Bluff
coastal zone

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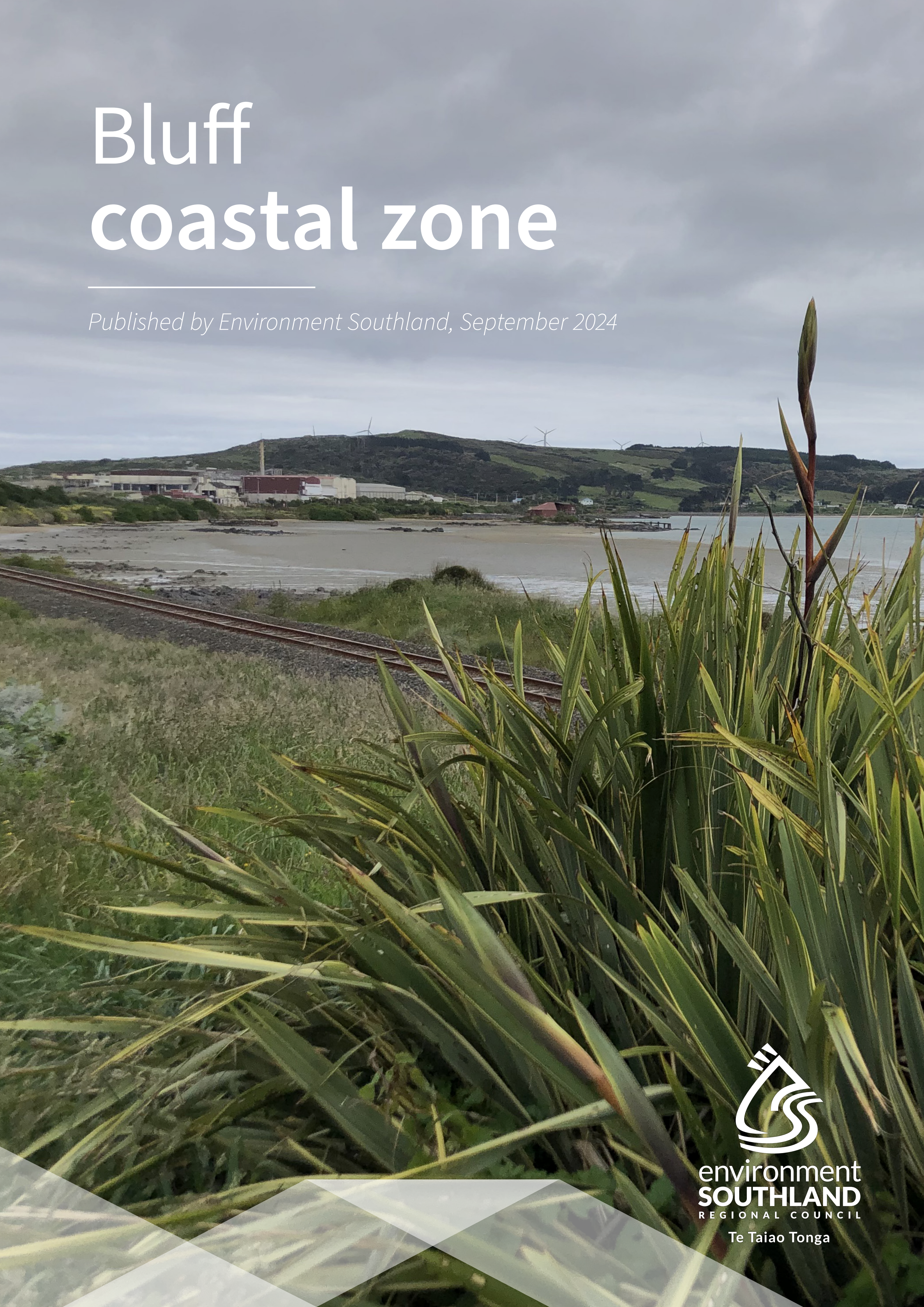

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Te Taiao Tonga

Bluff coastal zone

This document summarises scientific information for freshwater and estuarine areas, opportunities for action and the socioeconomic context of the Bluff coastal zone.

It is one of twelve catchment summaries prepared for the Murihiku Southland region.

We have collated and presented scientific data at the catchment scale to provide an understanding of freshwater quality and quantity challenges, and their underlying factors. We have included an evaluation of the current state of freshwater within the catchment and highlighted the magnitude of change necessary to meet freshwater aspirations.

The information in this document should be considered alongside other information sources, including mātauranga Māori.

Main features

Land area: 10,700ha

Major rivers and streams:
Muddy Creek, Duck Creek

Aquifers:
Awarua

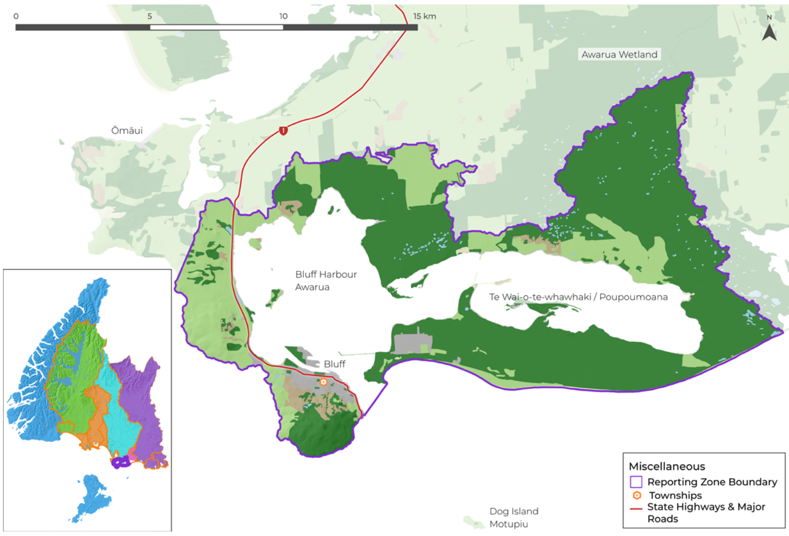
Lakes:
None

Estuaries:
Bluff Harbour and Awarua Bay

Townships:
Bluff

Population:
Approximately 2,000

Catchment outline



For most attributes, current state is assessed using data from the 2018 – 2022 period.

Key messages

Issues

- Limited monitoring data is available within the Bluff coastal zone. The harbour and lagoon are in relatively good condition regarding eutrophication. However, if further land use change and wetland loss occur, they may be susceptible to increased nutrient and sediment inputs.
- The zone has multiple high-risk industrial sites, such as the harbour with vessel movement and associated structures, the Rio Tinto Aluminium Smelter on Tiwai Peninsula and the urban catchment from Bluff.
- Modelling indicates contaminant load reductions are required to achieve desired freshwater and estuary outcomes. Reductions are needed for nitrogen (9%), phosphorus (24%), sediment (40%) and *E. coli* (65%).
- Approximately 772ha of wetlands have been lost since 1996 in the Bluff coastal zone. There are wetlands on non-conservation land that are at risk of being lost.

Opportunities for action

- Implement property-scale mitigations tailored to the land's physiographic characteristics, the sensitivities of the receiving environments and the outcomes sought for the catchment.
- Identify and remediate contaminated sites, including ongoing improvement of standards and management of contamination at the Tiwai smelter site. Integrate issues associated with the smelter into catchment planning and objectives.
- Protect and enhance the remaining wetland areas within the catchment. These form a valuable part of the more expansive Ramsar Awarua wetland complex.
- Ensure wastewater and stormwater are not cross connected in industrial and municipal systems.
- Incorporate best-practice stormwater management methods into urban development.

Socioeconomic context for action

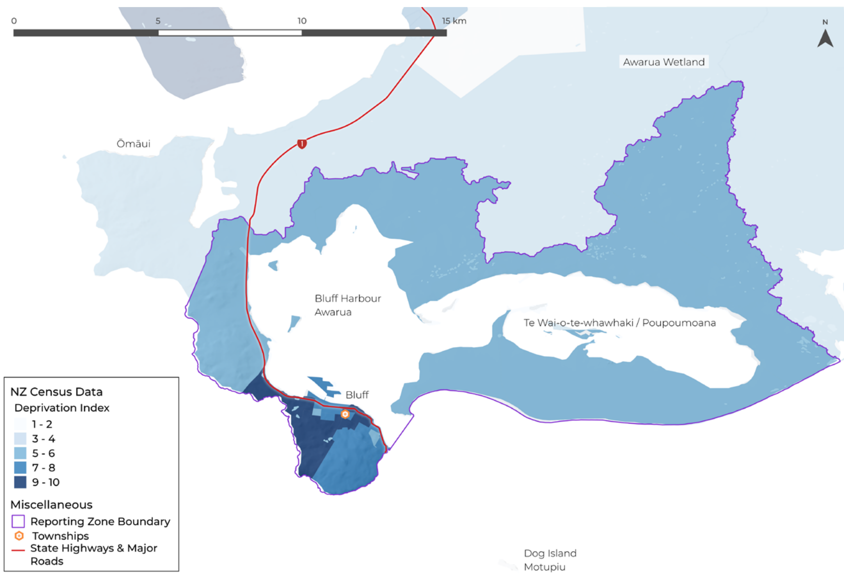
Historic socioeconomic shifts later in the 19th and 20th century have shaped Bluff township and the communities in and around the Bluff coastal zone, such as Woodend-Greenhills. The Ocean Beach Freezing works, and the opening of the Tiwai Aluminium Smelter in 1971 created employment and other opportunities that brought new people into the area. The impacts of neoliberal deregulation from the 1980s removed agricultural subsidies and export assistance, creating a period of austerity for many farming communities. Around the same time, a series of financial and industrial issues surrounding the Ocean Beach Freezing Works caused its eventual closure in 1991. The loss of this significant source of employment for Bluff has had a substantial impact on the community. It led to a deterioration of socioeconomic conditions for local dependent townships, driving population decline in Bluff and surrounding areas from the late 1980s until the mid-2000s. Also, in 1986, the introduction of Quota Management Systems (QMS) restricted harvests of specific fish with a view towards sustainable fishing. This change led to a decline in the fishing industry in Bluff and contributed to additional challenges for the community.

The rise in dairy farming across the region in the 1990s began to reverse economic conditions for the more expansive zone, ushering in land use, industry, and demographic changes, especially with changes in the Awarua wetland areas.

Most of the estimated 2000 people in the Bluff coastal zone reside in or near Bluff township. As a port town, Bluff has strong connections with primary industries (notably fishing). In the 2018 Census, around 6% of the total population of Bluff was directly involved in primary industry work. However, tertiary industries, such as shipping, are just as crucial to Bluff, with a similar percentage of people working for South Port New Zealand Limited.

Following a general population decline from the 1990s to the mid-2000s, the Bluff coastal zone stabilised around 2006, with minor fluctuations between 2016 and 2023. Woodend-Greenhills has also shown population fluctuations but has generally increased since 2018. The catchment has experienced steady increases in ethnic diversity since the 2000s.

Social Deprivation Index



Social Deprivation Index

The Deprivation Index measures socioeconomic deprivation based on census information. It considers income, income benefits, communication access, employment, educational qualifications, home ownership, care support, living space and living conditions.

The main demographic disparities in the zone compared with the broader district are fewer younger people (20-44 years) and more older people aged 50+. Younger people frequently leave for tertiary education or employment opportunities elsewhere in Murihiku Southland or outside the region.

Although housing prices have increased regionally and nationally since 2020, Bluff has remained one of the most affordable places to buy or rent in New Zealand.

While the area has a considerably higher Māori population and speakers of Te Reo Māori than the Invercargill city average, it is not as ethnically diverse in terms of Pacific, Asian and MELAA populations as elsewhere in the region.

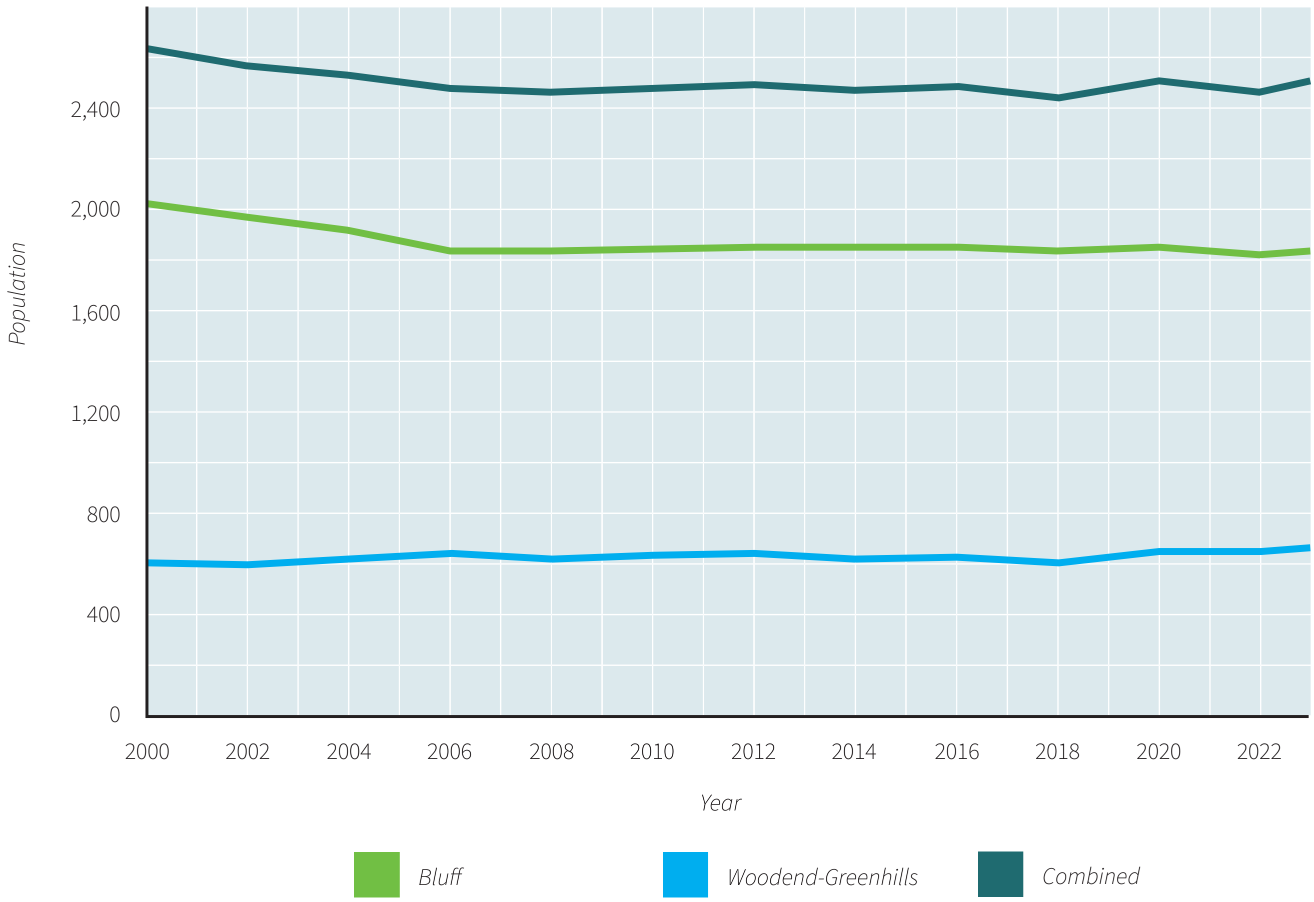
The largest group by occupation in Bluff is labourers, with 36.3% of the total population and 47.5% of the Māori population employed as labourers. These figures are nearly double the percentages of labourers in Invercargill city.

Although Invercargill city has a moderate level of socioeconomic deprivation, the Bluff coastal zone contains some of the city's most deprived areas.

Deprivation trends from 2014 -2023 show that Bluff has had consistently high deprivation levels, with Woodend-Greenhills experiencing increases in deprivation over that time.

Pockets of higher levels of deprivation within the Bluff coastal zone area (7-9 on the index) are mainly concentrated within closely settled areas. Higher levels of deprivation tend to correlate with less capacity, fewer resources and higher vulnerability, and poorer wellbeing outcomes for communities.

Estimated population trends (Dot Loves Data, 2024)



The Bluff coastal zone comprises two main census-based statistical areas (SA2s). Parts of these statistical areas may lay outside the catchment. This graph indicates general population trends across both areas, not just the catchment.

Summary

- The rural economy relies heavily on intensive lowland agriculture, and the settled area is reliant on maritime activities, including fishing, shipping and tourism, increasing risks from industry or regulatory changes.
- Higher deprivation levels in Bluff township could result in less resilience and poorer wellbeing outcomes for their communities.
- Lower education attainment levels in parts of the catchment may reduce the capacity to adapt to economic, technological and environmental changes.
- There is no established catchment group for the Bluff coastal zone. However, the New River Estuary Forum and Waituna catchment groups are nearby and may provide a support system for members to facilitate adaptation to external pressures and challenges.

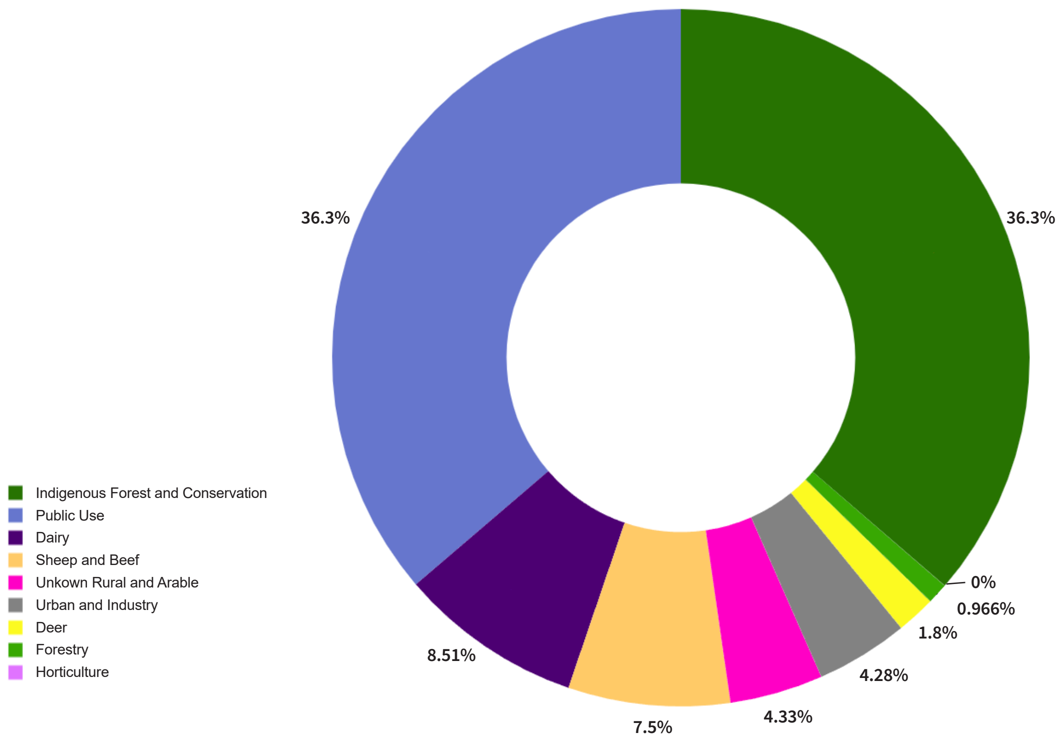
Catchment overview

The Bluff coastal zone comprises the coastal areas surrounding Bluff Harbour and Awarua Bay, including Greenhills and Bluff Hill, Tiwai Peninsula and parts of the Awarua Wetland.

Land use

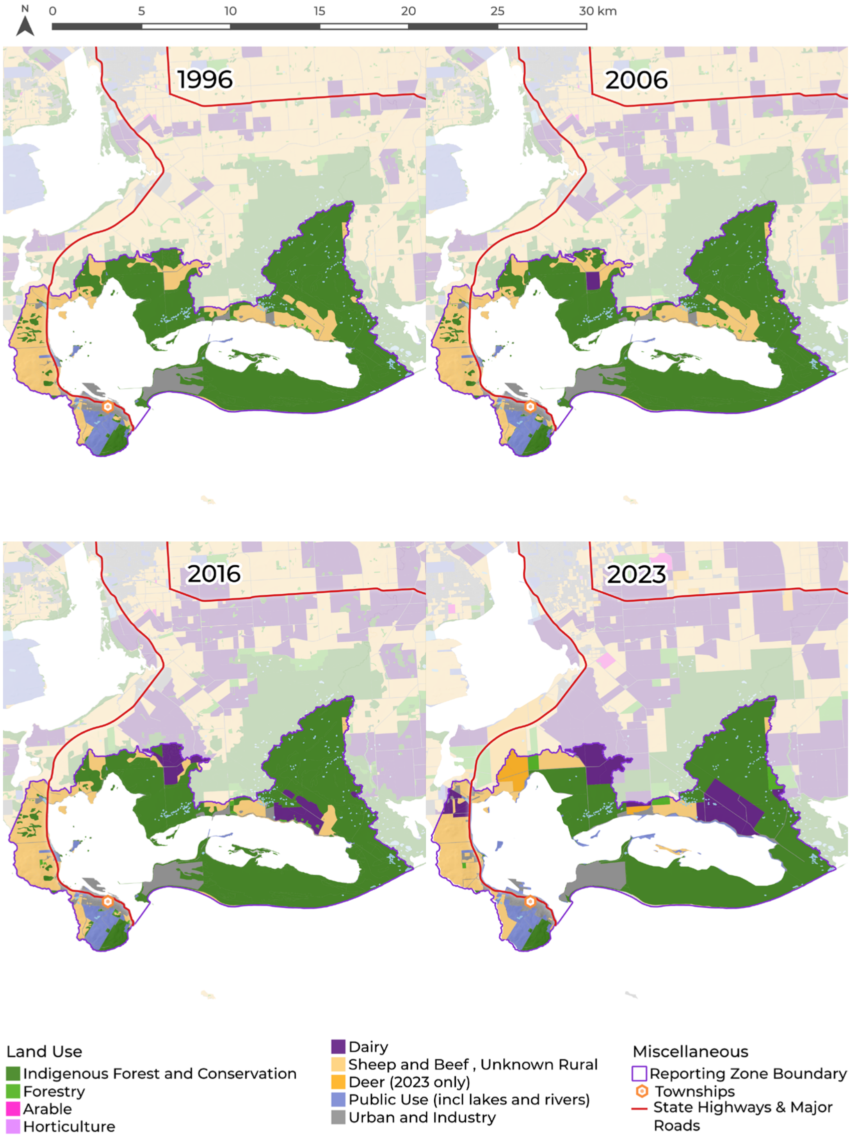
The Bluff coastal zone covers approximately 10,700 hectares, split evenly between two primary land uses. Public Use comprises 36.3%, including council, coastal, lakes and rivers. Indigenous Forest and Conservation Land comprise 36.3%.

The rest of the catchment is mixed with dairy (8.51%), sheep and beef (7.5%), arable farming (4.33%), urban and industry(4.28%), deer farming (1.8%) and forestry (0.97%).



Changes in land use in the last 25 years include some increase in agricultural land use intensity.

Historic land use



Please note that these maps and figures are indicative only due to land use class aggregation and differences in mapping methodologies.

Historic land use

	1996 to 2006	2006 to 2016	2016 to 2023	Overall 1996 to 2023
Pastoral land	↑ 2%	↑ 4%	↑ 53%	↑ 63%
Dairy	↑ 73ha	↑ 705%	↑ 135%	↑ 1,390ha
Drystock	↓ 1%	↓ 19%	↓ 26%	↓ 20%

Climate

Understanding climate at a catchment scale helps to explain spatial and temporal variation in land use, water quality and quantity.

Current climate

Bluff has a cool-wet climate, with small seasonal variations in temperature and fairly consistent rainfall.

Future climate

Potential changes to the future climate of the Bluff coastal zone have been examined in a regional study exploring scenarios for two Representative Concentration Pathways (RCPs): 4.5 and 8.5, representing lower and higher carbon emissions, respectively. These potential changes are summarised in the following table.

Precipitation

		Historic / now	RCP 4.5		RCP 8.5	
			Mid 21st century	End of 21st century	Mid 21st century	End of 21st century
Temperature	Daily mean (°C)		↑ 0.5-0.75	↑ 1-1.25	↑ 0.5-0.75	↑ 1.75-2
	Mean minimum (°C)		↑ 0-0.5	↑ 0.5-0.75	↑ 0.25-0.5	↑ 1.25-1.5
	Number of hot days		↑ 0-5	↑ 5-10	↑ 0-5	↑ 10-15
	Number of frosty nights		↓ 5-10	↓ 5-15	↓ 5-10	↓ 15-20
Rainfall	Annual rainfall change (%)	↑ 5-10%	↑ 5-10%	↑5-10%	↑ 0-5%	↑ 15-20%
	Number of wet days	175	174	176	175	176
	5-Day maximum rainfall (mm)		↑ 0-15mm	↑ 0-15mm	↑0 -15mm	↑ 15-30mm
	Heavy rainfall days	30	32	32	33	37
	Seasonal changes	Wetter spring and summer	Increases concentrated in spring	All seasons equally affected	Higher in spring	Much wetter in spring and winter

Catchment landscapes and hydrology

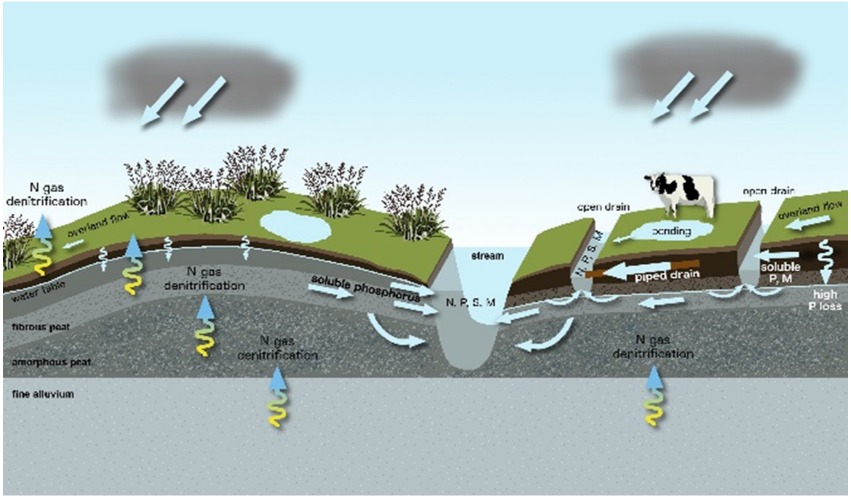
Water quality variations within a catchment are influenced by biogeochemical and physical processes. Understanding hydrology, geology, and soil types within a catchment helps explain variations in water chemistry and water quality outcomes that are independent of land use.

Catchment setting

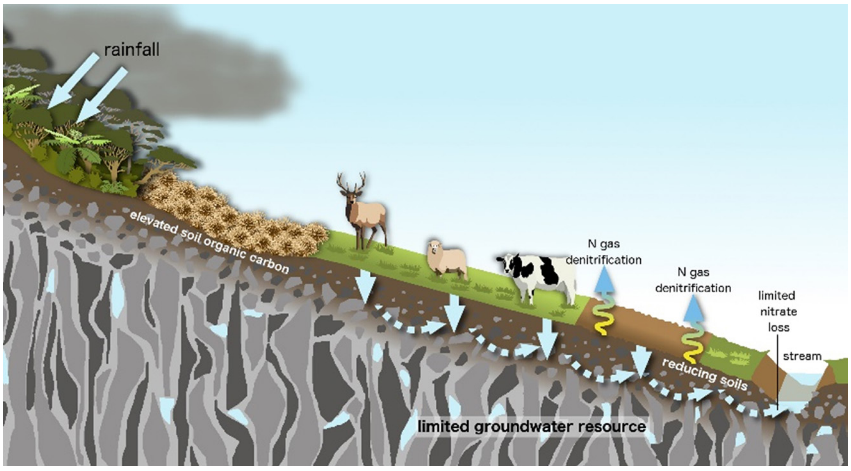
Muddy Creek, Duck Creek and associated tributaries drain the Awarua Wetland adjacent to Bluff Harbour and Awarua Bay. Waterways are generally small in size (< order 4), flow slowly over flat terrain and have estimated median flows of less than 0.3 cumecs.

Bluff Hill and Greenhills are formed by the ultramafic and mafic igneous intrusive rocks of the Brook Street Terrane. No large streams drain from these hilly areas, but numerous small streams flow into Bluff Harbour. Muddy and Duck creeks carry tannin-stained water from the Awarua Wetland area, through agricultural pasture before discharging into Awarua Bay and Bluff Harbour, respectively.

Soils are predominantly deep, very poorly drained peat in the Awarua Wetland area. Here, water and contaminants flow laterally through the soil and drains. Due to extensive artificial drainage networks, flow lag times are relatively short in the agricultural landscape. Soils comprised of silts and sands with variable drainage make up the Greenhills, Bluff Hill and Tiwai Peninsula.



▲ *Conceptual illustration of the hydrological and landscape setting in the Awarua Wetland area. This diagram shows water and contaminant flow pathways.*

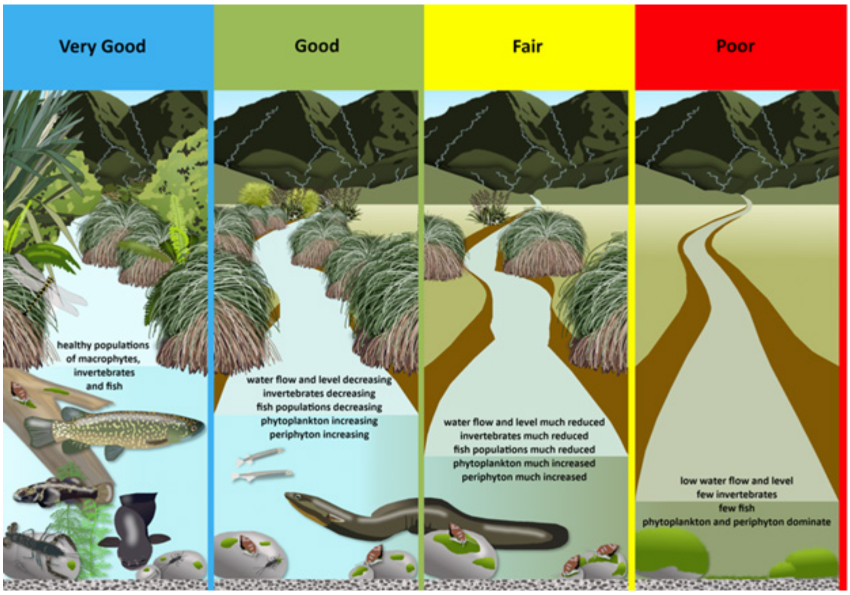


▲ *Conceptual illustration of the hydrological and landscape setting in the Bluff Hill and Greenhills area. The diagram shows water and contaminant flow pathways.*

What are the water issues for this catchment?

Freshwater outcomes and how we measure them

Freshwater outcomes can be described on a spectrum from 'very good' to 'poor'. Using this spectrum helps us to understand the current freshwater environment state and what we might be trying to achieve in the future. This concept is depicted for rivers and streams in this image (right).



Although many factors contribute to freshwater outcomes, we can only measure some of these to get an understanding of ecosystem health. We measure the aspects of the freshwater environment that can help us define and determine freshwater outcomes. The aspects that we measure are called 'attributes'.

Attributes (the things we measure)

Attributes can relate to the ecosystem's physical or chemical environment, or biological communities, such as periphyton, macroinvertebrates and fish. Each measured state of an attribute tells us about some aspects of the environmental state. Together, they build a picture of the ecosystem's overall health. The more attributes we monitor, the more precise the picture can become.

Attributes may relate to ecosystem health or human health outcomes (e.g. phosphorus or *E. coli*). Some attributes are graded using 'ABCD' categories: A (very good), B (good), C (fair) and D (poor). In some cases, *E. coli* has an additional E (very poor) grade. Other attributes have simple 'pass' or 'fail' grades.

The more attributes with a higher grade, the better the overall ecosystem health. Conversely, when many attributes have poorer grades the overall ecosystem health is poorer.

Hauora target attribute states

In 2020, Environment Southland and Te Ao Mārama Inc (TAMI) approved in principle the use of hauora as a freshwater target to be achieved within a generation.

These targets provided the basis for the Regional Forum recommendations, on how freshwater aspirations may be achieved.

The concept of hauora encompasses far more than the numeric attributes and targets described here. For simplicity, a reduced number of attribute states are presented in this document as they relate to ecosystem and human health. Hauora is a state of healthy resilience and is generally associated with the A 'very good' and B 'good' attribute states. However, attribute states that support hauora can be anywhere on the scale from A 'very good' to C 'fair', depending on the natural characteristics of that freshwater environment.

The natural characteristics have been differentiated through the use of classes.

We use monitoring results to compare the current attribute state with the hauora target state for different classes in the Bluff coastal zone.

Streams and rivers

River classes

‘River classes’ group rivers (or parts of rivers) with similar characteristics. Similarities can include natural characteristics of the rivers, such as climate, gradient and flow. River classes can also group environments with similar pressures, such as land use.

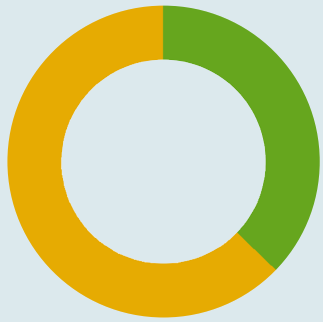
The river classes used in Murihiku Southland are: Mountain, Hill, Lowland, Spring-fed, Lake-fed and Natural State.

About two-thirds of the rivers in the Bluff coastal zone are classified as Lowland. The rest are Natural State rivers. The rivers in the zone are small, short catchments, such as Duck Creek and Muddy Creek.

Target states can differ between attributes and between different river classes, which may have different target states for the same attribute.

Periphyton is an example of an attribute with different target states for different river classes.

Length of river network in each class



Lowland = 62,898m

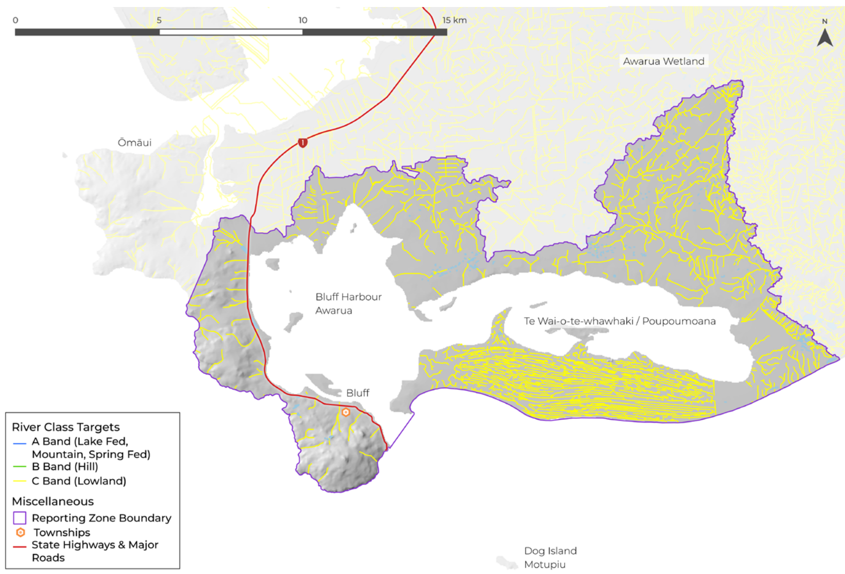
Natural State = 37,243m

The different target states reflect the differences in natural characteristics for each river class.

- C target state: Lowland class
- B target state: Hill class
- A target state: Mountain, Spring-fed and Lake-fed classes.

Natural State waterbodies can be identified for management purposes but are assigned attribute targets according to their underlying river classification (displayed here).

River class hauora targets



▸ *The map shows the distribution of periphyton targets for each river class within the Bluff coastal zone.*

Results for the river classes

Hauora targets and current states for ecosystem and human health attributes are summarised in the table below for the catchment’s Lowland river class. Table colours correspond to the ‘ABCDE’ grading for attributes described above.

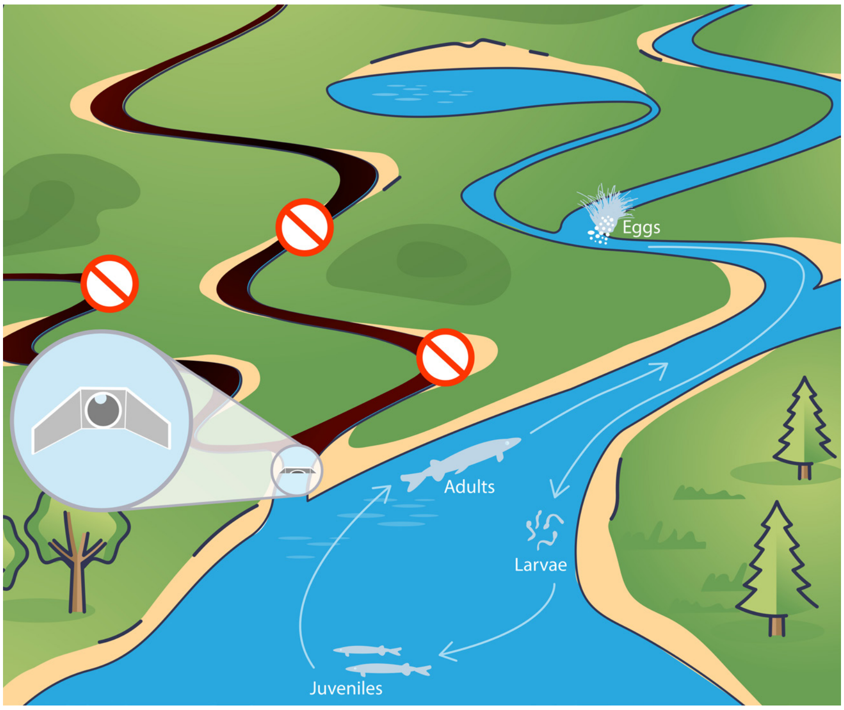
Ecosystem health attributes	Lowland hauora target
Periphyton	C
Nitrate toxicity	A
Ammonia toxicity	A
Dissolved oxygen	A
Suspended fine sediment	C
Macroinvertebrates (MCI, QMCI)	C
Deposited fine sediment	A
Dissolved reactive phosphorus	B
Water temperature (summer)	C

Human contact attributes	Lowland hauora target
Benthic cyanobacteria	A
E. coli	A
E. coli at primary contact sites	A
Visual Clarity	B

Fish passage

Fish passage barriers obstruct the passage of fish species. This particularly impacts migratory fish species that complete their lifecycles in both freshwater and the ocean, such as tuna/eels, kanakana/pouched lamprey and migratory galaxiids/ whitebait. Generally, the closer a barrier is to the coast, the larger the area of habitat that becomes inaccessible to migratory fish, making it a higher priority for restoring passage. Common examples of fish passage barriers include structures like culverts, weirs and dams, while natural features such as waterfalls can also form barriers. Different fish species and life stages have varying climbing and swimming abilities, so a barrier for one species or life stage may not be a barrier for another.

Whitebait lifecycle



In some cases, fish barriers may be desirable to protect populations of non-migratory galaxiids that struggle to co-exist with trout. In these cases, a barrier could be installed or maintained in a specific location to prevent trout from reaching the population of non-migratory fish.

In the Bluff coastal zone, culverts are the most common type of fish passage barrier, with some tide gates also present in the lower catchment. Considering fish passage during the design and installation of structures, along with regular maintenance, will help improve fish passage.

Groundwater

Human consumption – is it safe to drink?

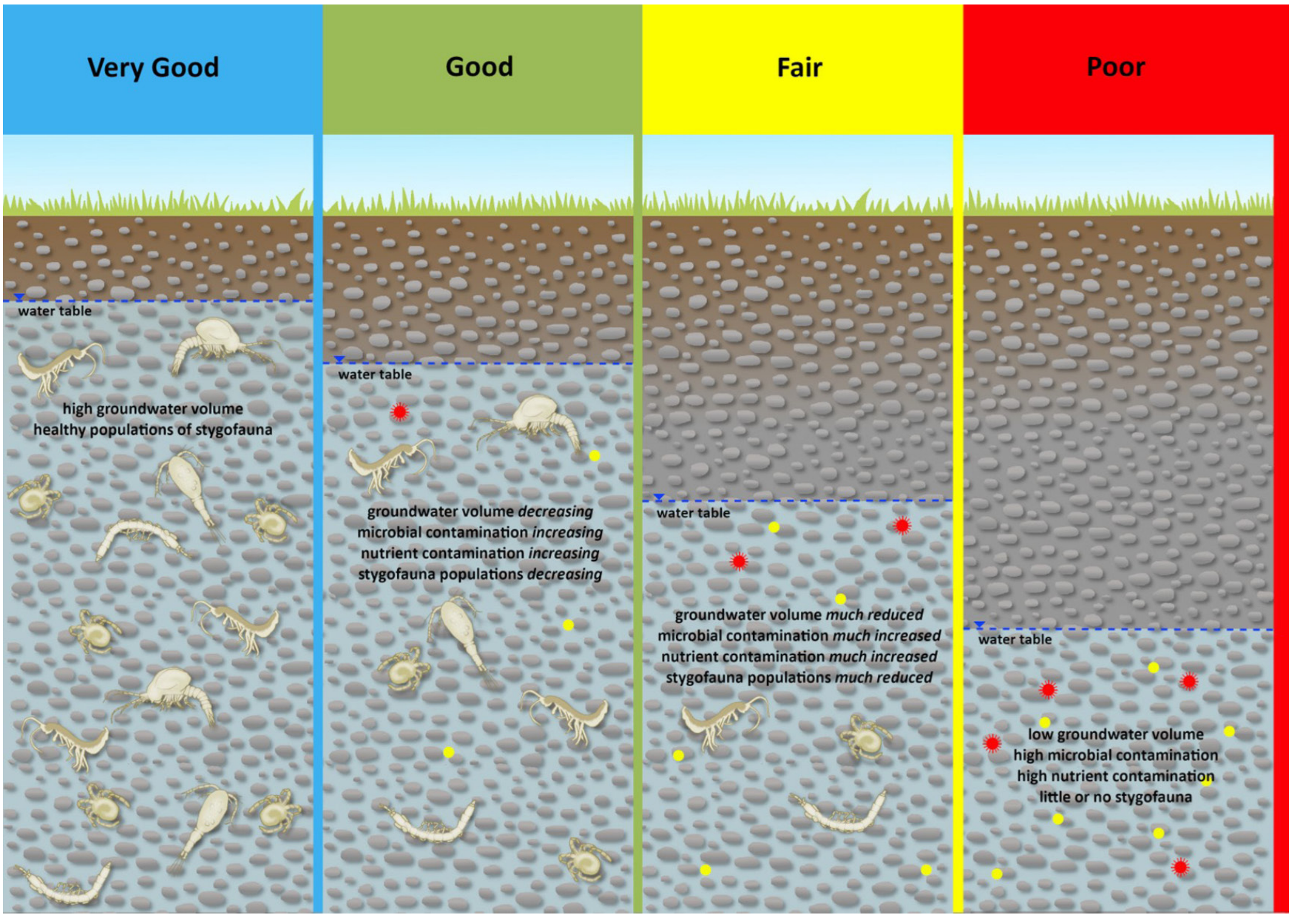
Groundwater is utilised around the margin of Awarua Bay and on the Tiwai Peninsula. Groundwater is generally shallow at 2-5m, with the median bore depth at 6m.

The presence of pathogens (*E. coli*) and nitrate are the main issues affecting the suitability of potable groundwater for drinking. Target states for groundwater are based on the New Zealand drinking water standards and use a pass/fail assessment system.

There is no groundwater monitoring data within the Bluff coastal zone.

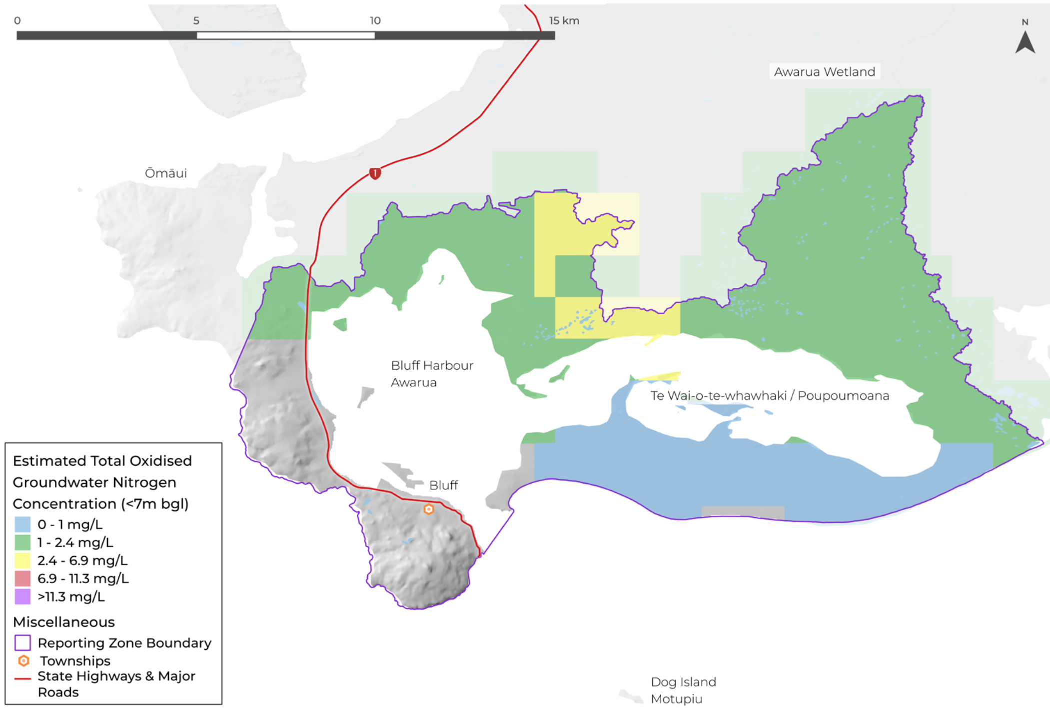
Ecosystem health

Nitrate concentrations are also used to monitor ecosystem health — for both groundwater ecosystems and connected surface waterways. The groundwater ecosystem health outcomes are represented conceptually in the figure below. Nitrate concentrations are one factor that contributes to overall ecosystem health. Nitrate concentrations that relate to surface water and groundwater ecosystem health outcomes are different to those used in relation to drinking water.



Modelling indicates that the risk of severe nitrate contamination in the zone is relatively low. Modelled nitrate concentrations are shown in the map.

Groundwater nitrogen



Wetlands – how many do we have left?

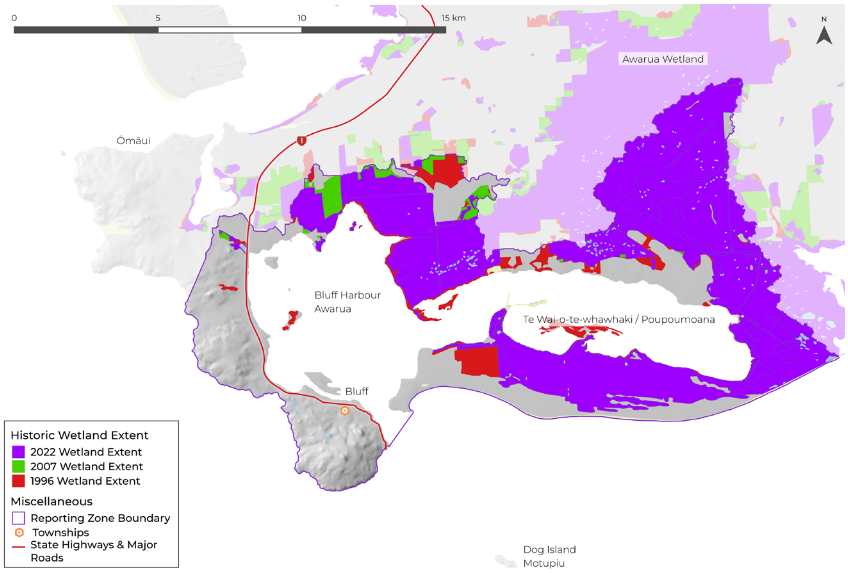
Wetlands and water quality

Wetlands are increasingly being recognised for their functional values within the landscape. For example, their ability to intercept and attenuate agricultural runoff is now recognised as an important contribution to farm nutrient management.

Wetlands purify water through sediment capture and storing nutrients in their soils and vegetation. This is particularly important for the agricultural nutrients nitrogen and phosphorus, which contribute to the eutrophication of receiving environments such as rivers, lakes and estuaries.

For the purposes of this document, wetlands are generally defined as per the Southland Water and Land Plan definition.

Historic wetland extent



This map shows the wetland extent over three time periods. Wetland areas lost since 1996 and 2007 are shown as the red and green areas respectively.

The following areas were not included as wetlands in this classification:

- Wet pasture or where water ponds after rain
- Pasture containing patches of rushes less than 50% total cover
- Ponds of any kind unless associated with 0.5 or more hectares of terrestrial wetland.
- Areas of forest unless previoulsy identified as wetland.
- Areas associated with the main active flood channels of rivers.

Current state

There is currently 5,990ha of wetlands in the Bluff coastal zone. Most wetlands lost were bogs and fens. These have been mainly converted to pasture farmland.

	1996 to 2007	2007 to 2022	Overall 1996 to 2022
Change in wetland area	↓ 8% 562 ha	↓ 3% 210 ha	↓ 11% 772 ha

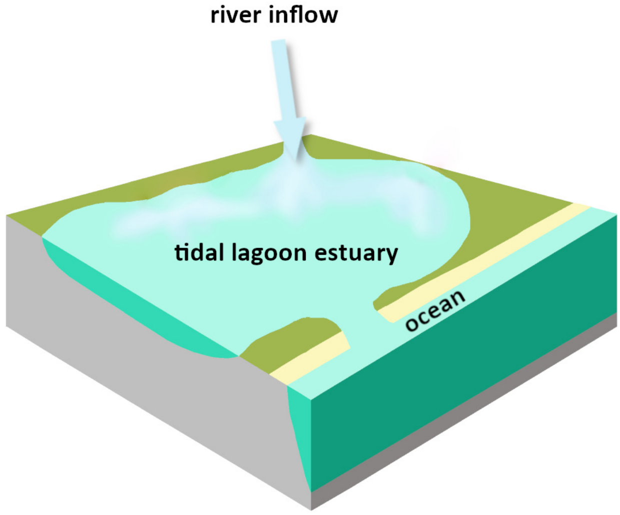
Remaining wetlands

Four regionally significant wetlands in the Bluff coastal zone are part of the nationally and internationally significant Ramsar Awarua Wetland complex. These wetlands comprise over half the entire zone and have high cultural and ecological values. Most of the wetlands are in the form of Bluff Harbour and Awarua Bay estuary. These areas of tidal lagoon and mudflats are important for wading birds, including the rare southern New Zealand dotterel. The other main type of wetland in the complex is bog, dominated by wire rush and manuka, and is mainly on Department of Conservation land. Very little wetland exists outside the Ramsar wetland area, and no wetland is identified in and around Bluff or Green Point.

	1	2	3	4	5
Risk of Loss (1 = low, 5 = high)	0%	13%	44%	31%	13%

Bluff Harbour

Located at the bottom of the catchment, estuaries are at risk of eutrophication from excess nutrients and sediment from inflowing rivers. Some estuaries are more at risk of eutrophication than others and are grouped into categories according to their risk.



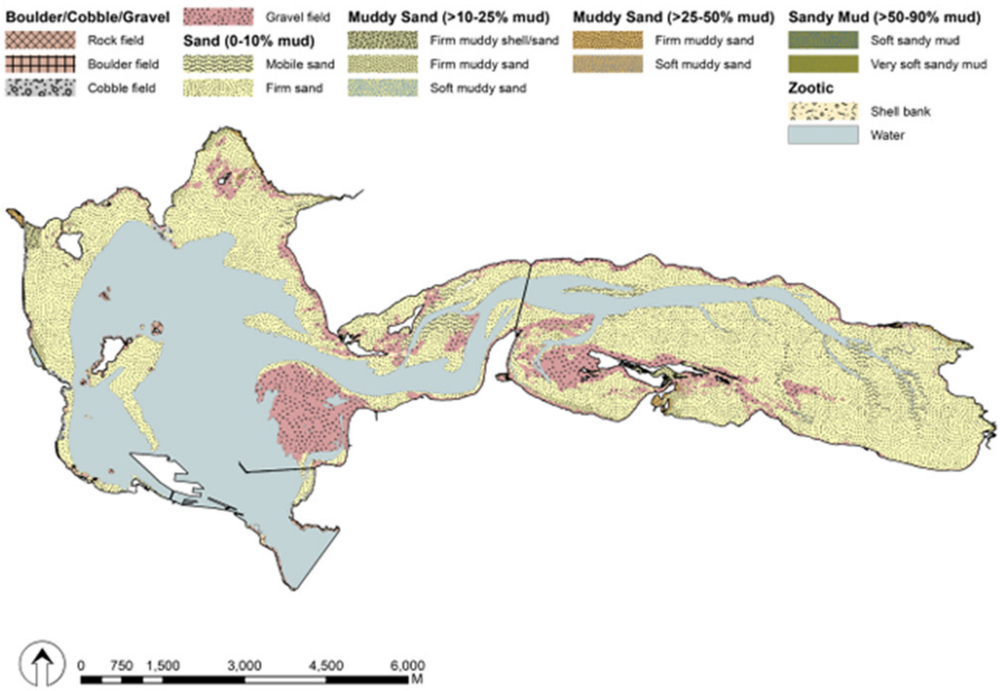
Bluff Harbour is a ‘tidal lagoon estuary’.

The tidal lagoon class of estuaries can often be at high risk of eutrophication if they are typically shallow and fed by rivers, have large intertidal areas of sand or mud, and are moderately influenced by tidal flow. However, Bluff Harbour does not have the typical significant freshwater input. Instead, it has many smaller streams and marginal inputs associated with the wetland complexes around the area. Despite the large number of small streams, less than 1% of the flows in the estuary can be attributed to these streams, meaning it is almost entirely ocean-dominated. It also has a relatively large deeper area and flow channels with significant tidal flushing.

Intertidal area mapping undertaken in 2021 indicates that Bluff Harbour and Awarua Bay are showing little in the way of muddy sediments accumulating and that there is very little coverage of nuisance macroalgae, suggesting that there is little eutrophication occurring in the area. Any areas with higher macroalgal cover or predominantly muddy sediment were isolated to the inflows of small streams on the margins of the bay.

The figure is a broadscale mapping of Bluff Harbour and Awarua Bay from 2021.

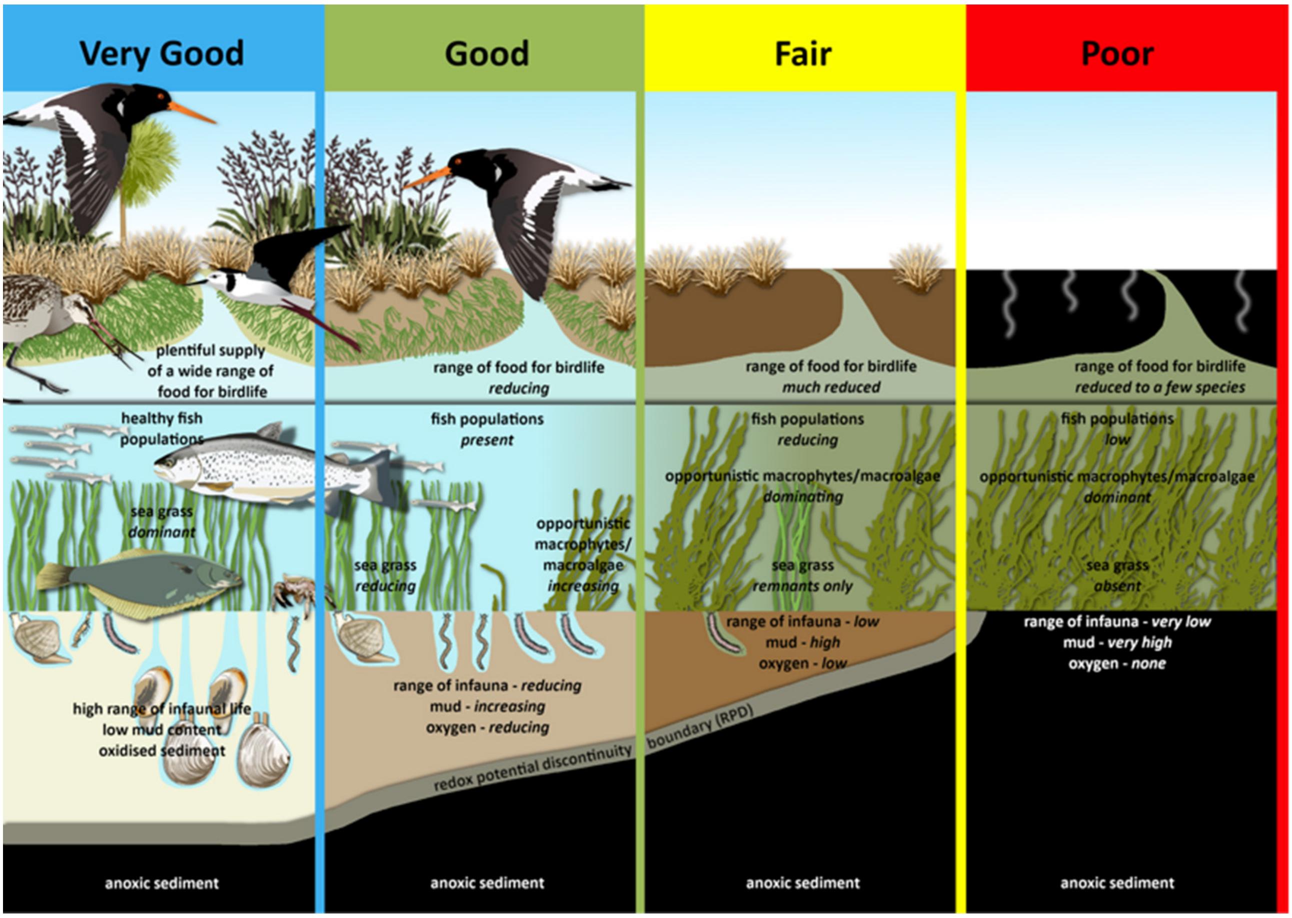
Bluff/Awarua substrate



Sediment and nutrients

Sediment and nutrients are of minor concern for Awarua Bay, given the ocean-dominated hydrology and a relatively small catchment. Inputs of sediment and nutrients could increase with changes to catchment land use.

Estuary health outcomes can be described on a scale from 'very good' to 'poor'. Using an outcome scale can help us understand the state of the environment and what we might be trying to achieve in the future. This concept is depicted for estuaries in the image below. We measure various aspects of the estuarine environment that can help us define and determine estuary outcomes.



Monitoring of Bluff Harbour indicates that the area is in good condition using the attributes routinely monitored.

Recent investigations into Tiwai Peninsula suggest limited impact from the smelter in Bluff Harbour, with most of the values of concern isolated to the immediate vicinity of the smelter's stormwater drains. The same work also indicates low bioaccumulation in several marine species associated with mahika kai and recreational values.

Ecosystem health attributes	Hauora target	Current state
Phytoplankton	C	-
Macroalgae	B	A
Gross eutrophic zone	A	A
Mud content	A	-
Sediment oxygen levels	B	-
Total nickel in sediment	A	-
Total arsenic, zinc, copper, cadmium, chromium, lead and mercury in sediment	A	-

Human health attributes		
Pathogens – *Enterococci*	A	B
Pathogens – *Enterococci* at popular bathing sites	A	B

Water quantity – how much do we have, and how much are we using?

There are currently no consented surface water abstractions in the Bluff coastal zone and only one groundwater abstraction. This abstraction is for the aluminium smelter at Tiwai Peninsula, which takes 1,659.3 m^3/year across four bores. Based on water-use data supplied by the consent holder, this take uses less than 75% of its consented volume.

How much do we need to reduce contaminants to achieve a state of hauora?

Regional contaminant modelling

We have undertaken contaminant modelling to help us better understand water quality across Murihiku Southland. This modelling utilises monitoring data to estimate water quality in all waterbodies (excluding Fiordland and Islands). This expanded view of water quality allows us to estimate the reductions in contaminant load and concentrations required to achieve the identified target attribute states and to test the impact of different land use scenarios.

For this work, we focused on four main contaminants of concern: nitrogen, phosphorus, sediment, and *E. coli*. Actions taken to reduce the impact of these contaminants on our freshwater systems will have benefits for ecological and human health outcomes.

How much do contaminant loads need to be reduced?

Load is a measure of the total mass of a contaminant (in kg or tonnes) coming from a given area past a given point over time. For example, the total amount of nitrogen delivered to the sea by a river in one year.

We use loads to quantify contaminants here because they describe the amount of contaminants lost over a whole catchment area. It is the land that consequently needs to be managed to reduce those loads. It is important to remember that concentrations (e.g., the mass of the contaminant per litre of water in the waterbody in kg/L) must also be considered. Concentrations in waterbodies are affected by the size of the contaminant load lost from land and the amount of water available to dilute that load. Hence, water takes and climate can affect concentrations too.

Concentrations are the relative amount of contaminant present in a given volume of water at that time. Concentrations are important because they have direct relevance to toxicity attributes as well as ecological processes.

This modelling considers draft targets for the following attributes:

Rivers
Periphyton biomass, nitrate toxicity, dissolved reactive phosphorus, visual clarity, suspended sediment, *E. coli*.

Lakes
Total nitrogen, total phosphorus, phytoplankton.

Estuaries
Macroalgae.

This modelling accounts for loads and concentrations required to achieve target states everywhere for all the above attributes.

The table presents estimated load reductions for the Bluff coastal zone. Load estimates were calculated using sites with ten years of data and relates to the 2017 year.

Contaminant	Total Load (2017 - Best estimate*)	Percentage load reduction required to achieve hauora (Best estimate*)
Total Nitrogen	39 Tonnes/Year	↓ 9% (6-13)
Total Phosphorus	2 Tonnes/Year	↓ 24% (14-39)
Sediment	120 Tonnes/Year	↓ 40%
E. coli	0.4 peta *E.coli*/Year	↓ 65% (49-78)

These values represent our best estimate. Levels of uncertainty are indicated by the 90% confidence interval shown in brackets where available.

What options do we have to reduce nutrient and sediment loads?

We have modelled different scenarios to indicate how far each may go toward achieving the estimated load reductions required. We have also bundled multiple scenarios to test the effect of combining multiple strategies.

This work is not intended to assess individual properties or activities; rather, it generalises land use so that we can make some broad catchment scale assessments of the impact of different actions. This can also help give information about the differences between possible allocation approaches.

The results for each of the scenarios modelled are presented below. Explanations of each scenario can be found in our published reports. The coloured table cells indicate how far each scenario achieves the required load reductions.

The results in the following table indicate that many of the scenarios tested would achieve the nitrogen reductions required.

We have also modelled phosphorus and suspended sediment load reductions under different mitigation options. These results are not presented here for simplicity, but broadly show:

- Implementation of scenarios 4, 5, 12, 13, 14 and 15 (over page) is estimated to achieve required phosphorus reductions required. Furthermore, scenario 3 was estimated to achieve reductions within the uncertainty of the required estimate. The range of reductions across all scenarios was 0-44%.
- Implementation of the existing rules and regulations relating to sediment is estimated to achieve an 18% reduction in suspended sediment load. This is less than the required 40% reduction to support hauora.

ID	Scenario	Reduction in nitrogen load (%)	Remaining deficit from target (%)
Individual methods			
1	100% adoption of established farm Good Management Practice (GMP) mitigations	13	0
2	Adoption of all established and developing farm mitigations	35	0
3	Wetlands returned to the same area as existed in 1996	25	0
4	Establishment of wetlands in a way that treats all surface runoff from agricultural land	33	0
5	Establishment of large community wetlands in inherently suitable areas	53	0
6	All wastewater point sources are discharged to land rather than directly to water	2	7
7	Reducing land use intensity on flood prone land	2	7
8	Reducing land use intensity on public land	4	5
9	Destocking (10% reduction drystock, 20% reduction dairy)	20	0
10	Riparian planting (full shading of streams <7m wide)	0 (indirect effect on periphyton)	9
Bundled methods			
11	1996 wetlands returned, wastewater discharged to land (3 + 6)	2	7
12	Established and developing farm mitigations, 1996 wetlands, wastewater to land (2 + 3 + 6)	49	0
13	Established and developing farm mitigations, 1996 wetlands, wastewater to land, repurposing public land (2 + 3 + 6 + 8)	50	0
14	Established and developing farm mitigations, 5% wetlands, wastewater to land, repurposing public land (2 + 4 + 6 + 8)	56	0
15	Established and developing farm mitigations, community wetlands, wastewater to land (2 + 5 + 6)	67	0
16	Established farm mitigations, wastewater to land, plantain on dairy farms, 1996 wetlands, repurposing of Environment Southland land, forestry expansion (1 + 6 + 3 + new individual methods)	24	0

Required reductions likely achieved (green) *Within uncertainty range* (orange) *Deficit remaining* (red)

Reducing load from pastoral land across the catchment

We also examined the effect of different nitrogen load reduction scenarios for dairy and drystock farms on the overall catchment load. The purpose of this work was to help show the reduction that could be achieved via reductions in loss from drystock and dairy land.

The table shows the catchment load reduction achieved (coloured cells) for each combination of simulated reductions on dairy and drystock farms. For example, we can see that a 40% reduction in loss from dairy farms combined with a 20% reduction from drystock farms will result in approximately 25% reduction in the instream TN load across the catchment.

While the required reductions for nitrogen might be reasonably achievable, modelling indicates that more considerable reductions are necessary for phosphorus, *E. coli* and sediment.

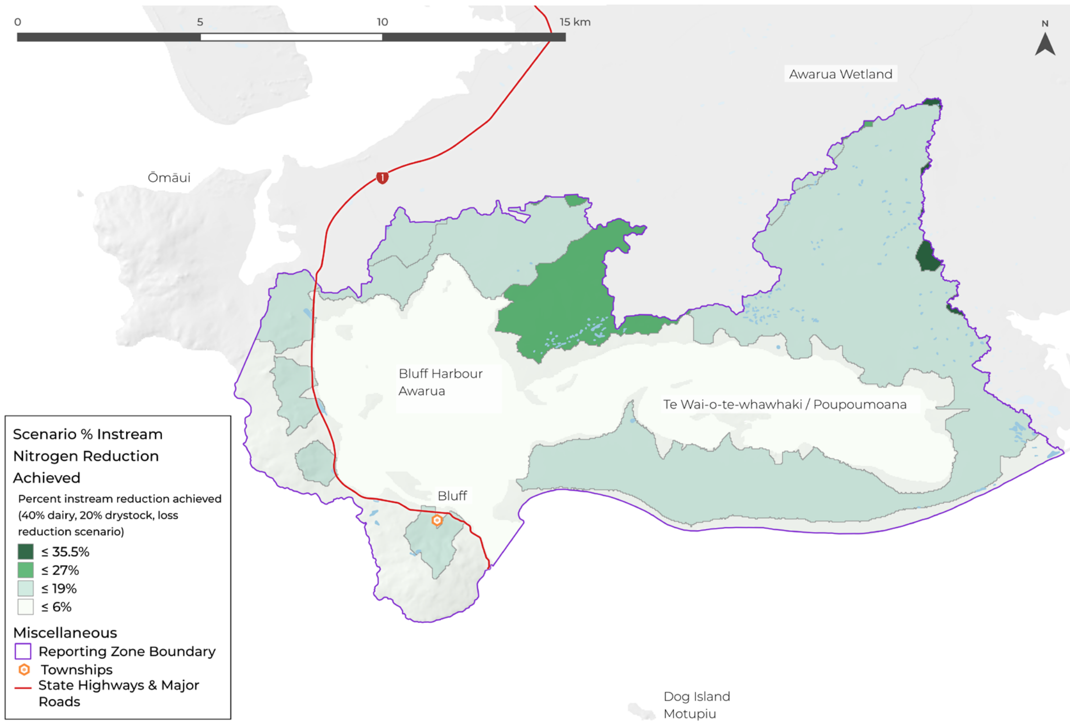
Basin-wide mean % TN reduction, relative to baseline

Drystock loss rate reduction (%)						
	80%	24%	33%	43%	53%	63%
	60%	18%	28%	37%	47%	57%
	40%	12%	22%	31%	41%	51%
	20%	6%	16%	25%	35%	45%
	0%	0%	10%	19%	29%	39%
		0%	20%	40%	60%	80%

Dairy loss rate reduction (%)

Required reductions likely achieved | *Within uncertainty range* | *Deficit remaining*

Instream nitrogen reduction achieved %



▲ *The map shows how the modelled nitrogen reductions achieved are predicted to vary spatially across the sub-catchments.*

Opportunities for action

We have put together opportunities for action in the Bluff coastal zone to improve the state of freshwater.

Farm scale opportunities for action

Farm-scale actions should be tailored to physiographic setting as well as catchment priorities. In the Bluff coastal zone, load reductions are required for all major contaminants to meet hauora targets (nitrogen, phosphorus, sediment, and *E. coli*).

We can use farm scale observations, physiographic information, and our understanding of water quality to help refine the most relevant actions for a given location or landscape.

Physiographic zones help us to understand better how contaminants move through the landscape. Each zone has common attributes that influence water quality, such as climate, topography, geology and soil type.

Physiographic zones differ in how contaminants build up and move through the soil, through areas of groundwater, and into rivers and streams.

Contaminants can move from the land to waterways via:

- overland flow (or surface runoff)
- artificial drainage, e.g. tile drains and mole pipe drainage
- deep drainage (or leaching) of either nitrogen or phosphorus to groundwater
- lateral drainage (or horizontal movement through soil) of phosphorus and microbes

These key transport pathways for contaminants differ for each physiographic zone. Understanding differences between zones allows for targeted land use and management strategies to be developed to reduce impacts on water quality.

Widespread implementation of property actions to improve water quality can have significant co-benefits for catchment hydrology (flood risk and climate change resilience) and biodiversity outcomes.

The Bluff coastal zone is made up of three distinct physiographic areas. The peat/wetlands dominated Awarua area, the bedrock/hill country dominated Greenhills and Bluff Hill areas and the oxidising Tiwai Peninsula.

Farm-scale or more resolute physiographic information may be available in some locations. We promote using the best information available to identify farm-specific risks and solutions.

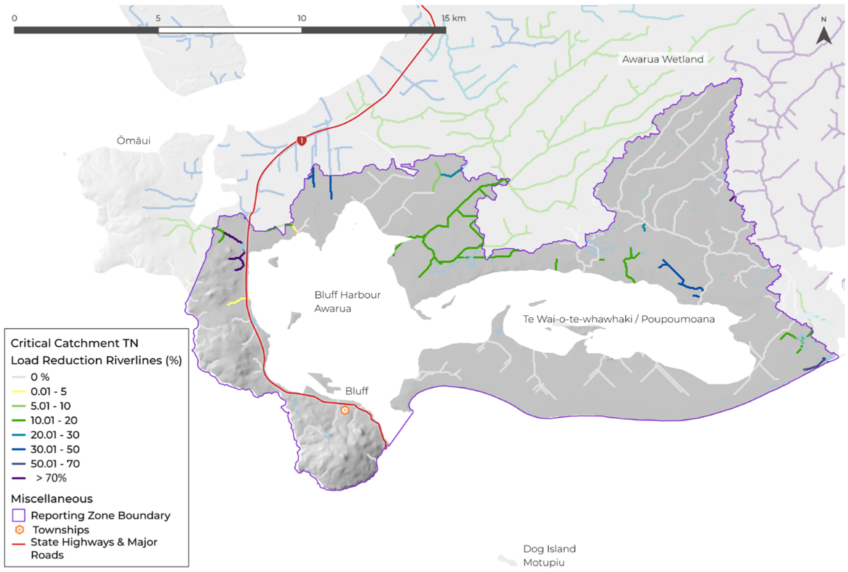
The following maps help to identify the most important actions to focus on in different parts of the catchment.

Property scale actions

Nitrogen

Physiographic zones can help to identify what contaminant loss pathways likely need attention in different locations. The excess load map shown here indicates where nitrogen loss mitigation should be a particular focus in farm planning.

Critical catchment TN load reduction (%)



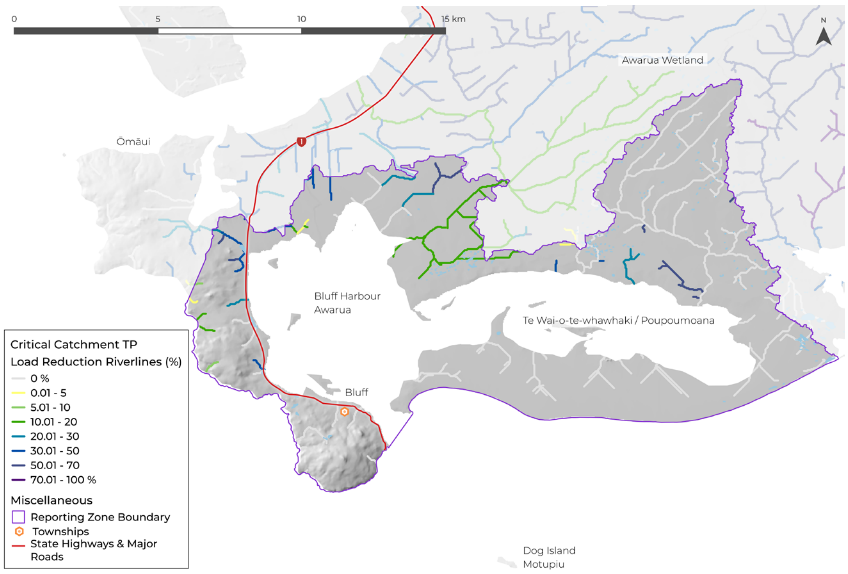
Phosphorus

Over time, reductions are required across the entire catchment area to achieve hauora targets.

This means reducing phosphorus loss should be a priority in all farm-scale mitigation planning.

Physiographic zones can help to identify what contaminant loss pathways likely need attention in different locations. The excess load map shown here indicates where phosphorus loss mitigation should be a particular focus in farm planning.

Critical catchment TP load reduction (%)

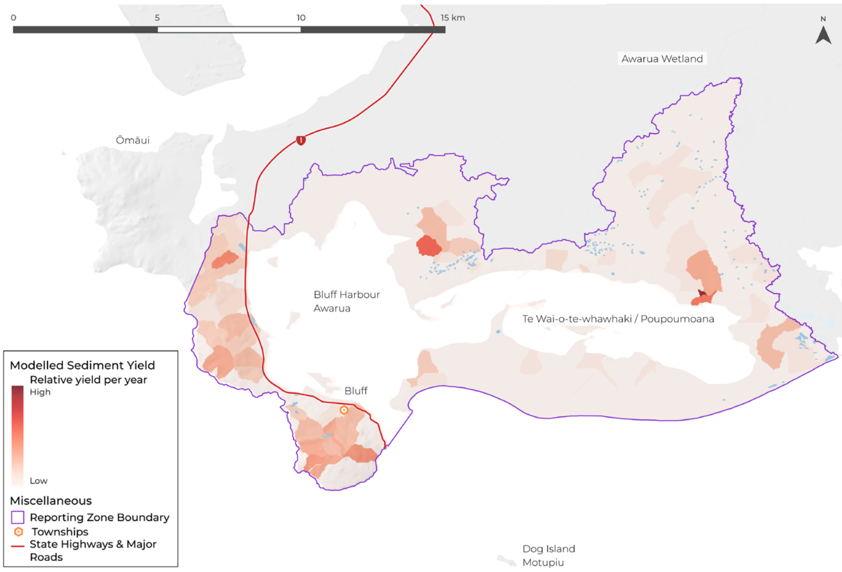


Phosphorus

The map (right) shows how we expect sediment loss to vary throughout the catchment. Some places in the agricultural landscape are estimated to have higher sediment loss rates. These are primarily areas with more sloping land, soils susceptible to erosion and where stream bank erosion is likely an issue.

Sediment from agricultural land generally poses a greater threat to rivers and lakes as it is often fine grained and carries higher concentrations of nutrients. Properties within the shaded, darker red areas should specifically look for opportunities and mitigations to reduce sediment loss.

Modelled sediment yield



E. coli

The risk of *E. coli* loss to water depends on landscape type, slope, stock and vegetation. Property-scale assessments should be used to mitigate the highest risk loss pathways on farms.

Urban and industrial opportunities for action

- Identify and remediate contaminated sites. Large bodies of information about contamination associated with the Tiwai smelter site are available. Recommendations should be adopted to remediate and minimise impacts.
- Ensure wastewater and stormwater are not cross-connected in municipal systems.
- Target improvements to on-site wastewater disposal systems to reduce the risk of human faecal contamination of freshwater.
- Incorporate best-practice stormwater management methods into urban development.

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