDIMENT DATA

ID	Estuary Name	Date	TN mg/kg	TP mg/kg	TS mg/kg	TOC %	Gravel* %	Sand* %	Mud* %
A1	Mātaikona	5-Apr-22	800	340	700	0.72	43.7	31.1	25.2
A2	Ōkau	5-Apr-22	<500	171	700	0.32	<0.1	43.9	56.0
A3	Whakataki	5-Apr-22	500	194	400	0.53	10.9	47.6	41.5
A4	Castlepoint	5-Apr-22	<500	460	200	0.26	<0.1	89.2	10.7
A5	Ngākauau	6-Apr-22	1100	240	300	1.2	0.1	33.6	66.2
A6	Humpies	6-Apr-22	<500	450	2500	0.29	<0.1	69.5	30.5
A7	Otahome	6-Apr-22	900	280	900	0.81	<0.1	33.0	67.0
A8	Otahome South	6-Apr-22	-	-	-	-	-	-	-
A9	Whareama	31-Mar-22	800	370	1000	0.79	<0.1	25.0	75.0
A10	Motuwaireka	29-Mar-22	1000	400	3200	1.1	0.2	23.7	76.1
A11	Riversdale North	29-Mar-22	-	-	-	-	-	-	-
A12	Riversdale Central	29-Mar-22	-	-	-	-	-	-	-
A13	Riversdale South	29-Mar-22	-	-	-	-	-	-	-
A14	Waironu	1-Apr-22	3700	430	10500	4.0	1.6	41.3	57.1
A15	Patanui	30-Mar-22	<500	290	300	0.23	59.1	33.8	7.1
A16	Waikaraka	30-Mar-22	1300	420	4900	1.5	<0.1	27.3	72.6
A17	Kaimokopuna	30-Mar-22	<500	270	400	<0.13	19.3	74.6	6.1
A18	Homewood	30-Mar-22	-	-	-	-	-	-	-
A19	Kaiwhata	30-Mar-22	<500	240	900	0.20	36.0	45.1	18.9
A20	Flat Point	1-Apr-22	<500	310	300	0.16	3.3	85.2	11.4
A21	Pāhāoa	6-Apr-22	<500	490	200	0.12	52.9	47.8	< 0.1
A22	Rerewhakaaitu	Not visited	-	-	-	-	-	-	-
A23	Ōterei	7-Apr-22	700	470	600	0.75	12.0	37.5	50.5
A24	Āwhea	7-Apr-22	600	570	500	0.50	1.2	34.7	64.1
A25	Āwheaiti	Not visited	-	-	-	-	-	-	-
A26	Ōpouawe	7-Apr-22	<500	510	200	0.14	68.8	30.1	1.1
A27	Whawahui	7-Apr-22	<500	470	100	0.11	17.0	80.6	2.3
A28	White Rock	7-Apr-22	-	-	-	-	-	-	-
A29	Cape Palliser	Not visited	-	-	-	-	-	-	-

[1]Gravel (≥2mm), sand (<2mm to ≥63mm), mud (<63µm)

[2]Condition ratings are presented in Forrest et al. (2022) and Roberts et al. (2021), broadly the colours represent the condition bandings outlined below and are highlighted here for indicative purposes.

APPENDIX 7. WATER QUALITY DATA (MID-ESTUARY SITE)

Surface measurements of water quality taken at a mid-estuary site.

ID	Estuary	Date	Easting	Northing	Temp (°C)	% DO sat.	DO (mg/L)	Salinity	pH	Chl-a (µg/L)	Secchi depth (m)	Max. depth (m)
A1	Mātaikona	5-Apr-22	1875434	5480396	15.9	97.0	9.6	0.4	8.54	5 to 10*	0.4	0.7
A2	Ōkau	5-Apr-22	1873402	5473164	15.4	99.7	10.0	0.3	7.86	<5*	0.3	0.7
A3	Whakataki	5-Apr-22	1871947	5470828	14.2	97.5	10.0	0.2	7.56	<5*	0.6	1.2
A4	Castlepoint	5-Apr-22	1871260	5467499	14.9	94.0	9.5	0.3	7.94	5 to 10*	0.4	0.6
A5	Ngākauau	6-Apr-22	1867937	5464616	14.6	97.1	9.8	0.5	7.76	<5*	0.3	1.7
A6	Humpies	6-Apr-22	1867418	5463932	15.3	96.4	9.7	0.4	7.71	<5*	0.3	1.3
A7	Otahome	6-Apr-22	1865577	5462454	15.5	93.0	9.2	1.4	8.04	<5*	0.4	1.6
A8	Otahome South	6-Apr-22	1865027	5461644	16.2	95.7	9.5	0.5	8.14	<5*	0.7	0.8
A9	Whareama	31-Mar-22	1858289	5455806	15.6	94.4	9.3	1.4	8.14	5.2	0.2	1.8
A10	Motuwaireka	29-Mar-22	1858295	5447116	14.3	94.8	9.7	0.2	7.37	4.3	0.2	1.5
A11	Riversdale North	29-Mar-22	1857881	5446243	15.7	81.6	8.1	0.2	7.18	10.5	0.2	0.2
A12	Riversdale Central	29-Mar-22	1857764	5445922	15.7	78.7	7.8	0.2	7.13	10.8	0.4	0.4
A13	Riversdale South	29-Mar-22	1857560	5445576	16.2	64.7	6.4	0.3	6.97	9.4	0.2	0.2
A14	Waironu	1-Apr-22	1856040	5441779	16.1	30.1	3.0	0.4	7.34	16.1	0.9	>2
A15	Patanui	30-Mar-22	1854005	5439833	16.6	84.9	8.3	0.2	7.60	9.1	0.3	1.2
A16	Waikaraka	30-Mar-22	1853091	5439279	17.1	92.3	8.9	0.3	6.99	4.1	0.5	1.2
A17	Kaimokopuna	30-Mar-22	1852393	5438459	16.3	98.7	9.7	0.1	7.26	2.9	0.4	0.6
A18	Homewood	30-Mar-22	-	-	-	-	-	-	-	-		
A19	Kaiwhata	30-Mar-22	1850459	5435221	14.7	98.2	10.0	0.2	7.90	2.7	0.2	0.7
A20	Flat Point	1-Apr-22	1847798	5429798	15.3	96.8	9.7	0.3	8.02	2.7	25.0	30.0
A21	Pāhāoa	6-Apr-22	1827655	5414011	16.6	98.6	9.6	0.2	6.10	<5*	0.7	0.7
A22	Rerewhakaaitu	Not visited	-	-	-	-	-	-	-	-		
A23	Ōterei	7-Apr-22	1815164	5404433	13.8	105.1	10.8	1.2	8.02	2.9	0.4	0.9
A24	Āwhea	7-Apr-22	1810186	5402134	13.3	97.4	10.2	0.2	8.29	4.0	0.1	1.3
A25	Āwheaiti	Not visited	-	-	-	-	-	-	-	-		
A26	Ōpouawe	7-Apr-22	1802128	5395483	13.6	100.8	10.4	0.9	8.19	2.3	0.1	1.2
A27	Whawahui	7-Apr-22	1800421	5395610	13.2	103.2	10.3	8.3	7.94	3.0	0.2	0.6
A28	White Rock	7-Apr-22	1799121	5395476	13.1	104.7	11.0	0.1	7.71	7.1	0.1	0.2
A29	Cape Palliser	Not visited	-	-	-	-	-	-	-	-		

Colour bandings represent condition ratings in Table 3.

* estimated values

Bottom water quality measurements taken when there was a temperature and/or salinity difference between the surface and bottom at a mid-estuary site.

ID	Estuary	Date	Stratified	Halocline depth (m)	Bottom measurement depth	Temp (°C)	% DO sat.	DO (mg/L)	Salinity	pH	Chl-*a* (µg/L)
A1	Mātaikona	5-Apr-22	no	-	-	-	-	-	-	-	-
A2	Ōkau	5-Apr-22	no	-	-	-	-	-	-	-	-
A3	Whakataki	5-Apr-22	no	-	-	-	-	-	-	-	-
A4	Castlepoint	5-Apr-22	no	-	-	-	-	-	-	-	-
A5	Ngākauau	6-Apr-22	yes	1.1	1.5	14.6	92.6	9.3	11.10	7.1	<5*
A6	Humpies	6-Apr-22	no	-	1.2	14.7	95.6	9.5	3.69	7.4	<5*
A7	Otahome	6-Apr-22	yes	0.4	1.1	15.8	84.1	7.4	20.80	7.7	<5*
A8	Otahome South	6-Apr-22	yes	0.5	0.7	15.7	56.5	5.6	2.24	8.2	<5*
A9	Whareama	31-Mar-22	yes	1.6	1.5	15.3	93.6	9.0	9.70	7.8	4.7
A10	Motuwaireka	29-Mar-22	no	-	-	-	-	-	-	-	-
A11	Riversdale North	29-Mar-22	no	-	-	-	-	-	-	-	-
A12	Riversdale Central	29-Mar-22	no	-	-	-	-	-	-	-	-
A13	Riversdale South	29-Mar-22	no	-	-	-	-	-	-	-	-
A14	Waironu	1-Apr-22	no	-	1.8	16.4	10.9	1.0	2.98	6.9	16.4
A15	Patanui	30-Mar-22	no	-	-	-	-	-	-	-	-
A16	Waikaraka	30-Mar-22	no	-	-	-	-	-	-	-	-
A17	Kaimokopuna	30-Mar-22	no	-	-	-	-	-	-	-	-
A18	Homewood	30-Mar-22	-	-	-	-	-	-	-	-	-
A19	Kaiwhata	30-Mar-22	no	-	-	-	-	-	-	-	-
A20	Flat Point	1-Apr-22	no	-	-	-	-	-	-	-	-
A21	Pāhāoa	6-Apr-22	no	-	-	-	-	-	-	-	-
A22	Rerewhakaaitu	Not visited	-	-	-	-	-	-	-	-	-
A23	Ōterei	7-Apr-22	no	-	0.8	13.6	104.7	10.7	1.87	7.9	2.0
A24	Āwhea	7-Apr-22	no	-	-	-	-	-	-	-	-
A25	Āwheaiti	Not visited	-	-	-	-	-	-	-	-	-
A26	Ōpouawe	7-Apr-22	no	-	0.9	13.6	99.8	10.3	16.00	7.6	2.0
A27	Whawahui	7-Apr-22	no	-	-	-	-	-	-	-	-
A28	White Rock	7-Apr-22	no	-	-	-	-	-	-	-	-
A29	Cape Palliser	Not visited	-	-	-	-	-	-	-	-	-

Colour bandings represent condition ratings in Table 3.

APPENDIX 8. ESTUARY TROPHIC INDEX (MID-ESTUARY SITE)

Estuary Trophic Index (ETI) (Robertson et al. 2016)) output for the listed estuaries using the online Tool 2 ETI calculator (Zeldis et al. 2017).

ID	Estuary Name	ETI Type	isICOE	Primary indicator	Secondary indicators			Can calculate ETI?	ETI score	ETI band
				Chl-a (µg/L)	DO (mg/L)	TN (mg/kg)	TOC (%)			
A1	Mātaikona	SSRTRE	TRUE	5 to 10*	9.57	800	0.72	Yes	0.36	B
A2	Ōkau	SSRTRE	TRUE	<5*	10.0	<500	0.3	Yes	0.19	A
A3	Whakataki	SSRTRE	TRUE	<5*	10.0	500	0.5	Yes	0.22	A
A4	Castlepoint	SSRTRE	TRUE	5 to 10*	9.50	<500	0.26	Yes	0.31	B
A5	Ngākauau	SSRTRE	TRUE	<5*	9.8	1100	1.2	Yes	0.29	B
A6	Humpies	SSRTRE	TRUE	<5*	9.7	<500	0.3	Yes	0.19	A
A7	Otahome	SSRTRE	TRUE	<5*	9.2	900	0.8	Yes	0.26	B
A8	Otahome South	SSRTRE	TRUE	<5*	9.5	-	-	No	-	-
A9	Whareama	SSRTRE	FALSE	5.2	9.3	800	0.8	Yes	0.31	B
A10	Motuwaireka	SSRTRE	TRUE	4.3	9.7	1000	1.1	Yes	0.32	B
A11	Riversdale North	SSRTRE	TRUE	10.5	8.1	-	-	No	-	-
A12	Riversdale Central	SSRTRE	TRUE	10.8	7.8	-	-	No	-	-
A13	Riversdale South	SSRTRE	TRUE	9.4	6.4	-	-	No	-	-
A14	Waironu	SSRTRE	TRUE	16.1	3.0	3700	4.0	Yes	0.88	D
A15	Patanui	SSRTRE	TRUE	9.1	8.3	<500	0.2	Yes	0.33	B
A16	Waikaraka	SSRTRE	TRUE	4.1	8.9	1300	1.5	Yes	0.34	B
A17	Kaimokopuna	SSRTRE	TRUE	2.9	9.7	<500	<0.13	Yes	0.19	A
A18	Homewood	SSRTRE	TRUE	-	-	-	-	No	-	-
A19	Kaiwhata	SSRTRE	TRUE	2.7	10.0	<500	0.2	Yes	0.18	A
A20	Flat Point	SSRTRE	TRUE	2.7	9.7	<500	0.2	Yes	0.18	A
A21	Pāhāoa	SSRTRE	TRUE	<5*	9.6	<500	0.1	Yes	0.17	A
A22	Rerewhakaaitu	SSRTRE	TRUE	-	-	-	-	No	-	-
A23	Ōterei	SSRTRE	TRUE	2.9	10.8	700	0.8	Yes	0.25	A
A24	Āwhea	SSRTRE	TRUE	4.0	10.2	600	0.5	Yes	0.25	A
A25	Āwheaiti	SSRTRE	TRUE	-	-	-	-	No	-	-
A26	Ōpouawe	SSRTRE	TRUE	2.3	10.4	<500	0.1	Yes	0.15	A
A27	Whawahui	SSRTRE	TRUE	3.0	10.3	<500	0.1	Yes	0.17	A
A28	White Rock	SSRTRE	TRUE	7.1	11.0	-	-	No	-	-
A29	Cape Palliser	SSRTRE	TRUE	-	-	-	-	No	-	-

*estimated values


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