Central Adaptation Area Risk Assessment

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Kāpiti Coast District Council
Takutai Kāpiti

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Central Adaptation Area Risk Assessment

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Revision no:	B	**Prepared by:**	Kate MacDonald
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Jacobs New Zealand Limited

Level 2, Wynn Williams Building
47 Hereford Street
Christchurch Central 8013
PO Box 1147
Christchurch 8140
New Zealand

T +64 3 940 4900
F +64 3 940 4901
www.jacobs.com

Executive summary

This report presents a summary of the identified risks to the built environment, human, ecological, natural character, and cultural domains in relation to the **Central Adaptation Area (CAA)** from projected coastal hazards over the next 100 years (i.e. to 2130) if no future adaptation is undertaken. This report identifies where the risk to domains within the coastal environment could change over time with increased projected relative sea level rise (RSLR); and identifies where and when high and extreme risks could occur. In combination with *Kāpiti Coast Coastal Hazards Susceptibility and Vulnerability Assessment Volumes 1 and 2* (Jacobs, 2021 & 2022), this and the other three risk assessments for the Northern, Raumati, and Paekākāriki Adaptation Areas are intended to collectively provide the substantive evidence base for a risk assessment in accordance with the direction set by the New Zealand Coastal Policy Statement 2010 (NZCPS).

The risks have been identified for individual elements to coastal erosion and coastal inundation hazards for the present day, 2050, 2070 and 2130 under the SSP2-4.5 and SSP5-8.5 sea level rise scenarios. Risks have been assessed by subject matter specialists from the Takutai Kāpiti Technical Advisory Group (TAG), which rely on a combination of spatial information of both the hazards and elements to assess the exposure of an element, and subject matter specialist opinion to determine how the element would fare when potentially exposed to the hazard now and in the future.

For this assessment, the MfE (2021) A guide to local climate change risk assessments definition of risk has been adopted, being a combination of 'exposure' and 'vulnerability'; whereby exposure is a measure of the extent to which elements intersect with the hazards layer; and vulnerability is the propensity or predisposition to be adversely affected by a coastal hazard in relation to climate change. Vulnerability encompasses a variety of concepts, including sensitivity to harm, and lack of capacity to naturally adapt (or adaptive capacity) (e.g. without intervention).

The overall risk ratings for each element within the five domains is presented in Table 1, and can be summarised for each domain as follows:

Built Environment Domain

- The built environment domain assesses the risk to infrastructure which provides a service to the CAA communities, such as transport (roads), electricity, three waters, gas supply, and electrical supply. It also includes private properties, for which these services are built, operated and maintained in order to deliver them on an ongoing basis.

- The risks to the built environment from coastal erosion are highly localised within the CAA to three key areas:
  - Southern Paraparaumu Beach - Southern Marine Parade (from Toru Road to Tahi Street)
  - Northern Paraparaumu Beach - Northern End of Manly Street
  - Waikanae Beach
- There are differences between the three key areas based on the type of infrastructure that is impacted first by the erosion hazard. For Waikanae Beach and Northern Paraparaumu Beach (Manly Street) areas, the erosion hazard impacts private properties before it impacts the infrastructure that services those properties. At the southern end of Marine Parade between Toru and Tahi Road, the erosion hazard impacts infrastructure (roads, wastewater, water supply, underground electrical transmission, gas supply mains) before it reaches private properties.

- Currently all elements assessed, with the exception of wastewater infrastructure, are considered to be at low risk from coastal erosion, and remain low-moderate risk over a 100-year timeframe under the lower SSP2-4.5 scenario. Risks to Waikanae Beach beachfront properties, Paraparaumu Beach beachfront properties and stormwater infrastructure from coastal erosion increase to high-extreme risk by 2130 under the higher SSP5-8.5 scenario.

- Wastewater infrastructure is the only element which at present is considered to be at moderate risk from coastal erosion due to a short section of wastewater pipes (240 m) at the southern end of Marine Parade being located within the area that could be impacted by short-term erosion in an extreme storm (1% AEP) under current sea levels.

- Risks to the Built Environment domain from coastal flooding are highest for private property and roads, with other elements being assessed as low-moderate risk across both SLR scenarios to 2130. As a result of the size of the CAA and the total number of properties within the CAA being large, the exposure to coastal flooding for property when considering the whole adaptation area is low, despite up to 2205 properties (31% of all properties in the CAA) being potentially exposed to some level of flooding in a 1% AEP by 2130 under the higher SSP5-8.5 scenario.

- Private property in Otaihanga increases to being at moderate risk to coastal flooding by 2050, and remains moderate risk to 2130 under the lower SSP2-4.5 SLR scenario. However, this risk increases to being at extreme risk by 2130 under the higher SSP5-8.5 scenario, where 50% of properties within the Otaihanga area are projected to be exposed to flooding to some degree during an extreme storm event, and sensitivity is considered to be extreme (e.g. depths greater than 1.65 m causing irreparable structural damage).

- Roads and bridges are considered to be at low-moderate risk of coastal flooding to 2050, where <1% of roads are projected to be exposed to flooding in an extreme coastal storm, with this mainly impacting Makora Road, Otaihanga. Under the lower SSP2-4.5 scenario, the risk increases to extreme by 2130 (11% of roads exposed). Under the higher SSP5-8.5 scenario, the risk increases to high in 2070 (3% of roads exposed), and extreme in 2130 (19% of roads exposed). By 2130, access to Waikanae along Te Moana Road is projected to be impacted during an extreme event, as well as access between Peka Peka and Waikanae along Huiawa street. Access to properties in Otaihanga around Makora Road, and in northern Paraparaumu (Te Kupe Road; Manly Street) could also be cut off by this time in an extreme event.

Human Domain

- The 'Human' Domain considers the risks to physical and mental health of those who live, work, or recreate in the CAA.

- Risks to elements of the human domain from coastal erosion are considered to be low to moderate across both SLR scenarios out to 2130. All elements, with the exception of mental health and wellbeing, are considered to be at low risk to at least 2070. Under the lower SSP2-4.5 scenario, the risk of exacerbating Inequities increases to a moderate risk by 2130, while under the higher SSP5-8.5 scenario, all elements except Physical Health and Social Infrastructure/amenity, which remain at low risk, have increased to moderate risk.

- The highest and earliest apparent risks from coastal erosion are associated with risk to mental health and wellbeing, which becomes moderate risk by 2070 under both SLR scenarios, and remains moderate risk to 2130. This increase to moderate risk by 2070 is driven by the increase in exposure of private property with SLR, and of other public space that may provide for residents' mental wellbeing and identity (e.g. the Waikanae Estuary).

- For coastal inundation, all six elements are currently a low-moderate risk, but only two remain at a low risk by 2050 ('exacerbating inequalities' and 'conflict, disruption, and loss of trust in government'). By 2070 all elements are considered to be at a moderate risk under both RSLR scenarios, except for risks to social cohesion and community wellbeing, which has increased to being high risk under both scenarios. This element increases to an extreme risk ranking by 2130 under the higher SSP5-8.5 RSLR scenario due to the increased exposure to the hazard, increasing the likelihood that community composition may change as people with the financial means move away from the area exposed to the hazard.

- The risk of exacerbating inequities from coastal flooding also increases to an extreme risk ranking by 2130 under the higher SSP5-8.5 RSLR scenario due to increase in exposure of properties to coastal flooding

during an extreme event creates a greater likelihood of creating/exacerbating inequities between households in the CAA.

- Of the other elements, risk of conflict, disruption and loss of trust in government increases to high risk by 2130 under both scenarios. Although flooding is a more widespread issue than erosion, and will affect more properties and areas of the CAA, conflict may be less because a greater proportion of residents may feel they directly benefit from adaptation actions. However, there will still be potential for conflict and resentment arising from the funding of adaptation, with households that do not directly benefit from adaptation actions potentially being placed in a position where they need to fund adaptation (via rates) that benefits others more significantly.

- The other three human elements (physical health, mental health and wellbeing, and social infrastructure and amenity) remain at a moderate risk rating from 2050 to 2130 under both SLR scenarios.

Ecological Domain

- The 'Ecological' domain considers the risks to the plants, animals and their habitats from the coast inland within the RAA.

- The risks to the ecological domain from coastal erosion are varied across elements, with coastal indigenous biodiversity being considered as at extreme risk currently, and remaining at extreme risk to 2130 under both SLR scenarios. This extreme risk is driven by the potential changes that may happen within the estuaries, which could result in less favourable habitat for fauna.

- Mapped ecological sites become extreme risk from coastal erosion by 2070 under both SLR scenarios. Rare and threatened species and bird habitat both become high risk by 2070, increasing to extreme risk by 2130. Coastal dune lands only become high risk under the higher SSP5-8.5 scenario by 2070, increasing to extreme risk by 2130. Wetlands become at high risk from coastal erosion in 2130 under the lower SSP2-4.5 scenario, and high risk by 2070 (remaining high to 2130) under the higher SSP5-8.5 scenario.

- Risks from coastal inundation to the ecological domain are highest for bird habitat, which are considered to be at extreme risk at present, and remain extreme risk through to 2130 under both SLR scenarios. Higher water levels and more extensive flooding could drown nests and burrows of species that nest adjacent or on waterways, which could have cascading effects on the size and genetic diversity of the affected bird populations.

- Fish habitat and rare and threatened species both become high risk from coastal inundation by 2050. Fish habitat remains high risk under both SLR scenarios through to 2130; Rare and threatened species remain high risk through to 2070, but by 2130 are considered to be at extreme risk.

- Coastal indigenous biodiversity and mapped ecological sites are both considered to be at moderate risk from coastal flooding at present day, and under both SLR scenarios increasing to being at high risk by 2070, and extreme risk by 2130. Wetlands are considered to be at moderate risk from coastal inundation at present. This risk only increases to high in 2130 under the higher SSP5-8.5 scenario.

Natural Character Domain

- The Natural Character domain considers the risks to the preservation of the natural character of the coastal environment. The coastal terrestrial area (CTA) is representative of the broader coastal environment, and within the adaptation area there is one CTA – "Waikanae and Paraparaumu." Within this CTA, the Peka Peka dunes and the Waikanae Estuary are sub areas of high natural character.

- All elements assessed are considered to be at low to moderate risk to coastal erosion up to 2050. Under the lower SSP2-4.5 scenario, both Peka Peka dunes and the Waikanae Estuary continue to be low or moderate risk through to 2130, indicating that coastal erosion per se will not have a significant impact on these areas of high natural character. The Waikanae and Paraparaumu Coastal Terrestrial Area (CTA)

becomes high risk under both scenarios by 2070 through to 2130. The increase to high risk in the Waikanae and Paraparaumu CTA is closely linked to the proximity and exposure of the settlement to erosion, with the ability to preserve the coastal environment becoming increasingly impacted by the removal of the remaining pockets of natural dunelands, and the 'coastal squeeze' of infrastructure behind the existing dune system limiting the dunes' ability to naturally adapt.

- All elements assessed within the Natural Character domain are considered to be at low to moderate risk of coastal inundation up to 2130 under both scenarios, with the exception of Waikanae Estuary which will remain susceptible to ongoing flooding which heightens the risk of a decline in natural character from 2050.

Cultural Domain

- A risk assessment for the Cultural domain in relation to coastal hazard is still to be undertaken with Mana Whenua, and will be added to this document prior to being finalised.

Table 1. Summary matrices of risks to all domains from coastal erosion and coastal flood hazards.

	Coastal Erosion						Coastal Inundation					
Climate Change Scenario	**Both**		**SSP2-4.5**		**SSP5-8.5**		**Both**		**SSP2-4.5**		**SSP5-8.5**	
Element	Present	2050	2070	2130	2070	2130	Present	2050	2070	2130	2070	2130
Built Environment												
Properties - Whole Adaptation Area	L	M	M	M	M	M	L	L	L	L	L	M
Properties - Waikanae Beach	L	M	M	M	M	E	L	L	L	M	L	M
Properties - Otaihanga	L	L	L	L	L	L	L	M	M	M	M	E
Properties - Paraparaumu	L	L	M	M	M	H	L	L	L	L	L	M
Water Supply Infrastructure	L	L	L	L	L	M	L	L	L	L	L	M
Wastewater Infrastructure	M	M	M	M	M	M	L	L	L	M	L	M
Stormwater Infrastructure	L	L	M	M	M	H	L	L	M	M	M	M
Roads and Bridges	L	L	L	L	L	M	L	M	M	E	H	E
Electrical Transmission and supply infrastructure	L	M	M	M	M	M	L	L	L	M	L	M
Natural gas supply mains	L	M	M	M	M	M	L	L	L	L	L	L
Human												
Physical health	L	L	L	L	L	L	L	M	M	M	M	M
Mental health and wellbeing	L	L	M	M	M	M	L	M	M	M	M	M
Conflict, disruption, and loss of trust in government	L	L	L	L	L	M	L	L	M	H	M	H
Exacerbating inequities	L	L	L	M	L	M	L	L	M	H	M	E
Social cohesion and community wellbeing	L	L	L	L	L	M	M	M	H	H	H	E
Social infrastructure and amenity	L	L	L	L	L	L	M	M	M	M	M	M

	Coastal Erosion						Coastal Inundation					
Climate Change Scenario	**Both**		**SSP2-4.5**		**SSP5-8.5**		**Both**		**SSP2-4.5**		**SSP5-8.5**	
Element	Present	2050	2070	2130	2070	2130	Present	2050	2070	2130	2070	2130
Ecological												
Coastal dunes	M	M	M	M	H	E	L	L	L	M	L	M
Wetlands	L	M	M	H	H	H	M	M	M	M	M	H
Ecological sites	L	M	E	E	E	E	M	M	H	E	H	E
Indigenous Trees	No Exposure						L	L	M	M	M	H
Rare and threatened species	M	M	H	E	H	E	M	H	H	E	H	E
Bird habitat	M	M	H	E	E	E	E	E	E	E	E	E
Fish habitat	M	M	M	M	M	M	M	H	H	H	H	H
Indigenous biodiversity (coastal)	E	E	E	E	E	E	M	M	H	E	H	E
Natural Character												
CTA2: Waikanae and Paraparaumu (Coastal Terrestrial Area)	M	M	H	H	H	H	M	M	M	M	M	M
Peka Peka Dunes (Pharazyn Reserve) (High Natural Character)	L	L	L	L	L	L	M	M	M	M	M	M
Waikanae Estuary (High Natural Character)	M	M	M	M	M	M	M	H	H	H	H	H
Cultural												
A risk assessment for the Cultural domain in relation to coastal hazard is still to be undertaken with Mana Whenua, and will be added to this document prior to being finalised.												

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to undertake a risk assessment of the Central Adaptation Area in accordance with the scope of services set out in the contract between Jacobs and the Kāpiti Coast District Council ('the Client'). That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate, or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Kāpiti Coast District Council and/or available in the public domain at the time or times outlined in this report. Several of the domains have been developed and assessed by KCDC and external consultants. The built environment domain has been assessed by Jacobs; the ecological domain has been assessed by Dr. Astrid Dijkgraaf and the human domain has been assessed by NIWA; and the natural character domain has been assessed by Boffa Miskell. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations, and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures, and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full, and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

This report has been prepared on behalf of, and for the exclusive use of, the Client, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the Client. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

Contents

Appendices

Glossary

Adaptation Areas	Five defined areas within the Kāpiti District where adaptation pathways for coastal hazards will be developed by the CAP and consolidated into the Coastal Hazards Adaptation Recommendations Report. The five Adaptation Areas are: Northern Kāpiti; Central Kāpiti; Raumati; Paekākāriki; and Queen Elizabeth Park.
Adaptive Capacity	The ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences. It relates to how easily or efficiently an element at-risk can adapt naturally.
Beachfront Properties	The most seaward row of properties within a settlement.
Central Adaptation Area (CAA)	The Central Adaptation Area is located in the centre of the Kāpiti Coast District and includes Waikanae Beach, Otaihanga, and Paraparaumu.
Consequence	The impact or effect of an element being exposed to a hazard, based on the level of exposure.
Domain	An umbrella term to describe an overall theme of what potentially may be at risk from coastal hazards. In this assessment five domains – Built Environment, Ecological, Natural Character, Human, and Cultural – have been assessed.
Element	The term used to represent the individual aspects of the domain that has been assessed. For example, 'roads' are an element within the built environment domain.
Exposure	A measure of the extent to which elements intersect with the hazards layer.
Hazard	The interaction between a physical process (natural) or phenomenon that causes harm or damage to elements within the human, cultural, built environment, ecological or natural character domains. In this report we have assessed the coastal hazards of erosion and inundation only.
NZILA	New Zealand Institute of Landscape Architects
Risk	A measure of combined exposure and vulnerability to determine the status of a people, place, or value when exposed to a hazard.
RSLR	Relative Sea Level Rise. This is the combination of global sea level rise due to climate change and the impacts of vertical land movement resulting in a local relative sea level rise.
Sensitivity	Subjective measure of how tolerant an element is to exposure to the hazard. Sensitivity relates to how the element will fare when exposed to a hazard, which is a function of its properties or characteristics.
SSP	Shared Socio-economic Pathway
Vulnerability	The propensity or predisposition to be adversely affected by a coastal hazard in relation to climate change. Vulnerability encompasses a variety of concepts, including sensitivity to harm, and lack of capacity to naturally adapt (or adaptive capacity) (e.g., without intervention).

1. Overview

As part of "*Takutai Kāpiti: Our community led coastal adaptation project*", the Kāpiti Coast District Council (KCDC) commissioned a *Coastal Hazard Susceptibility and Vulnerability Assessment* for the whole 38 km of the Kāpiti Coast District coastline from Ōtaki in the north to Paekākāriki in the south. The methodology employed for the underlying coastal modelling in this assessment is presented in Jacobs (2021)[1] and the results in Jacobs (2022a)[2,3]. The purpose of the assessment was to update previous coastal hazard assessments undertaken along the KCDC shoreline defining the spatial extent of areas potentially susceptible to current and future coastal erosion and inundation hazards, and undertake a high-level assessment of the exposure to built environment elements from coastal hazards. The purpose of this assessment was also to form the base hazard information and understanding for input into the development of adaptation pathways in the Takutai Kāpiti process. In combination with *Kāpiti Coast Coastal Hazards Susceptibility and Vulnerability Assessment Volumes 1 and 2* (Jacobs, 2021 & 2022), this and the other three risk assessments for the Northern, Central and Paekākāriki Adaptation Areas are intended to collectively provide the substantive evidence base for a risk assessment in accordance with the direction set by the New Zealand Coastal Policy Statement 2010 (NZCPS).

A Coastal Advisory Panel (CAP) has been established and is tasked with developing and recommending coastal adaptation pathways for the district. A *Decision Making Framework* report (Jacobs 2022)[4] was prepared for the CAP to guide them in forming their recommendations to KCDC. The report outlines a three phase process for the CAP to work through to develop a set of adaptation pathways as shown in Figure 1.1.

In Phase 1 of this process, which focused on defining criteria and options to be used across the entire district, the district has been divided into five '**Adaptation Areas'** based on common morphological features, and exposure to present day and future hazards, as shown in Figure 1.2.

Phase 2 of the decision making framework is repeated separately for each Adaptation Area, and begins with the presentation of a **risk assessment** for the adaptation area to the CAP:

"In Phase 2 Task 1, the CAP will be presented with a risk assessment for the Adaptation Area they are focusing on. This risk assessment will be a consolidation of all the technical assessments to date, which will provide maps of the intersection of the hazard exposure with the spatial location of elements which are at risk of damage or loss from the hazards (e.g. land parcels, land-uses, infrastructure, community services, areas of significant cultural, social and environmental uses), and commentary on the consequence of hazards to both spatial and non-spatial social, cultural, and environmental values (e.g. loss of ability to access the beach).

The presentation of this risk assessment will bring the CAP up to speed on all of the consequences of coastal erosion and inundation hazards in the Adaptation Area they are focusing on, and will provide a baseline case for the consequences of failing to address SLR in order to test the success of their potential pathways against for the MCDA assessment (e.g., the 'do-nothing' option)."[5]

The purpose of this report is to present the methodology and results of the risk assessment for the **Central Adaptation Area** (CAA), defined in Figure 1.3, and to clearly identify where the risk is greatest across multiple domains. This assessment considers the risks from coastal hazards if no future adaptation is implemented to manage these risks. Adaptation options can be tested against this no intervention scenario through the

[1] Jacobs (2024). Kāpiti Coast Coastal Hazards Susceptibility and Vulnerability Assessment Volume 1: Methodology. Report to Kāpiti Coast District Council.

[2] Jacobs (2022a). Kāpiti Coast Coastal Hazards Susceptibility and Vulnerability Assessment Volume 2: Results. Report to Kāpiti Coast District Council.

[3] It is noted that in the context of the Volume 2 report, the terms 'susceptibility' and 'vulnerability' are different from those used in this report as given in the glossary.

[4] Jacobs (2022b). Decision Making Framework Report. Report to Kāpiti Coast District Council. September 2022.

[5] Jacobs (2022b). Decision Making Framework Report. Report to Kāpiti Coast District Council. September 2022.

decision-making processes to evaluate the effectiveness of an adaptation pathway in lowering the risk across multiple domains. This assessment will be used to inform recommendations made by the CAP, and can be drawn on by Council to assist their future decisions around adaptation options and pathways to have a holistic view of risk and mitigation. This assessment follows the guidance provided by Ministry for the Environment (2021) which encourages the assessment of risk to be undertaken across a range of domains.

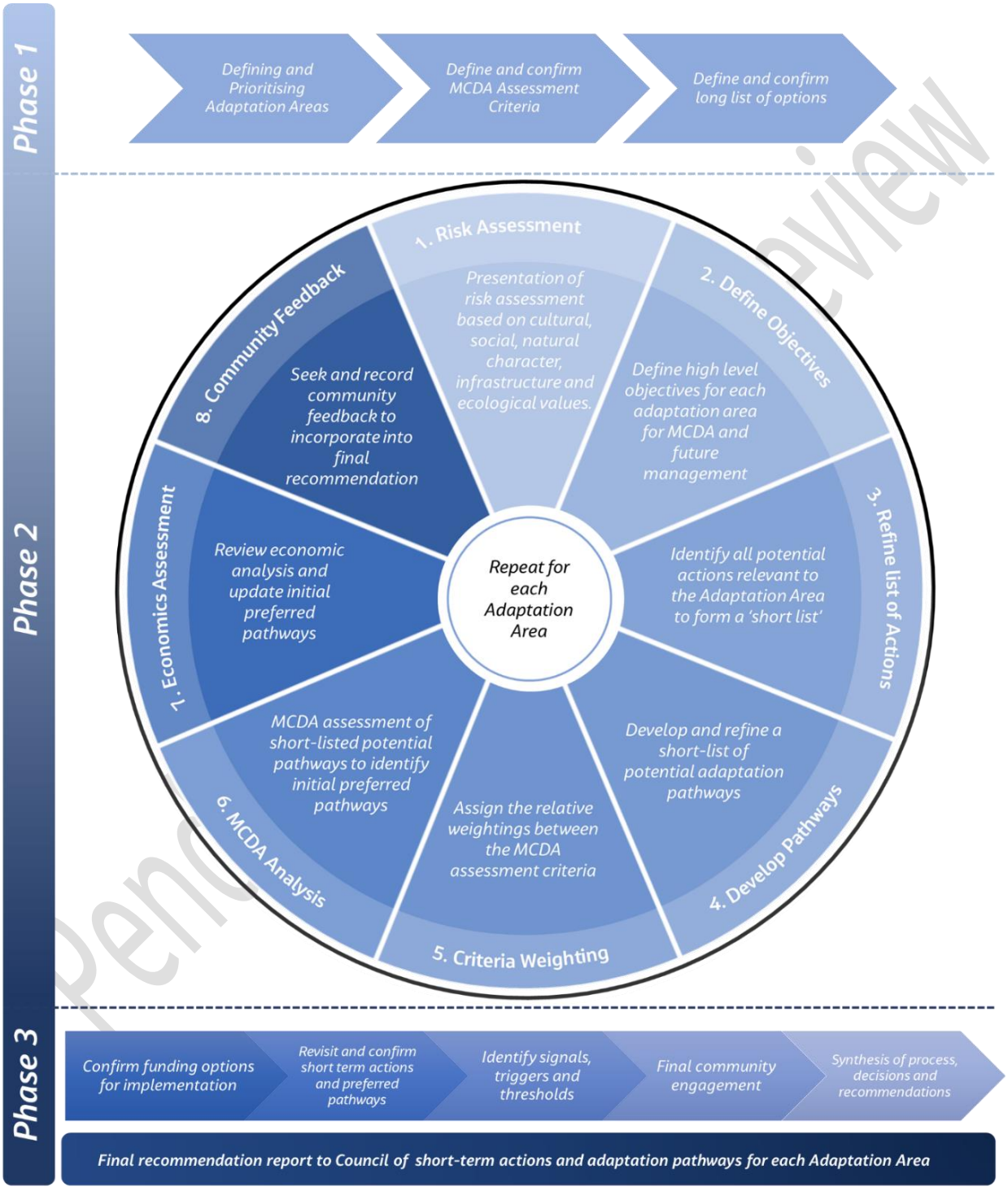

Figure 1.1: Decision Making Framework for the Coastal Advisory Panel (Jacobs, 2022)

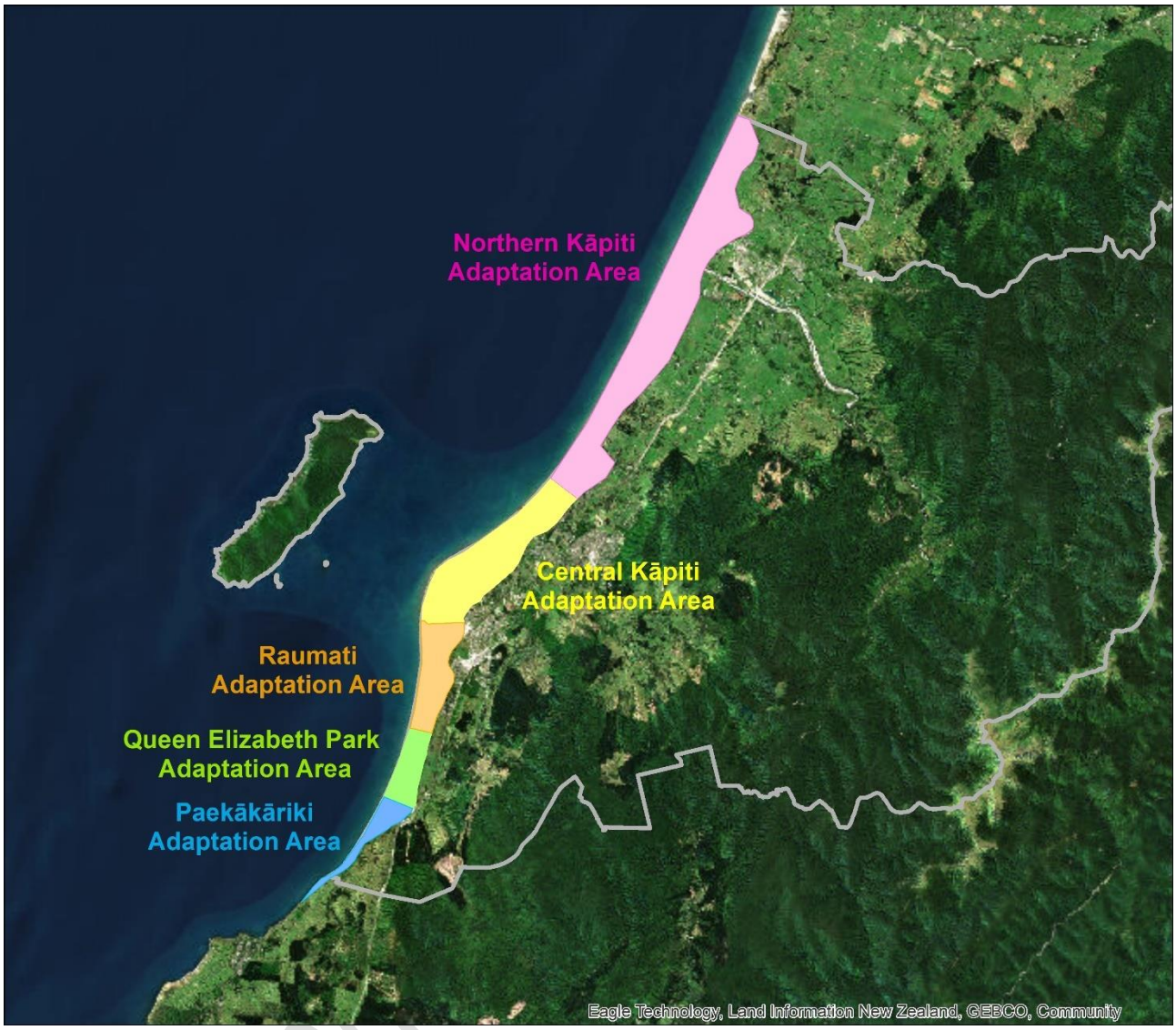

Figure 1.2: Takutai Kāpiti Adaptation Areas. The inland extent of the adaptation areas are determined by the inland extent at which either coastal inundation occurs, or where the interaction from SLR and groundwater ends. The long-shore boundaries of the adaptation areas are based on a combination of coastal processes, development, and location of communities.

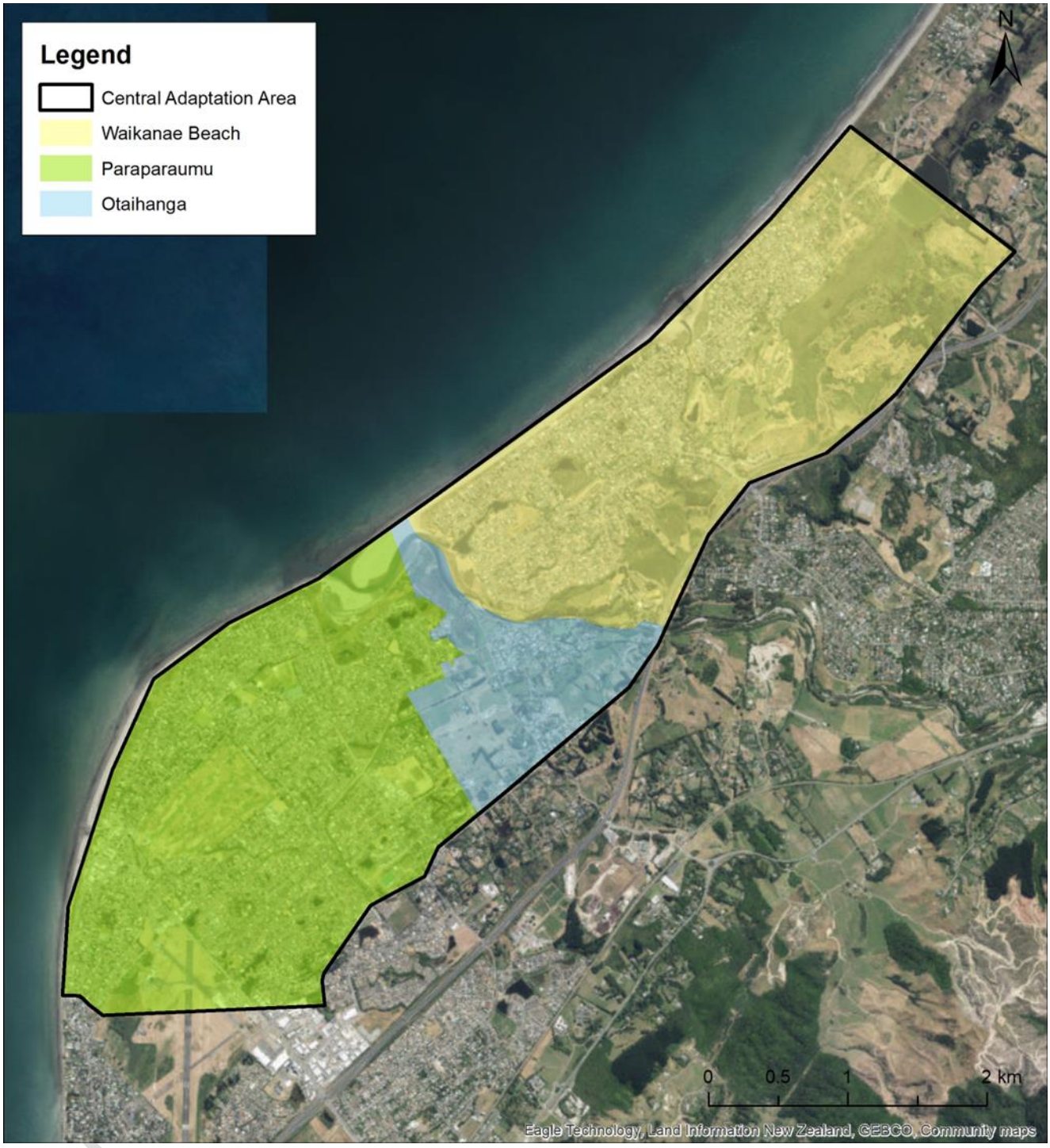

Figure 1.3: Extent and location of the Central Adaptation Area.

This assessment looks at the risks to five 'domains':

- Built Environment
- Cultural
- Human
- Ecological
- Natural Character

The risk to individual 'elements' within each of these five domains from coastal erosion and coastal inundation hazards has been assessed by subject matter specialists for the present day, 2050, 2070 and 2130 under the SSP2-4.5 and SSP5-8.5 sea level rise scenarios[6]. The use of these scenarios is consistent with the MfE (2021), MfE (2022a)[7], and MfE (2024)[8] guidance for climate change risk assessments and adaptation planning.

This risk assessment presents a summary of the risk for a number of the elements within each domain but is not an exhaustive assessment of all possible elements present along the Central Kāpiti coast. Rather, elements have been selected for assessment based on the availability of data and the expert judgement of the subject matter specialists.

It should be noted that within the CAA the domains are also at risk from other sources of hazard, such as pluvial and fluvial flooding, elevated groundwater, and tsunami, which are not included in this assessment.

This report has been prepared by Jacobs in collaboration with subject matter specialists from the Technical Advisory Group (TAG). The Built Environment domain has been assessed by Jacobs; the Natural Character domain has been assessed by Boffa Miskell; the Ecological domain has been assessed by Dr. Astrid Dijkgraaf, the Human domain has been assessed by NIWA; and the Cultural domain is still to be completed with mana whenua.

1.1 Structure of this report

The structure of this risk assessment report is as follows:

- Section two provides the methodology employed to undertake the risk assessment;
- Section three provides a summary of the risk assessment results for the **Built Environment** domain;
- Section four provides a summary of the risk assessment results for the **Human** domain;
- Section five provides a summary of the risk assessment results for the **Ecological** domain;
- Section six provides a summary of the risk assessment results for the **Natural Character** domain; and
- Section seven will provide a summary of the risk assessment results for the **Cultural** domain.
- Appendix A presents the element 'templates' used to record and assess the risk to each individual element under both SLR scenarios.
- Appendix B presents the complete risk matrices for the assessments including exposure, sensitivity, adaptive capacity, and risk ratings.

[6] Data averaged across KCDC sites from NZSeaRise (https://www.searise.nz/) with 1 mm/yr land subsidence.

[7] Ministry for the Environment (2022a). Interim guidance on the use of new sea-level rise projections. Wellington: Ministry for the Environment.

[8] Ministry for the Environment (2024). Coastal hazards and climate change guidance. Wellington: Ministry for the Environment.

2. Methodology

2.1 Background

There are several central government documents produced by Ministry for the Environment since 2017 which provide guidance on the process, steps, and scenarios that should be considered when assessing risks from climate change and coastal hazards.

The MfE (2017)[9] *Coastal hazards and Climate Change: Guidance for Local Government* identifies the following three-level risk assessment approach for coastal hazard adaptation planning:

- A first-pass risk screening can be conducted as a desktop study to screen the climate change related exposure using readily available datasets.
- A second-pass risk assessment takes a standard risk-based approach using national data, regional and local information (input from hazard assessments for various SLR scenarios or increments, demographics, asset attributes) and expert knowledge. It enables identification of how climate change may compound existing risks or the emergence of new ones.
- A third-pass (detailed) risk assessment process enables further investigation of short-listed risks and enables prioritization and testing of strategies and actions in conjunction with the vulnerability assessments.

MfE (2024) *Coastal hazards and climate change guidance* released an update to this report, which provides further details on the first-pass risk screening and the detailed risk assessment stages, and highlights the importance of cascading hazards and the linkages between risks across domains. This document recommends that for detailed risk assessments, a timeframe out to 2130 should be assessed, as well as adopting both medium confidence SSP2-4.5 and SSP5-8.5 RSLR projections that include the relevant VLM rate.

A similar three-level approach was employed in the *National Climate Change Risk Assessment for New Zealand* (MfE, 2020)[10] and is recommended in the MfE (2021) *A guide to local climate change risk assessments.*

The *National Climate Change Risk Assessment for New Zealand (MfE, 2020)* applied RCP8.5 and RCP4.5 climate change scenarios to their assessment of risk for coastal and non-coastal areas. These scenarios were also those recommended by MfE (2021) guidance to be applied in local climate change risk assessments. The guidance notes (Section 2.2.1) that "t*he RCP 8.5 scenario is useful to identify the most significant risks if warming continues unabated. The RCP8.5 'high-end' scenario is a precautionary, underpinning assumption for a risk assessment (Hausfather, 2019). Predicting emissions trajectories, and their likelihood, is complex and depends on factors including climatic and atmospheric science, socio-economic and technological change over time, and international/national climate policies. Most, if not all, are extremely hard to predict with certainty. The RCP4.5 scenario is useful to identify risks under a more ambitious reduction pathway, where emissions peak around 2040 and then decline."* This is a narrower range of scenarios for sea level rise than assessed in the Jacobs (2022a) report, which included a lower RCP2.6 scenario and a higher RCP8.5H+ scenario, which was consistent with the MfE (2017) guidance for coastal hazard assessments developed for adaptation planning.

Jacobs (2022a) presented a first-pass risk screening using available information on the exposure of selected built environment assets (e.g. properties and roads) to coastal erosion and flooding hazards under relative sea level rise projections to 2120. This Raumati Adaptation Area risk assessment report is considered to be a

[9] Ministry for the Environment (2017). Coastal Hazards and Climate Change – Guidance for Local Government. Wellington. Ministry for the Environment.

[10] Ministry for the Environment (2020). National Climate Change Risk Assessment for Aotearoa New Zealand: Main report - Arotakenga Tūraru mō te Huringa Āhuarangi o Āotearoa: Pūrongo whakatōpū. Wellington: Ministry for the Environment.

second-pass risk assessment, which builds on the first-pass assessment by considering the hazard risks from relative sea level rise to a broader range of domains and additional elements in the built environment.

MfE (2022b)[11] *Aotearoa New Zealand's first national adaptation plan* was published in 2022 following the release of the Jacobs (2022a) report. This document recommends that for detailed hazard and risk assessments in coastal and non-coastal areas, both the 'middle-of-the-road' scenario (**SSP2-4.5**) and the fossil fuel intensive development scenario (**SSP5-8.5**) to 2130 should be used to assess climate change risks. These two scenarios have been modelled and are used to assess risk in this assessment (see Section 2.2.3).

The most recent IPCC global climate change assessments (IPCC, 2021)[12], which post-dates the above 2017 and 2021 MfE guidance, present the scenarios as SSP (Shared Socioeconomic Pathways) rather than RCP (Representative Concentration Pathways) scenarios, with SSP5-8.5 and SSP2-4.5 scenarios being the equivalent of the former RCP 8.5 and RCP4.5 scenarios respectively. The MfE (2022a) *Interim guidance on the use of new sea level rise projections* recommends that in planning for sea level rise, the new SSP scenarios combined with local Vertical Land Movements (VLM) should be used in place of the previous RCP scenarios.

In light of the more recent information that became available since modelling for the Jacobs (2022a) was undertaken in 2021, Jacobs (2024)[13] provided an addendum to the Jacobs (2022a) report that updates the SLR scenarios and VLM used to inform the coastal inundation and erosion hazard mapping. The addendum documents the new RSLR projections that were developed for the Kāpiti Coast in light of the updates, and these new RSLR scenarios were used to inform remapping of coastal hazards under the SSP2-4.5 and SSP5-8.5 scenarios to inform the risk assessments for Takutai Kāpiti (this report and the risk assessments for the other adaptation areas).

MfE (2021) *A guide to local climate change risk assessments* provides the specific steps to be carried out to assess the risks associated with climate change across multiple domains. This guidance provides a calculation for risk as being a combination of 'exposure' and 'vulnerability', as per the equation in Figure 2.1. Exposure is a measure of the extent to which elements intersect with the hazards layer; and vulnerability is the propensity or predisposition to be adversely affected by a coastal hazard in relation to climate change. Vulnerability encompasses a variety of concepts, including sensitivity to harm, and lack of capacity to naturally adapt (or adaptive capacity) (e.g. without intervention).

This definition of risk adopted by the MfE (2021) guidance is consistent with the risk definition from the IPCC, where risks are framed through the concept of hazard, exposure, and vulnerability. This differs slightly from other standard risk assessment and management processes (AS/NZS ISO 3100:2018) which uses a combination of likelihood and consequences to define risk.

The definitions and steps from the MfE (2021) guidance have been adopted in this assessment, and are discussed in detail in the following sections.

[11] Ministry for the Environment (2022b). Aotearoa New Zealand's first national adaptation plan. Wellington. Ministry for the Environment.

[12] IPCC (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group 1 to the Sixth Assessment Report.

[13] Jacobs (2024) Comparison of Relative Sea Level Rise projections presented in the Kāpiti Coast Coastal Hazards and Susceptibility and Vulnerability Assessment Reports Volume 1 (2021) and Volume 2 (2022) with new information from more recent IPCC publications and MfE Guidance.

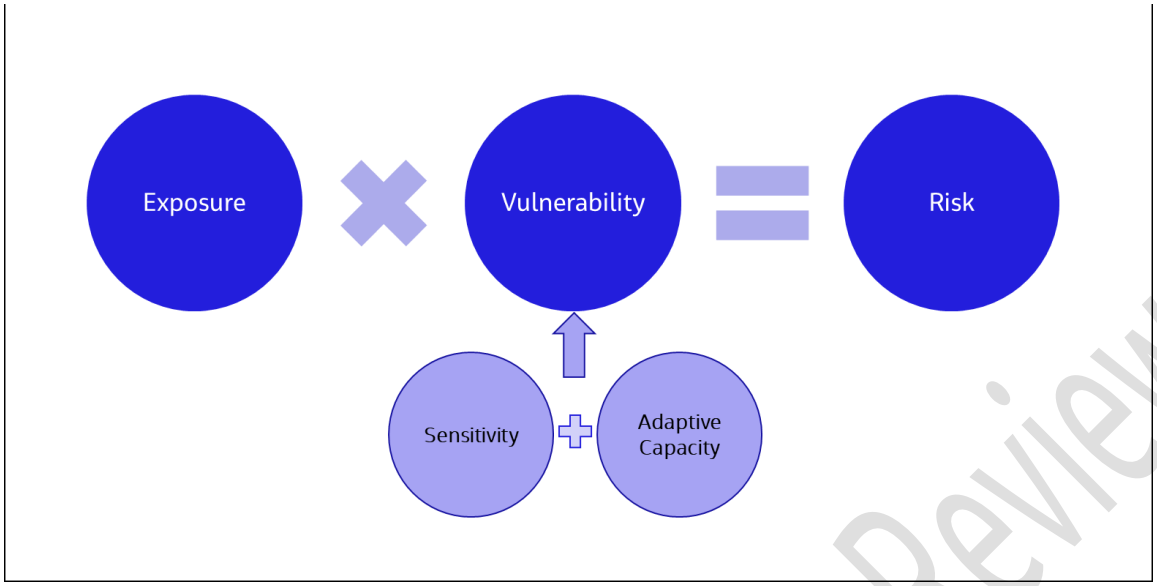

Figure 2.1: Risk equation used for this assessment from MfE (2021) Guidance for climate change risk assessments.

2.2 Methodology

2.2.1 Overview

The risk assessment methodology relies on a combination of spatial information of both the hazards and elements to assess the exposure of an element to the hazard, and subject matter specialist opinion to determine how the element would fare when exposed to the hazard. The process of calculating risk based on the equation outlined in Figure 2.1 comprises of multiple steps of information gathering to define the risk. These steps are summarised in Figure 2.2, and are outlined in detail from Sections 2.2.2-2.2.7 below.

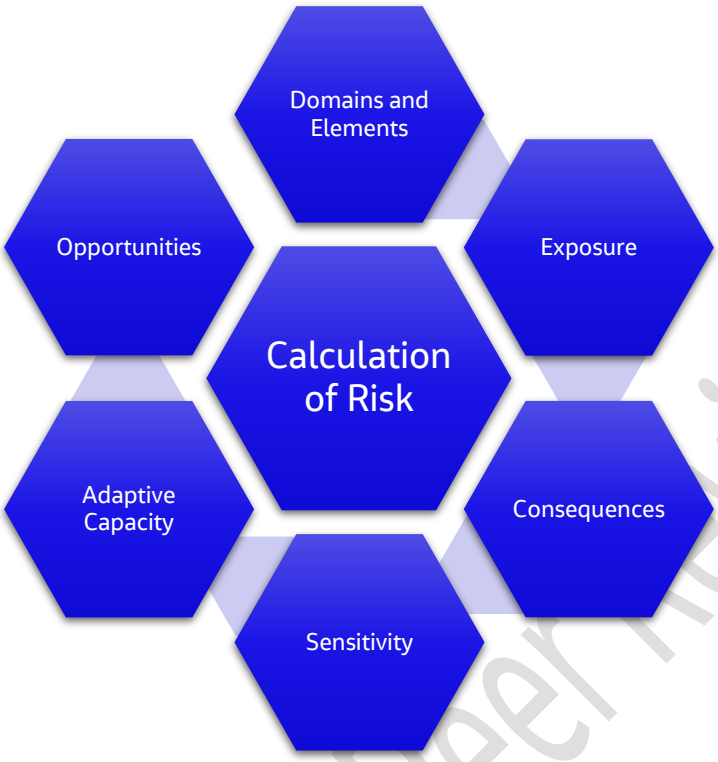

Figure 2.2: Steps for calculating risk.

2.2.2 Domains and Elements

For this risk assessment, five 'domains' have been defined based on current available information to cover the broad ranges of interests and values of the community and council, and relate to people, places and assets. These domains are similar to those outlined in the MfE (2021) guidance, and are based on information that is currently available. Each domain has been assessed by subject matter specialists, which are listed in brackets below.

These domains are:

- Built Environment (Jacobs)
- Cultural (to be completed with mana whenua)
- Human (NIWA)
- Ecological (Dr. Astrid Dijkgraaf)
- Natural character (Boffa Miskell)

For each domain, 'elements' have been selected that are representative components of the broader domain. Elements have been selected for assessment based on the availability of data and the expert judgement of the subject matter specialists in identifying the most relevant elements to inform the development of adaptation pathways. The elements assessed for each domain are presented in Table 2.1.

Some elements are broader terms which cover the risk to a range of smaller sub-elements. For example, Wastewater services has assessed the risk to wastewater pipes, pump stations and treatment plants.

Each element has been individually assessed for risks from coastal erosion and inundation under two sea level rise scenarios (see Section 2.2.3).

Table 2.1: Domains and Elements considered in this assessment.

Domain	Elements
Built Environment	▪ Properties ▪ Roads and Bridges ▪ Wastewater services ▪ Water supply services ▪ Stormwater services ▪ Electrical supply and transmission ▪ Natural gas supply
Cultural	▪ Still to be completed with Mana Whenua
Human	▪ Physical health ▪ Mental health and wellbeing ▪ Social infrastructure and amenity ▪ Exacerbating inequities ▪ Social cohesion and community wellbeing ▪ Conflict, disruption and loss of trust in government
Ecological	▪ Coastal dunes ▪ Wetlands ▪ Mapped ecological sites ▪ Indigenous trees ▪ Rare and threatened species ▪ Bird habitat ▪ Fish habitat ▪ Indigenous Biodiversity Coastal
Natural Character	▪ CTA2: Paraparaumu and Waikanae ▪ Peka Peka Dunes (South) ▪ Waikanae Estuary

2.2.3 Exposure

Exposure in this assessment is defined as a measure of the extent to which elements intersect with the hazards. Exposure has been assessed for two climate change scenarios across four timeframes (Present day, 2050, 2070, 2130), and for one likelihood occurrence of each hazard, as presented in Table 2.2.

The RSLR projections used in this assessment uses the most recent data for the Kāpiti Coast from NZ SeaRise Programme[14] , which incorporates the most recent IPCC (2021) SLR projections offset slightly for the New Zealand region as per MFE (2017), and a -1 mm/yr VLM, being the average for the 21 assessment sites on the Kāpiti coast presented in the NZ SeaRise data. The assessment includes the SSP2-4.5 and SSP5-8.5 RSLR scenarios as per the recommendations of the MfE (2021,2022, & 2024) guidance documents. This approach recognises the emergence of increasing exposure and uncertainty with time, with the RSLR in the 2050 timeframe being the same amount for both SSP2-4.5 and SSP5-8.5 scenarios before becoming increasingly different over the 2070 and 2130 timeframes. All RSLR increments presented are taken from a 2020 baseline and are for the median value of the projections for that scenario over the specified timeframe.

For coastal erosion, the hazard is defined by the projected future shoreline position for which there is a 10% probability of the shoreline being further inland at the timeframe considered. For coastal inundation, the hazard is defined by the area of land potentially exposed to inundation under a storm tide event for which

[14] https://www.searise.nz/

there is a 1% annual exceedance probability (AEP) – equivalent to a 10% chance of occurrence over a 10-year period, or a 50% chance of occurring over a 50-year period.

Table 2.2: Scenarios and likelihoods considered in this risk assessment.

Timeframe	Climate change scenario and Relative Sea level Rise (RSLR)	Coastal Erosion Hazard Likelihood	Coastal Inundation Hazard Likelihood
Present Day	0m RSLR	10% probability of shoreline exceeding landward limit of mapped extent (i.e., P10)	1% Annual Exceedance Probability storm tide event
2050 (30 years)	SSP2-4.5 & SSP5-8.5 (0.2 m RSLR in both cases)		
2070 (50 years)	SSP2-4.5 (0.35 m RSLR) SSP5-8.5 (0.45 m RSLR)		
2130 (110 years)	SSP2-4.5 (0.85 m RSLR) SSP5-8.5 (1.25 m RSLR)		

Updated mapping of both the erosion and inundation hazard from the Jacobs (2022a) report has been undertaken for the new SSP2-4.5 and SSP5-8.5 RSLR projections for the Kāpiti Coast from NZ SeaRise data (Jacobs, 2024)[15].

A summary of the coastal erosion distances (up to a 10% exceedance probability) calculated from the updated mapping is as follows:

- At Paraparaumu Beach and Waikanae Beach, the present-day erosion hazard (i.e. what could occur in an extremely large storm (which has a 1% chance of occurring each year in the immediate/near future)) could result in up to 10 m of erosion.
- At Waikanae Beach, including the short-term storm erosion, the shoreline is projected to suffer net erosion of 8 m by 2050 (less than the short-term storm erosion); 5 m (SSP2-4.5) to 11 m (SSP5-8.5) by 2070; and 8 m (SSP2-4.5) to 30 m (SSP5-8.5) by 2130.
- In the future with RSLR, the shoreline within the Paraparaumu area of the CAA is projected to erode (including the above mentioned 'short-term' storm erosion) by the following range of distances:
  - At the northern end of Paraparaumu Beach, erosion could be on average 22 m by 2050, 33 m (SSP2-4.5) to 36 m (SSP5-8.5) by 2070, and 65 m (SSP2-4.5) to 81 m (SSP5-8.5) by 2130.
  - The central part of the Paraparaumu shoreline is projected to continue to grow in the future (around Tikotu Stream), regardless of the level of RSLR, with 14 m accretion by 2050; 23 m (SSP5-8.5) to 27 m (SSP2-4.5) by 2070; and 47 m (SSP5-8.5) to 65 m (SSP2-4.5) by 2130.
  - South of Tikotu stream, the shoreline is projected to erode on average 6 m by 2050, 5 m (SSP2-4.5) to 11 m (SSP5-8.5) by 2070; and 8 m (SSP2-4.5) to 30 m (SSP5-8.5) by 2130.

[15] Jacobs (2024) Comparison of Relative Sea Level Rise projections presented in the Kāpiti Coast Coastal Hazards and Susceptibility and Vulnerability Assessment Reports Volume 1 (2021) and Volume 2 (2022) with new information from more recent IPCC publications and MfE Guidance.

For coastal flooding, in a 1% AEP under present day sea levels, there is projected to be localised coastal flooding around Tikotu Stream and the wetlands next to the Waikanae Estuary, including land around the Mazengarb Stream at Makora Road.

Ground levels along the coastline south of Tikotu Creek are relatively high and above the highest extreme water level with RSLR considered in this assessment. However, some lower lying areas inland are connected to sea by stormwater drains which provide pathways for future flooding. To the north of Tikotu Creek, there are more extensive areas of lower lying land around the Waikanae River and Estuary and its tributary streams and drains. At Waikanae Beach, flooding under present day sea levels is likely to occur alongside the Waimeha and Ngarara Streams, and around the edges of the Waimanu Lagoon. The causeway and outlet structure at the Waimanu Lagoon protects the lagoon and drainage network inland of the lagoon from inundation but there is a residual susceptibility to flooding if the control structure fails.

In the future with SLR, key flooding pathways at Waikanae Beach are through the Waimeha Stream and Waikanae Estuary, and the streams and stormwater network that flow into them (Ngarara Stream and Waimanu Lagoon). In Paraparaumu, ground levels along the coastline south of Tikotu Creek are relatively high and above the highest extreme water level with RSLR considered in this assessment. However, some lower lying areas inland are connected to sea by stormwater drains which provide pathways for future flooding. In Otaihanga, there are more extensive areas of flooding around the Waikanae River and Estuary and its tributary streams and drains.

Exposure of an element was assessed through GIS mapping, where the subject matter specialist could overlay their spatial element data with the spatial hazard data. Exposures were then assigned one of four ratings from low to extreme, using the Exposure rating scale in Table 2.3 as a guide. Where the extent of elements was readily quantifiable (e.g., number of properties), then a spatial analysis was undertaken to determine the numerical exposure rating based on the quantitative definitions in Table 2.3. Where exposure was not quantifiable (e.g. inequities), or the element covered multiple spatial datasets (e.g. waste supply infrastructure – pipes, pump stations, treatment plants), then a more qualitative assessment was made by the subject matter specialist based on the qualitative definitions in Table 2.3.

Exposure ratings together with any limitations or assumptions made in determining an exposure rating are recorded in Appendix A.

Table 2.3: Exposure rating scale from MfE (2021).

Exposure rating	Qualitative definition	Quantitative definition
Extreme	Significant and widespread exposure of elements to the hazard.	>75% of element is exposed to the hazard.
High	High exposure of the elements to the hazard.	50-75% of element is exposed to the hazard.
Moderate	Moderate exposure of the elements to the hazard.	25-50% of element is exposed to the hazard.
Low	Isolated elements exposed to the hazard.	5-25% of element is exposed to the hazard.

2.2.4 Vulnerability

The vulnerability component in this assessment forms half of the risk equation (Figure 2.1) and is determined through the combination of Sensitivity and Adaptive Capacity. Vulnerability represents how sensitive an element is to the hazard and recognises its ability to naturally adapt, or be adapted with only small amounts of intervention.

A four level vulnerability rating is produced using the matrices in Table 2.4, which combines rating categories for Sensitivity and Adaptive Capacity, outlined in detail below. Vulnerability rating can rank from low to extreme, with the definitions being as per Table 2.5.

Vulnerability ratings for each element are recorded in Appendix A.

Table 2.4: Vulnerability matrix (combining Sensitivity and Adaptive Capacity) from MfE (2021).

		Sensitivity			
		Low (L)	Moderate (M)	High (H)	Extreme (E)
Adaptive Capacity	Very low (VL)	Moderate	High	Extreme	Extreme
	Low (L)	Low	Moderate	High	Extreme
	Moderate (M)	Low	Moderate	Moderate	High
	High (H)	Low	Low	Low	Moderate

Table 2.5: Vulnerability rating and definitions from MfE (2021).

Vulnerability rating	Definition
Extreme	Extremely likely to be adversely affected, because the element is highly sensitive to a given hazard and has a low capacity to adapt.
High	Highly likely to be adversely affected, because the element is highly sensitive to a given hazard and has a low capacity to adapt.
Moderate	Moderately likely to be adversely affected, because the element is moderately sensitive to a given hazard and has a low or moderate capacity to adapt.
Low	Low likelihood of being adversely affected, because the element has low sensitivity to a given hazard and a high capacity to adapt.

2.2.4.1 Sensitivity

Sensitivity is a subjective measure of how sensitive (or tolerant) an element is to exposure to the hazard, which is a function of its properties or characteristics. Each element is assigned a sensitivity ranking (low to extreme) for input into the vulnerability matrix (
Table 2.4). Sensitivity was assigned qualitatively based on subject matter specialists' opinions, as well as further analysis of the spatial data. Sensitivity is different for each hazard.

A low sensitivity ranking was assigned when, despite being potentially exposed, the element would be unlikely to be adversely impacted. For example, stormwater infrastructure is unlikely to be sensitive to flooding at the present day, as its primary purpose is to mitigate the effects of flooding. A high-extreme sensitivity ranking was assigned when the impacts or consequences of the hazard were severe due to the element being exposed. For example, sensitivity of wastewater infrastructure being exposed to erosion was

considered to be extreme as the consequences of damage to the infrastructure would be critical to the settlement.

For some elements, further assessment of the intensity of the exposure was included in the sensitivity ranking. For example, when assessing the sensitivity to private properties, consideration was given for where the erosion reached on the property in relation to the location of the primary dwelling using a visual inspection of aerial imagery of the properties. If the erosion hazard intersected with most dwellings along the coast, it was considered to be an extreme hazard as a result of the consequences this would lead to. For properties where the erosion hazard only intersected with the edges or undeveloped parts of the properties, and dwellings were setback from the hazard, these were considered to be less sensitive (e.g. low-moderate rating). In a similar sense, the sensitivity of private property to inundation hazards generally increases over time due to the increase in water depth during a flood event, causing greater potential impacts on dwellings and other buildings.

For the human domain, where some intangible elements occur, sensitivity was attributed to the ability for humans to respond and deal with the hazard. Sensitivity to exposure to the hazard would become inherently worse over time as the hazard frequency and extent increases or causes periods of prolonged disruption.

A sensitivity rating for each element is provided in Appendix A.

2.2.4.2 Adaptive capacity

Adaptive capacity refers to the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences. It relates to how easily/efficiently an element at-risk can adapt naturally. An adaptive capacity rating was assigned to each element, irrespective of timeframe, from very low to high for input into the vulnerability matrix (Table 2.4).

Generally, infrastructure based elements (e.g. roads, electrical transmission infrastructure) have a lower adaptive capacity, as they would not be able to naturally adapt. In some instances, adaptive capacity of built environment elements can be moderate as small easy interventions can be undertaken to adapt (e.g. installing temporary flood protection controls to protect pump station power controls). However, infrastructure such as roads would require a significant amount of intervention and therefore would be considered to have a low adaptive capacity. Natural systems (ecological and natural character) tend to have a moderate-high adaptive capacity, which is generally based on the available space where species or natural forms can migrate to away from the hazard. However, natural systems may have a lower adaptive capacity or need human intervention to aid adaption if the ecological values are already compromised or impacted (e.g. a species that has been impacted by predation).

An Adaptive Capacity rating for each element as well as commentary is provided in Appendix A.

2.2.5 Consequences

Commentaries based on subject matter specialists' experience, local knowledge and broader literature research on the elements' response to the hazards were prepared for each element. This provides a general overview on what the potential consequences of exposure of the element could be, irrespective of the timeframe. This commentary also included, where appropriate, a description of the cascading impacts which could occur.

Consequences of coastal erosion were generally related to partial or total loss of the element (e.g., loss of property area) and what the consequences of this loss could be. Consequences of coastal inundation were more complex due to variations in effects with depth of flooding. For example, the consequence of flooding of a road could vary from nuisance surface flooding which could be controlled through vehicle speeds, to blocking off access to settlements if significant water depths occurred across key access roads.

These consequences are recorded as commentary in Appendix A for each element.

2.2.6 Opportunities

Climate change could present opportunities that lead to positive or beneficial outcomes. There will be direct and indirect opportunities from mitigation and adaptation. Direct opportunities relate to the changes that occur as a result of the hazard – for example, erosion of a road could re-establish a hydrological connection to a wetland; or can be indirect opportunities as a result of adaptation or planning/management. Opportunities, where applicable, have been recorded for each element to highlight the potential positive outcomes of allowing the hazard to occur; as well as potential opportunities where interventions may occur outside of the adaptive planning process which would change the outcome of the identified risk. For example, the wastewater supply network that could be eroded in the 2070-2130 period consists of old infrastructure that requires upgrading prior to being exposed, therefore taking the opportunity to relocate this infrastructure away from the hazard as part of the upgrade, which would reduce the future risk.

Commentary on the potential opportunities are recorded for each element in Appendix A.

2.2.7 Overall Risk Rating

Based on the ratings developed for exposure (Section 2.2.3) and vulnerability (Section 2.2.4), a risk rating is developed for each element against each hazard from low to extreme. This matrix is presented in Table 2.6. These risk ratings are compiled together in an overall matrix with the exposure, sensitivity, adaptive capacity, vulnerability and overall risk score over time is provided in Appendix B.

Table 2.6: Risk Matrix (combining vulnerability and exposure).

		Exposure			
		Low (L)	Moderate (M)	High (H)	Extreme (E)
Vulnerability	Extreme (E)	Moderate	High	Extreme	Extreme
	High (H)	Low	Moderate	High	Extreme
	Moderate (M)	Low	Moderate	Moderate	High
	Low (L)	Low	Low	Moderate	High

2.3 Risk Assessment Outputs

The following outputs have been developed as part of the risk assessment:

- A summary of the risk assessment methodology, results, and conclusions (this report).
- Risk assessment templates were produced for each element under each climate change scenario (SSP2-4.5 and SSP5-5). These are appended to this report in Appendix A, and provide the following information:
  - A descriptive overview of the element
  - A description of the consequence of exposure to the element to coastal erosion or flooding
  - A description of the potential opportunities
  - A description and rating of the exposure of the element to the coastal erosion and flood hazards
  - A description and rating of the elements' sensitivity to the coastal erosion and flooding hazards
  - A description and rating of the elements' adaptive capacity to the coastal erosion and flooding hazards

  - A calculated vulnerability rating for the element based on sensitivity and adaptive capacity ratings
  - A calculated overall risk rating for the element based on combined exposure and vulnerability ratings

- Complete risk assessment matrices are appended to this report in Appendix B. This provides the ratings for the individual components (e.g. exposure, sensitivity etc) for each element and summarises it into one table for coastal flooding, and one table for coastal erosion.

3. Built Environment Domain

The 'Built Environment' domain refers to the infrastructure which provides a service to the CAA communities, such as transport, electricity, three waters, gas supply, and electrical supply. It also includes private properties, for which these services are built and maintained to service. The risk to the elements assessed under the built environment domain will likely result in cascading impacts on the human, cultural and ecological domains in the CAA.

The following outlines the information used to assess the risks to the built environment in the CAA, and a summary of the findings related to the risks to the built environment. Details for each element, including assumptions and limitations used to identify the risks, are provided in Appendix A.

3.1 Built Environment Elements

The risk assessment primarily relies on spatial information to establish how exposed an element is to coastal hazards, and also how this exposure changes over time. Table 3.1 provides a summary of the elements assessed within the built environment domain, and what spatial information was used to inform the assessment of risk.

Elements were assessed using publicly available data from online sources such as LINZ Data service, private infrastructure providers (e.g. electricity, gas supply), or supplied by KCDC using their asset management database. This assessment looks at the risk to public infrastructure, therefore whilst some properties may privately manage their wastewater or water supply, these have not been included in the assessment.

More detailed information about the method employed to establish exposure, sensitivity, and adaptive capacity ratings for each element is included in Appendix A.

Table 3.1: Summary of elements assessed in the built environment domain and representative data used to inform the assessment.

Element	Description	Representative Data
Private properties	**Risks to private properties in the total CAA**. Property boundaries are used as a proxy for the number of homes which may be exposed to the hazards. Property boundaries have been used to quantify the exposure, with a visual assessment of where dwellings were situated on exposed properties to indicate sensitivity.	Private property boundary outlines provided by KCDC.
Private properties (by settlement)	**Risks to private properties by settlements.** The CAA has been split into three subsets of the CAA, primarily based on key settlements (Waikanae Beach, Otaihanga, and Paraparaumu Beach) to assess whether the risk profile varies across the CAA and between settlements. For coastal erosion, exposure is evaluated relative to the number of beachfront properties in the settlement (i.e., the most seaward line of properties). For coastal inundation exposure is assessed for the number of properties in the broader settlement footprint. Maps of these areas are provided in Appendix A.1.2-A.1.4.	Private property boundary outlines provided by KCDC. Subset areas defined based on the Statistical Area 2 (2022) boundaries around Otaihanga to split the CAA into three.
Roads and Bridges	**Risk to roads and bridges in the CAA** that could disrupt access to individual properties, settlements and services.	Road centrelines were taken from LINZ Dataservice. Bridges have been identified manually using the intersection of the road centreline layer and stream centreline layer (accessed via LINZ dataservice)

Element	Description	Representative Data
		with verification using aerial imagery and Google maps street view.
Wastewater services	**Risks to public wastewater infrastructure in the CAA** which service the treatment and disposal of wastewater. This includes: • Wastewater pump stations • Wastewater network (pipes). There are no wastewater treatment plants identified in the CAA.	Data for public wastewater infrastructure was supplied by KCDC. This included wastewater pump stations and network pipes.
Water supply services	**Risk to public water supply infrastructure in the CAA** which supports the supply, treatment and distribution of water to private properties. This includes: • Water supply pipe network • Water supply bores. Nearby reservoirs and pump stations are generally located landward of SH1 outside of the CAA.	Data for public water supply services including pipe network were supplied by KCDC. This included the location of supply bores, the water supply network pipes, water treatment plants and pump stations.
Stormwater services	**Risk to public stormwater infrastructure** that manages stormwater in significant pluvial, fluvial and coastal driven events to support drainage of the land. This includes: • Stormwater network pipes • Stormwater outfalls • Pump stations.	Data for public stormwater services was supplied by KCDC. This included stormwater network pipes, stormwater outfalls, and pump stations.
Electrical supply and transmission	**Risk to electricity supply and distribution to and within the CAA.** This includes: • Distribution transformers (converts from 11kV to 230v for households) • Underground transmission lines (11kV) • Overhead transmission lines (11kV).	Data for electricity supply and transmission was supplied by Electra (supplier for Kāpiti Coast).
Natural gas supply	**Risk to supply and distribution of natural gas to private properties in the CAA**. This included assessing the location of the gas supply mains (pipes) relative to the hazards.	Data for natural gas supply was supplied by FirstGas (supplier for Kāpiti Coast).

3.2 Built Environment Risk Matrix

A summary of the final risk ratings for each element is presented in Table 3.2. A more extensive matrix which details the exposure, sensitivity, adaptive capacity, vulnerability, and final risk ratings is provided in Appendix B.

Table 3.2: Built Environment domain risk matrix.

	Coastal Erosion						Coastal Inundation					
Climate Change Scenario	**Both**		**SSP2-4.5**		**SSP5-8.5**		**Both**		**SSP2-4.5**		**SSP5-8.5**	
Element	Present	2050	2070	2130	2070	2130	Present	2050	2070	2130	2070	2130
Built Environment												
Properties - Whole Adaptation Area	L	M	M	M	M	M	L	L	L	L	L	M
Properties - Waikanae Beach*	L	M	M	M	M	E	L	L	L	M	L	M
Properties – Otaihanga*	L	L	L	L	L	L	L	M	M	M	M	E
Properties – Paraparaumu*	L	L	M	M	M	H	L	L	L	L	L	M
Water Supply Infrastructure	L	L	L	L	L	M	L	L	L	L	L	M
Wastewater Infrastructure	M	M	M	M	M	M	L	L	L	M	L	M
Stormwater Infrastructure	L	L	M	M	M	H	L	L	M	M	M	M
Roads and Bridges	L	L	L	L	L	M	L	M	M	E	H	E
Electrical Transmission and supply infrastructure	L	M	M	M	M	M	L	L	L	M	L	M
Natural gas supply mains	L	M	M	M	M	M	L	L	L	L	L	L

*For assessing risks from coastal erosion, beachfront properties only are considered.

3.3 Built Environment Risk Summary

3.3.1 Risks from coastal erosion

The exposure rankings of infrastructure in the CAA are heavily influenced by the amount of infrastructure in the CAA required to service the intense development which has occurred throughout the area. There are 'hot spots' of risk within the CAA where the built environment will be impacted over the 2130 timeframe, however generally the exposure in relation to the whole CAA area is relatively small.

The risks to the built environment from coastal erosion are highly localised within the CAA to three key areas:

- Southern Paraparaumu Beach - Southern Marine Parade (from Toru Road to Tahi Street)
- Northern Paraparaumu Beach - Northern End of Manly Street
- Waikanae Beach

The area shown in black on Figure 3.1 shows the erosion hazard over the 2130 timeframe. Around much of the Paraparaumu Beach area, the erosion hazard is limited to dynamic short term storm erosion due to the apex of the cuspate foreland slowly migrating to the south resulting in net long-term shoreline advance.

There are differences between the three key areas based on the type of asset or infrastructure that is impacted first by the erosion hazard. For Waikanae Beach and Northern Paraparaumu Beach (Manly Street) areas, the erosion hazard impacts private properties before it impacts the infrastructure that services those properties. At the southern end of Marine Parade between Toru and Tahi Road, the erosion hazard impacts infrastructure (roads, wastewater, water supply, underground electrical transmission, gas supply mains) before it reaches private properties.

Currently all elements assessed, with the exception of wastewater infrastructure, are considered to be at low risk from coastal erosion, and remain low-moderate risk over a 100-year timeframe under the lower SSP2-4.5 scenario. Risks to Waikanae Beach properties, Paraparaumu Beach properties and stormwater infrastructure increase to high-extreme risk by 2130 under the higher SSP5-8.5 scenario. These results are discussed in detail below.

Private Property

Across the total CAA, private properties are currently at low risk from coastal erosion, increasing to moderate risk by 2050 and continuing as a moderate risk to 2130 under both SLR scenarios. There are 7064 private properties in the CAA, and currently none of these properties are exposed to short term storm erosion. However, by 2050 34 properties could be exposed to erosion under both SLR scenarios, increasing to 61 properties (SSP2-4.5) to 73 properties (SSP5-8.5) by 2070, and 129 properties (SSP2-4.5) to 228 properties (SSP5-8.5) by 2130. In relative to the total number of properties within the CAA, it is considered that there is low exposure for private properties to coastal erosion.

When this assessment is considered at a finer scale for beachfront properties only within the three key areas defined in Figure 3.1, the risk to beachfront properties becomes high in 2130 under the SSP5-8.5 scenario at Paraparaumu Beach, and extreme at Waikanae Beach. There are no beachfront properties in the Otaihanga area.

At Waikanae Beach, 26 of the 184 private beachfront properties are projected to be impacted by erosion by 2070. These are generally located around the Waimeha Stream. In 2130 under both SLR scenarios, coastal properties along Tutere Street and Field Way become impacted. In 2130, 38 properties could be impacted under the lower SSP2-4.5 scenario, and 101 properties under the higher SSP5-8.5 scenario. At Waikanae Beach, Council-owned infrastructure is generally located on the landward side of coastal properties along Tutere Street and Field Way. Therefore, private properties are impacted prior to the infrastructure.

In Paraparaumu, 7 of the 320 private beachfront properties are projected to be impacted by erosion by 2050. This increases to 31 properties (under SSP2-4.5 scenario) to 42 properties (under SSP5-8.5 scenario) by

2070, and 64 properties (under SSP2-4.5 scenario) to 87 properties (under SSP5-8.5 scenario) by 2130. These properties are located within the two 'hotspot' areas identified in Figure 3.1, being the northern end of Manly Street, and the southern end of Marine Parade. Properties throughout the central coastline of Paraparaumu Beach are projected to be protected from erosion risks due to the southward migration of the apex of the cuspate foreland, resulting in long term accretion through this area, and the existing large dune system that fronts a number of beachfront properties there.

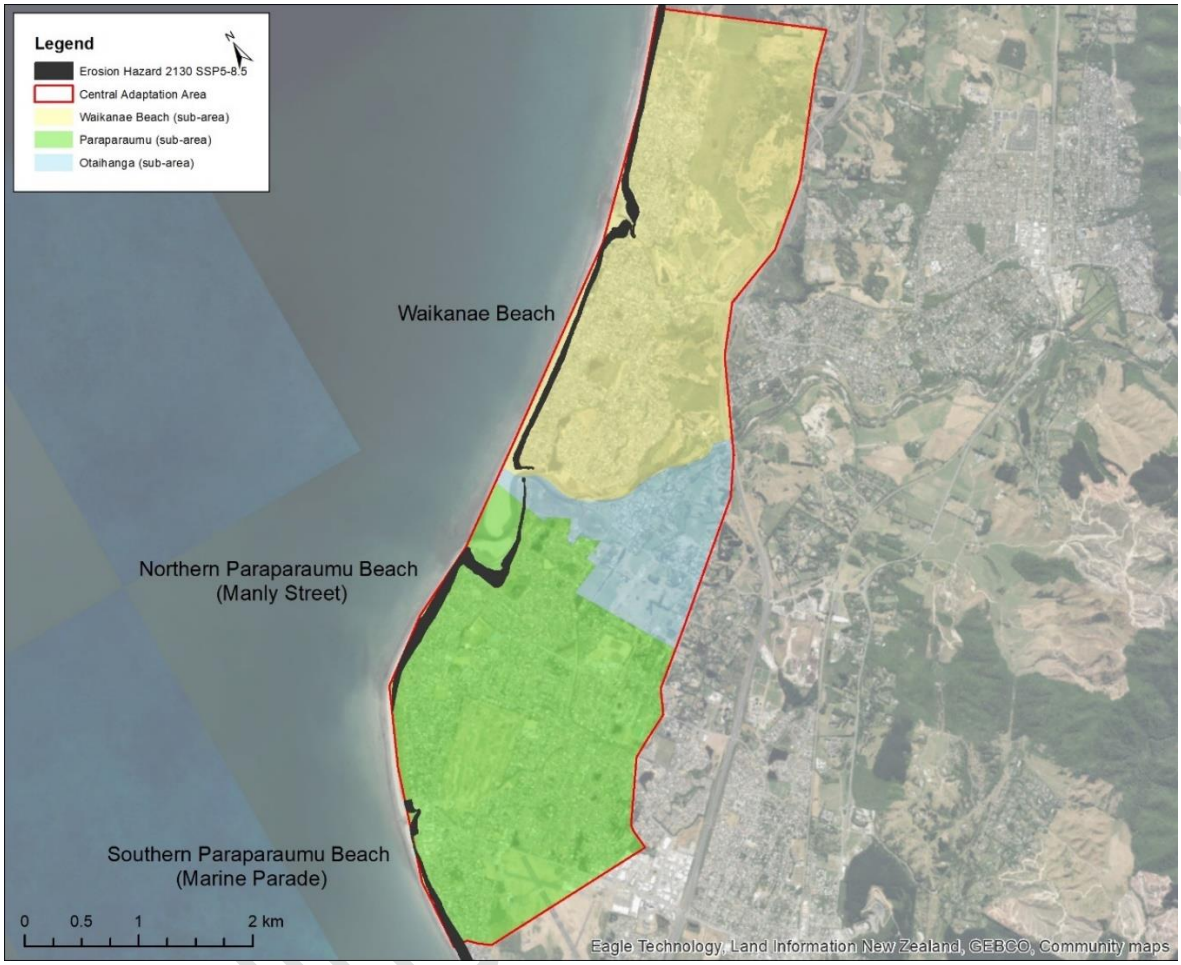

Figure 3.1: Overview of erosion hazard at 2130 (SSP5-8.5) across the CAA and sub-areas, identifying three key 'hotspots' where the built environment elements are impacted.

Infrastructure

Water supply infrastructure, wastewater infrastructure, roads, electrical transmission infrastructure and natural gas supply infrastructure are considered to be low-moderate risk over the 2130 timeframe for both SLR scenarios. However, exposure of infrastructure to erosion is highly localised around the southern Marine Parade area where infrastructure is located landward of properties, as shown in Figure 3.2, and in isolated areas along Manly Street where the erosion hazard extends through private properties to the road by 2130 under SSP5-8.5, as shown in Figure 3.3.

Wastewater infrastructure is considered to be at moderate risk from coastal erosion at present due to a short section of wastewater pipes (240 m) at the southern end of Marine Parade being located within the area that could be impacted by short-term erosion under current sea levels, as shown in Figure 3.2. When exposed to coastal erosion, the wastewater pipes have the potential to be undermined, be damaged and fail, which could result in the service to a number of dwellings being impacted, without the erosion hazard directly impacting the property itself. The length of wastewater pipe projected to be impacted by coastal erosion over the 2130

timeframe under both SLR scenarios increases along the Marine Parade area, with one small, isolated area along Manly Street also impacted. The risk to wastewater infrastructure remains moderate across both SLR scenarios up to 2130, however the impacts of this risk will be generally only felt in the southern end of the CAA along Marine Parade.

Stormwater infrastructure is considered to be at moderate risk by 2070 under both SLR scenarios and increases to being high risk under the SSP5-8.5 scenario by 2130. This high risk is a result of 1.4 km of stormwater pipe being exposed to erosion (increasing from 650 m in 2070), and 27 stormwater outfalls being exposed to coastal erosion. Of these outfalls, 21 are currently exposed to coastal erosion hazards, however by 2130 under both SLR scenarios the integrity of the outfalls in their current locations is likely to be totally compromised due to the projected erosion which will impact their functionality. Stormwater pipes were considered to have a lower sensitivity than other three waters infrastructure, as sections of the network that are projected to be affected by coastal erosion generally run perpendicular to the coast. Therefore, it may be possible to adapt the pipes and outfalls so they can still discharge stormwater from the broader catchment.

Roads and bridges are considered to be at low risk to erosion in both SLR scenarios up to 2070, where up to 0.3 km of road could be affected by erosion. This may impact on access to properties along Marine Parade between Rua Road and Tahi Road. In 2130, this increases to moderate risk under the higher SSP5-8.5 scenario due to 0.75 km of the road length being impacted, which would affect access to a number of properties along Marine Parade, as well as access to some properties along Manly Street.

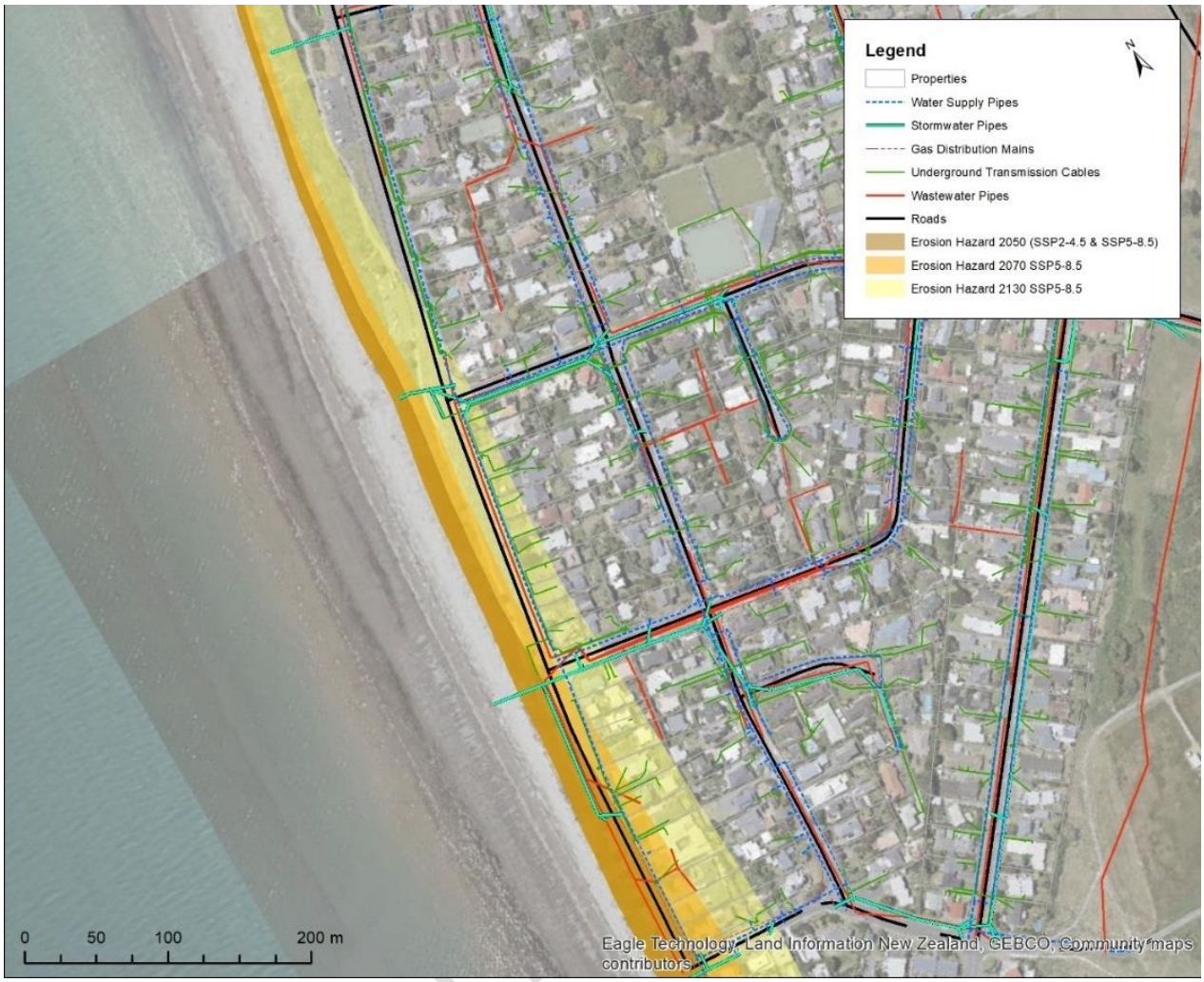

Figure 3.2: Infrastructure network impacted by projected future coastal erosion at the southern end of Marine Parade.

Figure 3.3: Key infrastructure around the Manly Street Area potentially impacted by coastal erosion.

Figure 3.4: Wastewater network pipes southern Paraparaumu potentially impacted from the short-term storm hazard at present sea levels.

3.3.2 Risks from coastal inundation

Risks to the Built Environment domain within the CAA from coastal flooding is generally highest for private properties and roads, with other elements being assessed as low-moderate risk across both SLR scenarios to 2130.

Private property

As a result of the size of the CAA and the total number of properties within the CAA, the exposure to coastal flooding for property when considering the whole adaptation area is low, despite up to 2205 private properties potentially being exposed to some degree of coastal flooding over the 2130 timeframe. The overall risk to property is considered to be low risk to 2070, and increase to moderate risk under the higher SSP5-8.5 scenario by 2130, when around 31% of total properties in the CAA (i.e. 2205 properties) are projected to be exposed to some level of flooding in an extreme coastal storm event.

When considering smaller sub-areas within the CAA, the risk to private property in Waikanae Beach is considered to only increase from low to moderate by 2130 under both SLR scenarios with 33% (721) and 43% (926) of properties within the sub-area being exposed to some degree of flooding under the SSP2-4.5

and SSP5-8.5 RSLR scenarios respectively. Sensitivity to flooding over this timeframe increases to high, with many properties experiencing deeper flooding across their properties than in previous timeframes assessed.

Private property in Paraparaumu is also considered to only increase to moderate risk by 2130 under the higher SSP5-8.5 SLR scenario, where 1120 (25% of properties within the Paraparaumu sub-area) are exposed to some degree of coastal flooding, and sensitivity is considered to be high (i.e. depths >0.65 m across majority of properties)

Private property in Otaihanga increases to being at moderate risk to coastal flooding by 2050, as 94 properties (30% of properties within the sub-area) become exposed to coastal flooding, with sensitivity being considered as high, as most of these properties are experiencing flooding of depths >0.65 m. The risk remains moderate to 2130 under the lower SSP2-4.5 SLR scenario, but increases to being extreme risk by 2130 under the higher SSP5-8.5 Scenario, where 50% of properties within the Otaihanga area are projected to be subjected to some degree of flooding during an extreme storm event, and sensitivity is considered to be extreme as water depths across many properties during a significant event could result in irreparable structural damage.

Infrastructure

Flooding of coastal roads and bridges can prevent them from being used to safely access properties in the community and can result in people becoming temporarily isolated during a flood event, with 0.3-0.5 m of flooding across a road generally causing it to be unsafe for small vehicles[16]. Roads and bridges are considered to be at low-moderate risk of coastal flooding to 2050, where <1% of roads are flooded in an extreme coastal storm, with this mainly impacting Makora Road, Otaihanga. Under the lower SSP2-4.5 scenario, the risk remains moderate by 2070 (with exposure increasing to 2% of road exposed), but increases to extreme by 2130 (11% of roads exposed). Under the higher SSP5-8.5 scenario, the risk increases to high by 2070 (3% of roads exposed), and extreme by 2130 (19% of roads exposed). Over this 2130 timeframe, access to Waikanae along Te Moana Road could be impacted during an extreme event, as well as access between Peka Peka and Waikanae along Huiawa Street. Access to properties in Otaihanga around Makora Road could be cut off, as well as access to properties around northern Paraparaumu (Te Kupe Road; Manly Street).

Three waters infrastructure (stormwater, water supply and wastewater) is considered to be at low-moderate risk to coastal flooding to 2130 across both SLR scenarios. Generally, three water infrastructure is considered to have low-moderate sensitivity, and be resilient to flooding. Pump stations that support the three waters network become increasingly exposed over time, hence the increase from low to moderate risk over the long term. By 2130, two stormwater pump stations (under both SLR scenarios) located in Waikanae Beach could be inundated in a coastal storm event, reducing the ability for the pumpstations to move water out of the local area. By 2130, 6 (SSP2-4.5) to 9 (SSP5-8.5) wastewater pumpstations could be exposed to coastal flooding in a significant event.

Water supply bores could become increasingly exposed to coastal flooding over the 2130 timeframe. Currently, no public water supply bores are exposed to coastal flooding, however this increases to 1 bore by 2050; 2 bores by 2070 (both SLR scenarios); and 5 (SSP2-4.5) to 10 (SSP5-4.5) water supply bores by 2130, which could lead to some temporary contamination of water supply by flood water.

Risks to natural gas supply from coastal flooding within the CAA is considered to be low across both SLR scenarios to 2130, as the buried pipelines are generally relatively resilient to coastal flooding.

Similarly, electrical transmission and supply infrastructure is considered to be low risk to 2070, and increase to moderate risk by 2130 under both SLR scenarios. By 2070, under the higher SSP5-8.5 scenario, one ground mounted distribution transformer is exposed to coastal flooding. By 2130, this increases to 8

[16] Ball J. et al (2019), Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) Australian Rainfall and Runoff: A Guide to Flood Estimation, © Commonwealth of Australia (Geoscience Australia).

distribution transformers under the lower SSP2-4.5 SLR scenario, up to 20 under the higher SSP5-8.5 scenario. Flooding of ground mounted distribution transformers can cause short circuits, loss of supply to properties, and damage to the transformer if depth exceeds the height of critical equipment.

4. Human Domain

The 'Human' Domain refers to physical and mental health of those who live, work, or recreate in the CAA. It is closely related to the Built Environment discussed in Section 3 above.

The following outlines the information used to assess the risks to the Human Domain in the CAA, and a summary of the findings related to the risks to the Human Domain. Details for each element, including assumptions and limitations used to identify the risks, are provided in Appendix A.

4.1 Human Elements

The risk assessment primarily relies on spatial information to establish how exposed an element is to coastal hazards, and how this exposure changes over time.

Table 4.1 provides a summary of the elements assessed within the Human Domain, and what spatial information was used to inform the assessment of risk. Elements were assessed using publicly available data from Statistics New Zealand (i.e. Stats NZ Infoshare), as well as spatial information from KCDC and GWRC including three waters infrastructure and social infrastructure online sources.

More detailed information about the method employed to establish exposure, sensitivity, and adaptive capacity ratings for each element is included in Appendix A.

Table 4.1: Summary of elements assessed in the human domain and representative data used to inform the assessment.

Element	Description	Representative Data
Physical Health	Risks to physical health from exposure to coastal flooding/inundation and the potential for water-borne disease, and issues with water quality, availability, and accessibility due to changes or disruption to essential services.	Private property boundary outlines provided by KCDC. This data is from December 2022. Data for public wastewater infrastructure was supplied by KCDC. This included wastewater pump stations and network pipes. Data for public water supply services including pipe network were supplied by KCDC. This included the location of supply bores (which has been filtered for public water supply), the water supply network pipes, water treatment plants and pump stations. Data for public stormwater services was supplied by KCDC. This included stormwater network pipes, stormwater outfalls, and pump stations. Stats NZ infoshare 2018 data was used to determine percentage of population over the age of 65 and below the age of 5.
Mental Health and Wellbeing	Risks to mental health, identity, autonomy and sense of belonging, connections to place and nature, and personal wellbeing from loss and trauma due to ongoing coastal erosion and periodic flooding.	Private property boundary outlines provided by KCDC. This data is from December 2022. 'Beachfront' properties were extracted from the

Element	Description	Representative Data
	This risk relates to the mental health and wellbeing of individuals who may experience ongoing stress, anxiety, depression, grief, feelings of powerlessness, and an altered sense of belonging to a place as coastal erosion and inundation becomes progressively worse. These feelings and experiences may emerge as people navigate loss of, or damage to property, irreversible changes or loss of valued natural places, feeling alone or powerless to affect change, on-going stress of managing damage to property or living in damaged building, and worry about the future. It includes the stress associated with disruption to everyday routines and activities, which can impact the ability to function, undertake actions that are enjoyed, and plan for the future.	property data supplied by KCDC, and only includes the most landward line of properties. Cycle and Shared Walkways, and location of Parks and Reserves supplied by KCDC. Central Adaptation Area Values Summary (Kāpiti Coast District Council, 2023) Qualitative literature on wellbeing and connection to the environment is referenced within the Mental Health and Wellbeing risk assessment template – Appendix A.2.2.
Social Infrastructure and Amenity	**Risk to social infrastructure and amenity**. This element includes the objects that keep society functioning and enable daily patterns of life (e.g. shopping or travelling to work, education, engaging in community or cultural activities), and the facilities that act as social support structures (e.g. churches, supermarkets, meeting places, community facilities or halls, health care services, care homes, early childhood centres). Additionally, it includes the locations and facilitates that afford visitors and local residents the opportunity to enjoy and participate in organised sport, exercise, and spend time outdoors (e.g. parks, swimming pools, boat clubs, walkways, reserves, and natural areas). It also includes the aesthetics and amenity of places where people live, the spaces they utilise, and whether changes can be tolerated by those who live there	GIS Spatial layers provided by KCDC: • Beach access points, • Parks and reserves, • Department of Conservation properties/land, • Medical centres, • Education providers, • Public transport routes Other social infrastructure facilities (e.g. Roads, Restaurants, Community Halls) were identified manually using Google maps and locations were assessed against the mapped coastal hazard projections.
Exacerbating Inequalities	**Risks of exacerbating existing inequities and creating new and additional inequities due to differential distribution of coastal erosion and coastal flooding impacts.** This element focusses on the existing inequities in society that mean some people, groups, and households are less able to access to services and resources (e.g. clean water, work, finance, insurance, safe and dry homes) that maintain and support wellbeing. It also includes the creation of new inequities though the actions taken to respond (or not) to the impacts and implications of a changing climate.	Private property boundary outlines provided by KCDC. This data is from December 2022. Stats NZ infoshare 2018 data was used to determine median income. Spatial locations of Public transport routes provided by KCDC. Roads and businesses were identified manually using Google maps and locations were assessed against the mapped coastal hazard projections.
Social Cohesion and Community Wellbeing	**Risks to social cohesion and community wellbeing from displacement of individuals, families, and communities due to climate change impacts.** This element is focused on the community level and includes aspects of community cohesion and wellbeing associated with living in a particular place. Cohesion is described as the bonds that link communities and people together, and these may be physical place based,	Private property boundary outlines provided by KCDC. This data is from December 2022. Stats NZ infoshare 2018 data was used to determine time of residence in area.

Element	Description	Representative Data
	cultural, or social connections. Wellbeing is considered a measure of happiness or satisfaction and the ability to achieve personal and collective aspirations and enjoy a "good life" as defined by an individual, family, or group. The National Climate Change Risk Assessment describes two aspects to the risk to social cohesion. First, the risk associated with displacement and second, the risk to those left behind (NCCRA 2020). Displacement can cause trauma linked to disruption and dislocation from familiar surroundings and breaking of social and cultural bonds, and the challenges of resettlement. Movement between communities within the Kāpiti and Wellington Region may change the composition of communities, affect housing availability and affordability, change demand for social services, recreational facilities and schools, alter commuting patterns and introduce competition for other resources. Conflict may arise between existing residents and relocated households as disagreements about social norms and practices emerge. With less ties to support networks and opportunities, poorer health and wellbeing outcomes are likely. Affected communities will see a decrease in the local population as the residents relocate or are relocated. Properties may be increasingly occupied by those (from outside and within the community) who can't afford to live anywhere else. Newcomers may not have the same sense of attachment to the community. As households leave, the community will reduce in size and essential services may be slowly withdrawn, for example, education facilities, job opportunities, or community services. Investment in the affected communities will probably be reduced. Similar to displaced households, those who remain may experience trauma due to the breaking of family, social, and cultural bonds, and poorer health and wellbeing outcomes are likely. The breakdown of communities and the social bonds and connections to special places is important because fractured, less cohesive communities can result in conflict and feelings of isolation and loss.	
Conflict, Disruption, and Loss of Trust in Government	**Risks of conflict, disruption, and loss of trust in government from changing patterns in the value of assets and competition for access to scarce resources, primarily due to periodic inundation events and ongoing erosion.**	Private property boundary outlines provided by KCDC. This data is from December 2022. GIS Spatial layers provided by KCDC: ▪ Beach access points, ▪ Parks and reserves, ▪ Medical centres and pharmacies, ▪ Education providers, ▪ Department of Conservation (DOC) properties

Element	Description	Representative Data
		Central Adaptation Area Values Summary (Kāpiti Coast District Council, 2023). Qualitative literature on conflict related to differing opinions on adaptation strategies and options is referenced within the Conflict, Disruption, and Loss of Trust in Government risk assessment template in Appendix A.2.6.

4.2 Human Risk Matrix

A summary of the final risk ratings for each element is presented in Table 4.2. A more extensive matrix which details the exposure, sensitivity, adaptive capacity, vulnerability, and final risk ratings is provided in Appendix B.

Table 4.2: Human domain risk matrix.

	Coastal Erosion						Coastal Inundation					
Climate Change Scenario	**Both**		**SSP2-4.5**		**SSP5-8.5**		**Both**		**SSP2-4.5**		**SSP5-8.5**	
Element	Present	2050	2070	2130	2070	2130	Present	2050	2070	2130	2070	2130
Human												
Physical Health	L	L	L	L	L	L	L	M	M	M	M	M
Mental Health and Wellbeing	L	L	M	M	M	M	L	M	M	M	M	M
Social Infrastructure and Amenity	L	L	L	L	L	L	M	M	M	M	M	M
Exacerbating Inequalities	L	L	L	M	L	M	L	L	M	H	M	E
Social Cohesion and Community Wellbeing	L	L	L	L	L	M	M	M	H	H	H	E
Conflict, Disruption, and Loss of Trust in Government	L	L	L	L	L	M	L	L	M	H	M	H

4.3 Human Risk Summary

4.3.1 Risks from coastal erosion

Risks to the human domain from coastal erosion are largely associated with the loss of private properties, and the impact on water infrastructure. The risk to property in the CAA overall is considered to be low at present, but increase to moderate by 2050 (34 properties, <1% of properties in the CAA exposed) and remain moderate through to 2130 (129 properties exposed (2%) under SSP2-4.5; and 228 properties (3%) under SSP5-8.5). Impacts to water infrastructure is generally low to moderate through to 2130 (stormwater infrastructure becomes high risk under SSP5-8.5 by 2130), however as noted in Section 3, there are isolated areas throughout the CAA that are directly impacted by erosion along Marine Parade, Manly Street, and Waikanae Beach. A detailed breakdown of properties and infrastructure exposed is provided in Section 3 above.

Physical Human Health

The risks to physical human health from coastal erosion event are considered to be low at present, and remain low under both SLR scenarios through to 2130. Relative to the wider CAA area, the number of properties directly exposed to erosion remains low to 2130 (2% of properties in 2130 under SSP2-4.5; 3% of properties in 2130 under SSP5-8.5). Under both SLR scenarios, the Kāpiti Rest Home which is located on Marine Parade, Paraparaumu, could be directly affected by erosion from 2070 onwards. The Coastguard building could be directly affected by erosion from 2050 onwards under both SLR scenarios, which poses a risk to public safety if nothing is done to relocate/protect the building, as there would be a reduced capacity to respond to local emergency incidents in the water. There are increasing amounts of water service pipes, stormwater pipes, and wastewater pipes in the CAA are exposed to coastal erosion as time progresses. However, these impacts (even by 2130) are quite localised to Marine Parade and affect less than 1% of the respective networks.

Mental Health and Wellbeing

Risk to mental health and wellbeing from coastal erosion is considered to be low at present and through to 2050. Under both SLR scenarios, the risk increases to moderate by 2070, and remains moderate through to 2130. The increase to moderate risk by 2070 is driven to the increase in exposure of both private property and other public space that may provide for residents' mental wellbeing and identity (e.g. the Waikanae Estuary). Loss of property and loss of access to the beach and recreation sites could have a potentially significant effect on residents' mental health and connections to natural spaces for recreation and enjoyment. The Central Adaptation Area Values Summary (KCDC, 2023) demonstrates that people within the Waikanae and Paraparaumu communities have a strong emotional affiliation to the area, particularly the beach and coastline, with some noting that it is integral to their sense of identity and belonging.

Social Infrastructure and Amenity

The risk to social infrastructure and amenity from coastal erosion is considered to be low at present, and remains low through to 2130 under both SLR scenarios. The low risk is derived from the relatively low exposure of social infrastructure and amenity to coastal erosion throughout the CAA over the 100 year timeframe. Over time there may be increased erosion of beach access points, parks and reserves, the area around Waikanae Estuary, the Kāpiti Rest Home, the Coastguard building, and the Waikanae Boating Club; however aside from these features, no other social infrastructure (schools, medical practices, place of worship) area exposed to coastal erosion based on projected future shoreline positions under either RSLR scenario.

Exacerbating Inequalities

Under both SLR scenarios, the risk of exacerbating inequalities from coastal erosion is considered to be at low risk, remaining low risk through to 2070, then increasing to moderate risk by 2130. The exposure of properties throughout the total CAA is considered to be low (i.e. 2-3% of properties exposed by 2130),

however in some sub-areas (e.g. Waikanae and approaching the southern CAA boundary) coastal erosion is more pronounced. Households in these areas are likely to experience greater inequities and could shift towards being occupied by those of lower socio-economic means over time. People with limited financial means may find it difficult to cope with, respond to, and adapt to erosion (e.g. by moving away) and may increase their exposure to hazards by moving to inexpensive homes in hazard areas.

Social Cohesion and Community Wellbeing

The risk to social cohesion and community wellbeing is considered to be low at present, and remain low through to 2070. Under the lower SSP2-4.5 SLR scenario, the risk remains low through to 2130. However, under the higher SSP5-8.5 scenario, the risk increases to moderate in 2130. An impact on social cohesion is possible as if the composition of the community changes. Hence, low exposure over the first 70 years may not cause a significant amount of change, except potentially for clusters of properties around Waimeha Stream, Manly Street and Marine Parade. As the exposure increases over time, there is more chance of impact to social cohesion. Based on the 2018 census approximately 44% of residents had lived at their usual residence in the CAA for less than 5 years, which means that there is a high population turnover. It is, however, also worth noting that approximately 8% of the population in the adaptation area had resided there (in 2018) for over 15 years and are likely to be embedded in the local community. The latter group are likely to be more sensitive to long term changes and challenges associated with social cohesion, whilst the former group (new residents) are likely to bring in different and diverse perspectives including about how adaptation should proceed.

Conflict, Disruption, and Loss of Trust in Government

The risk of conflict, disruption, and loss of trust in government from coastal erosion is considered to be low risk at present, and under both SLR scenarios remain low risk through to 2070. Under the lower SSP2-4.5 scenario, the risk remains low through to 2130. Under the higher SSP5-8.5 scenario, the risk increases to moderate by 2130. As time passes, there is a risk that conflict between community members will escalate as differing opinions on how to respond to erosion comes to the fore, and people differ in their thoughts on when different sets of adaptation should occur. It is highly likely that residents of beachfront properties will favour hard protection structures that protect their properties, yet this action may not be universally accepted by others in the community, leading to intra-community conflict. Due to the low exposure to erosion over the next 50 years, risk of this conflict is low, however if exposure increases with sea level rise, the risk of this taking place will increase.

4.3.2 Risks from coastal inundation

Physical Human Health

Risks associated with human health in relation to coastal flooding may include risk of being washed away or isolated in homes and unable to escape (which could lead to drowning/injury). Additionally, if wastewater, stormwater, or drinking water supply systems (pipes, bores, pumping stations, etc) are overwhelmed or damaged by floodwaters, people may be exposed to pathogens and contaminants in flood waters or drinking water, with subsequent risk of illness. Risk of water contamination to those recreating in the area may extend beyond the initial event, for example, lingering contamination for swimmers.

The risk to physical human health from coastal inundation within the CAA is considered to be low at present, and increases to moderate by 2050. Under both SLR scenarios, the risk remains moderate from 2050 through to 2130. The increase to moderate risk is due to the increase in exposure to flooding from low (present day) to moderate (2050 and 2070) to high (2130), combined with the high sensitivity of physical health to coastal inundation. Adaptive capacity is considered to be moderate, as people have warning of incidents of inundation and are able to avoid being in the area during times when hazards and risks to health may be more likely. Once removed from the area of hazard they are no longer exposed or at risk. Residents may be exposed to hazards on return to their homes or at other places (for example, when recreating around Wainui Stream) however through careful actions (e.g. checking weather forecast, listening to local emergency/civil defense warnings) the hazard could be avoided.

Mental Health and Wellbeing

There is likely to be stress, anxiety and trauma associated with the loss of property or on-going damage to property due to flooding. Stress could be associated with the temporary effects of the event (i.e. being trapped at home or within a small geographic area), or due to further financial loss (e.g. insurance withdrawal or repair costs, loss of stock or business revenue) and/or stress and uncertainty regarding the future.

The risk to mental health and wellbeing from coastal inundation within the CAA is considered to be low at present, and increases to moderate by 2050. Under both SLR scenarios, the risk remains moderate from 2050 through to 2130. The increase to moderate risk is largely derived from the increase in exposure to flooding, with 7% of the CAA are exposed to some degree of flooding by 2050; 10-13% exposed in 2070; and 22-31% exposed in 2130. This increasing exposure could present risks for stress and anxiety related to residents being isolated in their homes, experiencing wastewater service and drinking supply loss, and insurance withdrawal.

Social Infrastructure and Amenity

The temporary inundation of social infrastructure during a 1% AEP event in coastal areas means that people are not able to access services that they need to go about their daily lives, do the things that they enjoy, or engage in social activities with others. Loss of amenity and recreational space reduces ability to enjoy outdoor activities and connect with nature (with flow on impacts to wellbeing), as well as the potential damage to infrastructure due to flooding.

The risk to social infrastructure and amenity from coastal flooding is considered to be moderate at present, and remains moderate to 2130 under both SLR scenarios. This is driven by the moderate to high exposure of social infrastructure and amenities to coastal flooding over time; the high sensitivity to flooding. Social infrastructure will become increasingly exposed over time, including the Waikanae Golf Course, and recreational areas such as the beach and the river tracks. Beach access points will be increasingly exposed (10 exposed by 2130 under SSP5-8.5), as well as one heritage site by 2050 (increasing to 3 by 2130 under SSP5-8.5); one medical facility (only in 2130 under SSP5-8.5); Waikanae Beach Community Hall and St Michaels Church (by 2130 under both SLR scenarios); The Waikanae Menz Shed (by 2130 under SSP5-8.5 only) and Waikanae Beach Tennis Club (by 2130 under SSP5-8.5 only) and public toilets at Weggery Reserve (from 2050 under both SLR scenarios The public transportation route in Waikanae becomes increasingly affected by inundation over time, and routes in Paraparaumu could also be impacted.

However, it is considered that social infrastructure and amenity has a moderate adaptive capacity. While there is likely to be limitations to adapt the configuration of parks due to constraints of surrounding private properties, walking tracks and public transportation routes could be re-routed out of inundation areas in the future.

Exacerbating Inequalities

The risk of exacerbating existing inequalities or creating new additional inequalities is considered to be low at present and remains low to 2050. Under both SLR scenarios, the risk increases to being moderate by 2070. Under the lower SLR scenario, the risk increases to high risk by 2130, and under the higher SLR scenario the risk increases to extreme by 2130. This increase to high and extreme risk by 2130 is largely driven by the increase in exposure of properties within the CAA to coastal flooding during a significant event (1552 properties (22%) of properties exposed by 2130 under SSP2-4.5; 2205 properties (31%) of properties exposed by 2130 under SSP5-8.5. This increase in exposure creates a greater likelihood of creating/exacerbating inequities between households in the CAA.

Social Cohesion and Community Wellbeing

The risk to social cohesion and community wellbeing from coastal inundation is considered to be moderate at present and to 2050. Under both SLR scenarios, the risk increases to high by 2070. Under the lower SSP2-4.5 scenario, the risk remains high to 2130; however under the higher SSP5-8.5 scenario the risk increases to being extreme. As noted in Section 4.3.1, social cohesion is linked to the composition of the community, which may change as the impacts of SLR are realised and people with the financial means to do so move,

either within the same community or further afield. Therefore, the greater the exposure of the hazard, the greater the likelihood that community composition may change, and hence over time there will likely be an impact on social cohesion. By 2070, the exposure to coastal flooding is considered to be high, and by 2130 under the higher SSP5-8.5 scenario, the exposure is projected to be extreme; hence a corresponding increase in risk.

Conflict, Disruption, and Loss of Trust in Government

The risk of conflict, disruption, and loss of trust in government due to the coastal inundation hazard is considered to currently be low, and remains low through to 2050. Under both SLR scenarios, the risk of this increases by 2070 to being moderate, and then increases to high by 2130. By 2130, there is some increase to flooding of public spaces along the coastal strip and around waterways including parks, reserves, walking tracks and beach access points over time, as well as flooding of properties around low-lying areas of Waikanae, Otaihanga and Paraparaumu. Given that flooding is a more widespread issue than erosion and will affect more properties and areas of the CAA, conflict may be less because a greater proportion of residents may feel they directly benefit from adaptation actions. However, there will still be the potential for conflict and resentment arising from the funding of adaptation, with households that do not directly benefit from adaptation actions potentially being placed in a position where they need to fund adaptation (via rates) that benefits others more significantly. Additionally, the increasingly widespread nature of coastal inundation could drive significant demand for properties and land outside of inundation hazard areas, and/or that are not at risk of being cut off by flooding. Competition amongst residents for these properties could drive tension and disruption to community relationships.

5. Ecological Domain

The risk assessment primarily relies on spatial information to establish how exposed an element is to coastal hazards, and how this exposure changes over time.

Table 5.1 provides a summary of the elements assessed within the ecological domain, and what spatial information was used to inform the assessment of risk.

Elements were assessed using publicly available data from online sources such as the Department of Conservation (DOC), Queen Elizabeth II National Trust (QEII), iNaturalist, or supplied by KCDC or Greater Wellington Regional Council (GWRC) through the various schedules included in the District Plan or Natural Resources Plan respectively.

Information available relevant to assessing the risks within the ecological domain varies between elements. Most ecologically significant sites in the CAA are fully or partially on private land. Location data for small species is often sparse as they tend to be overlooked. This includes small plant species, lizards, and invertebrates. Information is also lacking for some large species such as the New Zealand fur seal. The location of Threatened and At Risk species are obscured in databases to stop people collecting rare species from the wild.

The Operative Kāpiti Coast District Plan 2021 includes maps of Ecological Sites, and Key Indigenous Trees across the district and four schedules identifying important ecological values:

- Schedule 1 – Ecological Sites - areas of significant indigenous vegetation, and significant habitats of indigenous fauna
- Schedule 2 - Key Indigenous Trees
- Schedule 3 – Rare and Threatened Vegetation Species
- Schedule 8 – Notable Trees

The GWRC Natural Resources Plan maps and describes ecosystems and habitats with significant indigenous biodiversity values, including in the coastal area. These areas and waterways were identified through surveys, but also modelling and meet at least one of the criteria set down in Policy 23 of the Regional Policy Statement for the Greater Wellington Region 2013 for representativeness, rarity, diversity and ecological context. Within the Kāpiti Coast coastal area there are Outstanding Wetlands, Significant Wetlands, Waterways with significant indigenous biodiversity values, Īnanga Spawning Habitat, significant Indigenous Bird Habitat, and Indigenous Biodiversity Coastal.

Also included are the GWRC spatial layer for Regional Parks, Community Environmental Restoration sites and Managed Open Space which compiles areas where management is being undertaken by various agencies including GWRC, QEII National Trust, District Councils, and some iwi and other organizations. Management may be undertaken for purposes other than ecological values (e.g. river management) but generally this map layer highlights areas with ecological importance.

There are QEII National Trust covenants within the Kāpiti coastal area. These areas of private land are legally protected in perpetuity to safeguard ecological, geological or cultural values. Additionally, there are areas of DOC managed land and Reserves Act 1977 Conservation Covenants.

More detailed information about the method employed to establish exposure, sensitivity, and adaptive capacity ratings for each element is included in Appendix A.

Table 5.1: Summary of elements assessed in the human domain and representative data used to inform the assessment.

Element	Description	Representative Data
Coastal dunelands	**Risks to any coastal dunelands in the total CAA.** This is a layer provided by GWRC, and the premise for selection is not known by this author. Presumably, these are areas where coastal dunes still retain some of their natural topography plant species. There are three areas of duneland within the CAA and these consist of: ▪ the southern section of the Peka Peka duneland extends down into the Central Adaptation Area at the northern boundary and ends at the Waikanae Beach Domain; ▪ the Waikanae Beach duneland extends from the southern end of Waikanae Beach domain to the northern end of Waikanae Estuary Scientific Reserve; and ▪ the Paraparaumu Beach duneland extends from the Waikanae Estuary down to the southern end of Marine Parade.	Natural Duneland map layer provided by GWRC.
Wetlands	**Risks to known or potential wetlands as defined by the National Policy Statement for Freshwater management (NPS-FM).** For coastal erosion and inundation, exposure is based on the number of wetlands exposed to the hazard relative to the total number of wetlands in the Adaptation Area. Maps for these areas are provided in Appendix A.3.2	GWRC NRP includes schedules for Outstanding Wetlands, and Significant Wetlands. These wetlands correspond with wetland areas within the KCDC District Plan Schedule 1- Ecological Sites. Additional mapping information referred to includes the Landcare Research current wetland extent (2013) which also includes deeper water, and GWRC scientific wetland extent (NPS-FM) (2016)
Mapped ecological sites	**Risk to ecological sites within the CAA** that could result in the complete or partial loss, or changes (adverse or positive) to the ecological and biodiversity values of these sites. The sites include KCDC Ecological Sites, QEII covenants, DOC managed reserves, Conservation covenants, Regional Parks, Managed Open Space, and Community Environmental Projects.	KCDC District Plan Schedule 1- Ecological Sites Queen Elizabeth II covenants map (29/09/2023) DOC managed reserves and Conservation covenants GWRC Regional Parks, Managed Open Space, and Community Environmental Projects
Indigenous trees	**Risks to trees identified as being significant within the CAA.** This information is obtained from the Operative Kāpiti Coast District Plan and assesses whether these trees would be lost or adversely affect by proposed management activities.	Operative Kāpiti Coast District Plan Schedules - Key Indigenous Trees (Schedule 2), and Notable Trees (Schedule 8)
Rare and threatened species	**Risk to indigenous species including the loss of their habitat within the CAA.** Some species may be able to move to other areas, but other species could be restricted because there are	The main data source used is KCDC Rare and Threatened Vegetation Species (Schedule 3) Other data referred to include:

Element	Description	Representative Data
	no other areas available, or potential habitat is too far away. The focus is on Threatened and At Risk17 species as defined by the New Zealand Threat Classification System. The effects on more common (Not Threatened) species will be similar, but less impactful because these species have larger populations and/or are more used to human activities and perturbations.	▪ DOC herpetofauna database and bioweb ▪ iNaturalist ▪ New Zealand Plant Conservation Network plant lists
Bird habitat	**Risk to significant bird habitat.** This includes habitat that provides feeding habitat or nesting or resting areas for Threatened or At Risk bird species, and also areas that provide important habitat for a range of species, or a significant proportion of a population of common species.	GWRC NRP - Bird habitat (Schedule F2) This data from GWRC was a combination of site visits and desktop assessment.
Fish habitat	**Risks to freshwater fish spawning and feeding habitat and loss of upstream and downstream connectivity.** Many indigenous freshwater fish species are diadromous meaning that they migrate between freshwater and saltwater. This includes species such as long-fin eel where the adults travel to Tonga to breed at the end of their lives. Short-fin eels are thought to breed in the Coral Sea between Fiji and Samoa. Many of the kōkopu species have larval stages that wash down to the ocean and then migrate back up to their preferred habitat once large enough – also known as whitebait.	GWRC NRP includes schedules for Migratory fish habitat (GWRC NRP Schedule F1), Threatened or At Risk fish habitat (GWRC NRP Schedule F1), High macroinvertebrate community health (GWRC NRP Schedule F1), and Īnanga spawning habitat (GWRC NRP Schedule F1b) Other data referred to includes: ▪ iNaturalist
Indigenous Biodiversity Coastal	**Risk to coastal indigenous biodiversity as mapped by GWRC.** Sites with significant indigenous biodiversity values in the Coastal Marine Areas (CMA) were identified with existing information and expert opinion and using the criteria in Policy 23 of the Regional Policy Statement for the Wellington Region.	GWRC NRP - Indigenous Biodiversity Coastal (Schedule F4)

5.1 Ecological Risk Matrix

A summary of the final risk ratings for each element is presented in Table 5.2. A more extensive matrix which details the exposure, sensitivity, adaptive capacity, vulnerability, and final risk ratings is provided in Appendix B.

[17] Capitalised as these are the threat classification terms used in the database.

Table 5.2: Ecological domain risk matrix

	Coastal Erosion						Coastal Inundation					
Climate Change Scenario	**Both**		**SSP2-4.5**		**SSP5-8.5**		**Both**		**SSP2-4.5**		**SSP5-8.5**	
Element	Present	2050	2070	2130	2070	2130	Present	2050	2070	2130	2070	2130
Ecological												
Coastal dunelands	M	M	M	M	H	E	L	L	L	M	L	M
Wetlands	L	M	M	H	H	H	M	M	M	M	M	H
Mapped ecological sites	L	M	E	E	E	E	M	M	H	E	H	E
Indigenous trees	No exposure						L	L	M	M	M	H
Rare and threatened species	M	M	H	E	H	E	M	H	H	E	H	E
Bird habitat	M	M	H	E	E	E	E	E	E	E	E	E
Fish habitat	M	M	M	M	M	M	M	H	H	H	H	H
Coastal Indigenous biodiversity	E	E	E	E	E	E	M	M	H	E	H	E

5.2 Ecological Risk Summary

5.2.1 Risks from coastal erosion

Coastal dunelands

There are three distinct coastal duneland systems in the CAA;

- The Peka Peka dune complex extends into the CAA at the northern boundary and ends at the Waikanae Beach Domain,
- The Waikanae Beach duneland extends from the southern end of Waikanae Beach Domain to the northern end of Waikanae Estuary Scientific Reserve, and
- The Paraparaumu Beach duneland extends from the Waikanae Estuary to the southern end of Marine Parade.

Dunes are known to provide habitat for a range of dune species and also help protect human infrastructure, as well as providing habitat for plants and animals. Under present day sea levels, the risk to coastal dunes from erosion in the CAA is considered to be moderate, as the dune toes are already subject to erosion during storm events, however dunes currently can generally recover between storm events. In an unmodified duneland, the function of eroded foredunes would be taken over by more inland dunes (i.e. the more inland dunes become the foredunes). However, human infrastructure on the landward side of existing dunes precludes this. Hence, areas with less human infrastructure potentially constraining the dune system could be more resilient.

Under the lower SSP2-4.5 scenario, the risk to the coastal dunes remains moderate to 2130. However, under the higher SSP5-8.5 scenario, coastal dunes become high risk by 2070 as the width to which the coastal dunes could be eroded increases substantially. This level of erosion may not be offset by available sand supply, or the ability for the dunes to migrate landward, and the amount of dune habitat lost would result in the loss of habitat for dune dwelling flora and fauna. Under this higher SLR scenario, by 2130 the dune ecology is considered to be at extreme risk.

Wetlands

There are ten mapped wetlands in the CAA, of which two are outstanding wetlands, four are identified natural wetlands, and another four that are known to be wetlands but are not yet included in GWRC Natural Resource Plan Schedules. Another two areas are currently not recognized as a natural wetland as they are constructed or highly modified, however these areas provide important habitat for birds and fish. There may be other wetlands that have not yet been identified or mapped that would qualify as natural wetlands under the National Policy Statement for Freshwater Management (NPS-FM) and/or the National Environmental Standard-Freshwater (NES-F). The NPS-FM excludes wetlands in the coastal zone, but the NES-F includes all wetlands.

Of the ten mapped wetlands present in the CAA, only one will experience coastal erosion under both the SSP2-4.5 and SSP5-8.5 scenarios. This is the wetland area north of Waikanae River Track and east of Manly Street and closest to the river mouth. This is part of the Waikanae Estuary saltmarsh wetland complex, which is scheduled by GWRC as an outstanding wetland. Erosion could remove part or all of this wetland area resulting in the loss of wetland vegetation and fauna, and altering the hydrology and wetland soil composition.

Present day risk from erosion under SSP2-4.5 is low, but this increases to moderate in 2050 as greater saline penetration could alter the wetland habitats. In 2070, this risk remains moderate under the lower SSP2-4.5 scenario, then increases to high risk by 2130. Under the higher SSP5-8.5 scenario, this risk increases to high in 2070, and remains high risk through to 2130. The increase to high risk in both scenarios is due to the wetland area potentially being eroded and impacted by the effects of the sea, and hence may longer function as a wetland.

Mapped ecological sites

There are 31 mapped ecological sites across the different management agencies that relate to 21 unique sites (i.e. several sites are mapped by more than one agency). Three of the areas are also being restored by community groups.

In summary there are:

- 8 KCDC Ecological Sites (Schedule 1 of the Operative Kāpiti Coast District Plan 2021)
- 3 QEII Trust sites (Queen Elizabeth the Second National Trust Act 1977)
- 4 DOC owned/managed sites including Waikanae Estuary Scientific Reserve
- 1 Conservation Area (Reserves Act 1977)
- 15 Areas identified by GWRC as being managed to protect environmental values
- 3 Sites that are being looked after by community groups.

Ecological Sites are found predominantly located in the northern 2/3rds of the CAA, including the two areas of outstanding wetland; Te Harakeke Swamp Complex and the Waikanae Estuary Scientific Reserve with its lagoons, estuaries, and wetlands. The Waikanae Estuary Scientific Reserve is a nationally significant DOC administered reserve as part of a 'mountains to sea' ecological corridor from the Tararua Ranges to the estuary to Kāpiti Marine Reserve. Erosion of these sites could result in the loss of dune and wetland vegetation and fauna, and altering the hydrology and soil composition. It could also result in modifications of the waterway beds leading to increased rates of erosion and loss of fish passage connectivity.

Coastal erosion will primarily impact areas of ecological significance close to the coastline and river and stream outlets. This includes the Waikanae Estuary, Pharazyn Reserve (including a portion of the Peka Peka Dunes), Waikanae Dunes, Paraparaumu Dunes, and the Waimeha Stream mouth. Up to seven coastal dune and/or wetland areas could be affected by erosion under the SSP2-4.5 and SSP5-8.5 scenarios to 2130.

Present day risk from coastal erosion is considered to be low, but this increases to moderate in 2050, and increases to extreme by 2070 in under both SLR scenarios and through to 2130 due to the potential effects on the Waikanae Estuary.

Indigenous trees

The CAA has 17 Key Indigenous Trees identified within the Kāpiti Coast Operative District Plan 2021 and another 23 Notable Trees. All of the notable trees are either exotic or indigenous but not naturally occurring species. None of these identified trees are exposed to coastal erosion under both SLR scenarios to 2130.

Rare and threatened species

Within the CAA, 47 nationally or regionally Threatened or At Risk species have been reported. Most of these species are associated with coastal areas such as the beach and dunes, or waterways and/or wetland areas. This includes 21 bird species, 11 freshwater fish species, 2 lizard species, 11 plant species and one each for liverwort and fungus species. Most of the fauna and some of the flora occur mostly within the Waikanae Estuary, wetlands and along the Paraparaumu Beach. The Waikanae Estuary is a regionally and nationally important stop-over site for several migrant shorebird species as it has extensive intertidal sand flats and is an important nesting site for a range of nationally Threatened or At Risk species. Eleven Threatened or At Risk fish species and fourteen migratory native freshwater fish species are known to be present in the Waikanae Estuary and River.

Erosion could result in the loss of habitat for rare and threatened species, including alterations to the Waikanae River and Waimeha Stream mouths, and coastal dune habitat. This will be a more significant adverse effect for species with less mobility such as lizards and plants. Due to the urban nature of much the inland landscape, rare and threatened species are probably in relatively low numbers, except for in reserve areas and areas where predator control is being undertaken. More mobile species, such as birds, could use other areas, including more inland areas. However, given that erosion will affect more of the coastline than just within the CAA, alternative coastal habitat may be significantly reduced even for mobile species.

Coastal fauna and flora habitats are already affected by erosion; hence the current risk is considered to be moderate, and remain moderate to 2050. Under both SLR scenarios, erosion risk increases to high by 2070, and to extreme by 2130, as more than 50% of the habitats could be affected.

Bird habitat

Significant bird habitats were classified in the 2019 report Preparing Coastal Communities for Climate Change by GWRC as one of three ecological criteria which were identified to be representative of components that would be affected by increases in sea level rise and coastal erosion. Three classes of significant bird habitats can be classified in the Wellington Region: lakes, rivers and coastal marine areas.

In the CAA, GWRC identified two coastal significant bird habitats; one at the Waikanae Estuary, and the other along the Paraparaumu Beach foreshore extending south from Waikanae Estuary to Rua Road - both within the Coastal Marine Area and includes approximately 63 hectares combined. Additionally, there are a number of lake-type habitats that provide significant breeding and/or roosting habitat for substantial populations of birds. This includes the old sewage treatment ponds in Pharazyn Reserve, the Waimanu Lagoons and the lagoon in Victor Weggery Reserve.

The risk from coastal erosion was estimated based on the proportion of the identified bird habitat potentially affected by erosion. The present-day exposure is high to extreme for coastal beaches, dunes and estuaries, but low for inland wetland bird habitats. The coastal systems and the species living in them are somewhat adapted to erosion processes. Hence the present-day risk is considered to be moderate overall. Under the SSP2-4.5 scenario, the risk remains moderate to 2050, but increases to high by 2070 as all coastal bird habitat will be affected to some extent. Risk increases to extreme in 2130 for the SSP2-4.5 scenario. Under the higher SSP5-8.5 scenario, by 2070 the risk has increased to extreme due to the potential opening of the northwestern part of the Waikanae Estuary saltmarsh (Outstanding Wetland) to the sea with consequent effects on bird habitat.

Fish habitat

The main-stem stream and all tributaries of the Waikanae River are listed in GWRC Natural Resources Plan Schedule F1: Rivers and lakes with significant indigenous ecosystems. These waterways provide habitat for 11 indigenous Threatened/At Risk fish species and habitat for 14 migratory indigenous fish species. The river mouth is also included in Schedule A3: Wetlands with outstanding indigenous biodiversity values, Schedule F1b: Known rivers and parts of the coastal marine area with īnanga spawning habitat and Schedule F4: Sites with significant indigenous biodiversity values in the coastal marine. Upstream portions are included in Schedule I: Important trout fishery rivers and spawning waters.

Waimeha Stream (Ngarara Stream) and all tributaries is listed in Schedule F1: Rivers and lakes with significant indigenous ecosystems. The species include five At Risk species and nine migratory species. The stream is also included in Schedule F1b: Known rivers and parts of the coastal marine area with īnanga spawning habitat and Schedule F4: Sites with significant indigenous biodiversity values in the coastal marine area.

It is assumed that erosion could undermine up and downstream connectivity for fish and cause deterioration of in-stream habitat and stream bank habitat, especially if any culverts are left perched above the inflow or outflow (as fish need connected wet surfaces and a sudden drop or waterfall is an obstacle for many species). For both the SSP2-4.5 and SSP5-8.5 scenarios, the present-day hazard is considered to be moderate as erosion already extents inland from the beach indicating that fish habitat may already be deteriorating, especially so at Waimeha Stream mouth. The risk remains moderate through to 2130 under both SLR scenarios.

Coastal indigenous biodiversity

Coastal indigenous biodiversity areas have been identified in GWRC Natural Resources Plan Schedule F4: Sites with significant indigenous biodiversity values in the coastal marine area. Within the CAA this includes the Waikanae Estuary, Kāpiti Island Marine Reserve, and Waimeha Stream.

Erosion can affect beaches causing them to lower and providing less foraging and roosting space at high tide for shore birds. It can also alter the habitat, including any saline wetlands or within the waterway mouths, and make it less appropriate habitat for indigenous fish, bird and plant species, and could cause habitats to be too deep to be suitable for shorebirds and wading birds.

Erosion could widen the mouth of the waterways, and create a greater exposure of these habitats to waves and tides and currents, potentially making it less suitable for fish, shorebirds and wading birds. Erosion will likely affect some of the dunes which could affect bird roosting or nesting habitat and loss of indigenous plant species and is likely to affect the waterway estuaries (especially the Waikanae Estuary) and result in a loss of intertidal feeding areas for shorebirds. Erosion could alter the near-shore environment resulting in reduction of food supplies which could adversely affect other populations. Increasing sea levels, coupled with erosion is likely to cause increased coastal squeeze for these coastal habitats as the amount of space available for bird habitats to 'migrate' is reduced due to human infrastructure and dense residential areas on the landward sides.

For both the SSP2-4.5 and SSP5-8.5 scenarios the present-day risk is considered to be extreme as some habitat areas could be exposed in a significant storm event currently, and remains extreme risk in both SLR scenarios to 2130, as the estuaries potentially become a more 'shallow bay' in shape, which will likely be less favourable habitat for fauna.

5.2.2 Risks from coastal inundation

Coastal dunelands

Generally, the exposure of the dunes in the CAA is low to coastal inundation hazards as a result of the higher dune elevations throughout the area. The highest exposure to coastal flooding is generally along the Waikanae River and Waimeha Stream and lower lying surrounding areas. Under both the SSP2-4.5 and SSP5-8.5 scenarios, the risk is considered to be low at present day and to 2070. The risk increases to moderate by 2130 under both SLR scenarios, as it is more likely that significant and/or more frequent flood events would undermine dune toes, increasing erosion and susceptibility to flooding.

Wetlands

Of the ten wetlands present in the CAA six are exposed to coastal flooding under SSP2-4.5 scenario and nine will experience flooding under SSP5-8.5 scenario by 2130. Coastal flooding could alter the vegetation composition within a wetland depending on the length of floodwater retention, the depth of the flooding, and whether the flooding changes the salinity of the wetlands for more than a few hours. Additional potential effects include changes in channels and water flow, sediment deposition killing plants and animals, decrease in light penetration, increased turbidity and reduce primary productivity, and changes in salinity - all of which could change ecosystems, habitats and the flora and fauna that use these areas. Flooding could also create additional wetland areas, but these need to be retained and protected if they are to replace lost habitats.

Under the SSP2-4.5 and SSP5-8.5 scenarios the current risk to wetlands from coastal flooding is considered to be moderate, as flooding of the saline wetlands occurs already and is expected. The risk remains moderate to 2130 under the lower SSP2-4.5 scenario. Under the higher SSP5-8.5 scenario, the risk increases to high in 2130, as low-lying areas adjacent to the wetlands also flood.

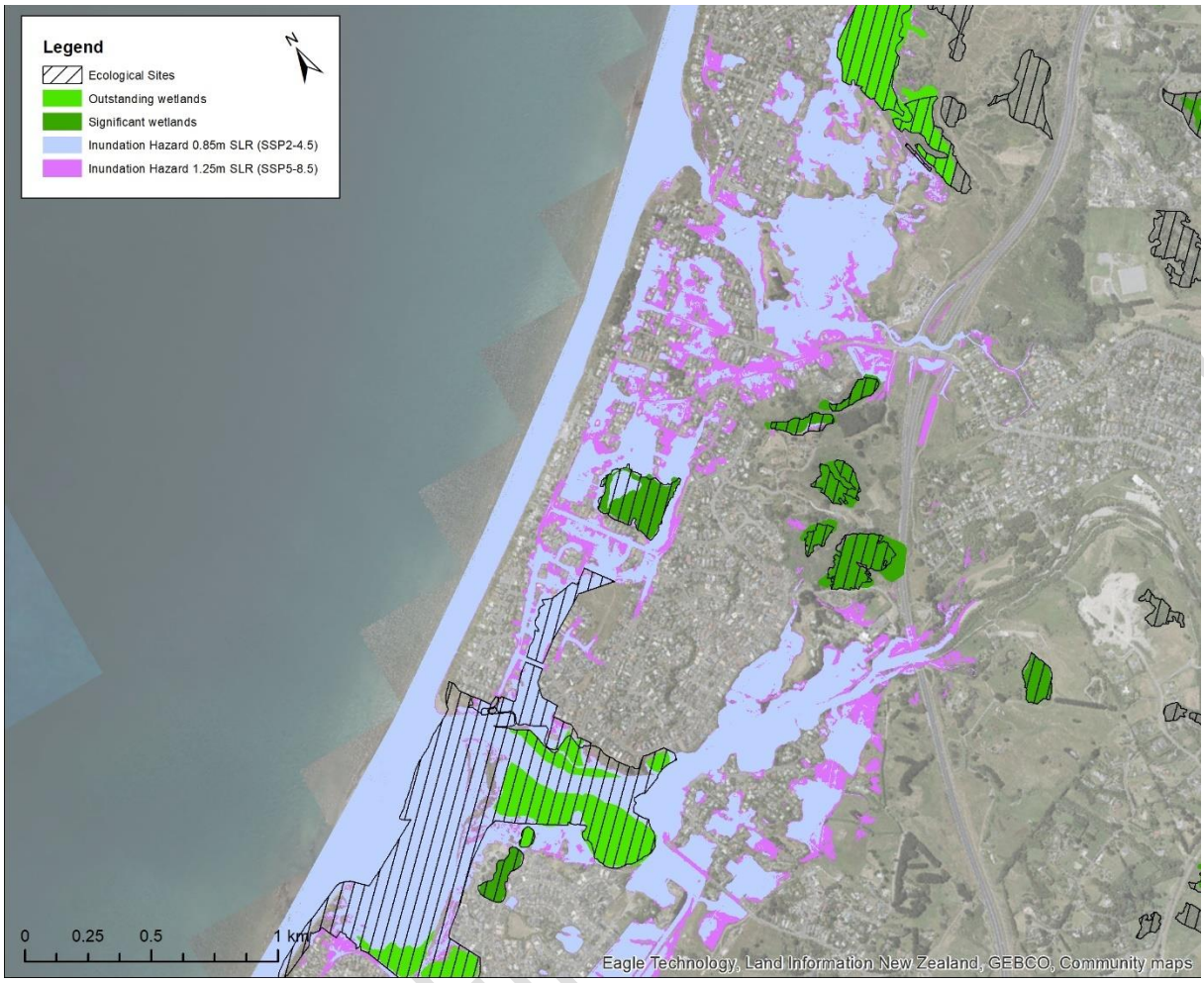

Figure 5.1: Exposure of Ecological sites and wetlands to inundation in a 1% AEP storm event by 2130, with 0.85m SLR (SSP2-4.5) and 1.25m SLR (SSP5-8.5).

Mapped ecological sites

A loss or permanent changes of the identified ecological sites due to coastal inundation will mostly affect coastal and waterway-based sites and existing wetland sites. Flood control measures already in place such as stop banks and floodgates present in Waikanae catchment have already modified the system. It is likely that increased frequency of flooding will exacerbate an already altered ecological system. Increased incidences of flooding in low lying areas due to sea level rise will be magnified during storm events causing floodwaters to back upstream and in the long term may lead to permanent inundation in some areas.

Under both scenarios the current flooding risk is considered to be moderate (as it already occurs) and the habitats have already been modified with little opportunity to 'migrate' within the landscape. The risk remains moderate to 2050, then increases to high in 2070, and extreme in 2130 under both SLR scenarios. This increase in risk is due to the ever-increasing areas flooded and the increased depth and duration of flooding.

Indigenous trees

In the CAA, there are 17 Key Indigenous Trees identified within the Operative Kāpiti Coast District Plan 2021 and another 23 Notable trees. However, all of the notable trees are either exotic or indigenous but not naturally occurring species (i.e. have been planted). Overall, the risk to Indigenous trees from coastal flooding is currently low as only a few trees are affected, and remains low to 2050. Under both SLR scenarios, by 2070

the risk increases to moderate. Under the lower SSP2-4.5 scenario, the risk remains moderate through to 2130; however under the higher SSP5-8.5 scenario the risk increases to high, when more than 50% of Key Indigenous Trees could be exposed to coastal flooding.

Rare and threatened species

There are 47 nationally or regionally Threatened or At Risk species reported within the CAA. Most of these species are associated with coastal areas such as the beach and dunes, or waterways and/or wetland areas. This includes 21 bird species, 11 freshwater fish species, 2 lizard species, 11 plant species and a one each for liverwort and fungus species. Further details can be found in Appendix A.3.5.

At present, coastal habitats and wetlands are already affected by coastal flooding; hence the current risk is considered to be moderate. For both the SSP2-4.5 and SSP5-8.5 scenarios, the risk increases to high in 2050 as greater portions of the habitat are affected. Under both SLR scenarios, the risk remains high to 2070, and increases to extreme by 2130 due to all wetland habitats and a large area of the Waikanae River Estuary being potentially affected by coastal flooding due to increased exposure to saltwater flooding, which may affect the habitats of the rare and threatened species.

Bird habitat

The risk to bird habitat is estimated based on the proportion of the bird habitats affected by flooding over time with SLR, and considers that flooding may result in additional areas of wetland which could provide alternative bird habitat. However, these potential opportunity for increased wetland environments would need to be secured through planting, (legal) protection, and predator control. Increased or more intense flooding may cause changes in the food availability due to diving depth, as well as plant and habitats dying due to salt water flooding, changes in waterflow patterns, and increased water velocity and sedimentation. Higher and more extensive flooding could drown nests and burrows of species that nest adjacent or on waterways, which could have cascading effects on the size and genetic diversity of the affected bird populations. Much of the coastline of the district will be similarly affected, which will not only reduce the local habitat within the CAA, but also reduce habitat for birds to move to.

For both the SSP2-4.5 and SSP5-8.5 the current flooding risk is considered to be extreme, as flooding of the coastal and saline bird habitats occurs already, however it is likely that the entire Kāpiti coastline will be experiencing similar effects, reducing the availability of possible alternative habitat. Flood risk remains extreme for both SLR scenarios to 2130, as low-lying areas adjacent to the bird habitat also flood and the frequency and depth of flooding continues to increase. This would severely limit bird habitat availability and could affect bird populations.

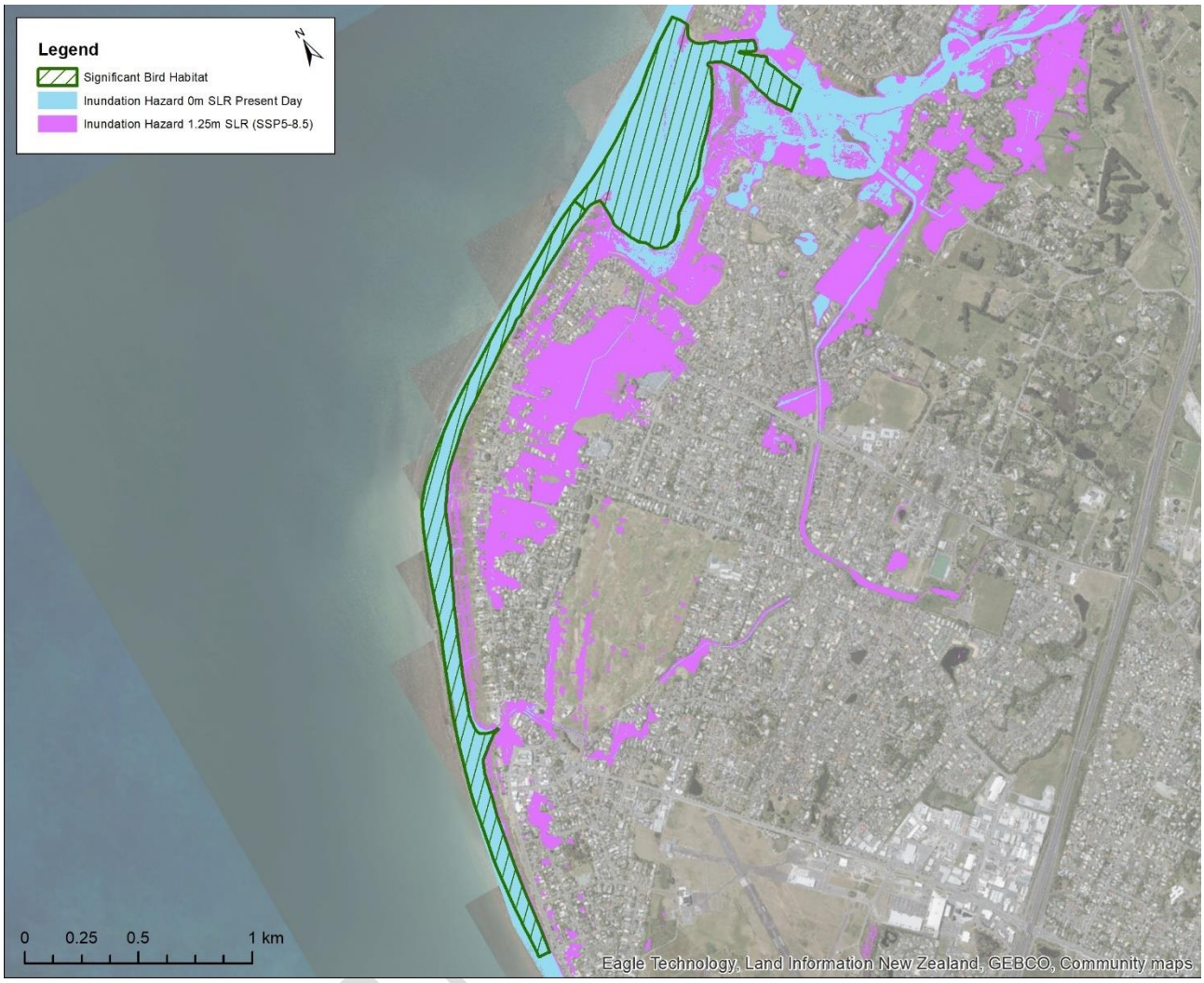

Figure 5.2: Exposure of significant bird habitat in the CAA to coastal flooding hazard in a present day 1% AEP event, and with 1.25 m SLR under the higher SSP5-8.5 scenario in 2130.

Fish habitat

Flooding could be beneficial to indigenous fish species as it could provide additional areas of flooded habitat for feeding and spawning. However, flooding could also be detrimental to indigenous fish species due to rapid changes in salinity, increased turbidity, reduced in-stream prey, preventing fish from swimming upstream or downstream ((temporary) loss of connectivity), washing fish out to sea, and salinity killing vegetation.

At present, the risk to fish habitats from coastal flooding is considered to be moderate, as whilst there is high exposure to coastal flooding, fish habitats are considered to have a moderate adaptive capacity, as they have the ability to migrate upstream if habitat is not already occupied. The effects of flooding are potentially offset by the temporary additional habitat creation that occurs across parts of the flood plain during events. By 2050, the risk to fish habitat increases to high, and remains high under both SLR scenarios to 2130.

Coastal indigenous biodiversity

More frequent and extensive flooding of indigenous bird and fish habitats may cause changes in the food availability due to increased diving depth, plants and habitats dying due to salt water flooding, changes in waterflow patterns, and increased water velocity and sedimentation smothering benthic food sources (buried

invertebrates in the sand). These changes will likely affect the prey species available in rivers, lagoons and coastal marine areas, reducing food availability for birds and fish. Saltwater is likely to penetrate further upstream during storm events, and could potentially kill freshwater species (especially plants). Importantly these could be areas where īnanga spawn. Higher water levels during flood events due to sea level rise, and the increase in ground area impacted could drown indigenous plants, lizards, invertebrates and nests and burrows of species that nest adjacent or on waterways. This will have cascading effects on the size and genetic diversity of the affected populations.

The present-day risk to indigenous biodiversity is considered to be moderate, as flooding is already occurring. Under both SLR scenarios, the risk remains moderate to 2050, increases to high by 2070, and extreme by 2130. This gradual increase is risk is due to the increase in depth of flooding, as well as the increase in additional areas flooded. However, these additional areas may also convey some benefits in providing additional (temporary) habitat for fauna.

6. Natural Character Domain

Natural Character has specific application under the RMA s.6(a) for:

The preservation of the natural character of the coastal environment (including the coastal marine area) wetlands, and lakes and rivers and their margins and the protection of them from inappropriate subdivision, use and development.

The New Zealand Coastal Policy Statement 2010 (NZCPS) sets out relevant policies for the identification of the coastal environment (Policy 1), preservation (Policy 13) and restoration (Policy 14) of coastal natural character.

In accordance with current NZILA best practice an understanding of natural character can be interpreted as:

> *The naturalness or degree of modification of an area*
> *An area's distinct combination of natural characteristics and qualities.*

Note: For the purpose of this Central Adaptation Area Risk Assessment Report and the CAA natural character domain risk assessments, the natural character rating and description of coastal environment are from the Kāpiti Coast Natural Character Evaluation (Boffa Miskell, 2024) [18] *report and not the Operative Kāpiti Coast District Plan 2021.*

Areas which are included within the CAA were recently assessed as part of the Kāpiti Coast Natural Character Evaluation (Boffa Miskell, 2024). Within that evaluation, these areas comprise part of the Coastal Terrestrial Area 2: Waikanae and Paraparaumu with an overall low-moderate natural character rating. The adjoining coastal marine area below Mean High Water Springs (MHWS), Coastal Marine Area A: Innershelf and nearshore, extends out to a depth of 35 meters and has an overall moderate natural character rating.

At a finer assessment scale, the CAA contains two components of high natural character comprising the southern part of the relatively intact dune systems at Peka Peka Dunes including Pharazyn Reserve and the Waikanae Estuary. In addition to preserving natural character which has been mapped or otherwise identified under NZCPS Policy 13, Policy 14 of the NZCPS promotes the restoration or rehabilitation of the natural character of the coastal environment. To achieve this outcome, Policy 14 directs the identification of areas and opportunities for restoration and the inclusion of provisions in statutory plans and the use of restoration conditions when granting resource consents and designations.

This assessment has been undertaken in the context of the inland extent of the coastal environment and associated evaluation of natural character when considering the effects of coastal erosion and inundation on coastal natural character. Notwithstanding this, where predicted inundation increasingly extends beyond the coastal environment and into the coastal context further inland, potential cascading impacts on natural character are considered, acknowledging this may include potential future delineation of this inherently dynamic environment.

[18] Boffa Miskell (2024) Kāpiti Coast Natural Character Evaluation: Natural Character of the Kāpiti Coast Coastal Environment

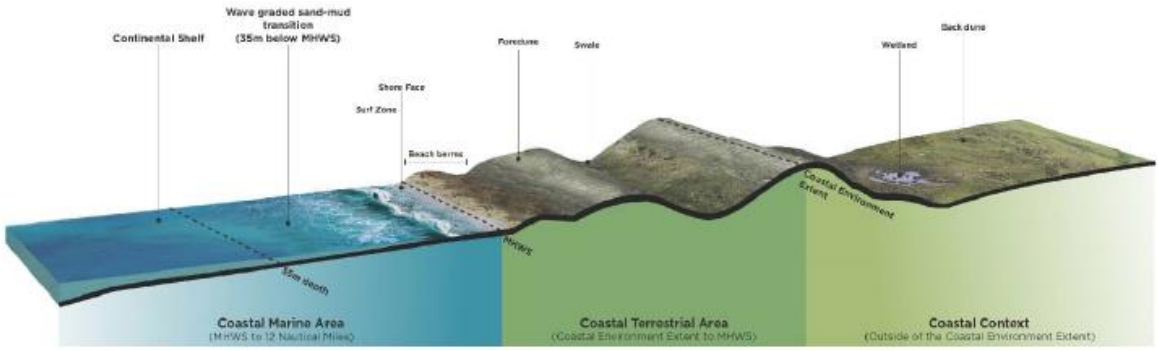

Figure 6.1: Typical transect through Kāpiti Coast duneland (from Boffa Miskell, 2024)

The following outlines the information used to assess the risks to the Natural Character domain in the CAA, and a summary of the findings. Details for each element, including assumptions and limitations used to identify the risks, are provided in Appendix A.

6.1 Natural Character Elements

The risk assessment primarily relies on spatial information to establish how exposed an element is to coastal hazards, and how this exposure changes over time. Table 7.1 provides a summary of the elements assessed within the natural character domain, and what spatial information was used to inform the assessment of risk.

The coastal terrestrial area (CTA) is representative of the broader coastal environment, and within the adaptation area there is one CTA – "Waikanae and Paraparaumu." Within the CTA there are areas of high natural character, being parts of the existing dune and estuary environments. The Peka Peka dunes and Waikanae Estuary are within the broader Waikanae and Paraparaumu CTA.

This assessment used spatial layers generated from the Boffa Miskell assessment of natural character for district and regional planning purposes, commissioned by GWRC and KCDC. More detailed information about the method employed to establish exposure, sensitivity, and adaptive capacity ratings for each element is included in Appendix A

Table 6.1: Summary of elements assessed in the natural character domain and representative data used to inform the assessment

Element	Description	Representative Data
CTA2: Waikanae and Paraparaumu	**Risks to the natural character of the Waikanae and Paraparaumu Coastal Terrestrial Area, which has a low-moderate level of natural character.** This is representative of the naturalness of the area, or degree of modification to the area, as well as an area's distinct combination of natural characteristics and qualities. The broader terrestrial coastal environment encompasses the most populated area in Kāpiti Coast's Coastal Environment and adjoining coastal context and is assessed as having **low-moderate** level of natural character overall within which	Spatial overlays of the identified coastal terrestrial area completed by Boffa Miskell for GWRC and KCDC.

Element	Description	Representative Data
	components of high natural character have been identified encompassing parts of the Peka Peka Dunes which extends into the Northern Adaptation Area and much of Waikanae Estuary.	
Peka Peka Dunes (South)	**Risks to the area of High Natural Character at the Peka Peka Dunes.** These areas encompass largely intact coastal dunes. The native vegetation is present but reduced.	Spatial overlays of the identified areas of high natural character completed by Boffa Miskell for GWRC and KCDC.
Waikanae Estuary	Risk to the area of High Natural Character at the Waikanae Estuary. The mouth of the estuary contains a dynamic sandspit. It sustains a representative native freshwater fishery.	Spatial overlays of the identified areas of high natural character completed by Boffa Miskell for GWRC and KCDC.

6.2 Natural Character Risk Matrix

A summary of the final risk ratings for each element is presented in Table 6.2. A more extensive matrix which details the exposure, sensitivity, adaptive capacity, vulnerability, and final risk ratings is provided in Appendix B.

Table 6.2: Natural Character Domain Risk Matrix

	Coastal Erosion						Coastal Inundation					
SLR Scenario	**Both**		**SSP2-4.5**		**SSP5-8.5**		**Both**		**SSP2-4.5**		**SSP5-8.5**	
Element	Present	2050	2070	2130	2070	2130	Present	2050	2070	2130	2070	2130
CTA2: Waikanae and Paraparaumu (Coastal Terrestrial Area)	M	M	H	H	H	H	M	M	M	M	M	M
Peka Peka Dunes (Pharazyn Reserve) (High Natural Character)	L	L	L	L	L	L	M	M	M	M	M	M
Waikanae Estuary (High Natural Character)	M	M	M	M	M	M	M	M	H	H	H	H

6.3 Natural Character Risk Summary

6.3.1 Risks from coastal erosion

All elements assessed are considered to be at low to moderate risk to coastal erosion up to 2050. Under the lower SSP2-4.5 scenario, both Peka Peka dunes and the Waikanae Estuary continue to be low or moderate risk through to 2130, indicating that coastal erosion per se will not have a significant impact on these areas of high natural character. The Waikanae and Paraparaumu Coastal Terrestrial Area (CTA) becomes high risk by 2070 through to 2130 under both SLR scenarios.

Coastal erosion impacts existing duneland areas, including much of the Peka Peka and Waikanae Dunes and parts of the more modified Paraparaumu Dunes south of the Waikanae Estuary. Erosion increases to the south of Paraparaumu Beach within an area subject to existing rock revetment. Coastal erosion also impacts the more dynamic mouths of Ngarara and Tikotu Stream as well as the more modified margins of the Waikanae Estuary including an area of approximately 100 metres to the south-west of the estuary in the vicinity of Manly Street.

The increase to high risk in the Waikanae and Paraparaumu CTA is closely linked to the proximity and exposure of the settlement to erosion. The exposure to coastal erosion typically impacts more modified areas of the coastal environment and increasingly extends inland of the current delineation of this area. The ability of this section to preserve the coastal environment is increasingly impacted by the removal of the remaining pockets of natural dunelands, and the 'coastal squeeze' of infrastructure behind the existing dune system limiting the dunes' ability to naturally adapt. Over time, erosion of these natural dunes will remove the contribution of existing natural elements within the coastal environment and result in an overall lower level of natural character.

The proximity to existing settlement and impacts of built coastal protection and associated human induced changes has resulted in lower levels of existing natural character in this coastal terrestrial area. In response to such changes, the introduction of further built coastal protection and associated human induced changes in has the potential to adversely impact natural elements, patterns and processes and therefore reduce natural character.

6.3.2 Risks from coastal inundation

All elements assessed are considered to be at a moderate risk of coastal inundation up to 2130 under both scenarios, with the exception of Waikanae Estuary which will remain susceptible to ongoing flooding which heightens the risk of a decline in natural character from 2050.

Outside of the existing river mouths and estuaries currently subjected to frequent inundation, relatively limited flooding occurs within the context of the current extent of the coastal environment and elements, patterns and process which contribute to existing levels of natural character. The existing coastal environment typically encompasses a more elevated sequence of duneland along which coastal development has been established, and along which the inland extent of the coastal environment used to inform an assessment of natural character has been defined.

The mouths of rivers, including Waikanae Estuary which maintains an area of high natural character, will remain susceptible to ongoing inundation. As flooding and SLR increases within Waikanae Estuary, this is anticipated to have changes in salinity, sedimentation and associated habitats which has potential to reduce existing high levels of natural character from 2050.

Coastal flooding increasingly extends inland of the identified coastal environment, including more modified areas containing coastal settlement and consequently more limited levels of natural character. As the risk of coastal flooding increases, this increases the risk that the measures to address coastal flooding will further modify natural character as potential for more significant coastal elements, patterns and processes associated with coastal flooding extends inland.

7. Cultural Domain

A risk assessment for the Cultural domain in relation to coastal hazard is still to be undertaken with Mana Whenua, and will be added to this document prior to being finalised.

Appendix A Risk Assessment Templates

The following templates were used to calculate the risk scores for each element within the domains by the subject matter specialists. Subject matter specialists were provided these templates to fill out for each of their defined elements under each domain. Each template contains the following information:

- Relative sea level rise scenario assessed (SSP2-4.5/SSP5-8.5)
- A descriptive overview of the element
- A description of the consequence of exposure to the element to flooding or erosion
- A description of the potential opportunities
- A description of the exposure of the element to the erosion and flood hazards
- An exposure 'ranking' (low/moderate/high/extreme)
- A sensitivity 'ranking' (low/moderate/high/extreme)
- A description of the elements' adaptive capacity and its 'ranking' (very low/low/moderate/high)
- A calculated vulnerability score based on sensitivity and adaptive capacity rankings (low/moderate/high/extreme)
- A calculated overall risk score based on combined exposure and vulnerability rankings (low/moderate/high/extreme)

One template has been prepared for each SLR scenario for each element in each domain. It is recognised that some generalized information about the element description and the consequences is duplicated, however these templates have been prepared to be read in isolation from each other to understand to full risk to an element under one sea level rise scenario.

A.1 Built Environment Risk Assessment Templates

A.1.1 Private Property (Whole Adaptation Area)

Domain	Element at Risk	Overview
Built Environment	Private property (whole adaptation area)	Private land parcels within the whole CAA, of which there is 7064 private properties. Properties are assessed as the property boundaries of private parcels, supplied by KCDC. Individual settlements (Waikanae, Otaihanga, and Paraparaumu) are assessed separately.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Potential erosion would lead to loss of an individual's property parcel (partially or whole). If erosion interacted with any buildings on the properties, they would likely become undermined and damaged, and result in loss or relocation of the dwelling. Erosion into the property boundary will also result in removal of any defence mechanisms (e.g. dune system, structures) and will have a cascading impact by increasing the coastal inundation hazard at the site.
Coastal Flooding	Flooding has the potential to cause damage to buildings and their contents through waterlogging, sediment deposition, contamination from pollutants, debris impacts and erosion. Flood affected buildings need to be repaired or rebuilt, depending on the severity of the damage, and contents replaced. The severity of the damage (and cost of repair or replacement) depends on the method of construction of the building and the materials used, its age and its contents and the depth and speed of the floodwater.

Opportunities

Hazard	Opportunities
Coastal Erosion	Replacement of the older building stock at risk to erosion with relocatable design, sustainable, low carbon buildings which abide to potential planning provisions – such as setback distances outside of the hazard zone.
Coastal Flooding	Replacement of the older building stock at risk of flooding with new, more sustainable, healthier, lower carbon buildings outside of hazard area.

A.1.1.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion Currently no properties are exposed to short term storm erosion.	Future exposure: • 2050: 34 private properties (<1%) – Generally located in Waikanae around the Waimeha Stream. • 2070: 61 private properties (1%) – Mostly located around Waimeha Stream; Northern end of Manly street (Paraparaumu beach); and Marine Parade at the southern end of the CAA boundary. • 2130: 129 private properties (2%) – Increase in properties along Manly street, Marine Parade, and same properties effected around Waimeha Stream.
Currently exposed to coastal flooding 287 private properties are exposed (4%)	Future exposure: • 2050: 505 private properties are exposed (7%) • 2070: 720 private properties are exposed (10%) • 2130: 1552 private properties are exposed (22%)

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	L	L	L

Note: For both coastal erosion and coastal flooding, exposure is calculated based on the percentage of private land parcels affected relative to the total private land parcels in the CAA (7064).

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	E	E	E
Coastal Flooding	M	M	H	H

Notes:

- Coastal erosion sensitivity is based on a subjective measure of the total area of property that has been lost to erosion, and whether the loss of the property has resulted in loss of a dwelling on the property. Generally, if erosion has resulted in the total loss of the property and dwelling, it is extremely sensitive; whereas if only the front edges of most of the properties effected is exposed and no dwellings are effected, the sensitivity is considered to be moderate. SensitiviMty therefore can increase over time as more of the property and dwellings on the property become exposed, and therefore results in loss of land that is not reestablished.

- Coastal flooding sensitivity is based on sample inspections of the potential depths of flooding above ground level at buildings in the affected properties and typical fragility characteristics for residential buildings (Reese & Ramsay, 2010):
  - Depth less than 0.15 m = Low sensitivity (below typical floor level as per Building Code)
  - Depth 0.15 m to 0.65 m = Medium sensitivity (up to a depth of 0.5 m above typical floor level in which a signficant proportion of contents are damaged)

- Depth 0.65 m to 1.65 m = High sensitivity (Reparable structural damage)
- Depth greater than 1.65 m = Extreme sensitivity (Irreparable structural damage)

The extent of features which may prevent or reduce flooding at properties – such as a dune, stopbank or non-return valves on stormwater outfalls has then been used to moderate the sensitivity rating if appropriate. The extents of the classes of water depth and mitigating measures have been evaluated in a qualitative manner

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Properties have no natural adaptive capacity as they have set boundaries. See note on potential adaption with relocation of buildings to enhance protection from flood and erosion hazards.
Coastal Flooding	L	Sensitivity of existing properties to damage by flooding can be reduced through use of more resilient materials and raising services and contents. Property-level protection (e.g. flood walls and stoplogs) or raising buildings can reduce exposure to flooding.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	L	E	E	E	L	L	E	E	E
Flooding	M	M	H	H	L	M	M	H	H

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	L	E	E	E	L	M	M	M
Risk from Flooding	L	L	L	L	M	M	H	H	L	L	L	L

A.1.1.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion • Currently no properties are exposed to short term storm erosion.	Future exposure: • 2050: 34 private properties (<1%) Generally located in Waikanae around the Waimeha Stream. • 2070: 73 private properties (1%) Mostly located around Waimeha Stream; Northern end of Manly street (Paraparaumu beach); and Marine Parade at the southern end of the CAA boundary. • 2130: 228 private properties (3%) Increase in properties along Manly street (Paraparaumu), Marine Parade (Paraparaumu), Tutere Street (Waikanae) and same properties effected around Waimeha Stream.
Currently exposed to coastal flooding • 287 private properties are exposed (4%)	Future exposure: • 2050: 505 private properties are exposed (7%) • 2070: 888 private properties are exposed (13%) • 2130: 2205 private properties are exposed (31%)

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	L	L	M

Note: For both coastal erosion and coastal flooding, exposure is calculated based on the percentage of private land parcels affected relative to the total private land parcels in the CAA (7064).

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	L	E	E	E
Coastal Flooding	M	M	H	H

Notes:

- Coastal erosion sensitivity is based on a subjective measure of the total area of property that has been lost to erosion, and whether the loss of the property has resulted in loss of a dwelling on the property. Generally, if erosion has resulted in the total loss of the property and dwelling, it is extremely sensitive; whereas if only the front edges of most of the properties effected is exposed and no dwellings are effected, the sensitivity is considered to be moderate. Sensitivity therefore can increase over time as more of the property and dwellings on the property become exposed, and therefore results in loss of land that is not reestablished.
- Coastal flooding sensitivity is based on sample inspections of the potential depths of flooding above ground level at buildings in the affected properties and typical fragility characteristics for residential buildings (Reese & Ramsay, 2010):
  - Depth less than 0.15 m = Low sensitivity (below typical floor level as per Building Code)
  - Depth 0.15 m to 0.65 m = Medium sensitivity (up to a depth of 0.5 m above typical floor level in which a signficant proportion of contents are damaged)
  - Depth 0.65 m to 1.65 m = High sensitivity (Reparable structural damage)

- Depth greater than 1.65 m = Extreme sensitivity (Irreparable structural damage)

The extent of features which may prevent or reduce flooding at properties – such as a dune, stopbank or non-return valves on stormwater outfalls has then been used to moderate the sensitivity rating if appropriate. The extents of the classes of water depth and mitigating measures have been evaluated in a qualitative manner

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Properties have no natural adaptive capacity as they have set boundaries. See note on potential adaption with relocation of buildings to enhance protection from flood and erosion hazards.
Coastal Flooding	L	Sensitivity of existing properties to damage by flooding can be reduced through use of more resilient materials and raising services and contents. Property-level protection (e.g. flood walls and stoplogs) or raising buildings can reduce exposure to flooding.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	L	E	E	E	L	L	E	E	E
Flooding	M	M	H	H	L	M	M	H	H

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	L	E	E	E	L	M	M	M
Risk from Flooding	L	L	L	M	M	M	H	H	L	L	L	M

A.1.2 Private Property (Waikanae)

Domain	Element at Risk	Overview
Built Environment	Private property (Waikanae)	Private properties in the Waikanae area. - For coastal erosion, only beachfront properties (i.e. most seaward row of houses) have been assessed. In the defined Waikanae erosion hazard area, there are 184 beach front private properties. Only beachfront properties have been assessed to ensure the risks are assessed relative to the hazard throughout the entire district, in relation to the housing density in the area. - For coastal flooding, all properties in the broader Waikanae area up to the landward extent of the CAA have been considered since properties inland of the shoreline are also susceptible to flooding. In the defined Waikanae coastal flood hazard area, there are 2176 private properties.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Potential erosion would lead to loss of an individual's property parcel (partially or whole). If erosion interacted with any buildings on the properties, they would likely become undermined and damaged, and result in loss or relocation of the dwelling. Erosion into the property boundary will also result in removal of any defence mechanisms (e.g. dune system, structures) and will have a cascading impact by increasing the coastal inundation hazard at the site.
Coastal Flooding	Flooding has the potential to cause damage to buildings and their contents through waterlogging, sediment deposition, contamination from pollutants, debris impacts and erosion. Flood affected buildings need to be repaired or rebuilt, depending on the severity of the damage, and contents replaced. The severity of the damage (and cost of repair or replacement) depends on the method of construction of the building and the materials used, its age and its contents and the depth and speed of the floodwater.

Opportunities

Hazard	Opportunities
Coastal Erosion	Replacement of the older building stock at risk to erosion with relocatable design, sustainable, low carbon buildings which abide to potential planning provisions – such as setback distances outside of the hazard zone.
Coastal Flooding	Replacement of the older building stock at risk of flooding with new, more sustainable, healthier, lower carbon buildings outside of hazard area.

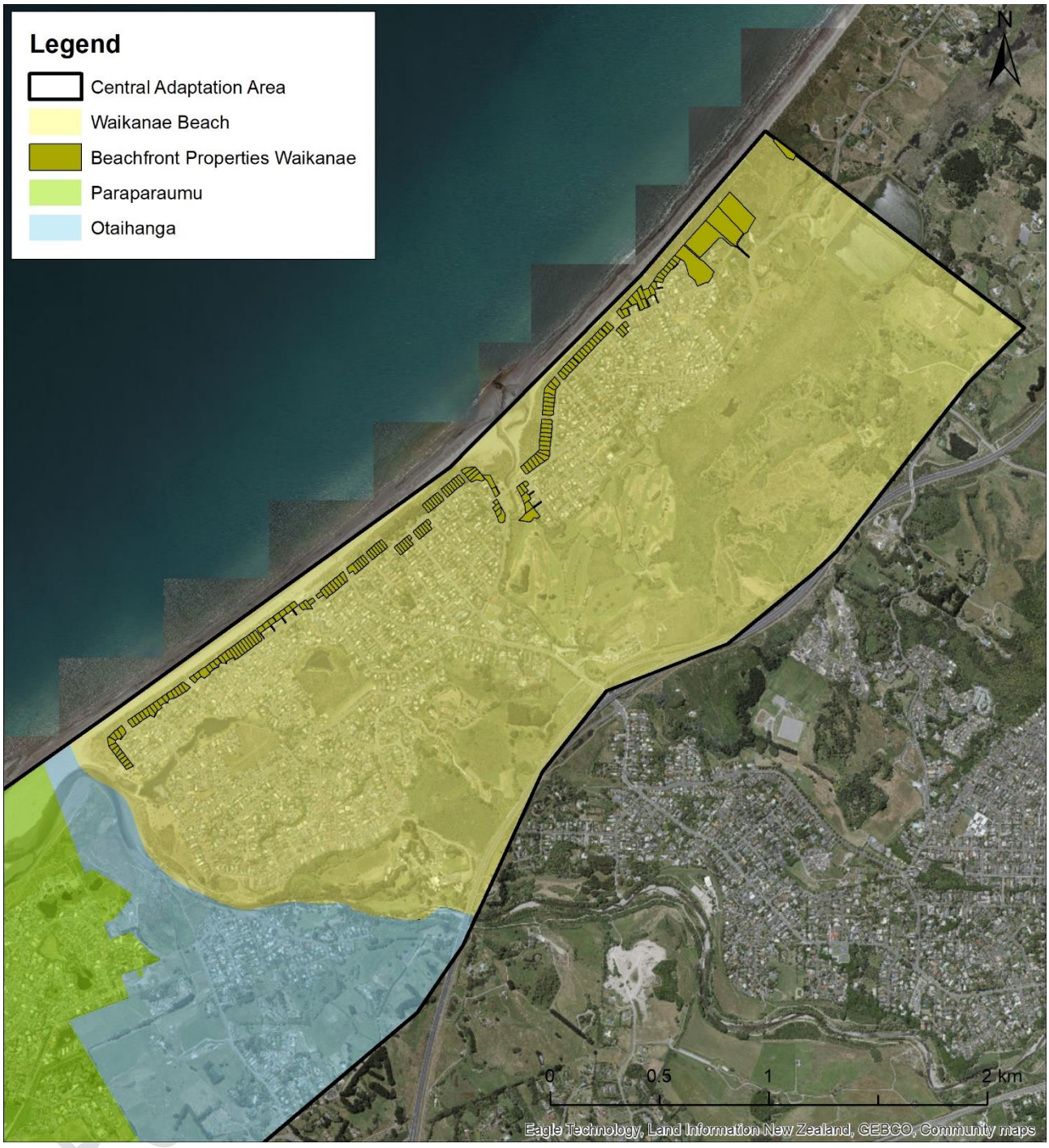

Figure A.1.1: Location of Waikanae sub-area and beachfront properties included in this analysis.

A.1.2.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion • No private properties (0%) in the defined area are currently exposed	Future exposure: • 2050: 26 private properties are exposed (14%) – Waimeha Stream • 2070: 26 private properties are exposed (14%) – Waimeha Stream • 2130: 38 private properties are exposed (21%) – Waimeha Stream and coastal properties along Tutere Street.
Currently exposed to coastal flooding • 107 private properties are exposed (5%)	Future exposure: • 2050: 210 private properties are exposed (10%) • 2070: 332 private properties are exposed (15%) • 2130: 721 private properties are exposed (33%)

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	L	L	M

Note:

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	L	E	E	E
Coastal Flooding	M	M	M	M

Notes:

- Coastal erosion sensitivity is based on a subjective measure of the total area of property that has been lost to erosion, and whether the loss of the property has resulted in loss of a dwelling on the property. Generally, if erosion has resulted in the total loss of the property and dwelling, it is extremely sensitive; whereas if only the front edges of most of the properties effected is exposed and no dwellings are effected, the sensitivity is considered to be moderate. Sensitivity therefore can increase over time as more of the property and dwellings on the property become exposed, and therefore results in loss of land that is not reestablished.

- Coastal flooding sensitivity is based on sample inspections of the potential depths of flooding above ground level at buildings in the affected properties and typical fragility characteristics for residential buildings (Reese & Ramsay, 2010):
  - Depth less than 0.15 m = Low sensitivity (below typical floor level as per Building Code)
  - Depth 0.15 m to 0.65 m = Medium sensitivity (up to a depth of 0.5 m above typical floor level in which a signficant proportion of contents are damaged)
  - Depth 0.65 m to 1.65 m = High sensitivity (Reparable structural damage)
  - Depth greater than 1.65 m = Extreme sensitivity (Irreparable structural damage)

The extent of features which may prevent or reduce flooding at properties – such as a dune, stopbank or non-return valves on stormwater outfalls has then been used to moderate the sensitivity rating if appropriate. The extents of the classes of water depth and mitigating measures have been evaluated in a qualitative manner

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Properties have no natural adaptive capacity as they have set boundaries. See note on potential adaption with relocation of buildings to enhance protection from flood and erosion hazards.
Coastal Flooding	L	Sensitivity of existing properties to damage by flooding can be reduced through use of more resilient materials and raising services and contents. Property-level protection (e.g. flood walls and stoplogs) or raising buildings can reduce exposure to flooding.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	L	E	E	E	L	L	E	E	E
Flooding	M	M	M	M	L	M	M	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	L	E	E	E	L	M	M	M
Risk from Flooding	L	L	L	M	M	M	M	M	L	L	L	M

A.1.2.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion • No private properties (0%) in the defined area are currently exposed	Future exposure: • 2050: 26 private properties are exposed (14%) – Waimeha stream • 2070: 26 private properties are exposed (14%) – Waimeha Stream • 2130: 101 private properties are exposed (55%) – most beachfront properties at the mid-southern end of Tutere Street and Field Way.
Currently exposed to coastal flooding • 107 private properties are exposed (5%)	Future exposure: • 2050: 210 private properties are exposed (10%) • 2070: 396 private properties are exposed (18%) • 2130: 926 private properties are exposed (43%)

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	H
Coastal Flooding	L	L	L	M

Note:

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	L	E	E	E
Coastal Flooding	M	M	M	H

- Coastal erosion sensitivity is based on a subjective measure of the total area of property that has been lost to erosion, and whether the loss of the property has resulted in loss of a dwelling on the property. Generally, if erosion has resulted in the total loss of the property and dwelling, it is extremely sensitive; whereas if only the front edges of most of the properties effected is exposed and no dwellings are effected, the sensitivity is considered to be moderate. Sensitivity therefore can increase over time as more of the property and dwellings on the property become exposed, and therefore results in loss of land that is not reestablished.

- Coastal flooding sensitivity is based on sample inspections of the potential depths of flooding above ground level at buildings in the affected properties and typical fragility characteristics for residential buildings (Reese & Ramsay, 2010):
  - Depth less than 0.15 m = Low sensitivity (below typical floor level as per Building Code)
  - Depth 0.15 m to 0.65 m = Medium sensitivity (up to a depth of 0.5 m above typical floor level in which a signficant proportion of contents are damaged)
  - Depth 0.65 m to 1.65 m = High sensitivity (Reparable structural damage)
  - Depth greater than 1.65 m = Extreme sensitivity (Irreparable structural damage)

  The extent of features which may prevent or reduce flooding at properties – such as a dune, stopbank or non-return valves on stormwater outfalls has then been used to moderate the sensitivity rating if

appropriate. The extents of the classes of water depth and mitigating measures have been evaluated in a qualitative manner

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Properties have no natural adaptive capacity as they have set boundaries. See note on potential adaption with relocation of buildings to enhance protection from flood and erosion hazards.
Coastal Flooding	L	Sensitivity of existing properties to damage by flooding can be reduced through use of more resilient materials and raising services and contents. Property-level protection (e.g. flood walls and stoplogs) or raising buildings can reduce exposure to flooding.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	L	E	E	E	L	L	E	E	E
Flooding	M	M	M	H	L	M	M	M	H

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	H	L	E	E	E	L	M	M	E
Risk from Flooding	L	L	L	M	M	M	M	H	L	L	L	M

A.1.3 Private Property (Otaihanga)

Domain	Element at Risk	Overview
Built Environment	Private property (Otaihanga)	Private properties in the Otaihanga area. For coastal flooding, all properties in the Otaihanga area up to the landward extent of the CAA have been considered since properties inland of the shoreline are also susceptible to flooding. In the defined Otaihanga coastal flood hazard area, there are 318 private properties. This is an inland area of the CAA, and no properties are impacted by coastal erosion hazards.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	There are no properties in the Otaihanga area which would be impacted by coastal erosion due to its locality inland away from the direct coastline. Therefore, there are no consequences of erosion hazards in this area.
Coastal Flooding	Flooding has the potential to cause damage to buildings and their contents through waterlogging, sediment deposition, contamination from pollutants, debris impacts and erosion. Flood affected buildings need to be repaired or rebuilt, depending on the severity of the damage, and contents replaced. The severity of the damage (and cost of repair or replacement) depends on the method of construction of the building and the materials used, its age and its contents and the depth and speed of the floodwater.

Opportunities

Hazard	Opportunities
Coastal Erosion	There are no properties in the Otaihanga area which would be impacted by coastal erosion due to its locality inland away from the direct coastline. Therefore, there are no opportunities identified for erosion hazards in this area.
Coastal Flooding	Replacement of the older building stock at risk of flooding with new, more sustainable, healthier, lower carbon buildings outside of hazard area.

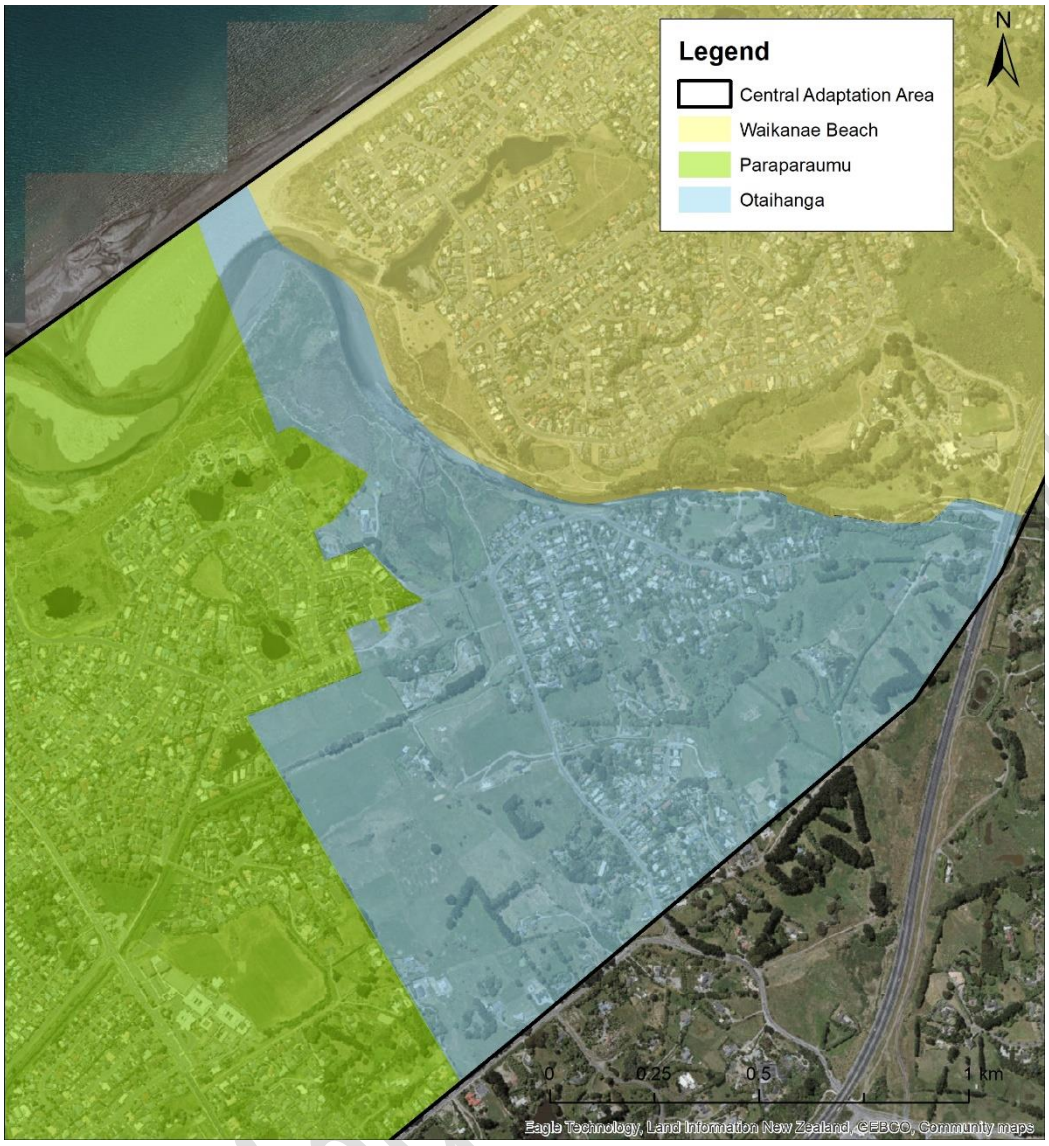

Figure A.1.2: Location of Otaihanga sub-area.

A.1.3.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
This is an inland area of the CAA, and no properties are impacted by coastal erosion hazards.	
Currently exposed to coastal flooding • 73 private properties are exposed (23%)	Future exposure: • 2050: 94 private properties are exposed (30%) • 2070: 111 private properties are exposed (35%) • 2130: 139 private properties are exposed (44%)

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	M	M	M

Note: Exposure to coastal erosion in this area is low as there are no properties that intersect with the hazard over the 100 year timeframe with SLR in Otaihanga.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	M	H	H	H

Notes:

- Sensitivity to coastal erosion is low because there is no coastal properties impacted by erosion over the 100 year period.

- Coastal flooding sensitivity is based on sample inspections of the potential depths of flooding above ground level at buildings in the affected properties and typical fragility characteristics for residential buildings (Reese & Ramsay, 2010):
  - Depth less than 0.15 m = Low sensitivity (below typical floor level as per Building Code)
  - Depth 0.15 m to 0.65 m = Medium sensitivity (up to a depth of 0.5 m above typical floor level in which a signficant proportion of contents are damaged)
  - Depth 0.65 m to 1.65 m = High sensitivity (Reparable structural damage)
  - Depth greater than 1.65 m = Extreme sensitivity (Irreparable structural damage)

  The extent of features which may prevent or reduce flooding at properties – such as a dune, stopbank or non-return valves on stormwater outfalls has then been used to moderate the sensitivity rating if appropriate. The extents of the classes of water depth and mitigating measures have been evaluated in a qualitative manner

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Properties have no natural adaptive capacity as they have set boundaries. See note on potential adaption with relocation of buildings to enhance protection from flood and erosion hazards.

Domain	Adaptive Capacity	Key Assumptions
Coastal Flooding	L	Sensitivity of existing properties to damage by flooding can be reduced through use of more resilient materials and raising services and contents. Property-level protection (e.g. flood walls and stoplogs) or raising buildings can reduce exposure to flooding.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	L	L	L	L	L	L	L	L	L
Flooding	M	H	H	H	L	M	H	H	H

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	L	L	L	L	L	L	L	L
Risk from Flooding	L	M	M	M	M	H	H	H	L	M	M	M

A.1.3.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
This is an inland area of the CAA, and no properties are impacted by coastal erosion hazards.	
Currently exposed to coastal flooding • 73 private properties are exposed (23%)	Future exposure: • 2050: 94 private properties are exposed (30%) • 2070: 122 private properties are exposed (38%) • 2130: 159 private properties are exposed (50%)

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	M	M	H

Note: Exposure to coastal erosion in this area is low as there are no properties that intersect with the hazard over the 100 year timeframe with SLR in Otaihanga.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	M	H	H	E

Notes:

- Sensitivity to coastal erosion is low because there is no coastal properties impacted by erosion over the 100 year period.

- Coastal flooding sensitivity is based on sample inspections of the potential depths of flooding above ground level at buildings in the affected properties and typical fragility characteristics for residential buildings (Reese & Ramsay, 2010):
  - Depth less than 0.15 m = Low sensitivity (below typical floor level as per Building Code)
  - Depth 0.15 m to 0.65 m = Medium sensitivity (up to a depth of 0.5 m above typical floor level in which a signficant proportion of contents are damaged)
  - Depth 0.65 m to 1.65 m = High sensitivity (Reparable structural damage)
  - Depth greater than 1.65 m = Extreme sensitivity (Irreparable structural damage)

  The extent of features which may prevent or reduce flooding at properties – such as a dune, stopbank or non-return valves on stormwater outfalls has then been used to moderate the sensitivity rating if appropriate. The extents of the classes of water depth and mitigating measures have been evaluated in a qualitative manner

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Properties have no natural adaptive capacity as they have set boundaries. See note on potential adaption with relocation of buildings to enhance protection from flood and erosion hazards.

Domain	Adaptive Capacity	Key Assumptions
Coastal Flooding	L	Sensitivity of existing properties to damage by flooding can be reduced through use of more resilient materials and raising services and contents. Property-level protection (e.g. flood walls and stoplogs) or raising buildings can reduce exposure to flooding.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	L	L	L	L	L	L	L	L	L
Flooding	M	H	H	E	L	M	H	H	E

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	L	L	L	L	L	L	L	L
Risk from Flooding	L	M	M	H	M	H	H	E	L	M	M	E

A.1.4 Private Property (Paraparaumu)

Domain	Element at Risk	Overview
Built Environment	Private property (Paraparaumu)	Private properties in the Paraparaumu area. - For coastal erosion, only beachfront properties (i.e. most seaward row of houses) have been assessed. In the defined Paraparaumu erosion hazard area, there are 320 beach front private properties. Only beachfront properties have been assessed to ensure the risks are assessed relative to the hazard throughout the entire district, in relation to the housing density in the area. - For coastal flooding, all properties in the broader Paraparaumu area up to the landward extent of the CAA have been considered since properties inland of the shoreline are also susceptible to flooding. In the defined Waikanae coastal flood hazard area, there are 4570 private properties.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Potential erosion would lead to loss of an individual's property parcel (partially or whole). If erosion interacted with any buildings on the properties, they would likely become undermined and damaged, and result in loss or relocation of the dwelling. Erosion into the property boundary will also result in removal of any defence mechanisms (e.g. dune system, structures) and will have a cascading impact by increasing the coastal inundation hazard at the site.
Coastal Flooding	Flooding has the potential to cause damage to buildings and their contents through waterlogging, sediment deposition, contamination from pollutants, debris impacts and erosion. Flood affected buildings need to be repaired or rebuilt, depending on the severity of the damage, and contents replaced. The severity of the damage (and cost of repair or replacement) depends on the method of construction of the building and the materials used, its age and its contents and the depth and speed of the floodwater.

Opportunities

Hazard	Opportunities
Coastal Erosion	Replacement of the older building stock at risk to erosion with relocatable design, sustainable, low carbon buildings which abide to potential planning provisions – such as setback distances outside of the hazard zone.
Coastal Flooding	Replacement of the older building stock at risk of flooding with new, more sustainable, healthier, lower carbon buildings outside of hazard area.

Figure A.1.3: Location of Paraparaumu sub-area and location of beachfront properties included in this analysis.

A.1.4.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion • No private properties (0%) in the defined area are currently exposed	Future exposure: • 2050: 7 private properties are exposed (2%) – Manly Street. • 2070: 31 private properties are exposed (10%) – Manly Street and southern end of Marine Parade. • 2130: 64 private properties are exposed (20%) – Manly Street and southern end of Marine Parade.
Currently exposed to coastal flooding • 107 private properties are exposed (2%)	Future exposure: • 2050: 201 private properties are exposed (4%) • 2070: 277 private properties are exposed (6%) • 2130: 692 private properties are exposed (15%)

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	L	L	L

Note:

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	L	H	E	E
Coastal Flooding	L	M	M	H

Notes:

- Coastal erosion sensitivity is based on a subjective measure of the total area of property that has been lost to erosion, and whether the loss of the property has resulted in loss of a dwelling on the property. Generally, if erosion has resulted in the total loss of the property and dwelling, it is extremely sensitive; whereas if only the front edges of most of the properties effected is exposed and no dwellings are effected, the sensitivity is considered to be moderate. Sensitivity therefore can increase over time as more of the property and dwellings on the property become exposed, and therefore results in loss of land that is not reestablished.

- Coastal flooding sensitivity is based on sample inspections of the potential depths of flooding above ground level at buildings in the affected properties and typical fragility characteristics for residential buildings (Reese & Ramsay, 2010):
  - Depth less than 0.15 m = Low sensitivity (below typical floor level as per Building Code)
  - Depth 0.15 m to 0.65 m = Medium sensitivity (up to a depth of 0.5 m above typical floor level in which a signficant proportion of contents are damaged)
  - Depth 0.65 m to 1.65 m = High sensitivity (Reparable structural damage)
  - Depth greater than 1.65 m = Extreme sensitivity (Irreparable structural damage)

The extent of features which may prevent or reduce flooding at properties – such as a dune, stopbank or non-return valves on stormwater outfalls has then been used to moderate the sensitivity rating if appropriate. The extents of the classes of water depth and mitigating measures have been evaluated in a qualitative manner

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Properties have no natural adaptive capacity as they have set boundaries. See note on potential adaption with relocation of buildings to enhance protection from flood and erosion hazards.
Coastal Flooding	L	Sensitivity of existing properties to damage by flooding can be reduced through use of more resilient materials and raising services and contents. Property-level protection (e.g. flood walls and stoplogs) or raising buildings can reduce exposure to flooding.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	L	H	E	E	L	L	H	E	E
Flooding	L	M	M	H	L	L	M	M	H

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	L	H	E	E	L	L	M	M
Risk from Flooding	L	L	L	L	L	L	M	M	H	L	L	L

A.1.4.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion • No private properties (0%) in the defined area are currently exposed	Future exposure: • 2050: 7 private properties are exposed (2%) – Manly Street • 2070: 42 private properties are exposed (13%) – Manly Street and southern end of Marine Parade. • 2130: 87 private properties are exposed (27%) - Manly Street and southern end of Marine Parade.
Currently exposed to coastal flooding • 107 private properties are exposed (2%)	Future exposure: • 2050: 201 private properties are exposed (4%) • 2070: 370 private properties are exposed (8%) • 2130: 1120 private properties are exposed (25%)

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	M
Coastal Flooding	L	L	L	M

Note:

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	L	H	E	E
Coastal Flooding	L	M	M	H

Notes:

- Coastal erosion sensitivity is based on a subjective measure of the total area of property that has been lost to erosion, and whether the loss of the property has resulted in loss of a dwelling on the property. Generally, if erosion has resulted in the total loss of the property and dwelling, it is extremely sensitive; whereas if only the front edges of most of the properties effected is exposed and no dwellings are effected, the sensitivity is considered to be moderate. Sensitivity therefore can increase over time as more of the property and dwellings on the property become exposed, and therefore results in loss of land that is not reestablished.

- Coastal flooding sensitivity is based on sample inspections of the potential depths of flooding above ground level at buildings in the affected properties and typical fragility characteristics for residential buildings (Reese & Ramsay, 2010):
  - Depth less than 0.15 m = Low sensitivity (below typical floor level as per Building Code)
  - Depth 0.15 m to 0.65 m = Medium sensitivity (up to a depth of 0.5 m above typical floor level in which a signficant proportion of contents are damaged)
  - Depth 0.65 m to 1.65 m = High sensitivity (Reparable structural damage)
  - Depth greater than 1.65 m = Extreme sensitivity (Irreparable structural damage)

  The extent of features which may prevent or reduce flooding at properties – such as a dune, stopbank or non-return valves on stormwater outfalls has then been used to moderate the sensitivity rating if

appropriate. The extents of the classes of water depth and mitigating measures have been evaluated in a qualitative manner

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Properties have no natural adaptive capacity as they have set boundaries. See note on potential adaption with relocation of buildings to enhance protection from flood and erosion hazards.
Coastal Flooding	L	Sensitivity of existing properties to damage by flooding can be reduced through use of more resilient materials and raising services and contents. Property-level protection (e.g. flood walls and stoplogs) or raising buildings can reduce exposure to flooding.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	L	H	E	E	L	L	H	E	E
Flooding	L	M	M	H	L	L	M	M	H

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	M	L	H	E	E	L	L	M	H
Risk from Flooding	L	L	L	M	L	M	M	H	L	L	L	M

A.1.5 Roads and Bridges

Domain	Element at Risk	Overview
Built Environment	Roads and Bridges	All roads and bridges in the CAA. Roads include unsealed and sealed roads as per the LINZ Roads Centreline dataset from LINZ Data service. In the CAA there is 90.5 km of roads. Bridges were determined by the intersect of the Road centreline layer with the river centreline layer (also obtained from LINZ Data service) and confirmed with inspection of aerial imagery. In the CAA there are 6 bridges/culverts identified.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Due to the large areas of development in the CAA, there are several key routes to accessing the coastal areas: - Waikanae – Accessed from SH1 on Te Moana Road; and from the north via Peka Peka along Paetawa Road. Main roads which run parallel with the shoreline include Tutere Street and Field Way. - Paraparaumu – Key access roads to the coastal areas from SH1 include Kāpiti Road and Mazengarb Road. Main roads that run adjacent to the coastline are Marine Parade (south of Tikotu Stream); and Manly Street (north of Tikotu Stream). - Otaihanga is in the inland area of the CAA and is not impacted by coastal erosion. Closure/loss of the access roads would lead to significant disruption to the local communities with limited alternative routes. Access to the beach would not be possible with loss of key access roads. Cascading impacts of loss of key access routes would include increased travel time through longer journeys and increased traffic, impact to tourism, impact to education, and reduced access for emergency services. Consequences of roads parallel to the coast being lost includes loss for individuals to their properties, with limited opportunity for relocation of the road further landward due to the development behind. This is particularly the case with roads which run parallel to the shoreline (e.g. Tutere Street; Field Way; Maine Parade; and Manly Street). The consequence of erosion reaching a bridge/culvert structure would likely result in undermining of the structure and cause failure. In some instances this would have a cascading impact on access to an area, and an alternative transport route would need to be used.
Coastal Flooding	Flooding of coastal roads and bridges can prevent them from being used to safely access properties in the community and can result in people becoming temporarily isolated during a flood event. Flooding of the four main roads which provide inland routes from the communities can prevent evacuation of people and property during a flood. Flooding can also damage the road surface or structural integrity of bridges, resulting in the need for repairs and potentially affecting or preventing access to the communities over a longer period. The severity of the damage depends on factors such as depth, speed and duration of flooding and the construction method and materials of the road or bridge.

Opportunities

Hazard	Opportunities
Coastal Erosion	No opportunities identified.
Coastal Flooding	No opportunities identified.

A.1.5.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion • 0.2 km of road (Southern end of Marine Parade between Rua and Tahi Road). • 0 Bridges	Future exposure: • 2050: 0.2 km of road (<1%) – Southern end of Marine Parade between Rua and Tahi Road; 0 Bridges. • 2070: 0.25 km of road (<1%) – – Southern end of Marine Parade between Rua and Tahi Road; 0 Bridges. • 2130: 0.5 km of road (1%) – Southern end of Marine Parade between Toru road and Rua Road, Road ens at Ngapotiki Street; 0 Bridges.
Currently exposed to coastal flooding • 0.25 km of road (<1%) – Mainly effects Makora Road, Otaihanga) • 3 bridges	Future exposure: • 2050: 0.5 km of road (1%) Mainly effects Makora Road, Otaihanga. Isolation of properties in Otaihanga Domain. • 2070: 1.95 km of road (2%) Isolated areas of Tutere Street, Waikanae; Makora Road, Otaihnaga; Te Kupe Road, Paraparaumu. • 2130: 9.6 km of road (11%) Mostly effecting roads in Waikanae with Te Moana Road flooded and surrounding roads, limiting access in/out of Waikanae; access in/out of Makora Road, Otaihanga impacted; Areas of Kāpiti Road and Mazengarb Road flooded which could isolate some properties, Te Kupe road flooded and restricting access; Isolated areas on Seaview Road but unlikley to restrict access.

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	M	M	H

Note:

- Exposure rankings for Coastal Erosion is calculated as a percentage of the effected road length of the total road length (90.5 km) in the CAA.
- Exposure ranking for Coastal Flooding additionally considers loss of access inland or isolation of sections of the community.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	H	H	H
Coastal Flooding	L	H	H	E

Notes:

- Sensitivity to coastal erosion is based where the effected area of road is, and if it would impact accessability to properties and key routes. In the CAA, erosion could impact the southern end of marine parade which could hinder access to properties and access along to Raumati; however the remainder of the CAA remains accessable.

- Sensitivity to coastal flooding is based on potential depth of flooding which affects accessibility and the amount of damage to roads and bridges and the importance of the road for access to the community from outside the hazard area.

  Sample inspections of the potential depths of flooding have been used to guide the hazard classe through reference to the combined flood hazard curves of the Australian Rainfall and Runoff Guide (Ball J. et al, 2019):

  - Depth less than 0.3 m = Low hazard (generally safe for people and vehicles)
  - Depth 0.3 m to 0.5 m = Medium hazard (unsafe for small vehicles)
  - Depth greater than 0.5 m = High hazard (unsafe for large vehicles)

  The importance of the road has been used with hazard class to assign the sensitivity to flooding – if a road is of low importance (not essential for access or evacuation) the hazard class (low/medium/high) is adopted for the sensitivity rating. If the road is of high importance (essential for access or evacuation) a sensitivity rating of one level higher than the hazrd class is assigned. E.G. A road of high importance exposed to 'medium' hazard is assigned a 'high' sensitivity rating. The presence of features which may prevent or reduce flooding of roads such as a stopbank, dune or stormwater management structures has then be used to moderate the rating if appropriate. These factors are considered through visual inspection and judgement of the hazard data.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Roads and bridges do not have any natural adaptive capacity.
Coastal Flooding	L	Roads and bridges do not have any natural adaptive capacity. Although they can be raised to adapt to increasing flood levels this can conflict with other infrastructure.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	H	H	H	L	M	H	H	H
Flooding	L	H	H	E	L	L	H	H	E

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	M	H	H	H	L	L	L	L
Risk from Flooding	L	M	M	H	L	H	H	E	L	M	M	E

A.1.5.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion • 0 m of road • 0 Bridges	Future exposure: • 2050: 0.2 km of road (<1%) Southern end of Marine Parade between Rua and Tahi Road; 0 Bridges. • 2070: 0.3 km of road (<1%) – Southern end of Marine Parade between Rua and Tahi Road; 0 Bridges. • 2130: 0.75 km of road (1%) – Southern end of Marine Parade between Toru Road and Rua Road, road end at Ngapotiki Street; Isolated stretch of Manly Street; 0 Bridges.
Currently exposed to coastal flooding • 0.25 km of road (<1%) – Mainly effects Makora Road, Otaihanga) • 3 bridges	Future exposure: • 2050: 0.5 km of road (1%) Mainly effects Makora Road, Otaihanga). Isolation of properties in Otaihanga Domain. • 2070: 3.2 km of road (3%) Isolated areas of Tutere Street, Waikanae; Makora Road, Otaihnaga; Te Kupe Road, Paraparaumu. • 2130: 17.6 km of road (19%) Access to Waikanae along Te Moana road impacted, access between Peka Peka and Waikanae along Huiawa street impacted; Access to properties in Otaihanga around Makora Road cut off; Access to properties around northern Paraparaumu (Te Kupe Road; Manly Street) cut off.

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	M	M	E

Note:

- Exposure rankings for Coastal Erosion is calculated as a percentage of the effected road length of the total road length (90.5 km) in the CAA.
- Exposure ranking for Coastal Flooding additionally considers loss of access inland.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	H	H	E
Coastal Flooding	L	H	E	E

Notes:

- Sensitivity to coastal erosion is based where the effected area of road is, and if it would impact accessability to properties and key routes. In the CAA, erosion could impact the southern end of marine parade which could hinder access to properties and access along to Raumati; however the remainder of the CAA remains accessable.
- Sensitivity to coastal flooding is based on potential depth of flooding which affects accessibility and the amount of damage to roads and bridges and the importance of the road for access to the community from outside the hazard area.

Sample inspections of the potential depths of flooding have been used to guide the hazard classe through reference to the combined flood hazard curves of the Australian Rainfall and Runoff Guide (Ball J. et al, 2019):

- Depth less than 0.3 m = Low hazard (generally safe for people and vehicles)
- Depth 0.3 m to 0.5 m = Medium hazard (unsafe for small vehicles)
- Depth greater than 0.5 m = High hazard (unsafe for large vehicles)

The importance of the road has been used with hazard class to assign the sensitivity to flooding – if a road is of low importance (not essential for access or evacuation) the hazard class (low/medium/high) is adopted for the sensitivity rating. If the road is of high importance (essential for access or evacuation) a sensitivity rating of one level higher than the hazrd class is assigned. E.G. A road of high importance exposed to 'medium' hazard is assigned a 'high' sensitivity rating. The presence of features which may prevent or reduce flooding of roads such as a stopbank, dune or stormwater management structures has then be used to moderate the rating if appropriate. These factors are considered through visual inspection and judgement of the hazard data.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Roads and bridges do not have any natural adaptive capacity.
Coastal Flooding	L	Roads and bridges do not have any natural adaptive capacity. Although they can be raised to adapt to increasing flood levels this can conflict with other infrastructure.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	H	H	E	L	M	H	H	E
Flooding	L	H	E	E	L	L	H	E	E

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	M	H	H	E	L	L	L	M
Risk from Flooding	L	M	M	E	L	H	E	E	L	M	H	E

A.1.6 Stormwater Infrastructure

Domain	Element at Risk	Overview
Built Environment	Stormwater Infrastructure	Stormwater infrastructure is council infrastructure used to control and discharge stormwater throughout the district. Infrastructure assessed in this category includes: Pump stations, Stormwater pipes, and Stormwater outfalls. Within the CAA there is 71.3 km of stormwater network pipes, 28 stormwater outfalls (direct to the coast), and four pump stations (two on Tutere Street, two in Paraparaumu). Data used to assess stormwater infrastructure was supplied by KCDC.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Erosion of stormwater infrastructure would result in exposure, undermining, and damage to the infrastructure. Erosion around stormwater outfalls on the open coast or in dynamic fluvial environments will result in undermining of the outfall, which can result in damage to the end of the outfall (i.e. breaking if not supported). If severely damaged in a large event, if could have a cascading impact on the flood hazard if the outfall is unable to efficiently discharge the stormwater to the sea.
Coastal Flooding	Stormwater outfalls and pipe mains are generally resilient to flooding although they do provide pathways for coastal flooding to inland areas. The electrical power supply and controlsystems for stormwater pumpstations can be damaged by surface flooding if this is sufficiently deep, causing the pump station to fail to operate during a storm event and so increasing flood hazard and requiring repair or replacement.

Opportunities

Hazard	Opportunities
Coastal Erosion	Upgrades to stormwater infrastructure as part of the LTP could incorporate designs which are more resilient to coastal erosion in the future to avoid exposure and failure.
Coastal Flooding	Stormwater upgrades can include measures to prevent inland flooding from coastal storms (e.g., non-return valves) and increased resilience of pump stations to surface flooding.

A.1.6.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion • Short lengths of outfall pipe currently exposed to storm erosion. • 21 Stormwater outfalls exposed.	Future exposure: • 2050: o 480 m of stormwater pipe - 1% of total network, mostly outfall pipes to the sea, no major disruptions to the network. Outfalls at Marine Parade and Manly Street become more exposed. o 21 stormwater outfalls exposed o No pump stations • 2070: o 540 m of stormwater pipe (1% of total network), no major disruptions to the network. Outfalls at Marine Parade and Manly Street become more exposed, and increasing exposure of outfalls at Waikanae beach. o 22 stormwater outfalls exposed o No pump stations • 2130: o 802 m of stormwater pipe (1% of total network), significant exposure of stormwater outfalls along Mainre Parade, northern end of Manly Street. Increasing exposure to three areas of outfall pipes at Waikanae Beach. o 24 stormwater outfalls exposed o No pump stations
Currently exposed to coastal flooding • No pump stations exposed to flooding.	Future exposure: • 2050: None • 2070: One pump station exposed (Northern Tuture Street) • 2130: Two pump stations exposed, both in Waikanae.

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	M	M
Coastal Flooding	L	L	M	H

Note:

- Exposure ranking for coastal flooding only considers stormwater pumpstations (pipes and outfalls are considered resilient).
- Exposure ranking for coastal erosion is based on total pipe length within the Central Adaptation Area. However, it is noted that stormwater outfall pipes are particularly exposed now due to their locality on the coast, and in the future. The exposure ranking increases in 2070 and 2130 to account for the continued exposure of these key pieces of infrastructure in which the erosion to these structures by that time could lead to some failure due to increased exposure

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	M	H
Coastal Flooding	L	L	M	H

Notes:

- For coastal erosion, sensitivity considers the increasing exposure of the infrastructure over the 100 year timeframe, where more exposure indicates the pipes will be more susceptible to damage and failure, and therefore effect their ablity to discharge water effectively in storms. Most stormwater pipes impacted are perpendicular to the coast, and therefore as long as the pipe can still discharge the catchment will still be able to be drained. Erosion may cause the pipe to need to be shortened, however until pipes that run parallel to the coast are impacted, the sensitivity is considered moderate as it becomes a maintenance issue, rather than a network disruption.
- For coastal flooding, sensitivity considers the potential depth of flooding at pump stations and effects on above ground equipment.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Stormwater pipes have no natural adaptive capacity. However, exposed ends of the pipes could be cut back to allow for continued support along the shoreline.
Coastal Flooding	M	Flood protection to power supply and controls can be implemented relatively readily

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	M	M	H	L	M	M	M	H
Flooding	L	L	M	H	M	L	L	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	M	M	M	M	M	H	L	L	M	M
Risk from Flooding	L	L	M	H	L	L	M	M	L	L	M	M

A.1.6.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion • 0 m of stormwater pipes • 21 Stormwater outfalls exposed.	Future exposure: • 2050: o 480 m of stormwater pipe - 2% of total network, mostly outfall pipes to the sea, no major disruptions to the network. Outfalls at Marine Parade and Manly Street become more exposed. o 21 stormwater outfalls exposed o No pump stations • 2070: o 650 m of stormwater pipe (1% of total network) no major disruptions to the network. Outfalls at Marine Parade and Manly Street become more exposed, and increasing exposure of outfalls at Waikanae beach. o 22 stormwater outfalls exposed o No pump stations • 2130: o 1440 m of stormwater pipe (2% of total network) – outfall pipes along Waikanae Beach, Northern Paraparaumu (Manly street); and Southern Paraparaumu along Marine Parade all impacted. o 27 stormwater outfalls exposed o No pump stations
Currently exposed to coastal flooding • No pump stations exposed to flooding.	Future exposure: • 2050: None • 2070: One pump station exposed (Northern Tuture Street) • 2130: Two pump stations exposed, both in Waikanae.

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	M	H
Coastal Flooding	L	L	M	H

Note:

- Exposure ranking for coastal flooding only considers stormwater pumpstations (pipes and outfalls are considered resilient).
- Exposure ranking for coastal erosion is based on total pipe length within the Northen Adaptation Area. However, it is noted that stormwater outfall pipes are particularly exposed now due to their locality on the coast, and in the future. The exposure ranking increases in 2070 and 2130 to account for the continued exposure of these key pieces of infrastructure in which the erosion to these structures by that time could lead to some failure due to increased exposure

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	M	H
Coastal Flooding	L	L	H	H

Notes:

- For coastal erosion, sensitivity considers the increasing exposure of the infrastructure over the 100 year timeframe, where more exposure indicates the pipes will be more susceptible to damage and failure, and therefore effect their ablity to discharge water effectively in storms. Most stormwater pipes impacted are perpendicular to the coast, and therefore as long as the pipe can still discharge the catchment will still be able to be drained. Erosion may cause the pipe to need to be shortened, however until pipes that run parallel to the coast are impacted, the sensitivity is considered moderate as it becomes a maintenance issue, rathr than a network disruption.
- For coastal flooding, sensitivity considers the potential depth of flooding at pump stations and effects on above ground equipment.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Stormwater pipes have no natural adaptive capacity. However, exposed ends of the pipes could be cut back to allow for continued support along the shoreline.
Coastal Flooding	M	Flood protection to power supply and controls can be implemented relatively readily

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	M	M	H	L	M	M	M	H
Flooding	L	L	H	H	M	L	L	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	M	H	M	M	M	H	L	L	M	H
Risk from Flooding	L	L	M	H	L	L	M	M	L	L	M	M

A.1.7 Wastewater Infrastructure

Domain	Element at Risk	Overview
Built Environment	Wastewater Infrastructure	Public wastewater infrastructure in the CAA includes wastewater pump stations (25) and the wastewater pipe network (115.4 km). There are no wastewater treatment plants identified in the CAA.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Erosion of wastewater pipes could lead to exposure and damage to the pipes. Erosion of the land surrounding the pipe would leave the pipe unsupported. Continued exposure could lead to failure of the pipe and cause contaminants enter the coastal environment. If a wastewater pump station was exposed to erosion, the structure would likely be undermined and fail, which could have cascading impacts into the broader waste collection network if it cannot be naturally carried to the treatment plant. Generally, the wastewater network pipes are on the landward side of properties; however the network that services properties along Marine Parade is located seaward of properties – indicating that the network could be impacted before the properties it services are impacted. Generally network running adjacent to the shoreline was installed in 1970-1980. Consequences of damage to these networks can be very high and result in spread of human disease and infection. Breakdown of the network will result in some properties no longer being able to be serviced.
Coastal Flooding	Wastewater pipe mains are generally resilient to flooding although they are susceptible to ingress of floodwater and consequent polluted flood water. The electrical power supply and control systems for stormwater pump stations can be damaged by surface flooding if this is sufficiently deep, causing the pump station to fail to operate during a storm event increasing foul flood hazard and requiring repair or replacement.

Opportunities

Hazard	Opportunities
Coastal Erosion	There is likely to be upgrades to some of the wastewater network as part of the LTP and asset management plan. Pipes affected by erosion in the 50-100-year timeframe are asbestos cement pipes or PVC pipes installed in 1970-1980's, so will be likely to need renewing prior to the 100-year timeframe when they would be affected. New designs can better account for the interaction of the infrastructure with sea level rise and coastal hazards in the future.
Coastal Flooding	Wastewater upgrades can include measures to increase the resilience of pump stations to surface flooding.

A.1.7.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion • No pumping stations are currently exposed. • 240 m of wastewater pipes are currently could be exposed during storms (Marine Parade, between Rua Road and Tahi Road).	Future exposure: • 2050: o No pumping stations are currently exposed o 240 m (<1%) of wastewater pipe could be exposed (Marine Parade, between Rua Road and Tahi Road) • 2070: o No pumping stations are exposed. o 280 m (<1%) of wastewater pipe could be exposed (Marine Parade, between Rua Road and Tahi Road). • 2130: o No pumping stations are exposed o 450 m (<1%) of wastewater pipe could be exposed - Marine Parade, between Toru Road and Tahi Road; isolated area along Manly Street.
Currently exposed to coastal flooding • 1 pump station (of 25)	Future exposure: • 2050: 2 pump station (of 25) • 2070: 2 pump station (of 25) • 2130: 6 pump station (of 25)

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	L	L	M

Note: It is considered that wastewater networks pipes will be resilient to flooding, and therefore exposure ranking is largely weighted by exposure of pump stations.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	E	E	E	E
Coastal Flooding	L	L	L	M

Note:

- Erosion would result in undermining and damage to the structure, and would result in a break in the network, with flow on effects to the human domain. Therefore, damage/breakage in the network would be considered extreme, as the pipes service a greater number of properties than those that are directly impacted.
- For flooding, sensitivity takes account of relative proportion of properties dependent on pump stations.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	No natural capacity for the wastewater network pipes to adapt. See note about opportunities to upgrade.
Coastal Flooding	M	Flood protection to power supply and controls for pump stations can be implemented relatively readily and remainder of infrastructure relatively resilient to flooding

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	E	E	E	E	L	E	E	E	E
Flooding	L	L	L	M	M	L	L	L	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	E	E	E	E	M	M	M	M
Risk from Flooding	L	L	L	M	L	L	L	M	L	L	L	M

A.1.7.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion • No pumping stations are currently exposed. • 240 m of wastewater pipes are currently could be exposed during storms (Marine Parade, between Rua Road and Tahi Road).	Future exposure: • 2050: o No pumping stations are currently exposed o 240 m (<1%) of wastewater pipe could be exposed (Marine Parade, between Rua Road and Tahi Road) • 2070: o No pumping stations are exposed. o 350 m (<1%) of wastewater pipe could be exposed (Marine Parade, between Rua Road and Tahi Road). • 2130: o No pumping stations are exposed o 830 m (1%) of wastewater pipe could be exposed - Marine Parade, between Toru Road and Tahi Road; isolated area along Manly Street.
Currently exposed to coastal flooding • 1 pump station (of 25)	Future exposure: • 2050: 2 pump station (of 25) • 2070: 3 pump station (of 25) • 2130: 9 pump station (of 25)

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	L	L	M

Note: It is considered that wastewater networks pipes will be resilient to flooding, and therefore exposure ranking is largely weighted by exposure of pump stations.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	E	E	E	E
Coastal Flooding	L	L	L	H

Note:

- Erosion would result in undermining and damage to the structure, and would result in a break in the network, with flow on effects to the human domain. Therefore, damage/breakage in the network would be considered extreme, as the pipes service a greater number of properties than those that are directly impacted.
- For flooding, sensitivity takes account of relative proportion of properties dependent on pump stations.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	No natural capacity for the wastewater network pipes to adapt. See note about opportunities to upgrade.
Coastal Flooding	M	Flood protection to power supply and controls for pump stations can be implemented relatively readily and remainder of infrastructure relatively resilient to flooding

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	E	E	E	E	L	E	E	E	E
Flooding	L	L	L	H	M	L	L	L	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	E	E	E	E	M	M	M	M
Risk from Flooding	L	L	L	M	L	L	L	M	L	L	L	M

A.1.8 Water Supply Infrastructure

Domain	Element at Risk	Overview
Built Environment	Water Supply Infrastructure	Water supply infrastructure in the CAA is the infrastructure used to service the treatment and supply of water to properties. For this assessment, this includes water supply service pipes and water supply bores; there was no identified pump stations or water treatment plants within the CAA area. In the CAA there is: - 157.5 km of water supply pipes - 38 water supply bores Nearby reservoirs and pump stations are generally located landward of SH1 outside of the CAA.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Exposure of water supply infrastructure to coastal erosion would generally result in damage to the infrastructure as a result of undermining and eventual failure of the structure. Damage to water supply pipes would result in loss in water supply to some properties within CAA, and could cause disruption to the wider network if pipes were damaged at critical points (i.e. along sections which connected the total network). The water supply network in the CAA is very extensive, and it is likely that small disruptions would not break the total network. Loss of water supply will affect individual properties and would likely lead to affects on people health as a result of loss of water for drinking and cleaning, and could have severe consequences to one's wellbeing. Generally, the water supply network pipes are located landward of private properties, and therefore erosion would result in damage to properties before the network itself, except for where it services houses along Marine Parade, south of Tikotu Stream.
Coastal Flooding	Water supply pipes are generally resilient to flooding provided pressure is maintained in the network. Power supply and controls at pump stations can be damaged by flooding resulting in interruption of supply and repair or replacement. Consequent loss of network pressure can result in contamination of supply from flood water. Bore supplies may be contaminated by flood water.

Opportunities

Hazard	Opportunities
Coastal Erosion	Many of the coastal water supply pipes were installed in 1970's-1980's (cement asbestos or PVC) and therefore are likely to need upgrading prior to erosion becoming an issue. There is an opportunity for the network to be realigned and incorporate design to accommodate/avoid coastal erosion in the future.
Coastal Flooding	Future upgrades to network and infrastructure could include further protection from flooding if required.

A.1.8.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	

Currently exposed to coastal erosion
• 0 m water supply pipes
• 0 water supply bores
	Future exposure:
	• 2050:
	  ○ 140 m water supply pipes (<1%) (Marine Parade between Rua Road and Tahi Road)
	  ○ 0 water supply bores
	• 2070:
	  ○ 150 m water supply pipes (<1%) (Marine Parade between Rua Road and Tahi Road)
	  ○ 0 water supply bores
	• 2130:
	  ○ 360 m water supply pipes (<1%) (Marine Parade between Rua Road and Tahi Road)
	  ○ 0 water supply bores

Currently exposed to coastal flooding • 0 water supply bores	Future exposure: • 2050: 1 water supply bore (3%) • 2070: 2 water supply bore (5%) • 2130: 5 water supply bores (13%)

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	L	L	L

Note: For exposure to flooding, only water supply bores have been considered and it is assumed the water supply pipe network is resilient to flooding. Reservoirs and pump stations do not appear in the CAA and therefore are not assessed.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	L	H	H	H
Coastal Flooding	L	L	L	M

Notes: For coastal erosion, supply pipes that are exposed are connecting pipes within the network could be damaged and break, and would therefore have a cascading effect on water supply to nearby houses within the area. Due to the extensive nature of the network, disruption is likely to directly impact a smaller number of houses relative to the total CAA; and therefore is considered high and not extreme.

Sensisitivity of water supply bores is weighted by how many properties could be impacted by contamination of the water supply bore. Given the flood is event driven, contamination is like to be temporary.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Water supply infrastructure does not have any natural adaptive capacity. See note in opportunities about potential for realignment to avoid hazards in future.
Coastal Flooding	M	Water supply bores could be easily floodproofed.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	L	H	H	H	L	L	H	H	H
Flooding	L	L	L	M	M	L	L	L	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	L	H	H	H	L	L	L	L
Risk from Flooding	L	L	L	L	L	L	L	M	L	L	L	L

A.1.8.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	

Currently exposed to coastal erosion
• 0 m water supply pipes
• 0 water supply bores
	Future exposure:
	• 2050:
	  ○ 140 m water supply pipes (<1%) (Marine Parade between Rua Road and Tahi Road)
	  ○ 0 water supply bores
	• 2070:
	  ○ 240 m water supply pipes (<1%) (Marine Parade between Rua Road and Tahi Road)
	  ○ 0 water supply bores
	• 2130:
	  ○ 465 m water supply pipes (<1%) (Marine Parade between Rua Road and Tahi Road)
	  ○ 1 water supply bore (3%) (Te Kowhai Stream, Waikanae)

Currently exposed to coastal flooding • 0 water supply bores	Future exposure: • 2050: 1 water supply bore (3%) • 2070: 2 water supply bores (5%) • 2130: 10 water supply bores (26%)

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	L	L	M

Note: For exposure to flooding, only water supply bores have been considered and it is assumed the water supply pipe network is resilient to flooding. Reservoirs and pump stations do not appear in the CAA and therefore are not assessed.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	L	H	H	E
Coastal Flooding	L	L	L	H

Notes:

- For coastal erosion, supply pipes that are exposed are connecting pipes within the network could be damaged and break, and would therefore have a cascading effect on water supply to nearby houses within the area. Due to the extensive nature of the network, disruption is likely to directly impact a smaller number of houses relative to the total CAA; and therefore is considered high and not extreme over the 2050-2070 period; but increasing the Extreme over 2130 due to the high number of properties that would be impacted.
- Sensisitivity of water supply bores is weighted by how many properties could be impacted by contamination of the water supply bore. Given the flood is event driven, contamination is like to be temporary.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Water supply infrastructure does not have any natural adaptive capacity. See note in opportunities about potential for realignment to avoid hazards in future.
Coastal Flooding	M	Water supply bores could be easily floodproofed.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	L	H	H	E	L	L	H	H	E
Flooding	L	L	L	H	M	L	L	L	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	L	H	H	E	L	L	L	M
Risk from Flooding	L	L	L	M	L	L	L	M	L	L	L	M

A.1.9 Natural Gas Supply Mains

Domain	Element at Risk	Overview
Built Environment	Natural Gas Supply Mains	Natural gas that is piped directly to homes/business, supplied by 'First Gas' on the Kāpiti Coast. Information about the location of existing gas supply mains was obtained from the First Gas website (https://firstgas.co.nz/connecting-natural-gas/connection-process/check-availability/). These supply mains are generally robust concealed underground pipes which would require high disturbance to cause damage. This assessment uses the Gas supply mains network to indicate potential exposure to the hazard. In the CAA there is 91.6 km of gas supply mains throughout the area.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Erosion of natural gas supply mains would result in exposing, undermining, and potential damage to the pipe. Damage to a gas pipeline could result in escaping gas, which can ignite and cause serious harm to life and property.
Coastal Flooding	Buried gas pipelines are relatively resilient to flooding.

Opportunities

Hazard	Opportunities
Coastal Erosion	Future upgrades to the network and infrastructure could inclue re-routing to avoid future erosion risks.
Coastal Flooding	Future upgrades to the network and infrastructure could inclue further protection from flooding if required to reduce risk.

A.1.9.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion • No natural gas supply mains effected at present.	Future exposure: • 2050: 130 m (Southern end of Marine Parade) (<1%) • 2070: 150 m (Southern end of Marine Parade) (<1%) • 2130: 260 m (Southern end of Marine Parade; Manly Street) (<1%)
Currently exposed to coastal flooding • At present, 200 m of supply mains could be inundated.	Future exposure: • 2050: 0.4 km (<1%) • 2070: 0.9 km (1%) • 2130: 5.7 km (6%)

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	L	L	L

Note:

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	L	E	E	E
Coastal Flooding	L	L	L	L

Notes: Gas mains will be generally resilient to flooding, and therefore the sensitivity is considered to be low.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Natural gas supply mains do not have any natural adaptive capacity. See note in opportunities about potential for realignment to avoid hazards in future.
Coastal Flooding	L	No natural adaptive capacity of gas supply mains.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	L	E	E	E	L	L	E	E	E
Flooding	L	L	L	L	L	L	L	L	L

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	L	E	E	E	L	M	M	M
Risk from Flooding	L	L	L	L	L	L	L	L	L	L	L	L

A.1.9.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion • No natural gas supply mains effected at present.	Future exposure: • 2050: 130 m (Southern end of Marine Parade) (<1%) • 2070: 170 m (Southern end of Marine Parade) (<1%) • 2130: 530 m (Southern end of Marine Parade, Manly Street) (1%)
Currently exposed to coastal flooding • At present, 200 m of supply mains could be inundated.	Future exposure: • 2050: 0.4 km (<1%) • 2070: 1.5 km (2%) • 2130: 12.5 km (14%)

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	L	L	L

Note: Gas mains will be generally resilient to flooding, and therefore the sensitivity is considered to be low.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	L	E	E	E
Coastal Flooding	L	L	L	L

Notes: Gas mains will be generally resilient to flooding, and therefore the sensitivity is considered to be low.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Natural gas supply mains do not have any natural adaptive capacity. See note in opportunities about potential for realignment to avoid hazards in future.
Coastal Flooding	L	No natural adaptive capacity of gas supply mains.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	L	E	E	E	L	L	E	E	E
Flooding	L	L	L	L	L	L	L	L	L

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	L	E	E	E	L	M	M	M
Risk from Flooding	L	L	L	L	L	L	L	L	L	L	L	L

A.1.10 Electrical transmission and supply infrastructure

Domain	Element at Risk	Overview
Built Environment	Electrical transmission and supply infrastructure	Electrical transmission through the Kāpiti Coast is supplied by Electra Energy. Electrical transmission infrastructure assessed includes distribution transformers; overhead and underground transmission lines; and substation zones. In the CAA there is: - 142 distribution transformers (which convert electricity from 11kV to 230 V for distribution to all households) – approximately 30% of these are ground mounted and the remainder are pole mounted. - 420 km of underground lines (11kV) - 103 km of overhead lines (11kV) Data was also obtained for the location of substations, however no substations are located within the CAA and therefore have not been assessed.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	The consequence of erosion to electricity transmission infrastructure could result in damage and eventual failure of the infrastructure. This would typically occur when the infrastructure is undermined due to the loss of support around the structure, and result in failure. For distribution transformers, loss of these structures due to erosion would result in electricity loss to households that the transformer was supplying. The number on households effected will vary depending how many households the transformer was servicing. The exposure of underground transmission lines would result in exposure and damage, and could potentially cut off transmission to larger groups of houses than the transformers are supplying. Exposure of the cables is also likely to result in significant health and safety issues in the surrounding area. The exposure of overhead transmission lines to erosion has little consequence due to being elevated far above ground level, and therefore would not interact, however the adjoining power poles exposure to erosion could result in structural failure and damage to the overhead lines. It is assumed that erosion of a property would result in the loss of electricity supply to that individual property.
Coastal Flooding	Overhead and underground transmission lines and pole mounted distribution transformers are relatively resilient to flooding. Ground mounted distribution transformers are vulnerable to flooding which can cause short circuits, loss of supply to properties and damage to the transformer if depth exceeds the height of critical equipment. Erosion or subsidence of the foundations of electricity transmission towers and poles could cause collapse, breakage of power lines and loss of supply.

Opportunities

Hazard	Opportunities
Coastal Erosion	Potential for cables to need to be upgraded in the future, which could provide opportunity for realignment of infrastructure away from the erosion hazard or more resilience built into design. Cables exposed over 100 years were installed as early as the 1970's, so may require upgrading prior to being exposed to coastal erosion.
Coastal Flooding	Routine upgrade of equipment can include floodproofing measures

A.1.10.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion: • No distribution transformers are exposed; • No underground transmission lines are exposed; and • No overhead tranmission lines are exposed.	Future exposure: • 2050: o No distribution transformers are exposed; o 30 m (<1%) underground transmission lines are exposed; and o 305 m (<1%) overhead tranmission lines are exposed. • 2070: o No distribution transformers are exposed; o 280 m (<1%) underground transmission lines are exposed; and o 320 m (<1%) overhead tranmission lines are exposed. • 2130: o No distribution transformers are exposed; o 860 m (<1%) underground transmission lines are exposed; and o 360 m (<1%) overhead tranmission lines are exposed.
Currently exposed to coastal flooding • 0 ground mounted distribution transformer	Future exposure: • 2050: 0 ground mounted distribution transformers • 2070: 0 ground mounted distribution transformers • 2130: 8 (29%) ground mounted distribution transformers

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	L	L	M

Note:

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	L	E	E	E
Coastal Flooding	L	L	L	H

Notes:

- Sensisitivity is based the consequence of the loss/damage to transmission infrastructure as it becomes exposed to the hazard. Exposure and damage would cause disruption to the network and could result in larger sections of the community being cut off from the transmission line, as well as healthy and safety risks from the line being exposed. Hence, if the infrastructure is not exposed to erosion then the

sensitivity is considered to be low; however when it becomes exposed it is considered to be extremely sensitive.

- For flooding, sensitivity considers depth of flood water at transformers and a typical protection level of 0.3 m for surface water flooding.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Electrical transmision lines and infrastructure has no natural adaptive capcity. See note on opportunities for potential realignment.
Coastal Flooding	M	Resilience of ground mounted transformers can be increased through flood proofing or raising pad level.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	L	E	E	E	L	L	E	E	E
Flooding	L	L	L	H	M	L	L	L	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	L	E	E	E	L	M	M	M
Risk from Flooding	L	L	L	M	L	L	L	M	L	L	L	M

A.1.10.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion: • No distribution transformers are exposed; • No underground transmission lines are exposed; and • No overhead tranmission lines are exposed.	Future exposure: • 2050: o No distribution transformers are exposed; o 30 m (<1%) underground transmission lines are exposed; and o 305 m (<1%) overhead tranmission lines are exposed. • 2070: o No distribution transformers are exposed; o 420 m (<1%) underground transmission lines are exposed; and o 325 m (<1%) overhead tranmission lines are exposed. • 2130: o One distribution transformers is exposed (Manly Street, Paraparaumu); o 2.9 km (1%) underground transmission lines are exposed; and o 450 m (1%) overhead tranmission lines are exposed.
Currently exposed to coastal flooding • 0 ground mounted distribution transformer	Future exposure: • 2050: 0 ground mounted distribution transformers • 2070: 1 ground mounted distribution transformers • 2130: 20 (42%) ground mounted distribution transformers

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	L	L	M

Note: For flood exposure, it is assumed transmission lines are resilient to flood hazards, and only distribution transformers have been assessed.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	L	E	E	E
Coastal Flooding	L	L	H	H

Notes:

- Sensisitivity is based the consequence of the loss/damage to transmission infrastructure as it becomes exposed to the hazard. Exposure and damage would cause disruption to the network and could result in larger sections of the community being cut off from the transmission line, as well as healthy and safety

risks from the line being exposed. Hence, if the infrastructure is not exposed to erosion then the sensitivity is considered to be low; however when it becomes exposed it is considered to be extremely sensitive.

- For flooding, sensitivity considers depth of flood water at transformers and a typical protection level of 0.3 m for surface water flooding.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Electrical transmision lines and infrastructure has no natural adaptive capcity. See note on opportunities for potential realignment.
Coastal Flooding	M	Resilience of ground mounted transformers can be increased through flood proofing or raising pad level.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	L	E	E	E	L	L	E	E	E
Flooding	L	L	H	H	M	L	L	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	L	E	E	E	L	M	M	M
Risk from Flooding	L	L	L	M	L	L	M	M	L	L	L	M

A.2 Human Risk Assessment Templates

A.2.1 Physical human health

Domain	Element at Risk	Overview
Human	Risks to physical health	Risks to physical health from collapse of/damage to infrastructure and homes, exposure to coastal flooding/inundation and the potential for water-borne disease, issues with water quality, availability, and accessibility due to changes or disruption to essential services.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Physical risk to life and health from erosion event. For example, sudden collapse of infrastructure, community assets, and homes leading to dangerous physical environments, and/or damage to stormwater and wastewater services (like stormwater outfalls, wastewater pipes and pumps) and subsequent exposure to pathogens and contaminants (for example, for beach users/swimmers).
Coastal Flooding	Risk to life and health resulting from periodic inundation of properties and coastal areas with sea water. This may include risk of being washed away or isolated in homes and unable to escape (which could lead to drowning/injury). Additionally, if waste-, storm-, or drinking water supply systems (pipes, bores, pumping stations, etc) are overwhelmed or damaged, people may be exposed to pathogens and contaminants in flood waters or drinking water, with subsequent risk of illness. Risk of water contamination to those recreating in the area may extend beyond the initial event, for example, lingering contamination for swimmers.

Opportunities

Hazard	Opportunities
Coastal Erosion	Reconfigure aging assets and infrastructure away from areas at risk, creating new fit-for-purpose services.
Coastal Flooding	Reconfigure aging assets and infrastructure away from areas at risk and/or remediate/update/enhance robustness of assets, creating new fit-for-purpose services.

A.2.1.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion • Currently, no properties in the adaptation area are exposed to coastal erosion • At present, 21 stormwater outfalls, short lengths of stormwater outfall pipe, 240m of wastewater pipes, and no water supply pipes or bores are at risk of erosion.	Future exposure • By 2050 <1% of properties (n= 34) in the adaptation area will be exposed to erosion and potentially at risk of collapse and loss of water and wastewater services, with associated risks for occupants and those recreating in the area. Properties cluster around Waikanae's Waimeha Stream (which accounts for 76% of all erosion affected properties in the CAA at this time) • By 2070 the number of properties in the CAA at risk (n=61) increases slightly (1% of all properties in the adaptation area). In addition to Waimeha Stream area, affected properties cluster around the northern end of Manly Street (Paraparaumu Beach) – approx 51% of affected properties in the CAA in 2070 – and Marine Parade in the southern end of the CAA • By 2130 the number of private properties in the CAA at risk of coastal erosion increases (n=129 or 2% of all properties), with more widespread effects in the locations listed above. • The Kāpiti Rest Home is located on Marine Parade, Paraparaumu, and is directly affected by erosion from 2070 onwards. • The Coastguard building is directly affected by erosion from 2050 onwards, which poses a risk to public safety if nothing is done to relocate/protect the building (reduced capacity to respond to local emergency incidents in the water) • Increasing amounts of water service pipes and points, stormwater pipes and points, and wastewater pipes and points in the CAA are exposed to coastal erosion as time progresses. However, these impacts (even by 2130) are quite localised to Marine Parade and affect less than 1% of the respective networks.
Currently exposed to coastal inundation/flooding • 4% of properties (n= 287) in the adaptation area are currently exposed to flooding with subsequent risks for residents of being isolated in their homes and experiencing water and waste water service loss. • Current flooding extent presents no risk to stormwater or water supply infrastructure in	Future exposure • By 2050 7% of properties (n=505) in the adaptation areas are exposed to periodic flooding, which could present risks for residents of being isolated in their homes and experiencing wastewater service and drinking supply loss. Of these 505 properties, approximately 42% (210) are located in Waikanae

Details of exposure	
the CAA, but 1 of 2 wastewater pumping stations are exposed with risk of exposure of CAA residents to contaminated water during inundation events	• By 2070 the % of properties at risk in the CAA (n=720) increases to 10% • By 2130 22% of private properties in the CAA are at risk of coastal flooding (n=1552). By this time, approximately 46% of the total impacted properties (n=721) are located in Waikanae, and approximately 41% (N=692) are in Paraparaumu • The remain 13% of impacted properties are within Otaihanga (n=139), which equates to 44% of all properties within the Otaihanga community. • By 2070, one stormwater pump station in the CAA is exposed, and by 2130, two (in Waikanae) are exposed, which magnifies the risk that floodwaters cannot be pumped away, with associated risk of injury, death, and exposure to contamination • The risk to wastewater pumping stations increases from 2 (of 25) in 2050 to 6 (of 25) by 2130, with consequent risks of contamination of flood water and vector-borne disease. • Over time there are increasing levels of flood risk (and therefore contamination of supply) for water supply bores. In 2050, 3% are at risk (1 bore), by 2070, 5% (2 bores) and by 2130 13% (5 bores).

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	M	M	H

Notes:

The percentage of the overall number of properties exposed to erosion is small compared to the total number of properties in the adaptation area. However, the percentage of homes exposed to erosion in certain areas (such as Waikanae and Paraparaumu) is much higher. In particular, the exposure covers beachfront properties along Marine Parade and Waimeha Stream in Waikanae. There is moderate exposure of properties to inundation and again, these tend to cluster throughout Waikanae and Paraparaumu.

Although erosion will impact on a relatively small percentage of the storm-, waste-water, and moderate amounts of drinking water supply networks, impacts are generally concentrated in one particular area (Waikanae Beach, Marine Parade, Manly Rd) and could have serious health implications for those in the immediate vicinity and further afield.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	M	M
Coastal Flooding	H	H	H	H

Notes:

Sensitivity is related to the impact of exposure to pathogens and contaminants in water (which may result in sickness, injury or death), the ability to move out of harms way quickly (e.g. in the events of a collapse or flood), and the implications of loss of water servies and supply on residents.

Because of their physiology, older and younger residents are likely to be more sensitive to harm from water contamination, have lowered capacity to move away from collapse events and floodwaters, and could be

more acutely In the central adaptation area approximately 25% of residents were aged over 65 in 2018 (which is higher than the national average of 15.2% (EHINZ 2018)) and 5% are below the age of 5 (which is 2.5% below the national average) (Stats NZ infoshare 2018 data). The Kāpiti Rest Home is located on Marine Parade, Paraparaumu, and is directly affected by erosion from 2070 onwards.

Many people in the area use the beach for swimming, fishing, surfing, and walking (KCDC, 2023), which increases potential for people to come into contact with contaminated waters and unstable areas.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	M	There are no co-ordinated adaptation actions, the shore line is allowed to erode People have warning of incidents of erosion and are able to avoid being in the area during times when hazards and damage may be more likely. Once removed from the area of hazard they are no longer exposed or at risk. Residents may be exposed to hazards on return to their homes or at other places (such as the beach), however through careful actions (e.g. listening to local emergency/civil defense/council warnings) the hazard could be avoided Diverting water, electricity and gas supply infrastructure away from erosion-prone areas is possible but could be costly
Coastal Flooding	M	There are no co-ordinated adaptation actions, indundation occurs frequently but intermittently. People have warning of incidents of inundation and are able to avoid being in the area during times when hazards and risks to health may be more likely. Once removed from the area of hazard they are no longer exposed or at risk. Residents may be exposed to hazards on return to their homes or at other places (for example, when recreating at the beach)however through careful actions (e.g. checking weather forecast, listening to local emergency/civil defense warnings) the hazard could be avoided.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	M	M	M	M	M	M	M	M
Flooding	H	H	H	H	M	M	M	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130

	Exposure				Vulnerability				Risk			
Risk from Erosion	L	L	L	L	M	M	M	M	L	L	L	L
Risk from Flooding	L	M	M	H	M	M	M	M	L	M	M	M

A.2.1.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion • Currently, no properties in the adaptation area are exposed to coastal erosion • At present, 21 stormwater outfalls, short lengths of stormwater outfall pipe, 240m of wastewater pipes, and no water supply pipes or bores are at risk of erosion.	Future exposure • By 2050 <1% of properties (n=34) in the adaptation area will be exposed to erosion and potentially at risk of collapse and loss of water and wastewater services, with associated risks for occupants and those recreating in the area. Affected properties cluster around Waimeha Stream in Waikanae (approximately 76% of all erosion-affected properties in the CAA in 2050 are located in this area) • By 2070 the % of properties at risk (n=73) becomes 1%. Affected properties cluster around Waimeha Stream, the northern end of Manly Street (Paraparaumu Beach), and Marine Parade in the southern end of the CAA • By 2130 3% of properties in the CAA are at risk of coastal erosion (n=228), with more widespread impacts to properties in the locations above, plus beachfront properties on Tutere Street (Waikanae). Properties in Waikanae make up 44% of erosion-affected properties in the CAA by 2130, and properties in Paraparaumu make up approximately 38% of erosion affected properties in the CAA • The Kāpiti Rest Home is located on Marine Parade, Paraparaumu, and is directly affected by erosion from 2070 onwards. • The Coastguard building is directly affected by erosion from 2050 onwards, which poses a risk to public safety if nothing is done to relocate/protect the building (reduced capacity to respond to local emergency incidents in the water) • Small but increasing amounts of the stormwater, wastewater and water supplynetworks are affected by erosion in the CAA over time. However, even by 2130, the % of the network affected remains below 2% localised to around Marine Parade.
Currently exposed to coastal inundation/flooding • 4% of properties (n= 287) in the adaptation area are currently exposed to flooding with subsequent risks for residents of being isolated in their homes and experiencing water and waste water service loss. • Current flooding extent presents no risk to stormwater or water supply infrastructure in the CAA, but 1 of 2 wastewater pumping stations are exposed with risk of exposure of	Future exposure • By 2050 7% of properties (n=505) in the adaptation areas are exposed to periodic flooding, which could present risks for residents of being isolated in their homes and experiencing water and wastewater service loss. In 2050, approximately 42% (210) of inundation affected properties in the CAA are located in Waikanae

Details of exposure	
CAA residents to contaminated water during inundation events	• By 2070 the % of properties at risk in the CAA (n=888) increases to 13% • By 2130 31% of private properties are at risk of coastal flooding in the CAA (n=2205). 42% of the total impacted properties (n=926) are located in Waikanae, whilst 51% are within Paraparaumu (n=1120). • Otaihanga has a comparitively smaller number of properties affected by inundation at 2130 (n=159), but when considered as a 50% of all properties within that communty, the number is high. • Stormwater, water supply and wastewater networks are increasingly affected increasing potential exposure to water boure contaminants and disease during inundation evetns. • Risks to stormwater infrastructure comprise impacts to 1 pump station by 2070 and 2 by 2130 (both in Waikanae). • In 2050 and 2070, 2 and 3 waterwater pump stations are impacted. However, 9 of 25 wastewater pumping stations are impacted by coastal flooding by 2130. Oxidation ponds are also exposed to flooding at this time • By 2050 1 water supply bore is impacted.This increases to 2 by 2070 and in 2130 26% of water suppy bores (n=10) are impacted by periodic inundation. • Only small areas of the road network is affected in 2050 and 270, however, by 2130 17.6km of road (19%) in the CAA is affected by periodic inundation. Impacts are expected to be particularly significant on roads leading in/out of Waikanae (e.g. Te Moana Rd, Huiawa St); and properties on Makora Road (Otaihanga), Te Kupe Road and Manly Street (both Paraparaumu) could be intermittantly cut off, creating barriers to evacuation, and placing people in harms way.

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	M	M	H

Notes:

The percentage of the overall number of properties exposed to erosion is small compared to the total number of properties in the adaptation area. However, the percentage of homes exposed to erosion in certain areas (such as Waikanae and Paraparaumu) is still signficant . In particular, the exposure covers beachfront properties along Marine Parade and Waimeha Stream in Waikanae. There is moderate to high exposure of properties to inundation and again, these tend to cluster throughout Waikanae, Paraparaumu, and Otaihanga.

Although erosion will impact on a relatively small percentage of the storm-, waste-waternetworks in the CAA, and moderate amounts of drinking water supply networks, impacts are generally concentrated in one particular area (Waikanae Beach, Marine Parade, Manly Road).

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	M	M
Coastal Flooding	H	H	H	H

Notes:

Sensitivity is related to the impact of exposure to pathogens and contaminants in water (which may result in sickness, injury or death), the ability to move out of harms way quickly (e.g. in the events of a collapse or flood)

Because of their physiology, older and younger residents are likely to be more sensitive to harm from water contamination, have lowered capacity to move away from collapse events and floodwaters,). In the central adaptation area approximately 25% of residents were aged over 65 in 2018 (which is higher than the national average of 15.2% (EHINZ 2018)) and 5% are below the age of 5 (which is 2.5% below the national average) (Stats NZ infoshare 2018 data). The Kāpiti Rest Home is located on Marine Parade, Paraparaumu, and is directly affected by erosion from 2070 onward.

Many people in the area use the beach for swimming, fishing, surfing, and walking (KCDC, 2023), which increases potential for people to come into contact with contaminated waters and unstable areas. Scoring of sensitivity assumes that beach use stays consistent into the future.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	M	There are no co-ordinated adaptation actions, the shore line is allowed to erode People have warning of incidents of erosion and are able to avoid being in the area during times when hazards and damage may be more likely. Once removed from the area of hazard they are no longer exposed or at risk. Residents may be exposed to hazards on return to their homes or at other places (such as the beach), however through careful actions (e.g. listening to local emergency/civil defense/council warnings) the hazard could be avoided Diverting water, electricity and gas supply infrastructure away from erosion-prone areas is possible but could be costly
Coastal Flooding	M	There are no co-ordinated adaptation actions, indundation occurs frequently but intermittently. People have warning of incidents of inundation and are able to avoid being in the area during times when hazards and risks to health may be more likely. Once removed from the area of hazard they are no longer exposed or at risk. Residents may be exposed to hazards on return to their homes or at other places (for example, when recreating around Wainui Stream) however through careful actions (e.g. checking weather forecast, listening to local emergency/civil defense warnings) the hazard could be avoided.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	M	M	M	M	M	M	M	M
Flooding	H	H	H	H	M	M	M	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	M	M	M	M	L	L	L	L
Risk from Flooding	L	M	M	H	M	M	M	M	L	M	M	M

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A.2. Mental health and wellbeing

Domain	Element at Risk	Overview
Human	**Risks to mental health and wellbeing**	Risks to mental health, identity, autonomy and sense of belonging, connections to place and nature, and personal wellbeing from loss and trauma due to ongoing coastal erosion and periodic flooding. This risk relates to the mental health and wellbeing of individuals who may experience ongoing stress, anxiety, depression, grief, feelings of powerlessness, and an altered sense of belonging to a place as coastal erosion and inundation becomes progressively worse. These feelings and experiences may emerge as people navigate loss of, or damage to property, irreversible changes or loss of valued natural places, feeling alone or powerless to affect change, on-going stress of managing damage to property or living in damaged buildings, and worry about the future. It includes the stress associated with disruption to everyday routines and activities, which can impact the ability to function, undertake activities that are enjoyed, and plan for the future.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Stress, anxiety, and trauma associated with the permanent loss of property or ongoing damage to property. This may generate further financial loss (e.g. insurance withdrawal or repair costs) and/or stress and uncertainty regarding the future Loss of or damage to key places and natural systems that provide a sense of identity or belonging, and/or support mental health and wellbeing. For example, the loss of a favorite beach or landscape that generates a sense of distress because a place that you know and love changes and there is relative powerlessness to do anything about it. Further impacts may be experienced on an individual's autonomy as constraints on individuals' options and choices arise, for example, ability to live certain places (e.g. erosion-prone areas), or undertake particular activities (e.g. needing to stay away from erosion-prone areas of the coast that are significant to the individual)
Coastal Flooding	Stress, anxiety, and trauma associated with the loss of property (homes and businesses) or on-going damage to property due to periodic potentially frequent coastal flooding. This may generate further financial loss (e.g. insurance withdrawal or repair costs, loss of stock or business revenue) and/or stress and uncertainty regarding the future. Stress may be associated with being trapped at home or within a small geographic area while coastal flooding recedes, potentially unable to get to work, school, or access other services. Loss of or damage to key places and natural systems that provide a sense of identity or belonging, and/or support mental health and wellbeing. For example, the loss of a favorite beach or landscape that generates a sense of distress because a place that you know and love changes and there is relative powerlessness to do anything about it. Further impacts may be experienced on an individual's autonomy as constraints on individuals' options and choices arise, for example ability to live certain places (flood areas), or undertake particular activities (e.g. walking in flood-prone areas).

Opportunities

Hazard	Opportunities
Coastal Erosion	Create new recreational options and areas away from erosion areas
Coastal Flooding	Create or explore new recreational options and areas away from inundation prone areas

A.2.2.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion • Currently, no properties in the adaptation area are exposed to coastal erosion, therefore risk of loss/damage to buildings is minimal • Beach, Maclean Park, George Pannel Reserve, and Waikanae Beach Domain are currently experiencing erosion, and may present limits on normal use of these places	Future exposure • By 2050 <1% of properties (n= 34) in the adaptation area will be exposed to erosion and potentially at risk of damage, collapse, loss of services, and insurance withdrawal. Properties cluster around Waikanae's Waimeha Stream (which accounts for 76% of all erosion affected properties in the CAA at this time) • By 2070 the number of properties in the CAA at risk (n=61) increases slightly (1% of all properties in the adaptation area). In addition to Waimeha Stream area, affected properties cluster around the northern end of Manly Street (Paraparaumu beach) – approx 51% of affected properties in the CAA in 2070 – and Marine Parade in the southern end of the CAA • By 2130 the number of private properties in the CAA at risk of coastal erosion increases (n=129 or 2% of all properties), with more widespread effects in the locations listed above. • The beach within the adaptation area will be progessively eroded, reducing beach access and impacting those who derive identity and wellbeing from the beach. • Other areas that may provide for residents' mental wellbeing and identity (e.g. the Waikanae Estuary) are also at risk of erosion
Currently exposed to coastal flooding • 4% of properties (n= 287) in the adaptation area are currently exposed to flooding and could be lost or damaged • One business is potentially exposed to periodic flooding in the CAA • Inundation currently affects the beach, Waikanae Golf Course, Waimea Lagoon and Wildlife Refuge, Waimanu Lagoon, The Esplanade, portions of Waikanae River Track, some areas of Waikanae Estuary Scientific Reserve, Otaihanga Domain, and portions of Maclean park, presenting possible limitations on access during inundation events	Future exposure • By 2050 7% of properties (n=505) in the adaptation areas are exposed to periodic flooding, which could present risks for stress and anxiety related to residents being isolated in their homes, experiencing wastewater service and drinking supply loss, and insurance withdrawal. Of these 505 properties, approximately 42% (210) are located in Waikanae • By 2070 the % of properties at risk in the CAA (n=720) increases to 10% • By 2130 22% of private properties in the CAA are at risk of coastal flooding (n=1552). By this time, approximately 46% of the total impacted properties (n=721) are located in Waikanae, and approximately 41% (N=692) are in Paraparaumu

Details of exposure	
	• The remain 13% of impacted properties are within Otaihanga (n=139), which equates to 44% of all properties within the Otaihanga community. • At least 19 businesses in the CAA are at risk of periodic inundation and service loss, with most exposed at 2130 although a few prior (e.g. 2070) • By 2130 coastal inundation reaches further inland, periodically flooding low-lying areas mainly around the beach and waterfront, and waterbodies such as the Waikanae River. • Other areas that may provide for residents' mental wellbeing (e.g. greater lengths of the Waikanae River Track) are at risk of inundation

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	M	M
Coastal Flooding	M	M	M	H

Note:

For exposure, focus is on all the properties within the adaptation area, not just the beach front properties. A focus on just the beach front properties would yield a different result. Exposure of other residents (living away from the beach front and flood-prone areas) is likely due to their connection with the coast and other features of the CAA.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	H	H	H	H
Coastal Flooding	H	H	H	H

Notes:

Loss of property and loss of access to the beach and recreation sites will have a potentially significant effect on residents' mental health and connections to natural spaces for recreation and enjoyment. Research demonstrates that many people globally (Bell et al., 2015; Bryce et al., 2016) and across Aotearoa New Zealand (Cosgriff, 2023; Foley et al., 2019; Foley & Kistemann, 2015; Panelli & Tipa, 2007; Wheaton et al., 2020) derive a sense of wellbeing and mental health from recreating on and near the beach, and many feel their identity and sense of belonging is strongly connected to their community, especially in coastal locations (Chen et al., 2021; Collins & Kearns, 2010, 2013; Floyd, 2023; Murton, 2006; Panelli et al., 2008; Schneider et al., 2017; Waiti & Awatere, 2019; Widener, 2018). The situation is likely to be similar for residents of Waikanae and Paraparaumu given that the Central Adaptation Area Summary (KCDC, 2023) demonstrates that people within the community have a strong emotional affiliation to the area, particularly the beach and coastline, with some noting that it is integral to their sense of identity and belonging.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	There are no co-ordinated adaptation actions, the shore line is allowed to erode.

Domain	Adaptive Capacity	Key Assumptions
		Few actions that can be taken be autonomously are applied on affected properies (can easily adapt as an individual in the long term). When identity and wellbeing is tied up with place, and these places are lost or damaged, coping and adapting is not a straightforward or linear task, and can take a long time and require considerable cognitive and social change to achieve. Special places are not easily replaced since the connections are highly personal, and have been built up over time. Their loss may cause grief and anxiety. Financial barriers to adaptation or relocation may cause significant stress or place an individual in the postion of needing to remain in a continually affected location.
Coastal Flooding	M	There are no coordinated adaptation actions, indundation occurs frequently but intermittently. Some actions that can be taken be autonomously are applied on affected properies (can easily adapt as an individual in the long term). When identity and wellbeing is tied up with place, and these places are lost or damaged, coping and adapting is not a straightforward or linear task, and can take a long time and require considerable cognitive and social change to achieve. Special places are not easily replaced since the connections are highly personal, and have been built up over time. Their loss may cause grief and anxiety. Financial barriers to adaptation or relocation may cause significant stress or place an individual in the postion of needing to remain in a continually affected location.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	H	H	H	H	L	H	H	H	H
Flooding	H	H	H	H	M	M	M	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	M	M	H	H	H	H	L	L	M	M
Risk from Flooding	M	M	M	H	M	M	M	M	L	M	M	M

A.2.2.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion • Currently, no properties in the adaptation area are exposed to coastal erosion, therefore risk of loss/damage to buildings is minimal • Beach, Maclean Park, George Pannel Reserve, and Waikanae Beach Domain are currently experiencing erosion	Future exposure • By 2050 1% of properties (n= 34) in the adaptation area will be exposed to erosion and potentially at risk of damage, collapse, loss of services, and insurance withdrawal. Properties cluster around Waikanae's Waimeha Stream (which accounts for 76% of all erosion affected properties in the CAA at this time) • By 2070 the number of properties in the CAA at risk (n=73) increases slightly (1% of all properties in the adaptation area). In addition to Waimeha Stream area, affected properties cluster around the northern end of Manly Street (Paraparaumu Beach) – approx 51% of affected properties in the CAA in 2070 – and Marine Parade in the southern end of the CAA • By 2130 the number of private properties in the CAA at risk of coastal erosion increases (n=228 or 3% of all properties), with more widespread effects in the locations listed above. • One business is at risk of erosion (Body Basics) by 2130 • The beach within the adaptation area will be progessively eroded, reducing beach access and impacting those who derive identity and wellbeing from the beach. • Other areas that may provide for residents' mental wellbeing and identity (e.g. the Waikanae Estuary) are also at risk of erosion
Currently exposed to periodic coastal flooding • 4% of properties (n= 287) in the adaptation area are currently exposed to flooding and could be lost or damaged • Inundation currently affects the beach, Waikanae Golf Course, Waimea Lagoon and Wildlife Refuge, Waimanu Lagoon, The Esplanade, portions of Waikanae River Track, some areas of Waikanae Estuary Scientific Reserve, Otaihanga Domain, and portions of Maclean park, presenting possible limitations on access during inundation events	Future exposure • By 2050 7% of properties (n=505) in the adaptation areas are exposed to periodic flooding. In 2050, approximately 42% (210) of inundation affected properties in the CAA are located in Waikanae • By 2070 the % of properties at risk in the CAA (n=888) increases to 13% • By 2130 31% of private properties are at risk of coastal flooding in the CAA (n=2205). 42% of the total impacted properties (n=926) are located in Waikanae, whilst 51% are within Paraparaumu (n=1120). • Otaihanga has a comparitively smaller number of properties affected by inundation at 2130 (n=159), but when considered as a 50% of all

Details of exposure	
	properties within that community, the number is high. • At least 26 businesses in the CAA area at at risk of periodic inundation by 2130 and related stresses associated with inability to access the business • By 2130 coastal inundation reaches further inland, periodically flooding low-lying areas mainly around the beach and water bodies. • More extensive inundation, compared to the SSP2-4.5 scenario, is observed at coastal locations and other areas that may provide for residents' mental wellbeing (e.g. walking tracks around the Waikanae River

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	M	M
Coastal Flooding	M	M	H	H

Note:
In the above, we are focussing on all the properties within the adaptation area, not just the beach front properties. A focus on just the beach front properties would yield a different result. Exposure of other residents (living away from the beach front and flood-prone areas) is likely due to their connection with the coast and other features of the CAA.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	H	H	H	H
Coastal Flooding	H	H	H	H

Notes:
Loss of property and loss of access to the beach and recreation sites will have a potentially significant effect on residents' mental health and connections to natural spaces for recreation and enjoyment. Research demonstrates that many people globally (Bell et al., 2015; Bryce et al., 2016) and across Aotearoa New Zealand(Cosgriff, 2023; Foley et al., 2019; Foley & Kistemann, 2015; Panelli & Tipa, 2007; Wheaton et al., 2020) derive a sense of wellbeing and mental health from recreating on and near the beach, and many feel their identity and sense of belonging is strongly connected to their community, especially in coastal locations (Chen et al., 2021; Collins & Kearns, 2010, 2013; Floyd, 2023; Murton, 2006; Panelli et al., 2008; Schneider et al., 2017; Waiti & Awatere, 2019; Widener, 2018). The situation is likely to be similar for residents of Waikanae and Paraparaumu given that the Central Adaptation Area Summary (KCDC, 2023) demonstrates that people within the community have a strong emotional affiliation to the area, particularly the beach and coastline, with some noting that it is integral to their sense of identity and belonging.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	There are no co-ordinated adaptation actions, the shore line is allowed to erode.

Domain	Adaptive Capacity	Key Assumptions
		Few actions that can be taken be autonomously are applied on affected properies (can easily adapt as an individual in the long term). When identity and wellbeing is tied up with place, and these places are lost or damaged, coping and adapting is not a straightforward or linear task, and can take a long time and require considerable cognitive and social change to achieve. Special places are not easily replaced since the connections are highly personal, and have been built up over time. Their loss may cause grief and anxiety. Financial barriers to adaptation or relocation may cause significant stress or place an individual in the postion of needing to remain in a continually affected location.
Coastal Flooding	M	There are no coordinated adaptation actions, indundation occurs frequently but intermittently. Some actions that can be taken be autonomously are applied on affected properies (can easily adapt as an individual in the long term). When identity and wellbeing is tied up with place, and these places are lost or damaged, coping and adapting is not a straightforward or linear task, and can take a long time and require considerable cognitive and social change to achieve. Special places are not easily replaced since the connections are highly personal, and have been built up over time. Their loss may cause grief and anxiety. Financial barriers to adaptation or relocation may cause significant stress or place an individual in the postion of needing to remain in a continually affected location.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	H	H	H	H	L	H	H	H	H
Flooding	H	H	H	H	M	M	M	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	M	M	H	H	H	H	L	L	M	M
Risk from Flooding	M	M	H	H	M	M	M	M	L	M	M	M

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A.2.3 Social infrastructure and amenity

Domain	Element at Risk	Overview
Human	Risk to social infrastructure and amenity	Risk to social infrastructure and amenity. This element includes the objects that keep society functioning and enable daily patterns of life (e.g. shopping or travelling to work, education, engaging in community or cultural activities), and the facilities that act as social support structures (e.g. churches, supermarkets, meeting places, community facilities or halls, health care services, care homes, early childhood centres). Additionally, it includes the locations and facilitates that afford visitors and local residents the opportunity to enjoy and participate in organised sport, exercise, and spend time outdoors (e.g. parks, swimming pools, boat clubs, walkways, reserves, and natural areas). It also includes the aesthetics and amenity of places where people live, the spaces they utilise, and whether changes can be tolerated by those who live there

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	The loss of social infrastructure along the seafront means that people are not able to access services that they need to go about their daily lives, do the things that they enjoy, or engage in social activities with others. Loss of amenity and recreational space reduces ability to enjoy outdoor activities and connect with nature (with flow on impacts to wellbeing).
Coastal Flooding	The semi-permanent inundation of social infrastructure in coastal areas means that people are not able to access services that they need to go about their daily lives, do the things that they enjoy, or engage in social activities with others. Loss of amenity and recreational space reduces ability to enjoy outdoor activities and connect with nature (with flow on impacts to wellbeing).

Opportunities

Hazard	Opportunities
Coastal Erosion	Creation of new outdoor recreational space
Coastal Flooding	Creation of new outdoor recreational space in areas that are intermittently inundated

A.2.3.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Present exposure – coastal erosion • The beach is currently exposed to erosion with 2 beach access points within the current day hazard line. • A total of 7 parks and reserves are exposed, and one parcel of DOC land. Maclean Park, George Pannel Reserve, and Waikanae Beach Domain are currently experiencing erosion, and may present limits on normal use of these places • No public transportation routes are affected by erosion • No other social infrastructure is exposed	Future exposure • The beach is increasingly exposed to erosion, with impacts to beach access points increasing over time (3 in 2050, 4 in 2070, and 6 in 2130) • At 2050, 2070, and 2130, 8 parks and reserves are exposed to erosion and one parcel of DOC land • The area around the Waikanae Estuary is impacted more extensively by erosion over time • The Kāpiti Rest Home is located on Marine Parade, Paraparaumu, and is directly affected by erosion from 2070 onwards. • The Coastguard/Kāpiti boating club building is directly affected by erosion from 2050 onwards, which poses a risk to public safety if nothing is done to relocate/protect the building (reduced capacity to respond to local emergency incidents in the water) and reduces/negates functionality of the boating club
Present exposure – Coastal inundation • At present, 24 parks and reserves and 6 parcels of DOC land are exposed to periodic inundation. Inundation currently affects the beach, Waikanae Golf Course, Waimea Lagoon and Wildlife Refuge, Waimanu Lagoon, The Esplanade, portions of Waikanae River Track, some areas of Waikanae Estuary Scientific Reserve, Otaihanga Domain, and portions of Maclean park, presenting possible limitations on access during inundation events • One business is potentially exposed to periodic flooding in the CAA • A public transport route in Waikanae is potentially impacted by periodic inundation, posing barriers to travel to work, and potentially inconveniencing households reliant on public transport	Future exposure • Coastal inundation has a growing impact on social infrastructure and amenity into the future • The number of DOC land parcels exposed to inundation grows from 6 (2050, 2070) to 7 (2130), and by 2130, 33 parks and reserves are affected (with 25 in 2050 and 26 in 2070 affected) • More extensive coastal inundation is observed at the golf course and recreational areas such as the beach and river tracks. • 2 beach access points are exposed in 2050 and 2070, and by 2130, 5 are exposed. • One heritage site is impacted by inundation in 2050, 2070, and 2130 • The public transportation route in Waikanae becomes increasingly affected by periodic inundation over time • At least 19 businesses are impacted by inundation by 2130 • Waikanae Beach Community Hall and St Michael's Church (Waikanae) may experience some inundation from 2130 • Public toilets at Weggery Reserve may experience inundation from 2050

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	M	M	M	H

Note:

Aside from features mentioned above, no other social infrastructure is exposed: the schools, medical practices, and places of worship are all unaffected.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	H	H	H	H
Coastal Flooding	H	H	H	H

Notes:

The elements that are exposed are highly sensitive to the hazard and would no longer be able to fulfil their intended purpose.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	M	Limited options to adapt because parks are constrained by adjoining private properties Beach access points and community facilities in erosion hazard areas could possibly be preserved in the short term through hard protection structures
Coastal Flooding	M	Limited options to adapt because parks are constrained by adjoining private properties, but walking tracks and public transportation routes could be re-routed out of inundation areas.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	H	H	H	H	M	M	M	M	M
Flooding	H	H	H	H	M	M	M	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	M	M	M	M	L	L	L	L
Risk from Flooding	M	M	M	H	M	M	M	M	M	M	M	M

A.2.3.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Present exposure – coastal erosion • The beach is currently exposed to erosion with 2 beach access points within the current day hazard line. • A total of 7 parks and reserves are exposed, and one parcel of DOC land. Maclean Park, George Pannel Reserve, and Waikanae Beach Domain are currently experiencing erosion, and may present limits on normal use of these places • No public transportation routes are affected by erosion • No other social infrastructure is exposed	Future exposure • The beach is increasingly exposed to erosion, with impacts to beach access points increasing over time (3 in 2050, 5 in 2070, and 11 in 2130) • At 2050, 2070, and 2130 8 parks and reserves are exposed to erosion and one parcel of DOC land (2050, 2070) rising to 2 in 2130 • The area around the Waikanae Estuary is impacted more extensively by erosion over time • The Kāpiti Rest Home is located on Marine Parade, Paraparaumu, and is directly affected by erosion from 2070 onwards. • The Coastguard building (and Kāpiti Boating Club) is directly affected by erosion from 2050 onwards, which poses a risk to public safety if nothing is done to relocate/protect the building (reduced capacity to respond to local emergency incidents in the water) • By 2130 the Waikanae Boating Club is also affected by erosion • One business is exposed to erosion by 2130
Present exposure – Coastal inundation • At present, 24 parks and reserves, and 6 parcels of DOC land are exposed to periodic inundation. Inundation currently affects the beach, Waikanae Golf Course, Waimea Lagoon and Wildlife Refuge, Waimanu Lagoon, The Esplanade, portions of Waikanae River Track, some areas of Waikanae Estuary Scientific Reserve, Otaihanga Domain, and portions of Maclean park, presenting possible limitations on access during inundation events • One business is potentially exposed to periodic flooding in the CAA • A public transport route in Waikanae is potentially impacted by periodic inundation, posing barriers to travel to work, and potentially inconveniencing households reliant on public transport	Future exposure • Coastal inundation has a growing impact on social infrastructure and amenity into the future • The number of DOC land parcels exposed to inundation grows from 6 (2050, 2070) to 7 (2130), and by 2130 36 parks and reserves are affected (25 in 2050 and 29 in 2070) • More extensive coastal inundation is observed at the golf course and recreational areas such as the beach and river tracks. • 2 beach access points are exposed in 2050, 3 in 2070, and by 2130, 10 are exposed. • One heritage site is impacted by inundation in 2050 and 2070, and 3 by 2130 • One medical facility is affected by periodic inundation by 2130 (0 prior) • Waikanae Beach Community Hall and St Michael's Church (Waikanae) may experience some inundation from 2130 • The Waikanae Menz Shed may be impacted by periodic inundation from 2130 • The Waikanae Beach Tennis Club may experience inundation from 2130 • Public toilets at Weggery Reserve may experience inundation from 2050 and at Waimanu Lagoon from 2130 (plus likely other locations) • The public transportation route in Waikanae becomes increasingly affected by periodic inundation over time, and the route(s) in Paraparaumu are also impacted

Details of exposure	
	• At least 26 businesses are impacted by inundation by 2130, including the four square supermarkets

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	M	M	M	H

Note: No other social infrastructure is exposed than that mentioned above.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	H	H	H	H
Coastal Flooding	H	H	H	H

Note:

Aside from features mentioned above, no other social infrastructure is exposed: the schools, medical practices, and places of worship are all unaffected.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	M	Limited options to adapt because parks are constrained by adjoining private properties Beach access points and community facilities in erosion zones could possibly be preserved in the short term through hard protection structures Walking tracks could be re-routed away from erosion hazard
Coastal Flooding	M	Limited options to adapt because parks are constrained by adjoining private properties, but walking tracks and public transportation routes could be re-routed out of inundation areas. Affected community infrastructure could be moved however this could prove costly

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	H	H	H	H	M	M	M	M	M
Flooding	H	H	H	H	M	M	M	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130

	Exposure				Vulnerability				Risk			
Risk from Erosion	L	L	L	L	M	M	M	M	L	L	L	L
Risk from Flooding	M	M	M	H	M	M	M	M	M	M	M	M

A.2.4 Conflict, disruption, and loss of trust in government

Domain	Element at Risk	Overview
Human	Risks of conflict, disruption, and loss of trust in government	Risks of conflict, disruption, and loss of trust in government from changing patterns in the value of assets and competition for access to scarce resources, primarily due to periodic inundation events and ongoing erosion.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Coastal erosion causes disruption and conflict as residents and businesses compete for government assistance and safe land. Conflict over who pays for adaptation actions lead to community fragmentation and disagreement, with flow on impacts to social cohesion and potential to exacerbate existing inequalities in the community. Inaction/action by the government leads to loss of trust in government institutions, cynicism within the community, and community opposition.
Coastal Flooding	Coastal flooding causes disruption and conflict as residents and businesses compete for government assistance and safe land. Conflict over who pays for adaptation actions lead to community fragmentation and disagreement, with flow on impacts to social cohesion and potential to exacerbate existing inequalities in the community. Inaction/action by the government leads to loss of trust in government institutions, cynicism within the community, and community opposition.

Opportunities

Hazard	Opportunities
Coastal Erosion	Build strong transparent relationships with the local community
Coastal Flooding	Build strong transparent relationships with the local community

A.2.4.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion • No properties in the adaptation area are currently exposed to coastal erosion	Future exposure • By 2050 <1% of properties (n=34) in the adaptation area are at risk of erosion and could be lost or damaged. • By 2070 the number of properties in the CAA at risk (n=61) increases slightly (1% of all properties in the adaptation area • By 2130 the number of private properties in the CAA at risk of coastal erosion increases (n=129 or 2% of all properties) • Erosion of properties clusters around Waimeha Stream (Waikanae) and Manly Street and Marine Parade (Paraparaumu). • Increasing erosion of public spaces along the coastal strips including parks, reserves, and beach access points over time (see risk to social infrastructure and amenity) • Increasing erosion increases competition for safe land over time As time passes, there is a risk that conflict between community members will escalate as differing opinions on how to respond to increases to inundation come to the fore, and people differ in their thoughts on when different sets of adaptation should occur. It is highly likely that residents of beachfront properties will favour hard protection structures that protect their properties, yet this action may not be universally accepted by others in the community, leading to intra-community conflict.
Currently exposed to coastal flooding • 4% of properties (n= 287) in the adaptation area are currently exposed to flooding and could be lost or damaged • Periodic flooding is mostly confined to the beach, and waterways (e.g. areas around Waikanae River and lagoons in the CAA)	Future exposure • By 2050 7% of properties (n=505) in the adaptation areas are exposed to periodic flooding • By 2070 the % of properties at risk in the CAA (n=720) increases to 10% • By 2130 22% of private properties in the CAA are at risk of coastal flooding (n=1552). • Flooding of properties clusters around low-lying areas of Waikanae and Paraparaumu • There is some increase to flooding of public spaces along the coastal strip and around waterways including parks, reserves, walking tracks and beach access points over time (see risk to social infrastructure and amenity) • Increasing periodic inundation over time increases the competition within the communtity for safe land. As time passes, there is a risk that conflict between community members will escalate as differing opinions on how to respond to increases to inundation come to the fore, and people differ in their thoughts on when different sets of adaptation should occur.

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	L	L	M	H

Notes:

Depending on how the impacts of the hazards unfold and the decisions made regarding what action (if any) are taken, a large number of residents within the adaptation area may be at risk of conflict and loss of trust in government. In particular, the conflict and tension arising from the percieved "winners" and "losers" of various courses of action. Erosion affects a limited number of properties in the CAA overall, which could drive resentment and conflict within the community and/or directed at council, especially if the majority of residents feel that adaptation actions do not directly benefit them. For example, seawalls and other hard protection structures offer significant benefits to the small number of beach-front properties affected by erosion, yet potentially cost all residents of the CAA if adaptation actions are funded through rates increases. Hard protection could also change the appearance and accessibility of the beach, compounding residents' frustrations and sense of loss as they witness the change in a place they cherish, because of adaptation actions they do not necessarily support.

Given that flooding is a more widespread issue than erosion, and will affect more properties and areas of the CAA, conflict may be less because a greater proportion of residents may feel they directly benefit from adaptation actions. However, there will still be the potential for conflict and resentment arising from the funding of adaptation, with households that do not directly benefit from adatpation actions potentially being placed in a position where they need to fund adaptation (via rates) that benefits others more significantly. Additionally, the increasingly widespread nature of coastal inundation could drive significant demand for properties and land outside of inundation hazard areas, and/or that are not at risk of being cut off by flooding. Competition amongst residents for these properties could drive tension and disruption to community relationships.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	H	H	H
Coastal Flooding	M	H	H	E

Notes:

Research has shown that intra-community conflict around the choice of coastal erosion control, hazard mitigation and climate change adaptation action is common in settlements around New Zealand. This includes conflict related to building seawalls or pursuing approaches such as dune reconstruction (Gesing, 2017, 2019, 2021; Hayward, 2008; Rouse et al., 2016; Scouller, 2011). Such conflicts could also arise in the CAA, especially since there is evidence that residents have strong feelings of attachment to their community, and particularly the beach (KCDC, 2023). There is likely to be a heightened risk of conflict about structures that change the appearance and access to the beach and other places of importance, particularly between property owners who directly benefit from these actions, and those who feel they "lose out" due to reduced amenity value and connection to important places and spaces. The Central Adaptation Area Summary (KCDC, 2023) demonstrates that community members place great importance on accessing the beach for recreational purposes, and also to maintain and enhance the wellbeing of themselves and their families. Additionally, the document shows that community members hold a range of different adaptation preferences which may serve as the basis for potential disagreement.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	M	Adaptation actions are consistent with existing pathways

Domain	Adaptive Capacity	Key Assumptions
		Some portions of the community will face financial barriers to relocation and competition for safe land, resulting in limited capacity to adapt to erosion at the household level It is possible to build trust and overcome intra-community and community/government conflicts through robust and transparent engagement
Coastal Flooding	M	Adaptation actions are consistent with existing pathways Some portions of the community will face financial barriers to relocation and competition for safe land, resulting in limited capacity to adapt to flooding at the household level It is possible to build trust and overcome intra-community and community/government conflicts through robust and transparent engagement

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	H	H	H	M	M	M	M	M
Flooding	M	H	H	E	M	M	M	M	H

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	M	M	M	M	L	L	L	L
Risk from Flooding	L	L	M	H	M	M	M	H	L	L	M	H

A.2.4.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion • No properties in the adaptation area are currently exposed to coastal erosion	Future exposure • By 2050 <1% of properties (n=34) in the adaptation area are at risk of erosion and could be lost or damaged. • By 2070 the % increases to 1% (n=73) of the total properties in the adaptation area • By 2130 the % increases to 3% (n=228) of the total properties in the adaptation area • Clutering of erosion around the southern portion of the CAA and parts of Waikanae (e.g. Waimeha Stream) • Increasing erosion of public spaces along the coastal strips including parks, reserves, and beach access points, etc over time (see risk to social infrastructure and amenity) • Increasing erosion increases competition for safe land over time As time passes, there is a risk that conflict between community members will escalate as differing opinions on how to respond to increases to inundation come to the fore, and people differ in their thoughts on when different sets of adaptation should occur. It is highly likely that residents of beachfront properties will favour hard protection structures that protect their properties, yet this action may not be universally accepted by others in the community, leading to intra-community conflict.
Currently exposed to coastal flooding • 4% of properties (n= 287) in the adaptation area are currently exposed to flooding and could be lost or damaged • Periodic flooding is mostly confined to the beach, and waterways (e.g. areas around Waikanae River and lagoons in the CAA)	Future exposure • By 2050, 7% of properties (n=505) within the adaptation area will experience coastal inundation and could be lost or damaged • By 2070 the % increases to 13% (n=888) • By 2130 the % increases to 31% (n=2205) • Increased incidence of flooding of public spaces along the coastal strips and low-lying areas around water bodies including parks, reserves, beach access points, and walking tracks over time (see risk to social infrastructure and amenity) • Increasing periodic inundation over time increases the competition within the communtity for safe land. • As time passes, there is a risk that conflict between community members will escalate as differing opinions on how to respond to increases to inundation come to the fore, and people differ in their thoughts on when different sets of adaptation should occur.

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	M
Coastal Flooding	L	L	M	H

Notes:

Depending on how the impacts of the hazards unfold and the decisions made regarding what action (if any) are taken, a large number of residents within the adaptation area may be at risk of conflict and loss of trust in government. In particular, the conflict and tension arising from the percieved "winners" and "losers" of various courses of action. Erosion affects a limited number of properties in the CAA overall, which could drive resentment and conflict within the community and/or directed at council, especially if the majority of residents feel that adaptation actions do not directly benefit them. For example, seawalls and other hard protection structures offer significant benefits to the small number of beach-front properties affected by erosion, yet potentially cost all residents of the CAA if adaptation actions are funded through rates increases. Hard protection could also change the appearance and accessibility of the beach, compounding residents' frustrations and sense of loss as they witness the change in a place they cherish, because of adaptation actions they do not necessarily support.

Given that flooding is a more widespread issue than erosion, and will affect more properties and areas of the CAA, conflict may be less because a greater proportion of residents may feel they directly benefit from adaptation actions. However, there will still be the potential for conflict and resentment arising from the funding of adaptation, with households that do not directly benefit from adatpation actions potentially being placed in a position where they need to fund adaptation (via rates) that benefits others more significantly. Additionally, the increasingly widespread nature of coastal inundation could drive significant demand for properties and land outside of inundation hazard areas, and/or that are not at risk of being cut off by flooding. Competition amongst residents for these properties could drive tension and disruption to community relationships.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	H	H	H
Coastal Flooding	M	H	H	E

Notes:

Research has shown that intra-community conflict around the choice of coastal erosion control, hazard mitigation and climate change adaptation action is common in settlements around New Zealand. This includes conflict related to building seawalls or pursuing approaches such as dune reconstruction (Gesing, 2017, 2019, 2021; Hayward, 2008; Rouse et al., 2016; Scouller, 2011). Such conflicts could also arise in the CAA, especially since there is evidence that residents have strong feelings of attachment to their community, and particularly the beach (KCDC, 2023). There is likely to be a heightened risk of conflict about structures that change the appearance and access to the beach and other places of importance, particularly between property owners who directly benefit from these actions, and those who feel they "lose out" due to reduced amenity value and connection to important places and spaces. The Central Adaptation Area Summary (KCDC, 2023) demonstrates that community members place great importance on accessing the beach for recreational purposes, and also to maintain and enhance the wellbeing of themselves and their families. Additionally, the document shows that community members hold a range of different adaptation preferences which may serve as the basis for potential disagreement.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	M	Adaptation actions are consistent with existing pathways Some portions of the community will face financial barriers to relocation and competition for safe land, resulting in limited capacity to adapt to erosion at the household scale

Domain	Adaptive Capacity	Key Assumptions
		It is possible to build trust and overcome intra-community and community/government conflicts through robust and transparent engagement
Coastal Flooding	M	Adaptation actions are consistent with existing pathways Some portions of the community will face financial barriers to relocation and competition for safe land, resulting in limited capacity to adapt to flooding at the household scale. It is possible to build trust and overcome intra-community and community/government conflicts through robust and transparent engagement

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	H	H	H	M	M	M	M	M
Flooding	M	H	H	E	M	M	M	M	H

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	M	M	M	M	M	L	L	L	M
Risk from Flooding	L	L	M	H	M	M	M	H	L	L	M	H

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A.2.5 Exacerbating existing inequities and creating new and additional inequities

Domain	Element at Risk	Overview
Human	**Risks of exacerbating existing inequities and creating new and additional inequities**	Risks of exacerbating existing inequities and creating new and additional inequities due to differential distribution of coastal erosion and coastal flooding impacts. This element focusses on the existing inequities in society that mean some people, groups, and households are less able to access to services and resources (e.g. clean water, work, finance, insurance, safe and dry homes) that maintain and support wellbeing. It also includes the creation of new inequities though the actions taken to respond (or not) to the impacts and implications of a changing climate.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	As erosion becomes more severe over time, the competition for "safe" land and homes within the CAA (away from erosion areas) will increase. Those with the financial resources to do so will be able to secure properties in lower-risk areas of the area while others will need to live with coastal erosion hazards. Some residents may have no option but to remain in highly impacted locations as safe locations become increasingly unattainable. These residents may experience difficulties with securing home insurance and could increasingly encounter situations that further deepen inequalities they face. With increased erosion, the value of affected properties will decrease. Decreasing values mean it is likely these properties will be sold by those who can afford to move and purchased or rented by people with less financial means to cope with and recover from hazard events or insure against loss. This will trigger a progressive downward spiral of worsening living conditions and less access to services for those with fewer resources, deepening existing socio-economic inequities over time. New inequalities may be created, or existing inequalities exacerbated through the response to managing the hazard. Inaction (or maladaptation) may create a series of ongoing losses and damages which will reduce wellbeing through lowered levels of access to services, opportunities, and safety.
Coastal Flooding	As flooding becomes more severe over time, the competition for "safe" land and homes within the CAA will increase. Those with the financial resources to do so will be able to secure properties in lower-risk areas while others with lower financial capacity will need to live with increasingly regular coastal flooding. Some residents may have no option but to remain in highly impacted locations as safe locations become increasingly unattainable. These residents may experience difficulties with securing home insurance and could increasingly encounter situations that further deepen inequalities they face. As coastal flooding becomes more pronounced over time, the value of affected properties will decrease. Decreasing values mean it is likely these properties will be sold by those who can afford to move away, and purchased or rented by people with less financial means to cope with and recover from hazard events or insure against loss. This will trigger a progressive downward spiral of worsening living conditions and less access to services for those with fewer resources, deepening existing socio-economic inequities over time. Living conditions in affected properties may be damp and create impacts on health and wellbeing or

Hazard	Description of Consequence (note any cascading impacts)
	exacerbate existing health inequities that are associated with low-income and other marginalised groups. New inequalities may be created, or existing inequalities exacerbated through the response to managing the hazard. Inaction (or maladaptation) may create a series of ongoing losses and damages which will reduce wellbeing through restricted access to services, opportunities, and safety.

Opportunities

Hazard	Opportunities
Coastal Erosion	Adaptation can allow for a specific focus on managing local inequalities and avoiding creating new inequities
Coastal Flooding	Adaptation can allow for a specific focus on managing local inequalities and avoiding creating new inequities

A.2.5.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion • No properties in the CAA are currently exposed to coastal erosion. As a result, the risk of excerbation of existing inequities or the creation of new ones are low. However, it is not possible to access data to describe the current situation. In particular, there is no data to indicate people may be moving due to the percieved risks; the impact of erosion on property values has not been explored in this region; and ability to access insurance has not been explored as data cannot be obtainined from insurance companies.	Future exposure • By 2050 <1% of properties (n=34) in the adaptation area are at risk of erosion and could be lost or damaged. • By 2070 the % increases to 1% of the total properties (n=61) in the adaptation area • By 2130 the % increases to 2% of the total properties (n=129) in the adaptation area • In certain areas of the CAA (for example Waikanae and southern CAA boundary) coastal erosion is more pronounced. Households in these areas are likely experience greater inequities and could shift towards being occupied by those of lower socio-economic means over time.
Currently exposed to coastal inundation • 4% of properties in the adaptation area (n=287) are at risk of coastal inundation. As a result, the excerbation of existing inequities or the creation of new ones are low. However, it is not possible to access data to describe the current situation. In particular, there is no data to indicate people may be moving due to the percieved risks; the impact of erosion on property values has not been explored in this region; and ability to access insurance has not been explored as data cannot be obtainined from insurance companies.	Future exposure • By 2050, 7% of properties within the adaptation area (n=505) will experience coastal inundation and could be lost or damaged. • By 2070 the % increases to 10% (n=720) • By 2130 the % increases to 22% (n=1552), creating greater likihood of creating/exacerbating inequities between households in the CAA

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	M
Coastal Flooding	L	L	M	H

Notes:

The total number of properties within the adaptation area has been assessed rather than just the beach front properties. As properties are impacted by erosion and flooding, homes are likely to devalue and people are likely to lose their ability to insure against loss. A recent paper by Storey et al. (2024) demonstrates that insurance withdrawal could become commonplace in coastal settlements around Aotearoa by 2020-2025 due to sea-level rise. Given these challenges, occupants may either sell their property (moving within the same community or further afield) or remain in place as long as possible (and experience a slow worsening of living conditions). Competition for "safe" properties within the area is likely to increase, and those with the financial resources to occupy these properties will likely do so, which could lead to hazard-affected areas

largely becoming home to households of lesser economic means. New socio-economic and health inequities may be created and experienced by property owners and/or renters living in or moving into lower value homes.

Reduction of services may occur as the community reduces in size, changes in socio-economic composision, and there is less investment in the area because of the known hazards. This can lead to "hollowing out" (Smith et al. 2011) of communities – people with fewer means are effectively trapped in a place with few opportunities to access services, resources, employment, and social connections. An impact on social cohesion is also possible if the composition of the community changes.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	H	H	H	H
Coastal Flooding	H	H	H	H

Notes:

Based on 2018 census data (StatsNZ), the median personal income in the central adaptation area was approximately $33,000 which is slightly higher than the national median personal income ($31,800) for 2018. While approximately 19% of residents in the CAA earned over $70,000 per annum in 2018, 32% earned under $20,000 per annum in 2018, and particular regions of the CAA (such as Waikanae, where flooding risk is also significant) displayed moderate to high levels of deprivation (Atkinson et al. 2019). People within low-income households may face financial inequities that increase their sensitivity to coastal erosion and inundation (for instance, being unable to strengthen their home so it withstands hazards more effectively or being unable move to non-hazardous locations) (Cutter et al. 2003, Chakraborty et al. 2019).

Additionally, the population of the adaptation area is somewhat diverse, containing groups (such as Māori, Pacific peoples, disabled, and older peoples) that have traditionally been shown to face barriers to home ownership and often occupy the lower end of the rental and property market (due to higher propensity for being rejected as tenants, and the intersection of multiple forms of inequity that increase the likelihood that these groups are also low-income (Houkamau et al. 2015, Murray and Loveless 2021)). These groups may end up occupying properties that have devalued in erosion and inundation areas, thereby potentially increasing the population of lower-income and more sensitive households in the CAA over time. Furthermore, older peoples' physiology and the health inequities faced by groups such as Māori, Pacific peoples, and members of the disablity community increase their sensitivity to risks from occupying damp and mouldy homes (due to inundation). With approximately 11% of CAA residents identifying as Māori in 2018, and 25% aged over 65 years old, there is significant sensitivity amongst the population of the CAA.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	There are no coordinated adaptation actions, coastal erosion continues. People with limited financial means may find it difficult to cope with, respond to, and adapt to erosion (e.g. by moving away) and may increase their exposure to hazards by moving to inexpensive homes in hazard areas. Owners of affected properties may face difficulties attaining home insurance, reducing their ability to respond to and recover from hazards like erosion.
Coastal Flooding	L	There are no coordinated adaptation actions, indundation occurs frequently but intermittently. People with limited financial means may find it difficult to cope with, respond to, and adapt to inundation (e.g. by

Domain	Adaptive Capacity	Key Assumptions
		moving away) and may increase their exposure to hazards by moving to inexpensive homes in hazard areas. Owners of affected properties may face difficulties attaining home insurance, reducing their ability to respond to and recover from hazards like coastal flooding. Not all residents can continue working from home, so may be vulnerable to income loss. Likewise, some businesses depend on customers physically accessing their premisis for income, therefore online sales may not be feasible during inundation events.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	H	H	H	H	L	H	H	H	H
Flooding	H	H	H	H	L	H	H	H	H

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	M	H	H	H	H	L	L	L	M
Risk from Flooding	L	L	M	H	H	H	H	H	L	L	M	H

A.2.5.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion • No properties or businesses in the CAA are currently exposed to coastal erosion. As a result, the risk of excerbation of existing inequities or the creation of new ones are low. However, it is not possible to access data to describe the current situation. In particular, there is no data to indicate people may be moving due to the percieved risks; the impact of erosion on property values has not been explored in this region; and ability to access insurance has not been explored as data cannot be obtainined from insurance companies.	Future exposure • By 2050 <1% of properties (n=34) in the adaptation area are at risk of erosion and could be lost or damaged. • By 2070 the % increases to 1% of the total properties (n=73) in the adaptation area • By 2130 the % increases to 3% of the total properties (n=228) in the adaptation area • In certain areas of the CAA (for example Waikanae and southern CAA boundary) coastal erosion is more pronounced. Households in these areas are likely experience greater inequities and could shift towards being occupied by those of lower socio-economic means over time.
Currently exposed to coastal inundation • 4% of properties in the adaptation area (n=287)are at risk of coastal inundation. As a result, the excerbation of existing inequities or the creation of new ones are low. However, it is not possible to access data to describe the current situation. In particular, there is no data to indicate people may be moving due to the percieved risks; the impact of erosion on property values has not been explored in this region; and ability to access insurance has not been explored as data cannot be obtainined from insurance companies.	Future exposure • By 2050, 7% of properties within the adaptation area (n=505) will experience coastal inundation and could be lost or damaged. • By 2070 the % increases to 13% (n=888) • By 2130 the % increases to 31% (n=2205), creating greater likihood of creating/exacerbating inequities between households in the CAA

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	M
Coastal Flooding	L	L	M	E

Note:

The total number of properties within the adaptation area has been assessed rather than just the beach front properties. As properties are impacted by erosion and flooding, homes are likely to devalue and people are likely to lose their ability to insure against loss. A recent paper by Storey et al. (2024) demonstrates that insurance withdrawal could become commonplace in coastal settlements around Aotearoa by 2020-2025 due to sea-level rise. Given these challenges, occupants may either sell their property (moving within the same community or further afield) or remain in place as long as possible (and experience a slow worsening of living conditions). Competition for "safe" properties within the area is likely to increase, and those with the financial resources to occupy these properties will likely do so, which could lead to hazard-affected areas largely becoming home to households of lesser economic means. New socio-economic and health inequities

may be created and experienced by property owners and/or renters living in or moving into lower value homes.

Reduction of services may occur as the community reduces in size, changes in socio-economic composision, and there is less investment in the area because of the known hazards. This can lead to "hollowing out" (Smith et al. 2011) of communities – people with fewer means are effectively trapped in a place with few opportunities to access services, resources, employment, and social connections. An impact on social cohesion is also possible if the composition of the community changes.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	H	H	H	H
Coastal Flooding	H	H	H	H

Notes:

Based on 2018 census data (StatsNZ), the median personal income in the central adaptation area was approximately $33,000 which is slightly higher than the national median personal income ($31,800) for 2018. While approximately 19% of residents in the CAA earned over $70,000 per annum in 2018, 32% earned under $20,000 per annum in 2018, and particular regions of the CAA (such as Waikanae, where flooding risk is also significant) displayed moderate to high levels of deprivation (Atkinson et al. 2019). People within low-income households may face financial inequities that increase their sensitivity to coastal erosion and inundation (for instance, being unable to strengthen their home so it withstands hazards more effectively or being unable move to non-hazardous locations) (Cutter et al. 2003, Chakraborty et al. 2019).

Additionally, the population of the adaptation area is somewhat diverse, containing groups (such as Māori, Pacific peoples, disabled, and older peoples) that have traditionally been shown to face barriers to home ownership and often occupy the lower end of the rental and property market (due to higher propensity for being rejected as tenants, and the intersection of multiple forms of inequity that increase the likelihood that these groups are also low-income (Houkamau et al. 2015, Murray and Loveless 2021)). These groups may end up occupying properties that have devalued in erosion and inundation areas, thereby potentially increasing the population of lower-income and more sensitive households in the CAA over time. Furthermore, older peoples' physiology and the health inequities faced by groups such as Māori, Pacific peoples, and members of the disablity community increase their sensitivity to risks from occupying damp and mouldy homes (due to inundation). With approximately 11% of CAA residents identifying as Māori in 2018, and 25% aged over 65 years old, there is significant sensitivity amongst the population of the CAA.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	There are no coordinated adaptation actions, coastal erosion continues. People with limited financial means may find it difficult to cope with, respond to, and adapt to erosion (e.g. by moving away) and may increase their exposure to hazards by moving to inexpensive homes in hazard areas. Owners of affected properties may face difficulties attaining home insurance, reducing their ability to respond to and recover from hazards like erosion.
Coastal Flooding	L	There are no coordinated adaptation actions, indundation occurs frequently but intermittently. People with limited financial means may find it difficult to cope with, respond to, and adapt to inundation (e.g. by moving away) and may increase their exposure to hazards by moving to inexpensive homes in hazard areas.

Domain	Adaptive Capacity	Key Assumptions
		Owners of affected properties may face difficulties attaining home insurance, reducing their ability to respond to and recover from hazards like coastal flooding.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	H	H	H	H	L	H	H	H	H
Flooding	H	H	H	H	L	H	H	H	H

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	M	H	H	H	H	L	L	L	M
Risk from Flooding	L	L	M	E	H	H	H	H	L	L	M	E

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A.2.6 Social cohesion and community wellbeing

Domain	Element at Risk	Overview
Human	Risks to social cohesion and community wellbeing	Risks to social cohesion and community wellbeing from displacement of individuals, families, and communities due to climate change impacts. This element is focused on the community level and includes aspects of community cohesion and wellbeing associated with living in a particular place. Cohesion is described as the bonds that link communities and people together, and these may be physical place based, cultural, or social connections. Wellbeing is considered a measure of happiness or satisfaction and the ability to achieve personal and collective aspirations and enjoy a "good life" as defined by an individual, family, or group. The National Climate Change Risk Assessment describes two aspects to the risk to social cohesion. First, the risk associated with displacement and second, the risk to those left behind (NCCRA 2020). Displacement can cause trauma linked to disruption and dislocation from familiar surroundings and breaking of social and cultural bonds, and the challenges of resettlement. Movement between communities within the Kāpiti and Wellington Region may change the composition of communities, affect housing availability and affordability, change demand for social services, recreational facilities and schools, alter commuting patterns and introduce competition for other resources. Conflict may arise between existing residents and relocated households as disagreements about social norms and practices emerge. With less ties to support networks and opportunities, poorer health and wellbeing outcomes are likely. Affected communities will see a decrease in the local population as the residents relocate or are relocated. Properties may be increasingly occupied by those (from outside and within the community) who can't afford to live anywhere else. Newcomers may not have the same sense of attachment to the community. As households leave, the community will reduce in size and essential services may be slowly withdrawn, for example, education facilities, job opportunities, or community services. Investment in the affected communities will probably be reduced. Similar to displaced households, those who remain may experience trauma due to the breaking of family, social, and cultural bonds, and poorer health and wellbeing outcomes are likely. The breakdown of communities and the social bonds and connections to special places is important because fractured, less cohesive communities can result in conflict and feelings of isolation and loss.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	An increased incidence of coastal erosion will affect homes, property, businesses, and facilities and over time, decrease the desire and ability of people to remain in affected areas. As residents reach the limits of their tolerance, or properties become unlivable, they may relocate to other safe areas within the same community or

Hazard	Description of Consequence (note any cascading impacts)
	elsewhere. Those leaving may experience loss of social and cultural bonds they held within their previous community, and an associated sense of 'dislocation.' They may also face challenges with integrating into new communities where there are different socio-cultural norms, precedents, and social networks. Those who stay because they are unable to leave may experience grief, sadness, anxiety and other emotional impacts from loss of social networks, which may be intensified if conflicts arise with newcomers (who may have different values or priorities in terms of how they live and how they wish to respond to hazards). Those who move to the community (to occupy lower value homes) may experience a sense of social isolation as the community 'hollows out' (Smith et al. 2011) and there are limited opportunities for social connection, and access to normal services and opportunities.
Coastal Flooding	Certain areas of the community will progressively become unlivable due to the risk of periodic inundation. This will affect social cohesion at a slow pace as the sea slowly rises, affecting coastal homes, assets, and key infrastructure and access routes. Households may relocate after an event or due to the on-going stress of living with coastal inundation, or isolation. The result will be a slowly reducing population size and the loss of essential services and opportunities, with consequent impacts for those who leave and those who stay. Community cohesion could be suddenly affected probably after an event as the desirability of the community is reduced by both the hazard and the diminishing provision of or access to support, education, job and education opportunities and social services. Social relationships, support networks and connections may be diminished, affecting wellbeing (Campbell, 2018; Boege, 2019).

Opportunities

Hazard	Opportunities
Coastal Erosion	Create new opportunities to grow social cohesion, perhaps other opportunities to connect with others nearby or new ways to connect.
Coastal Flooding	Create new opportunities to grow social cohesion, perhaps other opportunities to connect with others nearby or new ways to connect.

A.2.6.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Current exposure to coastal erosion • Minimal impacts to social cohesion due to no exposure of properties and other community services to erosion • However, there is no data to indicate people may be moving due to the percieved risks	Future exposure • By 2050, <1% of properties (n=34) in the adaptation area are in erosion areas that could be lost or damaged. • By 2070 the % increases to 1% (n=61) • By 2130 the % increases to 2% (n=129) • Affected properties cluster around Waimeha Stream, Manly St and Marine Parade
Current exposure to coastal inundation • Moderate impact to social cohesion due to exposure of 287 properties (4%) and other community services • However, there is no data to indicate people may be moving due to the percieved risks	Future exposure • By 2050, 7% of properties (n=505) will experience coastal indunadation and could be lost or damaged • By 2070, the % increases to 510% (n=720) • By 2130 the % increases to 22% (n=1552)

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	L
Coastal Flooding	M	M	H	H

Notes:

Exposure for the total properties in the adaptation area is considered, rather than just a focus on the beach front properties. As these properties are impacted by erosion and periodic inundation they will likely devalue and become harder to insure (Storey ey al. 2024). People with the financial means to do so are likely to move, either within the same community or further afield. An impact on social cohesion is possible as if the compostion of the community changes. Conversly, some residents may not be able to leave because of financial consrtaints. Hazard affected areas are likely to become home to households with lesser economic means.

Hollowing out of services may occur as the community reduces in size, potentially becomes less affluent and there is less investment in the area because of the known hazards.Conflict between different elments of the community may emerge over change in social norms and disagreement over what to do about ongoing physical, social, and economic change.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	H	H	H
Coastal Flooding	M	H	H	H

Notes:

Based on the 2018 census approximately 44% of residents had lived at their usual residence in the CAA for less than 5 years, which means that there is a significant population turnover. It is, however, also worth noting that approximately 8% of the population in the adaptation area had resided there (in 2018) for over 15 years

and are likely to be embedded in the local community. The latter group are likely to be more sensitive to long term changes and challenges associated with social cohesion, whilst the former group (new residents) are likely to bring in different and diverse perspectives including about how adaptation should proceed.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	People generally struggle to adjust to change within their communities, particularly where loss of properties and change in community composition occur. If people move, it is hard to maintain and re-establish social networks and connections that underpin social cohesion.
Coastal Flooding	L	People generally struggle to adjust to change within their communities, particularly where loss of properties and change in community composition occur. If people move, it is hard to maintain and re-establish social networks and connections that underpin social cohesion.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	H	H	H	L	M	H	H	H
Flooding	M	H	H	H	L	M	H	H	H

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	L	M	M	M	M	L	L	L	L
Risk from Flooding	M	M	H	H	M	H	H	H	M	M	H	H

A.2.6.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Current exposure to coastal erosion • Minimal impacts to social cohesion due to no exposure of properties and other community services to erosion • However, there is no data to indicate people may be moving due to the percieved risks	Future exposure • By 2050, <1% of properties (n=34) in the adaptation area are in erosion areas that could be lost or damaged. • By 2070 the % increases to 1% (n=74) • By 2130 the % increases to 3% (n=228) • Affected properties cluster around Waimeha Stream, Manly Street and Marine Parade
Current exposue to coastal inundation • Moderate impact to social cohesion due to exposure of 287 properties (4%) and other community services • However, there is no data to indicate people may be moving due to the percieved risks	Future exposure • By 2050, 7% of properties (n=055) will expereince periodic coastal indundation and could be lost or damaged • By 2070, the % increases 13% (n=888) • By 2130 the % increases to 31% (n=2205)

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	M
Coastal Flooding	M	M	H	E

Note:

Exposure for the total properties in the adaptation area is considered, rather than just a focus on the beach front properties. As these properties are impactedby erosion and periodic inundation they will likely devalue and become harder to insure (Storey ey al. 2024). People with the financial means to do so are likely to move, either within the same community or further afield. An impact on social cohesion is possible as if the compostion of the community changes. Conversly, some residents may not be able to leave because of financial consrtaints. Hazard affected areas are likely to become home to households with lesser economic means.

Hollowing out of services may occur as the community reduces in size, potentially becomes less affluent and there is less investment in the area because of the known hazards.Conflict between different elments of the community may emerge over change in social norms and disagreement over what to do about ongoing physical, social, and economic change.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	H	H	H
Coastal Flooding	M	H	H	H

Notes:

Based on the 2018 census approximately 44% of residents had lived at their usual residence in the CAA for less than 5 years, which means that there is a significant population turnover. It is, however, also worth noting that approximately 8% of the population in the adaptation area had resided there (in 2018) for over 15 years

and are likely to be embedded in the local community. The latter group are likely to be more sensitive to long term changes and challenges associated with social cohesion, whilst the former group (new residents) are likely to bring in different and diverse perspectives including about how adaptation should proceed.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	People generally struggle to adjust to change within their communities, particularly where loss of properties and change in community composition occur. If people move, it is hard to maintain and re-establish social networks and connections that underpin social cohesion.
Coastal Flooding	L	People generally struggle to adjust to change within their communities, particularly where loss of properties and change in community composition occur. If people move, it is hard to maintain and re-establish social networks and connections that underpin social cohesion.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	H	H	H	L	M	H	H	H
Flooding	M	H	H	H	L	M	H	H	H

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	L	L	M	M	H	H	H	L	L	L	M
Risk from Flooding	M	M	H	E	M	H	H	H	M	M	H	E

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A.3 Ecological Risk Assessment Templates

A.3.1 Coastal dunelands

Domain	Element at Risk	Overview
Ecological	Coastal dunelands	There are three distinct dune systems in the CAA: ▪ the southern section of the Peka Peka duneland extends down into the Central Adaptation Area at the northern boundary and ends at the Waikanae Beach Domain; ▪ the Waikanae Beach duneland extends from the southern end of Waikanae Beach domain to the northern end of Waikanae Estuary Scientific Reserve; and ▪ the Paraparaumu Beach duneland extends from the Waikanae Estuary down to the southern end of Marine Parade. The Peka Peka dunes (c. 21 hectares within CAA) are characterised by active coastal sand foredunes with native vegetation present. The southern extent of these dunes is the Waimeha Stream. The dunes are relatively unmodified, with native species planted in the foredunes to support indigenous biodiversity. There are no known protective structures. The Waikanae dunes (c. 16.6 hectares) are located between the mouth of the Waimeha Stream and the Waikanae River Estuary. They are dominated largely by exotic vegetation with dense areas of kikuyu, buffalo grass and marram grass. Some of the exotic species present readily invade the sand binding area (area where you find species like spinifex and pingao trapping sand), displacing native species and thereby disrupting the natural dune building and repair processes after storm erosion (Coastline Consultants, 2009). The Waikanae Estuary Care Group Inc looks after parts of the estuary, and the Department of Conservation has ultimate responsibility for the Waikanae Scientific Reserve. There are no known protective structures. The Paraparaumu dunes (38.2 hectares) extend south from behind the Waikanae River Estuary to the end of Marine Parade. For most of its length, these dunes are backed by the Esplanade Reserve on the landward side. Paraparaumu dunes are also primarily vegetated by exotic species but native sand binding spinifex occurs on the foredunes (Forrest & Stevens, 2019). There is a Paraparaumu Beach care group. Seawalls occur along a section of Raumati Beach Road opposite Manly Gardens and south of Rua Road, and seawalls and retaining walls occur near the mouth of the Tikotu Stream.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	▪ Removal of sand from the beach, lowering the beach profile, and allowing waves to travel further inland. Removal of the toe of the dunes and potentially erosion of much or even all of the fore- and mid-dunes if wave action or storm surge is severe enough. In an unmodified duneland, the function of eroded foredunes would be taken over by more inland dunes. That is the more inland dunes would become the foredunes. The substantive amount of human infrastructure inland from the Waikanae Beach dunes and the Paraparaumu Beach dunes would limit this progression. Thus, there is a risk that coastal foredunes would be completely eroded and not replaced. There is less human infrastructure behind the Peka Peka dunes, but existing houses, roads and other infrastructure would still limit inland dune migration. ▪ These dunes and the sandy beaches are known to provide habitat for a range of dune species. here would be a consequent loss of dune and beach dwelling species (indigenous animals and plants – see Appendix A.3.5 for further details on these species) due to loss of habitat but also due to lack of alternative habitat to move to. ▪ Native dune species such as pīngao and spinifex are deep rooting plants, a loss of such species would create dune instability, and create a higher susceptibility to aeolian erosion. ▪ Ecological weeds are widespread through the dune systems and are considered one of the greatest threats to the ecological value of the dunes. A species of concern is marram grass,

Hazard	Description of Consequence (note any cascading impacts)
	which can alter sand dune structure and function, creating higher, steeper dune systems which are less stable, resulting in increased erosion and steeper erodible dune faces. Marram grass dominated dunes do not have the same ability to recover after storm events as pīngao or spinifex dunes. ▪ Natural coastal dunes are important elements of natural character, protection and enhancement of coastal biodiversity and habitat, and the protection of landscape and other costal amenity values (Coastline Consultants, 2009). ▪ Increased stream flooding could result in accelerated erosion of dunes around stream and river mouths (Waimeha Stream, Waikanae River, Tikotu Stream).
Coastal Flooding	▪ Storm surges can result in increased storm damage and/or complete inundation of sea water into dune systems dramatically affecting the condition of the vegetation communities and or breeding succession of fauna within the dunes. ▪ Flooding could increase the rate of sand removal through scour and subsequent dune collapse accelerating coastal erosion. ▪ Flooding would also reduce the area of beach available to shoreline nesting bird species. ▪ Increased sedimentation from coastal flooding can reduce habitat suitability and smother existing indigenous species and increase the risk of invasion by more saline-tolerant, exotic species. ▪ Bacteria contamination from ponding water in and around dune systems can pose a threat to human health and the social value people place on dunes for amenity values.

Opportunities

Hazard	Opportunities
Coastal Erosion	▪ Remove pest plant species, especially marram grass and plant the foredunes with pīngao and spinifex to make the dunes more resilient and less prone to erosion. These indigenous species typically result in a more stable but lower elevation dunes and can assist with retaining sand and growing the beach seawards. Remove pest plant species from mid and more rearward dunes and replace these with appropriate indigenous species; keeping in mind that the natural habitat is alternating dry sandy ridges and wetter swamp forest hollows. ▪ Undertaking further ecological weed control, working with Greater Wellington Regional Council to work on their Key Native Ecosystem program and align KCDC environmental management schemes. ▪ Undertake pest animal control to enable greater breeding success of birds and other species and partially offset loss of habitat. ▪ A key threat to dunes is through human off-road recreational driving causing dune erosion disturbing and native species. While driving and recreation is banned within dunes, there is the opportunity for further education on why it is banned, and the importance of the dunes. Further signage and human deterrents (i.e.) more and better sectioning off the dunes could be placed. ▪ Where other required coastal works enable this (e.g. sewerage line or road upgrades), include dune reconstruction and restoration to create additional/greater areas of natural duneland.
Coastal Flooding	▪ Opportunity to plant more saline resistant flora surrounding hydro systems to allow for better drainage and less sedimentation and nutrient leeching. ▪ Remove pest plant species, especially marram grass and plant the dunes with pīngao and spinifex to make the dunes more resilient and less prone to erosion and reduce potential for future flooding. Remove pest plant species from mid and more rearward dunes and replace these with appropriate indigenous species; keeping in mind that the natural habitat is alternating dry sandy ridges and wetter swamp forest hollows. The wetter swamp hollows could serve as temporary flood holding areas and reduce more inland flooding. ▪ Increased ecological weed control in alignment with the GWRC Key Native Ecosystem plans. ▪ Undertake pest animal control to enable greater breeding success of birds and other species and partially offset loss of habitat.

Figure A.3.1: Exposure of the dunelands to erosion hazards in 2130 under SLR scenario SSP5-8.5.

A.3.1.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion ▪ Southern Peka Peka duneland: Average of 17.5 m inland erosion along the Peka Peka dunes foreshore. This is half to most of the width (near Waimeha Stream) of the dunes except for at Pharazyn Reserve which is wider. Moderate exposure (50%) of dunes at risk of erosion ▪ Waikanae Beach duneland: Average of 18 m of inland erosion across the Waikanae shoreline, which is two-thirds of the dune width expect at the mouths of waterways where there is a greater depth of mapped dunes. Moderate exposure (50%) of dunes at risk of erosion. ▪ Paraparaumu Beach duneland: Variable width of inland erosion across the Paraparaumu shoreline ranging from 30 m to 9.5 m average of 18 m. The width of dune affected ranges from 100% to 25%.. Low exposure (25%) of dunes at risk of erosion. Overall exposure: Moderate.	Future exposure: 2050 ▪ Southern Peka Peka duneland : Average of 30 m inland erosion. Moderate exposure (50%) of dunes at risk of erosion ▪ Waikanae Beach duneland : Average of 33 m inland erosion Moderate exposure (25-50%) to hazard with increased erosion at the lower Waimeha Stream. ▪ Paraparaumu Beach duneland: Average of 30 m inland erosion. Moderate exposure (25-50%) to hazard with increased erosion surrounding waterways, and the southern end of the dunes experiencing full erosion. 2070 ▪ Southern Peka Peka duneland: Average of 30 m inland erosion. Moderate exposure (50%) of dunes at risk of erosion ▪ Waikanae Beach duneland: Average of 34 m inland erosion. Continued moderate exposure (25-50%) to the erosion hazard. ▪ Paraparaumu Beach duneland: Average of 34 m inland erosion. Continued moderate exposure (25-50%) to the erosion hazard. 2130 ▪ Southern Peka Peka duneland: Average of 35 m inland erosion. Moderate exposure (50%) of dunes at risk of erosion ▪ Waikanae Beach duneland: Average of 38 m inland erosion. Increased moderate exposure (approximately 40%) to erosion hazards. ▪ Paraparaumu Beach duneland: Average of 48 m inland erosion. Increased moderate exposure to erosional hazards (<50%).
Currently exposed to coastal flooding ▪ Southern Peka Peka dunelands: Low exposure (5-25%) of dunes to flooding. ▪ Waikanae Beach dunelands: Low exposure (5-25%) of dunes to flooding. ▪ Paraparaumu Beach dunelands: Low exposure (5-25%) of dunes to flooding.	Future exposure: 2050 ▪ Southern Peka Peka dunelands: Continued low exposure of dunes to coastal flooding (5-25%). ▪ Waikanae: Continued low exposure of dunes to coastal flooding (5-25%). ▪ Paraparaumu Beach dunelands: Increases in flooding in the dunes surrounding the Waikanae Estuary however overall low exposure of dunes to coastal flooding (5-25%). 2070 ▪ Southern Peka Peka dunelands: Continued low exposure of dunes to coastal flooding (5-25%). ▪ Waikanae Beach dunelands: Continued low exposure of dunes to coastal flooding (5-25%).

Details of exposure

	▪ Paraparaumu Beach dunelands: Continued low exposure of dunes to coastal flooding (5-25%). **2130** ▪ Southern Peka Peka dunelands: Continued low exposure of dunes to coastal flooding (5-25%). ▪ Waikanae dunelands: Minimal increases with continued low exposure of dunes to coastal flooding (5-25%). ▪ Paraparaumu Beach dunelands: Increase to moderate exposure (25-50%) of dunes, particularly centred around the Waikanae Estuary and within depressions of the dune system in front of Manly Street from Beach Haven Pl, south towards and surrounding the outlet at Maclean Park.

Hazard	Present	2050	2070	2130
Coastal Erosion	M	M	M	M
Coastal Flooding	L	L	L	M

Note:

- This part of the shoreline has a good supply of sand and has reduced wave action as it is protected by Kāpiti Island.

Erosion:

- Measured from the toe of the dunes mapped by GWRC to the highest modelled erosion line.
- Erosion is more significant adjacent to stream and river mouths.
- Present day sensitivity has been ranked as moderate due to present day erosion risk, some room for the dune re-establish inland, and good coastal sand input.
- This continues into the future.

Flooding:

- Measured as the approximate area of dune affected by the modelled flooding.
- Present-day risk of flood events is ranked as Low as dunes are elevated and therefore somewhat resilient to to flooding.
- This increases to Moderate from 2130 as it is more likely that significant and/or more frequent flood events would undermine dune toes and increase erosion and susceptibilty to flooding.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	H	H	H
Coastal Flooding	L	L	L	M

Notes:

- Due to good sand supply it is likely damaged dunes will re-establish after storm events, up to a point. Once the erosion exceeds the sand supply then dunes would progressively 'move' inwards with the more inland dunes taking up the role of the foredunes. This is still possible to some extent for all dune areas but the human built environment would limit this movement eventually.
- Storm surge lowering the beach profile, ongoing tectonic subsidence, and increased flood or high flow events coming from waterways increase the level of sensitivity.
- Pest plant species such as marram increasing the height of dunes, and providing a less robust sand retention environment than indigenous dune species. This makes the toes of the foredunes more susceptible to being undermined, causing dune collapse and further erosion.

Erosion:

- Present day sensitivity has been ranked as moderate due to present day erosion risk, some room for the dune re-establish inland, and good coastal sand input.
- From 2050 on the sensitivity has been increased to high because in certain locations the mapped dunes could be completely eroded.

Flooding:

- Present day sensitivity to flood events is ranked as low as dunes are elevated and therefore somewhat resilient to to flooding.
- This increases to moderate from 2130 as it is more likely that significant and/or more frequent flood events would undermine dune toes and increase erosion.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	▪ The dunes at the southern end Peka Peka, Waikanae Beach and along the Paraparaumu Beach shore front are restricted in their ability to naturally migrate back from rising seas due to intensive human development already creating coastal squeeze. ▪ Storm surge and more frequent flood events lowering beach profile, and tectonic subsidence, allowing storm surge to move further inland and causing greater erosion. Pest plants resulting in less stable dunes. ▪ There are small reserves present however current dune systems cover those, and therefore erosion would create natural shrinking of the natural dunelands.
Coastal Flooding	M	▪ The area is generally more elevated and therefore flooding may not be as frequent or severe as in other parts of the Kāpiti Coast. ▪ Ecosystems and species that are more tolerant of periodic exposure to saline waters are likely to have a greater adaptive capacity (Ministry for the Environment, 2020).

Notes:

- Dunes in the Kāpiti Coast district are fed by a typically westerly swell and locally generated waves which transport large quantities of sand-sized sediment along the coast down to the south. Dunes in the CAA are influenced by Kāpiti Island creating a wave shadow effect allowing sediments to accumulate at the beaches creating the dramatic cuspate foreland seen at Paraparaumu Beach. Due to this, dunelands in the CAA are typically stable as the sediment supplies are greater than the transport losses to the south which cause long term shoreline growth.
- Dunes provide a natural dynamic environment acting as a host for indigenous flora and fauna as key habitat for breeding with species including a mix of regionally threatened species, other key indigenous dune land species, species highlighted in the regional pest management plan and emerging pest plants. As well as existing as a natural protection for human settlements and infrastructure from actions of the sea.
- For adaptive capacity of coastal ecosystems to occur, it will rely on effective human management rather than on their own characteristics.
- Natural adaptation will take sufficient time and space but is limited along the Waikanae and Paraparaumu coastlines due to a lack of sufficient space available behind dune systems due to the presence of settlements.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	H	H	H	L	M	H	H	H

Hazard	Sensitivity			Adaptive Capacity		Vulnerability			
Flooding	L	L	L	M	M	L	L	L	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	M	M	M	M	M	H	H	H	M	M	M	M
Risk from Flooding	L	L	L	M	L	L	L	M	L	L	L	M

A.3.1.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion ▪ Southern Peka Peka dunelands: Average of 17.5 m inland erosion along the Peka Peka dunes foreshore. This is half to most of the width (near Waimeha Stream) of the dunes except for at Pharazyn Reserve which is wider. Moderate exposure (50%) of dunes at risk of erosion ▪ Waikanae Beach dunelands: Average of 18 m of inland erosion across the Waikanae shoreline, which is two-thirds of the dune width expect at the mouths of waterways where there is a greater depth of mapped dunes. Moderate exposure (50%) of dunes at risk of erosion. ▪ Paraparaumu Beach dunelands: Variable width of inland erosion across the Paraparaumu shoreline ranging from 30 m to 9.5 m average of 18 m. The width of dune affected ranges from 100% to 25%.. Low exposure (25%) of dunes at risk of erosion. Overall risk Moderate.	Future exposure: 2050 ▪ Southern Peka Peka dunelands : Average of 30 m inland erosion. Moderate exposure (50%) of dunes at risk of erosion. ▪ Waikanae Beach dunelands: Average of 33 m inland erosion. Moderate exposure (25-50%) to hazard with increased erosion at the lower Waimeha Stream. ▪ Paraparaumu Beach dunelands: Average of 30 m inland erosion. Moderate exposure (25-50%) to hazard with increased erosion surrounding waterways, and the southern end of the dunes experiencing full erosion. 2070 ▪ Southern Peka Peka dunelands: Average of 37 m inland erosion. Moderate exposure (50%) of dunes at risk of erosion ▪ Waikanae Beach dunelands: Average of 38 m inland erosion. High exposure (50-75%) to hazard extending further into Waikanae Beach settlement with a near full loss of dunes in front of some properties. ▪ Paraparaumu Beach dunelands: Average of 39 m inland erosion. High exposure (>50%) to the hazard with increases in from of the Esplanade Reserve in the first kilometre south of Waikanae Estuary and in the southern part of the CAA. 2130 ▪ Southern Peka Peka dunelands: Average of 62 m inland erosion. High exposure (approximately 50%-75%) of dunes in Peka Peka at risk of erosion, with complete loss of dunes surrounding hydrosystems. ▪ Waikanae Beach dunelands: Average of 60 m inland erosion. Continued high exposure (50-75%) to hazard with most of the dunes in front of properties experiencing erosion and increased erosion around waterways. ▪ Paraparaumu Beach dunelands: High exposure (50-75%) to erosion hazard with over half of the length of dunes along Paraparaumu Beach expected to experience complete erosion.
Currently exposed to coastal flooding ▪ Southern Peka Peka dunelands: Low exposure (5-25%) of dunes to flooding. ▪ Waikanae Beach dunelands: Low exposure (5-25%) of dunes to flooding. ▪ Paraparaumu Beach dunelands: Low exposure (5-25%) of dunes to flooding.	Future exposure: 2050 ▪ Southern Peka Peka dunelands: Continued low exposure of dunes to coastal flooding (5-25%). ▪ Waikanae Beach dunelands: Continued low exposure of dunes to coastal flooding (5-25%). ▪ Paraparaumu Beach dunelands: Increases in flooding in the dunes surrounding the Waikanae Estuary however overall low exposure of dunes to coastal flooding (5-25%).

Details of exposure

2070

- Southern Peka Peka dunelands: Continued low exposure of dunes to coastal flooding (5-25%).
- Waikanae Beach dunelands: Continued low exposure of dunes to coastal flooding (5-25%).
- Paraparaumu Beach dunelands: Continued low exposure of dunes to coastal flooding (5-25%).

2130

- Southern Peka Peka dunelands: Continued low exposure of dunes to coastal flooding (5-25%).
- Waikanae Beach dunelands: Minimal increases with continued low exposure of dunes to coastal flooding (5-25%).
- Paraparaumu Beach dunelands: High exposure of dunes to flooding (50-75%) as flooding begins to occur in depressions in the dune system and the section of the duneland bordering Waikanae Estuary.

Hazard	Present	2050	2070	2130
Coastal Erosion	M	M	H	H
Coastal Flooding	L	L	L	M

Notes:

- This part of the shoreline has a good supply of sand and has reduced wave action as it is protected by Kāpiti Island.

Erosion:

- Measured from the toe of the dunes mapped by GWRC to the highest modelled erosion line.
- Erosion is more significant adjacent to stream and river mouths.
- Current risk is set to Moderate as erosion is already occuring. At the moment the supply of sand is sufficient for dunes to rebuilt between storm events, but pest plants such as marram create more unstable dunes that erode much easier.
- Risk increases to High from 2070 because the depth to which the coastal dunes could be eroded inceases substantially. This level of erosion may not be offset by available sand supply.

Flooding:

- Measured as the approximate area of dune affected by the modelled flooding.
- As dunes are generally elevated above predicted flood levels the current risk is Low and continues to be Low until 2070.
- The flooding risk increases to Moderate from 2130 because the Paraparaumu dune system is being affected by flooding.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	H	H	E
Coastal Flooding	L	L	L	M

Notes:

- Due to good sand supply it is likely damaged dunes will re-establish after storm events, up to a point. Once the erosion exceeds the sand supply then dunes would progressively 'move' inwards with the more inland dunes taking up the role of the foredunes. This is still possible to some extent for all dune areas but the human built environment would limit this movement eventually.

- Storm surge lowering the beach profile, ongoing tectonic subsidence, and increased flood or high flow events coming from waterways increase the level of sensitivity.
- Pest plant species such as marram increasing the height of dunes, and providing a less robust sand retention environment than indigenous dune species. This makes the toes of the foredunes more susceptible to being underminded, causing dune collapse and further erosion.

Erosion:

- Present day sensitivity has been ranked as Moderate due to present day erosion risk, some room for the dune re-establish inland, and good coastal sand input.
- From 2050 on the sensitivity has been increased to High because in certain locations the mapped dunes could be completely eroded.
- In 2130 substantial areas of dune would be undermined with knock-on effects on adjacent areas of dune, hence the risk is seen to be Extreme.

Flooding:

- Present-day sensitivity to flood events is ranked as Low as dunes are elevated and therefore somewhat resilient to to flooding.
- This increases to Moderate from 2130 as it is more likely that significant and/or more frequent flood events would undermine dune toes and increase erosion.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	▪ The dunes at the southern end Peka Peka, Waikanae Beach and along the Paraparaumu shore front are restricted in their ability to naturally migrate back from rising seas due to intensive human development already creating coastal squeeze. ▪ Storm surge and more frequent flood events lowering beach profile, and tectonic subsidence, allowing storm surge to move further inland and causing greater erosion. Pest plants resulting in less stable dunes. ▪ There are small reserves present however current dune systems cover those, and therefore erosion would create natural shrinking of the natural dunelands. ▪
Coastal Flooding	M	▪ The area is generally more elevated and therefore flooding may not be as frequent or severe as in other parts of the Kāpiti Coast. ▪ Ecosystems and species that are more tolerant of periodic exposure to saline waters are likely to have a greater adaptive capacity (Ministry for the Environment, 2020).

Notes:

- Dunes in the Kāpiti Coast district are fed by a typically westerly swell and locally generated waves which transport large quantities of sand-sized sediment along the coast down to the south. Dunes in the CAA are influenced by Kāpiti Island creating a wave shadow effect allowing sediments to accumulate at the beaches creating the dramatic cuspate foreland seen at Paraparaumu Beach. Due to this, dunelands in the CAA are typically stable as the sediment supplies are greater than the transport losses to the south which cause long term shoreline growth.
- Dunes provide a natural dynamic environment acting as a host for indigenous flora and fauna as key habitat for breeding with species including a mix of regionally threatened species, other key indigenous dune land species, species highlighted in the regional pest management plan and emerging pest plants. As well as existing as a natural protection for human settlements and infrastructure from actions of the sea.
- For adaptive capacity of coastal ecosystems to occur, it will rely on effective human management rather than on their own characteristics.

- Natural adaptation will take sufficient time and space but is limited along the Waikanae, Paraparaumu coastlines due to a lack of sufficient space available behind dune systems due to the presence of settlements.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	H	H	H	L	M	H	H	M
Flooding	L	L	L	M	M	L	L	L	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	M	H	H	H	M	H	H	E	M	H	H	E
Risk from Flooding	L	L	L	M	L	L	L	M	L	L	L	M

A.3.2 Wetlands

Domain	Element at Risk	Overview
Ecological	Wetlands	There are 12 know wetlands in the CAA. Of theses, there are ten mapped wetlands, of which two are outstanding wetlands, four are identified natural wetlands and another four that are known to be wetlands but not yet included in GWRC Natural Resource Plan Schedules. Another two areas are currently not recognized as a natural wetland they are constructed or highly modified but are important habitat for birds and fish. GWRC Schedule A3: Wetlands with outstanding indigenous biodiversity values: ▪ Te Harakeke Wetland ▪ Waikanae Estuary saltmarsh GWRC Schedule F3: Identified natural wetlands: ▪ Osbornes Swamp ▪ Waimeha Lagoon - Victor Weggery Reserve ▪ El Rancho Wetlands ▪ Ngarara Lake GWRC other scientific wetlands: ▪ Ngarara Wetlands ▪ Waikanae River Oxbow ▪ Kāpiti Airfield Wetland A ▪ Kāpiti Airfield Raupo Swamp Other wetlands - Not assessed here but under bird and fish habitat: ▪ (Pharazyn ponds – constructed but becoming naturalized and important for birds and fish species.) ▪ (Waimeha Lagoon-Tutere Street – highly modified by important for birds and fish species) Note that there may be other wetland that have not yet been identified or mapped that would qualify as natural wetlands under the National Policy Statement for Freshwater Management (NPS-FM) and/or the National Environmental Standard-Freshwater (NES-F). The NPS-FM excludes wetlands in the coastal zone, but the NES-F includes all wetlands.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	▪ Of the ten mapped wetlands present in the CAA, only one will experience coastal erosion under SSP2-4.5 scenario. This is the wetland area north of Waikanae River Track and east of Manly Street and closest to the river mouth. This is part of the Waikanae Estuary saltmarsh wetland complex, which is scheduled by GWRC as an outstanding wetland. ▪ Erosion could remove part or all of this wetland area resulting in the loss of wetland vegetation and fauna, and altering the hydrology and wetland soil composition. ▪ Existing modified channels already restrict the extent of the salt marsh vegetation in the upper estuary, further potential erosion of estuary edges would place further pressure on existing vegetation (Stevens & Forrest, 2019). ▪ Wetlands are effective sinks for carbon dioxide and encouraged as carbon sequestration tools. Wetlands that experience erosion and as a result habitat loss can have cascading impacts on the amount of carbon the ecosystem is able to take in in the future (Were, et al, 2019). ▪ Ongoing erosion is likely to result in the displacement of a coastal ecosystems for breeding and migratory species and has the potential to block or alter upstream pathways for migratory breeding fish. ▪ Erosion could result in seawater penetrating further inland in groundwater systems changing salinity of nearby coastal wetlands and affecting vegetation and habitat types.

Hazard	Description of Consequence (note any cascading impacts)
	▪ Loss of wetland vegetation can also result in further destabilization of dunes and loss of storm surge protection for inland portions and could also result in modifications of the Waikanae River bed leading to more or increased rates of erosion.
Coastal Flooding	▪ Of the ten wetlands present in the CAA six will experience flooding under SSP2-4.5 scenario. These are - Outstanding wetlands: -Te Harakeke Wetland and Waikanae Estuary saltmarsh; Identified wetlands: Waimeha Lagoon - Victor Weggery Reserve and Ngarara Lake; Other scientific wetlands: Waikanae River Oxbow and the coastal part of Ngarara wetlands. ▪ Flooding could alter the vegetation composition within a wetland depending on the length of floodwater retention, the depth of the flooding and whether the flooding changes the salinity of the wetlands for more than a few hours. ▪ Flooding can adversely affect fauna populations especially if these are sedentary (don't or can't move very far), during nesting or breeding, and/or if connections to other habitat are cut off so individuals are unable to retreat from flooding (this includes increased flows preventing fish movements). ▪ Saltmarshes, such as the Waikanae Estuary, have the potential to have reduced species richness and experience species shifts in response to increased periods of salinity and flooding following disturbance events (Baldwin & Mendelssohn, 1998). ▪ Increased sediment deposition through increased storm and flood frequencies are likely to decrease light penetration, increase turbidity and reduce primary productivity. Silt deposition can smother plants and animals. Changes in sediment size can reduce habitat suitability for aquatic species causing species mortality, through for example fine silts deposited over coarser sandy sediments (Ministry for the Environment, 2020a). ▪ Coastal wetlands in areas of low relief are susceptible to saline intrusion, which can then impact the community structure of wetland plants and animals (Finlayson., et al, 2017). ▪ Flood waters could move plant seeds or parts around the landscape, expanding and/or introducing new pest species that are likely to impact the integrity and functioning of indigenous ecosystems. This includes species such as willows (*Salix* spp), blackberry (*Rubus fruticosus* agg) and gorse (*Ulex europaeus*) (Robertson et al, 2016) from (Ministry for the Environment, 2020a). ▪ Increased flooding may result in additional areas of natural inland wetland establishing or being recognized. Many of the low-lying areas within the sand dune belt of Kāpiti were historically wetlands. These have been drained or are continually suppressed through mowing, grazing, plowing and weed spraying. Flood events may result in 'boggy' areas expressing their previous wetland characteristics including a change to more wetland plant species dominance. ▪ The disruption of wetland ecosystems and loss of species is likely to impact on the agricultural sector, which relies on freshwater systems for water. The agricultural sector could also further impact wetland ecosystems (Ministry for the Environment, 2020a). ▪ This risk to wetlands can pose a threat to Māori social, economic, cultural capital and cultural heritage values and spiritual wellbeing (Ministry for the Environment, 2020a).

Opportunities

Hazard	Opportunities
Coastal Erosion	▪ Plant up adjacent low-lying areas with estuarine and inland wetland species to help retain wetland habitat. Remove pest plants from dunes and existing wetlands. Where possible, create additional estuarine wetland habitat upstream of waterways to retain wetland habitat and enable plant and animal species to migrate. Include habitat suitable as whitebait spawning sites. Undertake pest animal control to enable terrestrial species to have higher survival and breeding success rates. ▪ Integrate governance, legislative and regulatory frameworks across sectors and scales to ensure effective wetland management (Finlayson., et al, 2017). ▪ Erosion and disturbance of wetland areas can create gaps in the vegetation that stimulate recruitment and colonization by indigenous plant species (Baldwin & Mendelssohn, 1998). However, this would need to be monitored to ensure that pest plant species do not establish. ▪ Prevent or limit future development surrounding wetlands to provide the ecosystems a greater chance at natural adaptation and reduce high-intensity human use.

Hazard	Opportunities
Coastal Flooding	▪ Plant up adjacent low-lying areas with estuarine and inland wetland species to help retain wetland habitat. Remove pest plants from dunes and existing wetlands. Where possible, create additional estuarine wetland habitat upstream of waterways to retain wetland habitat and enable plant and animal species to migrate. Include habitat suitable as whitebait spawning sites. Undertake pest animal control to enable terrestrial species to have higher survival and breeding success rates. ▪ Consider adaptation actions such as land acquisition in areas adjacent to wetlands. ▪ The extent of flooding may result in areas of wetland expanding from the current situation. This could include saline, semi-saline, riparian and other fresh-water wetlands. Create buffers of suitable indigenous plant species around wetlands so that the wetland edge protected/maintained when flooded. Introduce new suitable indigenous species so that local seed sources are available to colonise deeper (higher water table) wetland types.

Figure A.3.2: Location of wetlands and ecological sites within the CAA.

A.3.2.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion ▪ There are no wetlands currently exposed to coastal erosion.	Future exposure: ▪ **2050:** There are no wetlands currently exposed to coastal erosion, however the northwestern part of the Waikanae Estuary saltmarsh is likely to experience flow on effects from the erosion of the dunes bordering the estuary. ▪ 2070: There are no wetlands currently exposed to coastal erosion, however northwestern part of the Waikanae Estuary saltmarsh is likely to experience flow on effects from the erosion of the dunes bordering the estuary. ▪ 2130: It is likely that erosion will open up the northwestern part of the Waikanae Estuary saltmarsh (part of an outstanding wetland system) to more frequent saline water penetration. This will change plant and animal species composition and reduce the buffer for human infrastructure..
Currently exposed to coastal flooding ▪ Much of the flooding is due to water accumulating or backing up in low lying areas. Wetlands tend to be low-lying. ▪ Outstanding wetland: Te Harakeke Wetland outflow will be restricted and 80% of the Waikanae Estuary saltmarsh floods ▪ Significant, natural wetland: 100% flooded - Waimeha Lagoon – Victor Weggery Reserve, Ngarara Lake ▪ Other wetlands: 100% flooded Waikanae Oxbow.	Future exposure: 2050: ▪ Outstanding wetland: Flows back up in at least half of Te Harakeke Wetland and 90% of the Waikanae Estuary saltmarsh floods ▪ Significant, natural wetland: 100% flooded Waimeha Lagoon – Victor Weggery Reserve and Ngarara Lake ▪ Other wetlands: 100% flooded Waikanae Oxbow 2070: ▪ Outstanding wetland: Flows back up in at least half of Te Harakeke Wetland and 100% of the Waikanae Estuary saltmarsh floods and floods into adjacent areas ▪ Significant, natural wetland: 100% flooded Waimeha Lagoon – Victor Weggery Reserve and Ngarara Lake ▪ Other wetlands: 100% flooded Waikanae Oxbow and floods into adjacent areas 2130: ▪ Outstanding wetland: Te Harakeke Wetland 100% flooded and 100% of the Waikanae Estuary saltmarsh floods and floods into adjacent areas ▪ Significant, natural wetland: 100% flooded Waimeha Lagoon – Victor Weggery Reserve and floods into adjacent areas, and Ngarara Lake ▪ Other wetlands: 100% flooded Waikanae Oxbow and floods into adjacent areas

Hazard	Present	2050	2070	2130
Coastal Erosion	L	M	M	H
Coastal Flooding	M	M	H	H

Note:

- There are ten mapped wetlands in the CAA, of which two are outstanding wetlands, four are identified natural wetlands and another four that are known to be wetlands.
- There may be inland areas where wetlands could be planted or established after flooding. This moderates some of the effects.
- Changes to salinity and duration and depth of flooding will change plant species composition. This will have knock-on effects on fauna and habitat types.

Erosion

- Estimated as the proportion of the wetland affected by erosion.
- Current threat is low.
- Due to the dunes along the coast wetlands will be protected from erosion for a considerable period of time. However, erosion could result in seawater penetrating further inland in groundwater systems and changing salinity of near coastal wetlands. Hence moderate risk from 2050 on as a precaution.
- Increases to high in 2130 due to opening the northwestern part of the Waikanae Estuary saltmarsh (Outstanding Wetland) to the sea with consequent effects on ecology.

Flooding

- Estimated as the proportion of the wetland affected by flooding. Includes flooding of adjacent areas as this may increase the area of wetland over time.
- Current flooding risk is moderate, as flooding of the saline wetlands occurs already (and is expected).
- Flood risk increases to high from 2070 as low-lying areas adjacent to the wetlands also flood. This could potentially be set as extreme risk, but moderate is seen as more appropriate because flooding tends to be more temporary and may also result in additional areas of wet land enabling potential expansion of wetlands (through planting or natural processes).

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	L	M	M	H
Coastal Flooding	M	M	M	M

Notes:

Erosion:

- Present-day sensitivity has been set as low as erosion currently has few adverse effects on wetlands.
- From 2050 on risk is considered to be moderate. Erosion of dunes along the northwestern part of the Waikanae Estuary saltmarsh (Outstanding Wetland) could result in increased salinity which would change plant species composition. Depending on the rate of erosion and the presence of saline tolerant plant species this could result in areas of this wetland dying back and slow recolonisation by other plant species.
- Risk increases to high in 2130 as it is likely that the area will have been opened up to the effects of the sea increasing the risk of further erosion and increased salinity in other parts of this wetland.

Flooding:

- Present-day sensitivity has been set as moderate as flooding could adversely affect plants within the wetland. On the other hand, flooding also contributes to keeping a wetland wet.
- The risk for future flooding scenarios has been maintained as moderate because it is uncertain if flooding would maintain or adversely affect wetlands. Effects would depend, in part, on the duration of flooding. There is potential for aditional areas of wetland to establish which moderates potential effects.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	▪ The Identified wetland at risk (Waikanae Estuary saltmarsh) will experience no erosion until 2130. Only the part of the saltmarsh that is the closest to the mouth of the river will experience erosion, which represents a small part of the saltmarsh (0.02 sq km).

Domain	Adaptive Capacity	Key Assumptions
		▪ Saline intrusion into the wetland can occur earlier as sand is a permeable medium. Increases salinity will affect the plant species composition with consequent effects on fauna. ▪ Waikanae Estuary is a significantly modified system without significant changes from 2007 – 2019 indicating an adaptatable system (Stevens & Forrest, 2019). But, it is backed by human infrastructure so unable to move further inland and may lack sufficient species diversity to cope with a change in salinity.
Coastal Flooding	M	▪ The effects of flooding will depend on the duration and height of flooding. Prolonged flooding and sustained emersion will kill plants (even tough species such as flax). ▪ Some terrestrial fauna species (e.g. lizards and small invertebrates) may not be able to escape floods quickly enough with effects on the local population. More mobile species may be able to find alternative habitat, but wetlands are rare in the landscape. ▪ Flooding could result in changes to the habitats within the wetland (e.g. more open water, greater area of deeper water reeds, less rushland), and could result in loss of species diversity. ▪ Areas adjacent to the wetlands will flood and could become permanent boggy over time. This has the potential to increase the area of wetlands through planting or natural processes. Hence adaptive capacity is Moderate rather than Low.

Notes:

- **The adaptive capacity of coastal ecosystems will rely somewhat on effective management, as well as intrinsic wetland characteristics. Wetland management plans should include provisions to adapt to and/or take advantage of climatic changes capacity and will need to be implemented by the relevant authorities or entities.**

Vulnerability Score

Hazard	Sensitivity					Vulnerability			
	Present	2050	2070	2130	Adaptive Capacity	Present	2050	2070	2130
Erosion	L	M	M	H	L	L	M	M	H
Flooding	M	M	M	M	M	M	M	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	M	M	H	L	M	M	H	L	M	M	H
Risk from Flooding	M	M	H	H	M	M	M	M	M	M	M	M

A.3.2.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion ▪ There are no wetlands currently exposed to coastal erosion.	Future exposure: ▪ **2050:** There are no wetlands currently exposed to coastal erosion, however northwestern part of the Waikanae Estuary saltmarsh is likely to experience flow on effects from the erosion of the dunes bordering the estuary. ▪ **2070:** It is likely that erosion will open up the northwestern part of the Waikanae Estuary saltmarsh (part of an outstanding wetland system) to more frequent saline water penetration. This will change plant and animal species composition and reduce the buffer for human infrastructure ▪ **2130:** Erosion will open up the northwestern part of the Waikanae Estuary saltmarsh (part of an outstanding wetland system) to the sea. This will change plant and animal species composition and reduce the buffer for human infrastructure.
Currently exposed to coastal flooding ▪ Much of the flooding is due to water accumulating or backing up in low lying areas. Wetlands tend to be low-lying. ▪ Outstanding wetland: Te Harakeke Wetland outflow will be restricted and 80% of the Waikanae Estuary saltmarsh floods ▪ Significant, natural wetland: 100% flooded - Waimeha Lagoon – Victor Weggery Reserve, Ngarara Lake ▪ Other wetlands: 100% flooded Waikanae Oxbow.	Future exposure: **2050:** ▪ Outstanding wetland: Flows back up in at least half of Te Harakeke Wetland and 90% of the Waikanae Estuary saltmarsh floods ▪ Significant, natural wetland: 100% flooded Waimeha Lagoon – Victor Weggery Reserve and Ngarara Lake ▪ Other wetlands: 100% flooded Waikanae Oxbow **2070:** ▪ Outstanding wetland: Flows back up in at least half of Te Harakeke Wetland and 100% of the Waikanae Estuary saltmarsh floods and floods into adjacent areas ▪ Significant, natural wetland: 100% flooded Waimeha Lagoon – Victor Weggery Reserve and Ngarara Lake, water start backing up in the outflow of Osbornes Swamp ▪ Other wetlands: 100% flooded Waikanae Oxbow and floods into adjacent areas **2130:** ▪ Outstanding wetland: Te Harakeke Wetland 100 flooded and 100% of the Waikanae Estuary saltmarsh floods and floods into adjacent areas ▪ Significant, natural wetland: 100% flooded Waimeha Lagoon – Victor Weggery Reserve and floods into adjacent areas, 100% flooded Ngarara Lake, and water levels increase in Osbornes Swamp, El Rancho Wetlands ▪ Other wetlands: 100% flooded Waikanae Oxbow and floods into adjacent areas and water levels increase in Kāpiti Airfield Wetland A

Hazard	Present	2050	2070	2130
Coastal Erosion	L	M	H	H
Coastal Flooding	M	M	H	H

Note:

- There are ten mapped wetlands in the CAA, of which two are outstanding wetlands, four are identified natural wetlands and another four that are known to be wetlands.
- There may be inland areas where wetlands could be planted, or established after flooding. This moderates some of the effects.
- Changes to salinity and duration and depth of flooding will change plant species composition. This will have knock-on effects on fauna and habitat types.

Erosion

- Estimated as the proportion of the wetland affected by erosion.
- Current threat is low.
- Due to the dunes along the coast wetlands will be protected from erosion for a considerable period of time. However, erosion could result in seawater penetrating further inland in groundwater systems and changing salinity of near coastal wetlands. Hence moderate risk in 2050 as a precaution.
- Increases to high in 2070 due to the likely opening the northwestern part of the Waikanae Estuary saltmarsh (Outstanding Wetland) to the sea with consequent effects on ecology.

Flooding

- Estimated as the proportion of the wetland affected by flooding. Includes flooding of adjacent areas as this may increase the area of wetland over time.
- Current flooding risk is moderate, as flooding of the saline wetlands occurs already (and is expected).
- Flood risk increases to high in 2070 as low-lying areas adjacent to the wetlands also flood. This could potentially be set as extreme risk, but moderate is seen as more appropriate because flooding tends to be more temporary and may also result in additional areas of wet land enabling potential expansion of wetlands (through planting or natural processes).
- Flood risk in 2013 could be set to extreme as the water levesl in one of the the Kāpiti Airfield wetlands will increase. This wetland includes a known population of threatened plant and an increase in watertable may actually prove beneficial for this species (increased watertable and reduced weed pressure). Hence the oderate risk is retained.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	L	M	H	H
Coastal Flooding	M	M	M	H

Notes:

Erosion:

- Present-day sensitivity has been set as low as erosion currently has few adverse effects on wetlands.
- In 2050 risk is considered to be Moderate. Erosion of dunes along the northwestern part of the Waikanae Estuary saltmarsh (Outstanding Wetland) could result in increased salinity which would change plant species composition. Depending on the rate of erosion and the presence of saline tolerant plant species this could result in areas of this wetland dying back and slow recolonisation by other plant species.
- Risk increases to high from 2070 as it is likely that the area will have been opened up to the effects of the sea increasing the risk of further erosion and increased salinity in other parts of this wetland.

Flooding:

- Present-day sensitivity has been set as moderate as flooding could adversely affect plants within the wetland. On the other hand, flooding also contributes to keeping a wetland wet.
- The risk for future flooding scenarios has been maintained as moderate because it is uncertain if flooding would maintain or adversely affect wetlands. Effects would depend, in part, on the duration of flooding. There is potential for aditional areas of wetland to establish which moderates potential effects.
- The risk from flooding is set to high for 2130 as the effects on a threatened plant species are not clear. Flooding may prove beneficial, or it may eliminate the population altogether

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	▪ The Identified wetland at risk (Waikanae Estuary saltmarsh) will experience no erosion until 2130. Only the part of the saltmarsh that is the closest to the mouth of the river will experience erosion, which represents a small part of the saltmarsh (0.02 sq km). ▪ Saline intrusion into the wetland can occur earlier as sand is a permeable medium. Increases salinity will affect the plant species composition with consequent effects on fauna. ▪ Waikanae Estuary is a significantly modified system without significant changes from 2007 – 2019 indicating an adaptatable system (Stevens & Forrest, 2019). But, it is backed by human infrastructure so unable to move further inland and may lack sufficient species diversity to cope with a change in salinity.
Coastal Flooding	L	▪ The effects of flooding will depend on the duration and height of flooding. Prolonged flooding and sustained emersion will kill plants (even tough species such as flax). ▪ Some terrestrial fauna species (e.g. lizards and small invertebrates) may not be able to escape floods quickly enough with effects on the local population. More mobile species may be able to find alternative habitat, but wetlands are rare in the landscape. ▪ Flooding could result in changes to the habitats within the wetland (e.g. more open water, greater area of deeper water reeds, less rushland), and could result in loss of species diversity. ▪ Areas adjacent to the wetlands will flood and could become permanent boggy over time. This has the potential to increase the area of wetlands through planting or natural processes. Hence adaptive capacity could be moderate rather than low. ▪ Flooding could substantially change the habitat of a threatened wetland species, but it is unclear if this will be a beneficial or adverse change, hence low adaptive level.

Notes:

- **The adaptive capacity of coastal ecosystems will rely somewhat on effective management, as well as intrinsic wetland characteristics. Wetland management plans should include provisions to adapt to and/or take advantage of climatic changes capacity and will need to be implemented by the relevant authorities or entities.**

Vulnerability Score

Hazard	Sensitivity					Vulnerability			
	Present	2050	2070	2130	Adaptive Capacity	Present	2050	2070	2130
Erosion	L	M	H	H	L	L	M	H	H
Flooding	M	M	M	H	L	M	M	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	M	H	H	L	M	H	H	L	M	H	H
Risk from Flooding	M	M	H	H	M	M	M	M	M	M	M	H

A.3.3 Mapped ecological sites

Domain	Element at Risk	Overview
Ecological	Mapped ecological sites	There are 31 mapped ecological sites across the different management agencies (aerial map shown above and associated table) that relate to 21 unique sites (several sites are mapped by more than one agency). Three of the areas are also being restored by community groups. In summary there are: ▪ 8 KCDC Ecological Sites (Schedule 1 of the Operative Kāpiti Coast District Plan 2021) ▪ 3 QEII Trust sites (Queen Elizabeth the Second National Trust Act 1977) ▪ 4 DOC owned/managed sites including Waikanae Estuary Scientific Reserve ▪ 1 Conservation Area (Reserves Act 1977) ▪ 15 Areas identified by GWRC as being managed to protect environmental values ▪ 3 Sites that are being looked after by community groups. Ecological Sites are found predominantly located in the northern 2/3rds of the CAA including the Te Harakeke Swamp Complex and the Waikanae Estuary Scientific Reserve, lagoons, estuaries, and wetlands. The Waikanae Estuary Scientific Reserve is a nationally significant DOC administered reserve part of a 'mountains to sea' ecological corridor from the Tararua Ranges to the estuary to Kāpiti Marine Reserve. This corridor provides a rare sequence of habitat for animals which move between sea, river, and inland habitats. The Waikanae Estuary Scientific Reserve includes freshwater lakelets, saltwater lagoons and marshes, tidal sand flats and the sandy beach at the mouth of the river. This Waikanae Estuary saltmarsh wetland complex is scheduled by GWRC as an outstanding wetland.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	▪ Seven areas would be affected by erosion under both the SSP2-4.5 and SSP5-8.5 scenarios. Coastal erosion will primarily impact areas of ecological significance close to the coastline and river and stream outlets. This includes the Waikanae Estuary, Pharazyn Reserve (including a portion of the Peka Peka Dunes), Waikanae Dunes, Paraparaumu Dunes, and the Waimeha Stream mouth. ▪ Waikanae Estuary scientific reserve provides habitat for a range of indigenous vegetation and fauna. Erosion could remove part of this area resulting in the loss of wetland vegetation and fauna, and altering the hydrology and wetland soil composition. It could also result in modifications of the Waikanae River bed leading to more or increased rates of erosion and loss of fish passage connectivity. ▪ Existing modified channels already restrict the extent of the salt marsh vegetation in the upper estuary, further potential erosion of estuary edges would place further pressure on existing vegetation (Stevens & Forrest, 2019). ▪ Ongoing erosion is likely to result in the displacement of a coastal ecosystems for breeding and migratory species and has the potential to block or alter upstream pathways for migratory breeding fish. ▪ Erosion could result in seawater penetrating further inland in groundwater systems changing salinity of nearby coastal wetlands and affecting vegetation and habitat types. ▪ A loss of riparian vegetation through coastal erosion at Waikanae Estuary and the Waimeha Stream mouth could affect the in-stream ecological quality as it slows the rate of run-off and water entering rivers and streams, contributes to the quality of water by trapping silt and other contaminants, provides a corridor of vegetation that birds and insects can use, and provides food and shelter for local animals (Greater Wellington Regional Council, 2014).

Hazard	Description of Consequence (note any cascading impacts)
	▪ Removal of sand from the beach, lowering the beach profile, and allowing waves to travel further inland. Removal of the toe of the dunes where these are not protected, and potentially erosion of much or even all of the fore- and mid-dunes if wave action or storm surge is severe enough. ▪ Pharazyn Reserve includes spinifex foredunes and these are at risk of erosion. This would reduce areas of relatively intact indigenous vegetation, as well as remove habitat for fauna including 26 species of indigenous bird species, and seven indigenous fish species in the streams. ▪ Erosion could result in the destabilization of the Waikanae and Paraparaumu dunes (including loss of any indigenous fauna and flora) and loss of storm surge protection for inland portions. ▪ Erosion of habitat of native fauna nesting areas, and resting and feeding areas of coastal and seabirds such as pied shag, red-billed gulls. More advanced erosion would also affect vegetation types of dry dune habitats including the flora and fauna associated with these. Dunes that have been over-steepened through erosion (or in combination with introduced marram grass) will be more prone to collapsing and this could destabilize more inland areas of the dune system. ▪ The natural environment is interconnected with the social and economic systems. Erosion could open up areas to invasive species which could in turn affect human health, wellbeing, cultural and spiritual wellbeing. Erosion would also remove some of the human infrastructure such as beach access locations and perhaps walking/cycling tracks, and bridges. ▪ Fisheries and aquaculture could be affected by species distribution changes due to changed habitats and increased sediment and nutrients run off (Ministry for the Environment, 2022).
Coastal Flooding	▪ Flooding would affect 16 mapped ecological sites under the SSP2-4.5 scenario, and 18 under the SSP5-8.5 scenario. A loss or permanent changes of the identified ecological sites due to inundation will mostly affect coastal and waterway-based sites and existing wetland sites. Flood control measures already in place such as stop banks and floodgates present in Waikanae catchment have already modified the system, further flooding will exacerbate an already altered ecological system. ▪ Increased incidences of flooding in low lying areas due to sea level rise will be magnified during storm events causing floodwaters to back upstream and in the long term may lead to permanent inundation in some areas (Greater Wellington Regional Council, 2014). ▪ Existing sites provide important nursery habitats for juvenile fish, which under increased flooding from inundation will reduce habitat quality, increase sedimentation and salinity, and change the nutrients present in these sites, overall reducing the quality of breeding habitats and creating shifts in species distributions. ▪ Flooding could scour out waterways and flood associated wetlands reducing habitat (temporarily). Prolonged flooding will kill existing vegetation or cause a change to more wet-tolerant vegetation. ▪ Any birds nesting in low lying areas or flooded wetland areas would be affected, as could lizards and skinks and invertebrates. ▪ Waikanae Estuary provides a tourism benefit for visiting birdwatchers as a nationally regarded bird watching site. Increased flooding events could cause changes in the habitat and also result in sedimentation of the lower reaches and this may impact the presence of estuary dwelling species. ▪ Flooding may result in additional 'wet areas' that could start to exhibit wetland characteristics.

Notes:

- Overall, the current expansion of pest species along with the additions of new ones (due to expanding species tolerances), is likely to significantly compromise the ability to maintain integrity and function of indigenous ecosystems, and will make protecting at-risk and threatened species more challenging (Ministry for the Environment, 2020).
- K066 Te Harakeke Swamp and K236 Pharazyn Reserve are split across the Northern Adaptation Area and the Central Adaptation Area, and will be assessed for the area within each risk assessment area for these ecological sites.

Opportunities

Hazard	Opportunities
Coastal Erosion	▪ Adding and implementing periodic monitoring of indigenous fauna into the Operative Kāpiti Coast District Plan 2021. ▪ Continued funding and encouragement for community environmental restoration projects to have partnership with Local, Regional and National government. ▪ Remove pest plant species, especially marram grass and plant the foredunes with pīngao and spinifex to make the dunes more resilient and less prone to erosion. These indigenous species typically result in a more stable but lower elevation dunes, and can assist with retaining sand and growing the beach seawards. Remove pest plant species from mid and more rearward dunes and replace these with appropriate indigenous species; keeping in mind that the natural habitat is alternating dry sandy ridges and wetter swamp forest hollows. ▪ Undertake predator control to protect fauna, create dog-exclusion areas to allow undisturbed nesting of birds; including more inland areas to replace coastal habitat. ▪ Where other required coastal works enable this (e.g. sewerage line or road upgrades), include dune reconstruction and restoration to create additional/greater areas of natural duneland.
Coastal Flooding	▪ Develop management plans for at risk sites, including identifying areas that will be prone to future flooding. Plant up potentially wet areas with a range of appropriate dry and wet-tolerant species (to cover the range of possibilities) to pre-empt a change to wetter conditions and enable the ecosystems and habitats to self-adjust to changes. This will also strengthen the protection for human infrastructure (vegetation reduces erosion). ▪ Remove willows and other exotic tree species (where not needed to provide front-line riverbank defenses) where there is a mix of indigenous and exotic species to encourage a greater abundance of indigenous vegetation (better habitat for other indigenous plant species and animals). ▪ Water quality monitoring in wetlands and estuaries where sedimentation is occurring to track the health of waterways and subsequent health of riparian vegetation and potential impacts on river dwellers including fish species. ▪ Remove existing waterway fish passage barriers to enable fish to more easily move up-/downstream so that they can escape more easily during a flood. Maintain/enhance connections with waterway floodplains. Some native fish species will 'graze' in flooded pastures and other habitat during flood events as the water velocity is slower there. ▪ In dune areas, remove pest plant species, especially marram grass, and plant the foredunes with pīngao and spinifex (and other appropriate species) to make the dunes more resilient and less prone to erosion, and reduce potential for future flooding. Remove pest plant species from mid and more rearward dunes and replace these with appropriate indigenous species; keeping in mind that the natural habitat is alternating dry sandy ridges and wetter swamp forest hollows. ▪ Anticipate future flooding and create vegetation types in those areas that are adaptable and also found in wetlands.

Figure A.3.3: Mapped ecological sites from all known sources.

Table A.3.1: Ecological sites.

Organization	Name	Area (ha)	Area within CAA	Max[19] coastal erosion	Max potential flood	Overlaps with
QEII Trust	5-07-240A	44.0926	100%	Nil	100%	GWRC
QEII Trust	5-07-240B	13.7904	100%	Nil	80%	GWRC

[19] Maximum, as per SSP5-8.5 2130

Organization	Name	Area (ha)	Area within CAA	Max[19] coastal erosion	Max potential flood	Overlaps with
QEII Trust	5-07-243	0.9756	100%	Nil	Nil	
KCDC Ecological Site	K236 Pharazyn Reserve	41.6217	73%	4%	60%	GWRC
KCDC Ecological Site	K066 Te Harakeke Swamp [20]	65.2637	60%	Nil	70%	GWRC/QEII
KCDC Ecological Site	K170 El Rancho	7.6161	100%	Nil	100%	
KCDC Ecological Site	K068 Osbournes Swamp	0.9480	100%	Nil	100%	
KCDC Ecological Site	K112 Victor Weggery Reserve	5.3304	100%	Nil	100%	
KCDC Ecological Site	K175 Waimanu Lagoons	8.0193	100%	Nil	100%	
KCDC Ecological Site	K081 Waikanae River mouth	68.2277	100%	20%	100%	DOC/GWRC
KCDC Ecological Site	K171 Orchid habitat	0.0587	100%	Nil	100%	
DOC owned/managed	Waikanae Estuary Scientific Reserve	65.1601	100%	20%	100%	KCDC/GWRC
DOC owned/managed	Waikanae estuary scientific reserve -Kotuku Parks addition	5,0676	100%	Nil	100%	
DOC owned/managed	Marginal Strip - Waimeha Stream	0.9716	33%	Nil	100%	GWRC
DOC owned/managed	Kāpiti Marine Reserve	2170.1103	N/A	N/A	N/A	
DOC Conservation Area	Waimeha Conservation Area	0.54	100%	Nil	100%	GWRC
GWRC Managed Open Space[21]	Pharazyn Reserve, Waikanae Beach (includes part of the Peka Peka Dunes)	17.45	80%	20%	20%	KCDC
GWRC Managed Open Space	Rutherford Drive Reserve, Waikanae Beach (Oxidation ponds)	29.48	70%	Nil	100%	KCDC
GWRC Managed Open Space	QEII Trust 5/07/240B	21.00	100%	Nil	100%	QEII/KCDC
GWRC Managed Open Space	QEII Trust 5/07/240A	44.52	100%	Nil	Nil	QEII/KCDC
GWRC Managed Open Space	Waimeha Domain (Wildlife Refuge), Waikanae Beach	17.18	100%	100%	90%	
GWRC Managed Open Space	Rutherford Drive Reserve, Waikanae Beach	29.48	100%	Nil	40%	
GWRC Managed Open Space	Waimeha Conservation Area	0.54	100%	Nil	100%	DOC
GWRC Managed Open Space	Waimeha Stream Reserve	0.67	50%	NIL	100%	DOC
GWRC Managed Open Space	Waikanae Beach	9.29	100%	60%	50%	
GWRC Managed Open Space	Waimanu and Waimeha Lagoons	8.90	100%	15%	100%	
GWRC Managed Open Space	Waikanae River Corridor	26.18	70%	Nil	100%	

[20] Includes most of QEII Trust Covenants 5-07-240A and 5-07-240A, and areas outside of the CAA.

[21] GWRC Managed Open Space only includes those sites that are managed for environmental reasons as one of the primary reasons.

Organization	Name	Area (ha)	Area within CAA	Max[19] coastal erosion	Max potential flood	Overlaps with
GWRC Managed Open Space	Waikanae Estuary Scientific Reserve	65.26	100%	20%	100%	DOC/KCDC
GWRC Managed Open Space	Hadfield Place /Manly Street	0.39	100%	Nil	40%	
GWRC Managed Open Space	Paraparaumu Coastal Dune Reserve	10.15	95%	60%	15%	
GWRC Managed Open Space	Guildford Drive Reserve, Paraparaumu	4.33	100%	Nil	Nil	
Community Environmental Projects	Paraparaumu Beach dunes					
Community Environmental Projects	Waikanae Estuary Care Group Inc					
Community Environmental Projects	Waimeha Restoration Group					

A.3.3.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion ▪ All coastal dune areas are currently at risk of experiencing erosion. The Waikanae Estuary Scientific Reserve is currently exposed to minimal erosion. ▪ Overall risk - low	Future exposure: ▪ **2050:** Coastal dune sites experience increased erosion, especially in mouths of waterways including Waikanae Estuary Scientific Reserve – moderate risk overall. ▪ **2070:** Erosion for dune areas will be similar to 2050 but increases in waterway mouths. Potential for dunes to be eroded into the first lagoon in Waikanae Estuary Scientific Reserve. High risk overall. ▪ **2130:** In places coastal dunes could be breached completely and the first lagoon in Waikanae Estuary Scientific Reserve on the south bank along Manly Street would opened to the sea. High risk overall.
Currently exposed to coastal flooding ▪ Coastal areas (beaches and foredunes) and sites associated with waterways such as the Waikanae Estuary, Waimeha Stream, Waimanu lagoons, Waimeha lagoon and the Te Harakeke Swamp are currently affected by flood or storm events. ▪ Overall risk - moderate	Future exposure: ▪ **2050:** Water starts backing up in all wetlands and streams and there is an increased risk of coastal flooding. Twelve sites will be affected by varying heights of flooding. High risk overall. ▪ **2070:** Water starts backing up in all wetlands and streams and there is an increased risk of coastal flooding. Thirteen sites will be affected by varying heights of flooding. High risk overall. ▪ **2130:** Water backs up in all wetlands and streams and in places extends quite some distance from the waterways and wetlands. Many wetland ecological sites are completely flooded and it is likely that vegetation types will be affected and changed through flooding. There is an increased risk of coastal flooding with the potential of dunes being breached. Sixteen sites will be affected by varying heights of flooding. Extreme risk overall.

Hazard	Present	2050	2070	2130
Coastal Erosion	L	M	H	H
Coastal Flooding	M	H	H	E

Note:

- Exposure is based on the approximate area of each of the mapped ecological sites potentially affected by erosion or flooding within the CAA.
- Some mapped ecological sites occur in more than one Adaptation Area.

Erosion:

- Risk was assessed as the approximate area affected for all sites (only including those that will be affected by erosion), and reflects the highest percentage of effect for any one site.

Flooding:

- Risk was assessed as the approximate area affected for all sites (only including those that will be affected by flooding), and reflects the highest percentage for any one site.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	L	M	H	E
Coastal Flooding	M	M	H	H

Notes:

- Many of New Zealand's ecosystems and species are very vulnerable to the projected changes in climate, due to the remaining areas being very fragmented, reduced in size, or highly modified, as well as the anticipated rapid changes. This limits their ability to adapt by moving through the landscape to adjust to changing environmental conditions. Ecosystems and habitats and plants can also move up and down gradients provide areas are connected or in close proximity and appropriate species and conditions are present.
- Ecological sites cannot move to another location, but it may be possible to relocate specific values within affected sites if there is sufficient room to do so.
- Each of the sites identified has different morphology, species distribution, density and communities. The sensitivity of these systems to climate change is an estimation, as we currently lack scientific knowledge and investigation into the adaptability and sensitivity of ecological sites.
- Sensitivity is scored on the basis of the mapped ecological sites that are most affected.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	VL	▪ Much of CAA is highly populated urban environment which provides little space for ecological sites to naturally adapt and migrate away from hazards. ▪ Erosion will affect a relatively narrow coastal area, and once the dune system is breached the potential effects on more inland systems could occur quickly. ▪ Ecological sites that are at risk that occur within dynamic river systems may have some ability to adapt due to continually adapting to tidal cycles and high flow scenarios. However substantial modifictions of waterways have have reduced the ability of ecosystems to adapt to changes.
Coastal Flooding	L	▪ Increased flooding may result in the loss of some vegetation and habitat types, but may also result in additional areas becoming 'wet' enabling expansion of some ecosystem and habitat types. ▪ To ensure good adaptive capacity for ecological sites, management plans will need to be developed and implemented to take advantage of these potential changes. ▪ Ecological sites will experience coastal squeeze in a similar way that dune systems will due to increasing human densities along the coast limited adequate space for adaptation (Holle., et al., 2019).

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	L	M	H	E	VL	M	H	E	E
Flooding	M	M	H	H	L	M	M	H	H

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	M	H	H	M	H	E	E	L	M	E	E
Risk from Flooding	M	H	H	E	M	M	H	H	M	M	H	E

A.3.3.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion ▪ All coastal dune areas are currently at risk of experiencing erosion. The Waikanae Estuary Scientific Reserve is currently exposed to minimal erosion. ▪ Overall risk - low	Future exposure: ▪ **2050:** Coastal dune sites experience increased erosion, especially in mouths of waterways including Waikanae Estuary Scientific Reserve – moderate risk overall. ▪ **2070:** Erosion for dune areas will be similar to 2050 but increases substantially in waterway mouths. It is likely that the seaward dunes in Waikanae Estuary Scientific Reserve will be completely eroded and the first lagoon in Waikanae Estuary Scientific Reserve on the south bank along Manly Street would opened to the sea. High risk overall. ▪ **2130:** In places coastal dunes could be breached or removed completely and the first lagoon in Waikanae Estuary Scientific Reserve on the south bank along Manly Street would opened to the sea. Changes to groundwater salinity may affect more inland systems. Extreme risk overall.
Currently exposed to coastal flooding ▪ Coastal areas (beaches and foredunes) and sites associated with waterways such as the Waikanae Estuary, Waimeha Stream, Waimanu lagoons, Waimeha lagoon and the Te Harakeke Swamp are currently affected by flood or storm events. ▪ Overall risk - moderate	Future exposure: ▪ **2050:** Water starts backing up in all wetlands and streams and there is an increased risk of coastal flooding. Twelve sites will be affected by varying heights of flooding. High risk overall. ▪ **2070:** Water starts backing up in all wetlands and streams and there is an increased risk of coastal flooding. Fifteen sites will be affected by varying heights of flooding. High risk overall. ▪ **2130:** Water backs up in all wetlands and streams and in places extends quite some distance from the waterways and wetlands. Many wetland ecological sites are completely flooded and it is likely that vegetation types will be affected and changed through flooding. There is an increased risk of coastal flooding with the potential of dunes being breached. Eighteen sites will be affected by varying heights of flooding. Extreme risk overall.

Hazard	Present	2050	2070	2130
Coastal Erosion	L	M	H	E
Coastal Flooding	M	H	H	E

Note:

- Exposure is based on the approximate area of each of the mapped ecological sites potentially affected by erosion or flooding within the CAA.
- Some mapped ecological sites occur in more than one Adaptation Area.

Erosion:

- Risk was assessed as the approximate area affected for all sites (only including those that will be affected by erosion), and reflects the highest percentage of effect for any one site.

Flooding:

- Risk was assessed as the approximate area affected for all sites (only including those that will be affected by flooding), and reflects the highest percentage for any one site.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	L	M	H	E
Coastal Flooding	M	M	H	E

Notes:

- Many of New Zealand's ecosystems and species are very vulnerable to the projected changes in climate, due to the remaining areas being very fragmented, reduced in size, or highly modified, as well as the anticipated rapid changes. This limits their ability to adapt by moving through the landscape to adjust to changing environmental conditions. Ecosystems and habitats and plants can also move up and down gradients provide areas are connected or in close proximity and appropriate species and conditions are present.
- Ecological sites cannot move to another location, but it may be possible to relocate specific values within affected sites if there is sufficient room to do so.
- The sensitivity of these systems to climate change is an estimation, as we currently lack scientific knowledge and investigation into the adaptability and sensitivity of ecological sites.
- Sensitivity is scored on the basis of the mapped ecological sites that are most affected.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	VL	▪ Much of CAA is highly populated urban environment which provides little space for ecological sites to naturally adapt and migrate away from hazards. ▪ Erosion will affect a relatively narrow coastal area, and once the dune system is breached the potential effects on more inland systems could occur quickly. ▪ Ecological sites that are at risk that occur within dynamic river systems may have some ability to adapt due to continually adapting to tidal cycles and high flow scenarios. However substantial modifictions of waterways have have reduced the ability of ecosystems to adapt to changes.
Coastal Flooding	L	▪ Increased flooding may result in the loss of some vegetation and habitat types, but may also result in additional areas becoming 'wet' enabling expansion of some ecosystem and habitat types. ▪ To ensure good adaptive capacity for ecological sites, management plans will need to be developed and implemented to take advantage of these potential changes. ▪ Ecological sites will experience coastal squeeze in a similar way that dune systems will due to increasing human densities along the coast limited adequate space for adaptation (Holle., et al., 2019).

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity				Vulnerability	
	Present	2050	2070	2130		Present	2050	2070	2130	

Hazard	Sensitivity			Adaptive Capacity			Vulnerability		
Erosion	L	M	H	E	VL	M	H	E	E
Flooding	M	M	H	E	L	M	M	H	E

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	L	M	H	E	M	H	E	E	L	M	E	E
Risk from Flooding	M	H	H	E	M	M	H	E	M	M	H	E

A.3.4 Indigenous trees

Domain	Element at Risk	Overview
Ecological	Indigenous Trees	The CAA has 17 Key Indigenous Trees identified within the Kāpiti Coast Operative District Plan 2021 and another 23 Notable Trees although all of the Notable Trees are either exotic or indigenous but not naturally occurring species. There are ten Key Indigenous Trees that could be affected by flooding, but none are at risk from coastal erosion.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	There are no consequences for Key Indigenous Trees or Notable Trees from erosion hazards under any of the scenarios.
Coastal Flooding	▪ Increased flooding and ponding around indigenous trees can cause waterlogging and poor health or even kill trees. ▪ Loss of amenity value for individuals upon whose properties the tree occurs if the trees decline in health or die. ▪ Opening up of the canopy due to tree poor health or death resulting in pest plants to establish.

Opportunities

Hazard	Opportunities
Coastal Erosion	While no Key Indigenous or Notable Trees are at risk from erosion in the next 100 years, there is continued opportunity to educate the public about the values of trees and continue the process to identify key indigenous trees on private and public properties within the CAA. Planting coastal shrubs and trees may help consolidate the dunes behind the seawall. However, this would reduce people's sea views from the houses, and if the trees got tall and fell over it may increase the rate of erosion.
Coastal Flooding	Enhance the habitats of identified Key Indigenous Trees so that they are part of a more resilient landscape. This can be done through pest plant and pest animal control and by planting up adjacent or additional areas. Collect seeds from the trees that are at risk and propagate these to grow in areas that are less susceptible to flooding to preserve the genes of these trees. Planting more flood tolerant tree species in at risk locations to potentially replace sensitive species in the future.

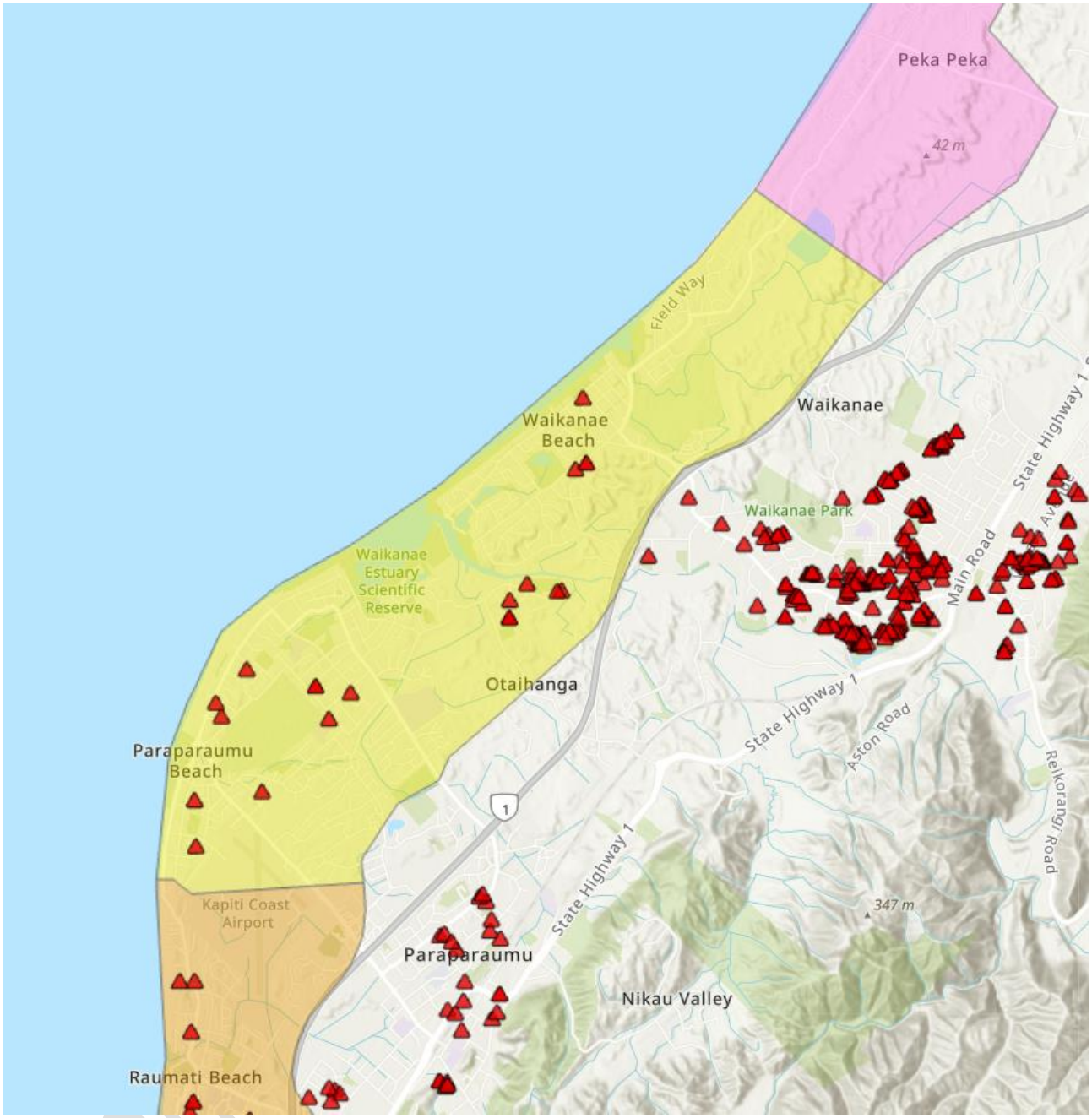

Figure A.3.4: Location of Key Indigenous Trees in the CAA.

The survey for Key indigenous trees (KCDC Schedule 2) within the Operative Kāpiti Coast District Plan 2021 was restricted to urban allotments. Rural areas were excluded. There are 17 Key Indigenous Trees (KCDC Schedule 2, red triangles), and about 23 Notable Trees (KCDC Schedule 8, not shown) within the CAA. Most of the notable trees are exotic trees, or indigenous trees such as pohutukawa, mountain celery pine, or kauri that are not native to the Kāpiti Coast. There are three titoki, two rimu, one black beech, one northern rata, one miro and two totara that will be affected by flooding.

Table A.3.2: List of Key indigenous trees in the CAA.

Key Indigenous Trees			Potentially affected by	
Common name	Scientific name	Location	SSP2 4.5	SSP5 8.5
Titoki	*Alectryon excelsus*	52 WAIMEA ROAD		2130
Titoki	*Alectryon excelsus*	23 RURU ROAD		2130
Titoki	*Alectryon excelsus*	69 MAKORA ROAD	2070	2070
Rimu	*Dacrydium cupressinum*	31 MAKORA ROAD	Present day	Present day
Rimu	*Dacrydium cupressinum*	20 VAUCLUSE AVENUE	2130	2130
Black beech	*Fuscospora solandri*	65 MAKORA ROAD	2070	2070
Northern rata	*Metrosiderous robusta*	3 QUEENS DRIVE		2130
Totara	*Podocarpus totara*	10 KOKAKO ROAD	2130	2070
Totara	*Podocarpus totara*	8 MIDDLETON ROAD	2130	2130
Miro	*Prumnopitys ferruginea*	44 TUTERE STREET	2050	2050
Total affected			7	10

A.3.4.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion ▪ No Key Indigenous Trees will be affected by coastal erosion ▪ No indigenous Notable Trees are exposed to coastal erosion	Future exposure: ▪ **2050**: No risk to Key Indigenous Trees ▪ **2070**: No risk to Key Indigenous Trees ▪ **2130**: No risk to Key Indigenous Trees
Currently exposed to coastal flooding ▪ One Key Indigenous Tree (a rimu) could be affected by coastal flooding ▪ No indigenous Notable Trees are exposed to coastal flooding	Future exposure: ▪ **2050**: Two Key Indigenous Trees (a rimu and a miro) will be exposed to inundation ▪ **2070**: Four Key Indigenous Trees will be exposed to inundation (one titoki, one rimu, one black beech, and one miro) ▪ **2130**: Seven Key Indigenous Trees will be exposed to inundation (one titoki, two rimu, one black beech, two totara, and one miro)

Hazard	Present	2050	2070	2130
Coastal Erosion	None	None	None	None
Coastal Flooding	L	L	M	M

Note:

The effects of coastal flooding would affect up to ten Key Indigenous Tree out of 17 (KCDC Schedule 2) and no indigenous notable trees (KCDC Schedule 8) will be affected. Hence the exposure is considered to be low initially (only a few trees affected) but increases to moderate once more than 25% and then high when more than 50% of Key Indigenous Trees could be affected.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	None	None	None	None
Coastal Flooding	L	L	M	M

Note:

The effects of coastal flooding would affect up to ten Key Indigenous Tree out of 17 (KCDC Schedule 2) and no indigenous notable trees (KCDC Schedule 8) will be affected. However, the affected trees could decline in health or even die from flooding and/or waterlogged ground. Hence the sensitivity is considered to be low initially (only a few trees affected) but increases to moderate once more than 25% and then high when more than 50% of Key Indigenous Trees could be affected.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	Not Applicable	There is no risk to Key Indigenous Trees from erosion under this scenario therefore any adaptive capacity is high.
Coastal Flooding	L	It would be very difficult and costly to relocate any of these large Key Indigenous Trees or Notable Trees.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	None	None	None	None	N/A	None	None	None	None
Flooding	L	L	M	M	L	L	L	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	None	None	None	None	None	None	None	None	None	None	None	None
Risk from Flooding	L	L	M	M	L	L	M	M	L	L	M	M

A.3.4.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion ▪ No Key Indigenous Trees will be affected by coastal erosion ▪ No indigenous Notable Trees are exposed to coastal erosion	Future exposure: ▪ **2050**: No risk to Key Indigenous Trees ▪ **2070**: No risk to Key Indigenous Trees ▪ **2130**: No risk to Key Indigenous Trees
Currently exposed to coastal flooding ▪ One Key Indigenous Tree (a rimu) could be affected by inundation ▪ No indigenous Notable Trees are exposed to coastal flooding	Future exposure: ▪ **2050**: Two Key Indigenous Trees (a rimu and a miro) will be exposed to inundation ▪ **2070**: Five Key Indigenous Trees will be exposed to inundation (one titoki, one rimu, one black beech, one totara and one miro) ▪ **2130**: Ten Key Indigenous Trees will be exposed to inundation (three titoki, two rimu, one black beech, one northern rata, two totara, and one miro)

Hazard	Present	2050	2070	2130
Coastal Erosion	None	None	None	None
Coastal Flooding	L	L	M	H

Note:

The effects of coastal flooding would affect up to ten Key Indigenous Tree out of 17 (KCDC Schedule 2) and no indigenous notable trees (KCDC Schedule 8) will be affected. Hence the exposure is considered to be low initially (only a few trees affected) but increases to Moderate once more than 25% and then high when more than 50% of Key Indigenous Trees could be affected.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	None	None	None	None
Coastal Flooding	L	L	M	H

Note:

The effects of coastal flooding would affect up to ten Key Indigenous Tree out of 17 (KCDC Schedule 2) and no indigenous notable trees (KCDC Schedule 8) will be affected. However, the affected trees could decline in health or even die from flooding and/or waterlogged ground. Hence the sensitivity is considered to be low initially (only a few trees affected) but increases to Moderate once more than 25% and then high when more than 50% of Key Indigenous Trees could be affected.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	Not Applicable	There is no risk to key indigenous trees from erosion under this scenario therefore any adaptive capacity is high.

Domain	Adaptive Capacity	Key Assumptions
Coastal Flooding	L	It would be very difficult and costly to relocate any of these large Key Indigenous Trees or Notable Trees.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	None	None	None	None	N/A	None	None	None	None
Flooding	L	L	M	H	L	L	L	M	H

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	None	None	None	None	None	None	None	None	None	None	None	None
Risk from Flooding	L	L	M	H	L	L	M	H	L	L	M	H

A.3.5 Rare and threatened species

Domain	Element at Risk	Overview
Ecological	Rare and threatened species	Within the CAA 47 nationally or regionally Threatened or At Risk species have been reported. Most of these species are associated with coastal areas such as the beach and dunes, or waterways and/or wetland areas. This includes 21 bird species, 11 freshwater fish species, 2 lizard species, 11 plant species and a one each for liverwort and fungus species (refer to tables above). Most of the fauna and some of the flora occur mostly within the Waikanae Estuary, wetlands and along the Paraparaumu Beach. Waikanae Estuary is a regionally important stop-over site for several migrant shorebird species (lesser knot, eastern bar-tailed godwit, wrybill) has extensive intertidal sand flats and is an important an important nesting site for nationally At Risk-Declining banded dotterel, and South Island pied oystercatcher, Threatened-Nationally Increasing dabchick, and nationally At Risk-Recovering variable oyster catchers, and red-billed gulls. Internal migrants such as wrybills, and South Island pied oystercatchers are attracted here as well as international migrants bar-tailed godwits (Todd, et al., 2016). Eleven Threatened or At Risk fish species and fourteen migratory native freshwater fish species. This is a highly sensitive site of national significance which is a DOC-administered scientific reserve which focuses on conservation and habitat restoration to the south, and KCDC esplanade and recreation reserves to the north. This site was previously neglected and little used other than for bird watching and white baiting but scores highly for both diversity and ecological context criteria used by McArthur, Robertson, Adams, & Small (2015). Paraparaumu Beach is habitat for At Risk-Recovering variable oyster catcher, At Risk-Declining red-billed gull and white-fronted tern, and Threatened-Nationally Vulnerable Caspian tern (McArthur, et al., 2015).

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	▪ Northern blue penguin or kororā nest in holes dug into the dunes. Erosion and flooding could destroy their nesting holes and drown or bury eggs and chicks. It could also make access to nesting and resting areas more difficult for the adults and/or put them at greater exposure of attack by predators and domestic dogs. ▪ Erosion could result in the loss of habitat for rare and threatened species, including alterations to the Waikanae River and Waimeha Stream mouths, and coastal dune habitat. This will be a more significant adverse effect for species with less mobility such as lizards and plants. Due to the urban nature of much the inland landscape, if rare and threatened species do occur then they are probably in relatively low numbers, except for in reserve areas and areas where predator control is being undertaken. More mobile species, such as birds, could use other areas, including more inland areas. However, given that erosion will likely affect more of the coastline than just within the CAA, alternative coastal habitat may be significantly reduced even for mobile species. ▪ Sea level rise induced hazards will threaten the stability and productivity of important fauna breeding, feeding and resting habitats. ▪ Increasing sea level rise, coupled with erosion is likely to cause increased coastal squeeze for these coastal habitats as erosion inland reduces the amount of space available for habitats to extend into due to infrastructure and dense residential areas on the landward sides. ▪ Loss of indigenous species can result in an invasion of exotic species which can also bring the threat of vector-borne diseases and associated health implications (Ministry for the Environment, 2020a). ▪ Erosion will have cascading effects for significant bird habitats as the surrounding environment including waterway estuaries and dunes are physically removed and habitat space is reduced.

Hazard	Description of Consequence (note any cascading impacts)
	▪ The Kāpiti Coast District has frequent rare and endangered birds returning to the coast for nesting which encourages tourism from wildlife photographers. Reduced habitat affecting the numbers of birds returning for nesting will have cascading effects for tourism to the district.
Coastal Flooding	▪ Coastal flooding could result in the loss of habitat (possibly temporary) for rare and threatened species, especially alterations to the Waikanae River Estuary, dune habitat and wetlands. This will be a more significant adverse effect for species with less mobility such as lizards and plants. In more inland areas where the landscape is more urban, if rare and threatened species do occur then they are probably in relatively low numbers, except for in reserve areas and areas where predator control is being undertaken. More mobile species, such as birds, could use other areas, including more inland areas. However, given that coastal flooding will likely affect more of the coastline and wetlands then just within the CAA, alternative habitat may be significantly reduced even for mobile species. ▪ More frequent and extensive flooding will cause increased sedimentation which is likely to affect the freshwater species present in rivers and coastal marine areas, reducing food availability for nesting birds through marine harvesting. ▪ Altered river flows and flood frequencies are likely to impact on habitat and food availability as well as breeding success for river-nesting birds. This is likely to be most significant for species that breed and forage on the beds of river islands, such as in the Waikanae Estuary, due to losses of intertidal feeding areas for shorebirds. ▪ Inundation due to sea level rise will reduce foraging area available to bird species in those areas where tidal zone movement (i.e. braided or meandering rivers) is limited or stopped by surrounding topography and human infrastructure (such as sea walls, stormwater infrastructure, roading and bridges). ▪ Nests of shorebirds and seabird species are regularly washed out with storm surges (Holle, et al., 2019). Birds may not continue to return to sites due to continued flooding creating unsuitable nesting habitats. Overall reducing biodiversity and increasing opportunity for exotic fauna to settle in its place. ▪ Increased flooding will reduce habitat for a range of species, but may also result in additional areas of wetland being created.

Opportunities

Hazard	Opportunities
Coastal Erosion	▪ Current management of the estuarine sites includes actively working to restore the ecosystem to a state that would align satisfactorily with that of an original habitat, and an intensive pest program has been initiated. Continuing and enhancing these works as well as planting efforts by Waikanae Estuary Care Group to enhance stability of salt marshes and the bordering plant system to prevent further erosion inland into residential dwellings. ▪ Planting more indigenous dune species to strengthen the dunes would also provide more habitat for rare or threatened fauna. This could include planting dune plant species that are Threatened or At Risk. ▪ Undertake pest animal and/or pest plant control to help retain rare and threatened species. ▪ Collect seed or plants of rare or threatened species and establish secure populations inland. ▪ Create inland habitat for fauna (e.g. lizards, invertebrates) with excellent predator control and establish secure inland populations (note for some species such as lizards a Wildlife Permit would be required from DOC). Fauna individuals could be relocated to these secure sites from other salvage operations in the district (with appropriate management plan and/or Wildlife Permit). ▪ Create areas in suitable northern blue penguin habitat where dogs are excluded and predator control is undertaken to increase where and how many penguins can nest outside of the coastal hazard areas.
Coastal Flooding	▪ Options to manage vehicle damage in the estuary and coastal bird habitats should be explored. Current access is technically restricted, however difficult to enforce and vehicles are often used irresponsibly in the areas.

Hazard	Opportunities
	▪ Coordinated governance may help to avoid maladaptation or inadequate adaptation actions that are aimed at protecting migratory, coastal and riverbed nesting birds and help to expand the ability of these species to adapt to climate change induced hazards. ▪ Identify coastal and riverine breeding sites that are most vulnerable to climate change impacts. ▪ The opportunity for a national coastal vulnerability index for coastal species could be adopted and manipulated to suit Aotearoa, New Zealand species as a way to monitor and rank risk for coastal ecosystems (as seen in Holle, et al., 2019). ▪ Minimise the effects of the flood gates on the Waikanae Estuary and artificial opening of the river mouth on the higher quality estuarine areas to the north of the river mouth would also help minimize any potential adverse effects on the estuarine uses and values. ▪ Planting more indigenous dune species to strengthen the dunes would also provide more habitat for rare or threatened fauna. This could include planting dune plant species that are Threatened or At Risk. ▪ Undertake pest animal and/or pest plant control to help retain rare and threatened species. ▪ Collect seed or plants of rare or threatened species and establish secure populations inland. ▪ Create inland habitat for fauna (e.g. lizards, invertebrates) with excellent predator control and establish secure inland populations (note for some species such as lizards a Wildlife Permit would be required from DOC). Fauna individuals could be relocated to these secure sites from other salvage operations in the district (with appropriate management plan and/or Wildlife Permit). ▪ Create areas in suitable northern blue penguin habitat where dogs are excluded and predator control is undertaken to increase where and how many penguins can nest outside of the coastal hazard areas.

Table A.3.3: Summary of Threatened and At Risk species known from the CAA. *Data from Operative Kāpiti Coast District Plan 2021 Schedule 3, iNaturalist and DOC herpetofauna and Bioweb databases*

	Species type						
National Threat category	Bird	Fish	Lizard	Plant	Liverwort	Fungus	Total
Threatened-Nationally Critical	1			2			3
Threatened–Nationally Endangered				1			1
Threatened-Nationally Vulnerable	1	2		1			4
Threatened-Nationally Increasing	4						4
At Risk-Declining	10	8	2	4	1		25
At Risk-Naturally Uncommon	1	1		2			4
At Risk-Recovering	3						3
Data Deficient				1		1	2
Not Threatened[22]	1						1
Grand Total	**21**	**11**	**2**	**11**	**1**	**1**	**47**

Table A.3.4: List of Threatened and At Risk species known from the CAA. This only includes those species that are known to naturally occur on the Kāpiti Coast, and also excludes historic records for species that may no longer occur within the CAA.

[22] National Classification - Not Threatened, but has Regional Threat Classification

Scientific Name	Common Name	National Threat Category[23]	GWRC Threat Category[24]	Species Type	Information Source
Anarhynchus frontalis	Wrybill	Threatened-Nationally Increasing	Regionally Critical	Shore bird	iNaturalist
Anas chlorotis	Brown teal	Threatened-Nationally Increasing	Regionally Critical	Wetland bird	iNaturalist
Botaurus poiciloptilus	Australasian Bittern	Threatened-Nationally Critical	Regionally Critical	Wetland bird	iNaturalist
Bowdleria punctata vealeae	North Island fernbird	At Risk-Declining	Regionally Critical	Wetland bird	iNaturalist
Calidris canutus rogersi	Lesser Knot	At Risk-Declining	Regionally Critical	Shore bird	iNaturalist
Charadrius bicinctus	Banded dotterel	At Risk-Declining	Regionally Vulnerable	Shore bird/ River bird	iNaturalist
Charadrius obscurus aquilonius	Northern New Zealand dotterel	Threatened-Nationally Increasing	Regionally Critical	Shore bird/ River bird	iNaturalist
Eudyptula minor iredalei	Northern blue penguin	At Risk-Declining	Regionally Vulnerable	Shore bird	iNaturalist
Fulica atra australis	Eurasian coot	At Risk-Naturally Uncommon	Regionally Critical	Wetland bird	eBird
Haematopus unicolor	Variable oystercatcher	At Risk-Recovering	Regionally Vulnerable	Shore bird	iNaturalist
Haematopus finschi	South Island pied oystercatcher	At Risk-Declining	Regional Migrant	Shore bird	iNaturalist
Hemiphaga novaeseelandiae	New Zealand pigeon, kereru	Not threatened	Regionally Recovering	Forest bird	iNaturalist
Hydroprogne caspia	Caspian tern	Threatened-Nationally Vulnerable	Regionally Critical	Shore bird	iNaturalist
Larus novaehollandiae scopulinus	red-billed gull	At Risk-Declining	Regionally Vulnerable	Shore bird	iNaturalist
Limosa lapponica baueri	Eastern bar-tailed godwit	At Risk-Declining	Regionally Critical	Shore bird	iNaturalist
Nestor meridionalis septentrionalis	North Island kaka	At Risk-Recovering	Regionally Recovering	Forest bird	iNaturalist

[23] Fungi - Conservation status of selected species of non-lichenised agarics, boletes and russuloid fungi in Aotearoa New Zealand, 2021; By: Jerry A. Cooper, Peter K. Buchanan, Pat Leonard, Lois Allison-Cooper, Peter Johnston, Mahajabeen Padamsee, Eric McKenzie and Pascale Michel. New Zealand Threat Classification Series 38. Department of Conservation, Wellington. 49p.

Birds - Conservation status of birds in Aotearoa New Zealand, 2021; By: Hugh A. Robertson, Karen A. Baird, Graeme P. Elliott, Rodney A. Hitchmough, Nikki J. McArthur, Troy Makan, Colin M. Miskelly, Colin. J. O'Donnell, Paul M. Sagar, R. Paul Scofield, Graeme A. Taylor and Pascale Michel. New Zealand Threat Classification Series 36. Department of Conservation, Wellington. 43 p.

Reptiles - Conservation status of New Zealand reptiles, 2021; Rod A. Hitchmough, Ben Barr, Carey Knox, Marieke Lettink, Joanne M. Monks, Geoff B. Patterson, James T. Reardon, Dylan van Winkel, Jeremy Rolfe and Pascale Michel. New Zealand Threat Classification Series 35. Department of Conservation, Wellington. 15 p.

Hornworts and liverworts - Conservation status of New Zealand Hornworts and liverworts 2020; de Lange, P.J.; Glenny, D.; Frogley, K.; Renner, M.A.M.; von Konrat, M.; Engel, J.J.; Reeb, C.; Rolfe, J.R. 2020: Conservation status of New Zealand hornworts and liverworts, 2020. New Zealand Threat Classification Series 31. Department of Conservation, Wellington. 30 p.

Freshwater fish - Conservation status of New Zealand freshwater fishes, 2017.; Nicholas R. Dunn, Richard M. Allibone, Gerard P. Closs, Shannan K. Crow, Bruno O. David, Jane M. Goodman, Marc Griffiths, Daniel C. Jack, Nicholas Ling, Jonathan M. Waters and Jeremy R. Rolfe. New Zealand Threat Classification Series 24. 11 p.

Plants - Conservation status of New Zealand vascular plants 2017; de Lange, P.J.; Rolfe, J.R.; Barkla, J.W.; Courtney, S.P.; Champion, P.D.; Perrie, L.R.; Beadel, S.M.; Ford, K.A.; Breitwieser, I.; Schonberger, I.; Hindmarsh-Walls, R.; Heenan, P.B.; Ladley, K. 2018: Conservation status of New Zealand indigenous vascular plants, 2017. New Zealand Threat Classification Series 22. Department of Conservation, Wellington. 82 p.

[24] Crisp P. 2020. Conservation status of native bird species in the Wellington region. Greater Wellington Regional Council Report GW/ESCI-G-20/75. 37pp.

Crisp P. 2020. Conservation status of indigenous lizard species in the Wellington region. Greater Wellington Regional Council Report WRC/ESCI-G-20/2. 10pp.

Crisp P. 2020. Conservation status of indigenous vascular plant species in the Wellington Region. Wellington Regional Council, Wellington, No. GW/ESCI-G-20/20 33 pp.

Scientific Name	Common Name	National Threat Category[23]	GWRC Threat Category[24]	Species Type	Information Source
Phalacrocorax varius	New Zealand Pied Shag	At Risk-Recovering	Regionally Vulnerable	Shore bird/ river/ wetland	iNaturalist
Poliocephalus rufopectus	New Zealand dabchick	Threatened-Nationally Increasing	Regionally Vulnerable	Wetland bird	iNaturalist
Porzana tabuensis	Spotless Crake	At Risk-Declining	Regionally Endangered	Wetland bird	eBird
Puffinus griseus	Sooty shearwater	At Risk-Declining	Regionally Critical	Shore bird	iNaturalist
Sterna striata	White-fronted tern	At Risk-Declining	Regionally Endangered	Shore bird	iNaturalist
Anguilla dieffenbachii	New Zealand Longfin Eel	At Risk-Declining		Fish	iNaturalist
Cheimarrichthys fosteri	torrentfish	At Risk-Declining		Fish	GWRC
Galaxias argenteus	giant kōkopu	At Risk-Declining		Fish	GWRC
Galaxias brevipinnis	koaro	At Risk-Declining		Fish	GWRC
Galaxias divergens	dwarf galaxias	At Risk-Declining		Fish	GWRC
Galaxias maculatus	īnanga	At Risk-Declining		Fish	GWRC
Galaxias postvectis	shortjaw kōkopu	Threatened-Nationally Vulnerable		Fish	GWRC
Geotria australis	lamprey	Threatened-Nationally Vulnerable		Fish	GWRC
Gobiomorphus gobioides	giant bully	At Risk-Naturally Uncommon		Fish	GWRC
Gobiomorphus hubbsi	bluegill bully	At Risk-Declining		Fish	GWRC
Neochanna apoda	brown mudfish	At Risk-Declining		Fish	GWRC
Mokopirirakau southern north island	Ngahere Gecko	At Risk-Declining	Regionally At Risk	Lizard	iNaturalist
Naultinus punctatus	barking gecko	At Risk-Declining	Regionally At Risk	Lizard	Herpofauna database
Korthalsella salicornioides	Mistletoe	Threatened-Nationally Critical	Regionally Threatened	Plant	KCDC Schedule 3
Carex litorosa	Sea sedge	At Risk-Declining	Regionally Critical	Dune plant	Bioweb
Clavaria zollingeri	violet coral fungus	Data Deficient		Fungus	iNaturalist
Coprosma acerosa	Sand Coprosma	At Risk-Declining	Regionally Declining	Dune plant	iNaturalist
Coprosma aff. *acerosa* (AK 36799; Taranaki)	Coprosma	At Risk-Naturally Uncommon		Dune plant	Bioweb
Kunzea amathicola	Sand dune kanuka	Threatened – Nationally Vulnerable	Regionally Data Deficient	Dune plant	iNaturalist
Mazus novaezeelandiae	Dwarf musk	Threatened– Nationally Endangered	Regionally Endangered	Plant (can occur in dunes)	KCDC Schedule 3
Pimelea villosa	Sand pimelea	At Risk-Declining	Regionally Endangered	Dune plant	Bioweb
Ranunculus macropus	Wetland buttercup	Data Deficient	Regionally Data Deficient	Wetland plant	Bioweb
Ricciocarpos natans	fringed heartwort	At Risk-Declining		Liverwort	iNaturalist
Spiranthes australis	Ladys tresses, Spiranthes orchid	At Risk-Declining	Regionally Critical	Wetland plant	Bioweb
Tetragonia tetragonoides	New Zealand spinach	At Risk-Naturally Uncommon	Regionally Naturally Uncommon	Dune plant	iNaturalist
Utricularia australis	Yellow Bladderwort	Threatened-Nationally Critical	Regionally Extirpated	Wetland plant	Bioweb

A.3.5.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion ▪ All coastal dune habitat areas are currently at risk of experiencing erosion. The Waikanae Estuary Scientific Reserve is currently exposed to minimal erosion. ▪ Overall exposure - moderate	Future exposure: ▪ **2050:** Coastal dune habitat sites experience increased erosion, especially in mouths of waterways including Waikanae Estuary Scientific Reserve. Moderate risk overall. ▪ **2070:** Erosion for dune habitat areas will be similar to 2050 but increases in waterway mouths. Potential for dunes to be eroded into the first lagoon in Waikanae Estuary Scientific Reserve. High Risk overall. ▪ **2130:** In places coastal dune habitats could be breached completely and the first lagoon in Waikanae Estuary Scientific Reserve on the south bank along Manly Street would opened to the sea. High Risk overall.
Currently exposed to coastal flooding ▪ Coastal areas (beaches and foredunes) and sites associated with waterways such as the Waikanae Estuary, Waimeha Stream, Waimanu lagoons, Waimeha lagoon and the Te Harakeke Swamp are currently affected by flood or storm events. ▪ Overall exposure - moderate	Future exposure: ▪ **2050:** Water starts backing up in all wetlands and streams and there is an increased risk of coastal flooding. Twelve sites providing habitat will be affected by varying heights of flooding. High risk overall. ▪ **2070:** Water starts backing up in all wetlands and streams and there is an increased risk of coastal flooding. Thirteen habitats will be affected by varying heights of flooding. High risk overall. ▪ **2130:** Water backs up in all wetlands and streams and in places extends quite some distance from the waterways and wetlands. Many wetland habitats are completely flooded and it is likely that vegetation types will be affected and changed through flooding, including potential loss of rare or threatened species. There is an increased risk of coastal flooding with the potential of dunes being breached. Sixteen habitats will be affected by varying heights of flooding. Extreme risk overall.

Hazard	Present	2050	2070	2130
Coastal Erosion	M	M	H	H
Coastal Flooding	M	H	H	E

Notes:

- Exposure is based on the approximate area of each of the mapped ecological habitats potentially affected by erosion or flooding within the CAA. It is not possible to assess effects on fauna or flora populations as there is little information about rare and threatened species and their local populations to help quantify effects.
- The lack of information may be due to there being few rare or threatened species but can also be due to lack of observations and recording of such species, rather than their absence. Many of the smaller species can still occur in people's backgardens without being observed, or observed but not reported to a national peer-reviewed database. Hence there is no or little information for most of these species.
- Adverse will be greater for species with less mobility such as lizards and plants, rather than seabirds or other birds.

- However, given that coastal erosion and flooding will likely affect more of the coastline than just within the CAA, alternative coastal habitat may be significantly reduced even for mobile species.
- Effects on the Waikanae River Esturary and areas of dune and wetlands elevate the risk of loss of rare or threatened species.
- Beach erosion and coastal dune erosion and limited space for habitat to 'migrate' inland (due to intensive human occupation and built environment in Paraparaumu and Waikanae), coupled with sea level rise will likely overall reduce the size of habitats over time.
- Flooding can result in both loss of habitat due to areas being drowned, but could potentially also increase wetland areas and provide future fauna and flora habitat.
- This is based on total exposure percentage of the existing habitats to the hazard. I.e Low: 0-25%, Moderate: 25-50%, High: 50-75%, Extreme: >75%.

Erosion:

- Risk was assessed as the approximate area of ecological habitats potentially affected (only including those that will be affected by erosion).
- Coastal fauna and flora habitats are already affected by erosion, hence the current risk is considered to be moderate.
- Erosion risk increases to high in 2070 as more than 50% of the habitats could be affected.

Flooding:

- Risk was assessed as the approximate area of ecological habitats potentially affected (only including those that will be affected by flooding).
- Coastal habitats and wetlands already affected by flooding, hence the current risk is considered to be moderate.
- This increases to high in 2050 as greater portions of the habitat are affected.
- The increase to extreme in 2130 is due to all wetland habitats and a large area of the Waikanae River Estuary being affected.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	H	E
Coastal Flooding	M	H	H	E

Notes:

- Assigned a moderate sensitivity as more mobile species such as birds can relocate to new habitat, but less mobile rare and threatened species such as lizards and plants will be at risk.
- However, given that coastal flooding will likely affect more of the coastline than just within the CAA, alternative coastal habitat may be significantly reduced even for mobile species. Similarly, risk to wetland habitats increases over time and more wetland are flooded and/or to a greater depth.
- There may also be some political/legislation sensitivity around loss of species and their habitat protected under the Wildlife Act 1977.

Erosion:

- To estimate the potential effects on rare and threatened species it was assumed that their habitat would dissapear at the same rate as has been used for loss of mapped ecological sites.
- The increase to high in 2070 is due to potential loss of dune habitats and the changes to the Waikanae River Estuary.
- The increase to extreme in 2130 is due to the ongoing loss of habitat both within the CAA but also in the wider Kāpiti Coast, which could have significant cumulative effects on populations of rare and treathened species.

Flooding:

- To estimate the potential effects on rare and threatened species it was assumed that their habitat would dissapear at the same rate as has been used for loss of mapped ecological sites.
- Flooding may only be temporary, which would reduce the effects, and flooding could also result in additional/adjacent areas of 'wetland'.

- This increases to high in 2050 as greater portions of the habitats are affected.
- The increase to extreme in 2130 is due to all wetland habitats and a large area of the Waikanae River Estuary being affected, as well as in the wider Kāpiti Coast, which could have significant cumulative effects on populations of rare and treathened species.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	Low	▪ A large number of Threatened and At Risk species are known from the CAA. ▪ That less mobile rare or threatened species will not be able to move to alternative habitat and will be lost. ▪ That mobile species such as birds move to other locations, or inland. ▪ No space for habitat to 'migrate' inland to adjust for changes. ▪ The total extent of area affected both within the CAA and the wider Kāpiti Coast could restrict where species can move to.
Coastal Flooding	Low	▪ A large number of Threatened and At Risk species are known from the CAA. ▪ That less mobile rare or threatened species will not be able to move to alternative habitat and will be lost. ▪ That mobile species such as birds move to other locations, or inland. ▪ No space for habitat to 'migrate' inland to adjust for changes. ▪ The total extent of area affected both within the CAA and the wider Kāpiti Coast could restrict where species can move to.

Note: The adaptive capacity of coastal ecosystems could rely somewhat on effective and adaptive management, such as creating additional areas of habitat, translocation of species and pest plant and animal control.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	H	H	E	L	M	H	H	E
Flooding	M	H	H	E	L	M	H	H	E

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	M	M	H	H	M	H	H	E	M	M	H	E
Risk from Flooding	M	H	H	E	M	H	H	E	M	H	H	E

A.3.5.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion ▪ All coastal dune habitat areas are currently at risk of experiencing erosion. The Waikanae Estuary Scientific Reserve is currently exposed to minimal erosion. ▪ Overall exposure - moderate	Future exposure: ▪ **2050:** Coastal dune habitat sites experience increased erosion, especially in mouths of waterways including Waikanae Estuary Scientific Reserve. Moderate risk overall. ▪ **2070:** Erosion for dune habitat areas will be similar to 2050 but increases substantially in waterway mouths. It is likely that the seaward dunes in Waikanae Estuary Scientific Reserve will be completely eroded and the first lagoon in Waikanae Estuary Scientific Reserve on the south bank along Manly Street would opened to the sea thus significanly altering or losing substantial areas of flora and fauna habitat with resultant losses of species and/or reduction of populations. High Risk overall.. ▪ **2130:** In places coastal dune habitats could be breached completely and the first lagoon in Waikanae Estuary Scientific Reserve on the south bank along Manly Street would opened to the sea. Changes to groundwater salinity may affect more inland systems. Thus significanly altering or losing substantial areas of flora and fauna habitat with resultant losses of species and/or reduction of populations. Extreme Risk overall.
Currently exposed to coastal flooding ▪ Coastal areas (beaches and foredunes) and sites associated with waterways such as the Waikanae Estuary, Waimeha Stream, Waimanu lagoons, Waimeha lagoon and the Te Harakeke Swamp are currently affected by flood or storm events. ▪ Overall risk - moderate	Future exposure: ▪ **2050:** Water starts backing up in all wetlands and streams and there is an increased risk of coastal flooding. Twelve sites providing habitat will be affected by varying heights of flooding. High risk overall. ▪ **2070:** Water starts backing up in all wetlands and streams and there is an increased risk of coastal flooding. Fifteen habitats will be affected by varying heights of flooding. High risk overall. ▪ **2130:** Water backs up in all wetlands and streams and in places extends quite some distance from the waterways and wetlands. Many wetland habitats are completely flooded and it is likely that vegetation types will be affected and changed through flooding, including potential loss of rare or threatened species. There is an increased risk of coastal flooding with the potential of dunes being breached. Eighteen habitats will be affected by varying heights of flooding. Extreme risk overall.

Hazard	Present	2050	2070	2130
Coastal Erosion	M	M	H	E
Coastal Flooding	M	H	H	E

Notes:

- Exposure is based on the approximate area of each of the mapped ecological habitats potentially affected by erosion or flooding within the CAA. It is not possible to assess effects on fauna or flora populations as

there is little information about rare and threatened species and their local populations to help quantify effects.

- The lack of information may be due to there being few rare or threatened species but can also be due to lack of observations and recording of such species, rather than their absence. Many of the smaller species can still occur in people's backgardens without being observed, or observed but not reported to a national peer-reviewed database. Hence there is no or little information for most of these species.
- Adverse will be greater for species with less mobility such as lizards and plants, rather than seabirds or other birds.
- However, given that coastal erosion and flooding will likely affect more of the coastline than just within the CAA, alternative coastal habitat may be significantly reduced even for mobile species.
- Effects on the Waikanae River Esturary and areas of dune and wetlands elevate the risk of loss of rare or threatened species.
- Beach erosion and coastal dune erosion and limited space for habitat to 'migrate' inland (due to intensive human occupation and built environment in Paraparaumu and Waikanae), coupled with sea level rise will likely overall reduce the size of habitats over time.
- Flooding can result in both loss of habitat due to areas being drowned, but could potentially also increase wetland areas and provide future fauna and flora habitat.
- This is based on total exposure percentage of the existing habitats to the hazard. I.e Low: 0-25%, Moderate: 25-50%, High: 50-75%, Extreme: >75%.

Erosion:

- Risk was assessed as the approximate area of ecological habitats potentially affected (only including those that will be affected by erosion).
- Coastal fauna and flora habitats are already affected by erosion, hence the current risk is considered to be moderate.
- Erosion risk increases to high in 2070 as more than 50% of the habitats could be affected, and to extreme in 2130 as more than 75% of habitats could be affected.

Flooding:

- Risk was assessed as the approximate area of ecological habitats potentially affected (only including those that will be affected by flooding).
- Coastal habitats and wetlands already affected by flooding, hence the current risk is considered to be moderate.
- This increases to high in 2050 as greater portions of the habitat are affected.
- The increase to extreme in 2130 is due to all wetland habitats and a large area of the Waikanae River Estuary being affected.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	H	E
Coastal Flooding	M	H	H	E

Notes:

- Assigned a moderate sensitivity as more mobile species such as birds can relocate to new habitat, but less mobile rare and threatened species such as lizards and plants will be at risk.
- However, given that coastal flooding will likely affect more of the coastline than just within the CAA, alternative coastal habitat may be significantly reduced even for mobile species. Similarly, risk to wetland habitats increases over time and more wetland are flooded and/or to a greater depth.
- There may also be some political/legislation sensitivity around loss of species and their habitat protected under the Wildlife Act 1977.

Erosion:

- To estimate the potential effects on rare and threatened species it was assumed that their habitat would dissapear at the same rate as has been used for loss of mapped ecological sites.
- The increase to high in 2070 is due to potential loss of dune habitats and the changes to the Waikanae River Estuary.

- The increase to extreme in 2130 is due to the ongoing loss of habitat both within the CAA but also in the wider Kāpiti Coast, which could have significant cumulative effects on populations of rare and treathened species.

Flooding:

- To estimate the potential effects on rare and threatened species it was assumed that their habitat would dissapear at the same rate as has been used for loss of mapped ecological sites.
- Flooding may only be temporary, which would reduce the effects, and flooding could also result in additional/adjacent areas of 'wetland'.
- This increases to high in 2050 as greater portions of the habitats are affected.
- The increase to extreme in 2130 is due to all wetland habitats and a large area of the Waikanae River Estuary being affected, as well as in the wider Kāpiti Coast, which could have significant cumulative effects on populations of rare and treathened species.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	▪ A large number of Threatened and At Risk species are known from the CAA. ▪ That less mobile rare or threatened species will not be able to move to alternative habitat and will be lost. ▪ That mobile species such as birds move to other locations, or inland. ▪ No space for habitat to 'migrate' inland to adjust for changes. ▪ The total extent of area affected both within the CAA and the wider Kāpiti Coast could restrict where species can move to.
Coastal Flooding	L	▪ A large number of Threatened and At Risk species are known from the CAA. ▪ That less mobile rare or threatened species will not be able to move to alternative habitat and will be lost. ▪ That mobile species such as birds move to other locations, or inland. ▪ No space for habitat to 'migrate' inland to adjust for changes. ▪ The total extent of area affected both within the CAA and the wider Kāpiti Coast could restrict where species can move to.

Note: The adaptive capacity of coastal ecosystems could rely somewhat on effective and adaptive management, such as creating additional areas of habitat, translocation of species and pest plant and animal control.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	M	H	E	L	M	M	H	E
Flooding	M	H	H	E	L	M	H	H	E

Overall Risk Score

Exposure					Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130

	Exposure				Vulnerability				Risk			
Risk from Erosion	M	M	H	E	M	M	H	E	M	M	H	E
Risk from Flooding	M	H	H	E	M	H	H	E	M	H	H	E

A.3.6 Bird habitat

Domain	Element at Risk	Overview
Ecological	Significant Bird Habitats	Significant bird habitats were classified in the 2019 report *Preparing Coastal Communities for Climate Change* by GWRC as one of three ecological criteria which were identified to be representative of components that would be affected by increases in sea level rise and coastal erosion. Three classes of significant bird habitats can be classified in the Wellington Region: lakes, rivers and coastal marine areas. In the CAA GWRC identified two coastal significant bird habitats; one at the Waikanae Estuary, and the other along the Paraparaumu Beach foreshore extending south from Waikanae Estuary to Rua Road - both within the Coastal Marine Area and includes approximately 63 hectares combined (see map above). Additionally, there are a number of lake-type habitats that provide significant breeding and/or roosting habitat for substantial populations of birds. This includes the old sewage treatment ponds in Pharazyn Reserve, the Waimanu Lagoons and the lagoon in Victor Weggery Reserve. Waikanae Estuary is a regionally important stop-over site for several migrant shorebird species, migrant shorebird species (lesser knot, eastern bar-tailed godwit, wrybill) has extensive intertidal sand flats and is an important an important nesting site for nationally At Risk-Declining banded dotterel, and South Island pied oystercatcher, Threatened-Nationally Increasing dabchick, and nationally At Risk-Recovering variable oyster catchers, and red-billed gulls. Important summer site for Arctic-breeding shorebirds; important winter site for NZ breeding shorebirds; year-round habitat for North Island fernbird. Waikanae Estuary, scored particularly highly for both the Diversity and Ecological Context criteria, as well as supporting a relatively high number of Threatened and At Risk bird species, and is one of only two sites in the Wellington region at which North Island fernbird can be found. This is a highly sensitive site of national significance which is a DOC-administered scientific reserve which focuses on conservation and habitat restoration to the south, and KCDC esplanade and recreation reserves to the north. Paraparaumu Beach habitat is habitat for At Risk-Recovering variable oyster catcher, At Risk-Declining red-billed gull and white-fronted tern, and Threatened-Nationally Vulnerable Caspian tern (McArthur, et al., 2015). Te Harakeke/Kawakahia provides excellent bird habitat as it includes a large diversity of bird habitats. The areas provide habitat for the Threatened-Nationally Critical Australasian Bittern and the At Risk-Declining North Island fernbird as well as a range of more common wetland and forest birds. Pharazyn Reserve has good populations of New Zealand Grebe, New Zealand dabchick, red-billed gull and New Zealand Pied Shag. Waimanu Lagoons is surrounded by trees that are used for nesting by New Zealand Pied Shags, and the lagoon is habitat for brown teal, New Zealand dabchick and New Zealand Grebe and also breeding habitat for more common birds such as black swans and a variety of ducks. Waimeha Lagoon in Victor Weggery Reserve is habitat for at least 35 water-loving species[25] including spotless crake, New Zealand scaup (*Aythya novaeseelandiae*), paradise shelduck (*Tadorna variegata*), New Zealand dabchick, New Zealand Grebe, Eurasian coot.

[25] https://ebird.org/hotspot/L2900927

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	▪ Erosion can affect beaches causing them to lower and providing less foraging and roosting space at high tide for shore birds. ▪ Erosion will affect the dunes along the inland portions of the Waikanae Estuary and the Paraparaumu Beach (as well as more northerly beaches). Some of the bird species roost in the dunes or nest at the toe of the dunes, and northern blue penguins may also have burrows in the dunes. Erosion will reduce the area available for roosting and may erode nests and burrows during the breeding season causing mortality of eggs/chicks and potentially adult birds. Sea level rise induced hazards will threaten the stability and productivity of important breeding, feeding and resting habitats. ▪ Erosion is likely to affect the waterway estuaries (especially the Waikanae Estuary) and result in a loss of intertidal feeding areas for shorebirds. ▪ Erosion and sea-level rise could over-deepen the water in the estuaries so that the area is no longer suitable for birds to wade and feed in. ▪ Erosion could alter the near-shore environment resulting in reduction of food supplies which could adversely affect bird populations, putting them at greater risk of (local or more wide-spread) extinction. Erosion could also bury in-shore benthic food sources (buried invertebrates in the sand), reducing food for the birds. ▪ Increasing sea level rise, coupled with erosion is likely to cause increased coastal squeeze for these coastal habitats as erosion inland reduces the amount of space available for bird habitats to 'migrate' due to human infrastructure and dense residential areas on the landward sides. ▪ Erosion will have cascading effects for significant bird habitats as the erosion will not only occur within the CAA but also the wider Kāpiti Coast and surrounding environment putting further pressure on bird populations and bird habitats. ▪ Loss of coastal bird habitat might result in greater human vs bird conflict/interaction if birds seek out alternative locations to rest, nest and feed. Locations such as sports fields, roof tops, trees in gardens and parks, local ponds and amenity features. ▪ The CAA provides habitat for a very large range of Threatened and At Risk bird species, NZ and international migrants, and rarely seen species. This encourages tourism from wildlife photographers. Reduced habitat will affect the species and the numbers of birds returning for nesting will have cascading effects for tourism.
Coastal Flooding	▪ More frequent and extensive flooding of indigenous bird habitats will cause changes in the food availability due to increased diving depth, plants and habitats dying due to flooding, changes in waterflow patterns, and increased water velocity and sedimentation smothering benthic food sources (buried invertebrates in the sand). These changes will likely affect the prey species available in rivers, lagoons and coastal marine areas, reducing food availability for birds. ▪ Higher and more extensive flooding could drown nests and burrows of species that nest adjacent or on waterways. This will have cascading effects on the size and genetic diversity of the affected bird populations. The issue will be that the whole or much of the coastline will be similarly affected, so not only reducing local habitat within the CAA but also reducing habitat for birds to move too. ▪ Flooding can scour waterway beds resulting in altered river flows and loss or flooding of any islands. This would reduce areas of safer (less disturbance by humans and their pets) nesting and foraging areas. Such losses will reduce breeding and feeding success and will likely result in a decline in the populations of the affected species. ▪ Inundation due to sea level rise will reduce tidal foraging area available to bird species especially because this habitat cannot 'migrate' inland due to surrounding topography and human infrastructure (such as sea walls, stormwater infrastructure, roading and bridges). ▪ Nests of shorebirds and seabird species are regularly washed out with storm surges (Holle, et al., 2019). Birds may not continue to return to sites due to continued flooding creating unsuitable nesting habitats. This would cause a decline in populations of these species or perhaps even local extinctions. ▪ The issue will be that flooding will affect the whole or much of the coastline, so not only reducing local habitat within the CAA but also reducing habitat for birds to move too. ▪ Flooding may result in additional areas of wetland in more inland habitat allowing some species to extend their range, but only if these newly wetted areas are retained and protected as wildlife habitat.

Hazard	Description of Consequence (note any cascading impacts)
	▪ The breeding success of a number of threatened river-dwelling bird species (such as wrybill plovers, black-fronter terns and blue ducks), that dwell in other districts, are already significantly impacted from flooding and predicted changes in the frequency and magnitude of floods may further significantly impact population viability (Death, Bowie & O'Donnell, 2016). ▪ A loss of visiting sea birds will cause a lower cultural value for food gathering, feathers for craft and spiritual connection as taonga Māori, and reduced tourism opportunities.

Opportunities

Hazard	Opportunities
Coastal Erosion	▪ The ongoing management of the Waikanae Estuary seeks to restore the ecosystems and includes intensive pest program. This effort should be continued. The Waikanae Estuary Care Group also undertakes planting to enhance the stability of the salt marshes and the bordering ecosystems to prevent further erosion inland into residential dwellings. ▪ Undertake predator control program in other bird habitat to keep birds safe. ▪ Creating and/or maintaining safe bird habitat somewhere away from coastal erosion such as. predator control in and around Queen Elizabeth Park, assisting private landowners with predator control around lakes and ponds with high bird values, creating an inland dune lake with beaches as bird habitat. ▪ Education to ensure that humans keep their dogs under control and allow birds to rest and recuperate. Dog exclusion areas to allow northern blue penguins and other coastal and seabirds to nest, breed and rest undisturbed. ▪ Ongoing or increased monitoring by the GWRC and KCDC to monitor and record effects on bird species and populations.
Coastal Flooding	▪ The ongoing management of the Waikanae Estuary seeks to restore the ecosystems and includes intensive pest program. This effort should be continued. The Waikanae Estuary Care Group also undertakes planting to enhance the stability of the salt marshes and the bordering ecosystems to prevent further erosion inland into residential dwellings. ▪ Undertake predator control program in other bird habitat to keep birds safe. ▪ Creating and/or maintaining safe bird habitat somewhere away from coastal erosion such as. predator control in and around Queen Elizabeth Park, assisting private landowners with predator control around lakes and ponds with high bird values, creating an inland dune lake with beaches as bird habitat. ▪ Education to ensure that humans keep their dogs under control and allow birds to rest and recuperate. Dog exclusion areas to allow northern blue penguins and other coastal and seabirds to nest, breed and rest undisturbed. ▪ Ongoing or increased monitoring by the GWRC and KCDC to monitor and record effects on bird species and populations. ▪ Better management of vehicle access to reduce vehicle damage in the estuary and coastal bird habitats. Current access is technically restricted, however difficult to enforce and vehicles are often used irresponsibly in the areas. ▪ Coordinated governance to ensure climate change related actions will protect migratory, coastal and riverbed nesting birds and help to expand the ability of these species to adapt to climate change induced hazards. ▪ Identify coastal and riverine and other breeding sites that are most vulnerable to climate change impacts and develop plans on how to address these effects. ▪ The opportunity for a national coastal vulnerability index for coastal species could be adopted and manipulated to suit Aotearoa, New Zealand species as a way to monitor and rank risk for coastal ecosystems (as seen in Holle, et al., 2019). ▪ Minimising the effects of the flood gates on the Waikanae Estuary and artificial opening of the river mouth on the higher quality estuarine areas to the north of the river mouth would also help minimize any potential adverse effects on the estuarine uses and values.

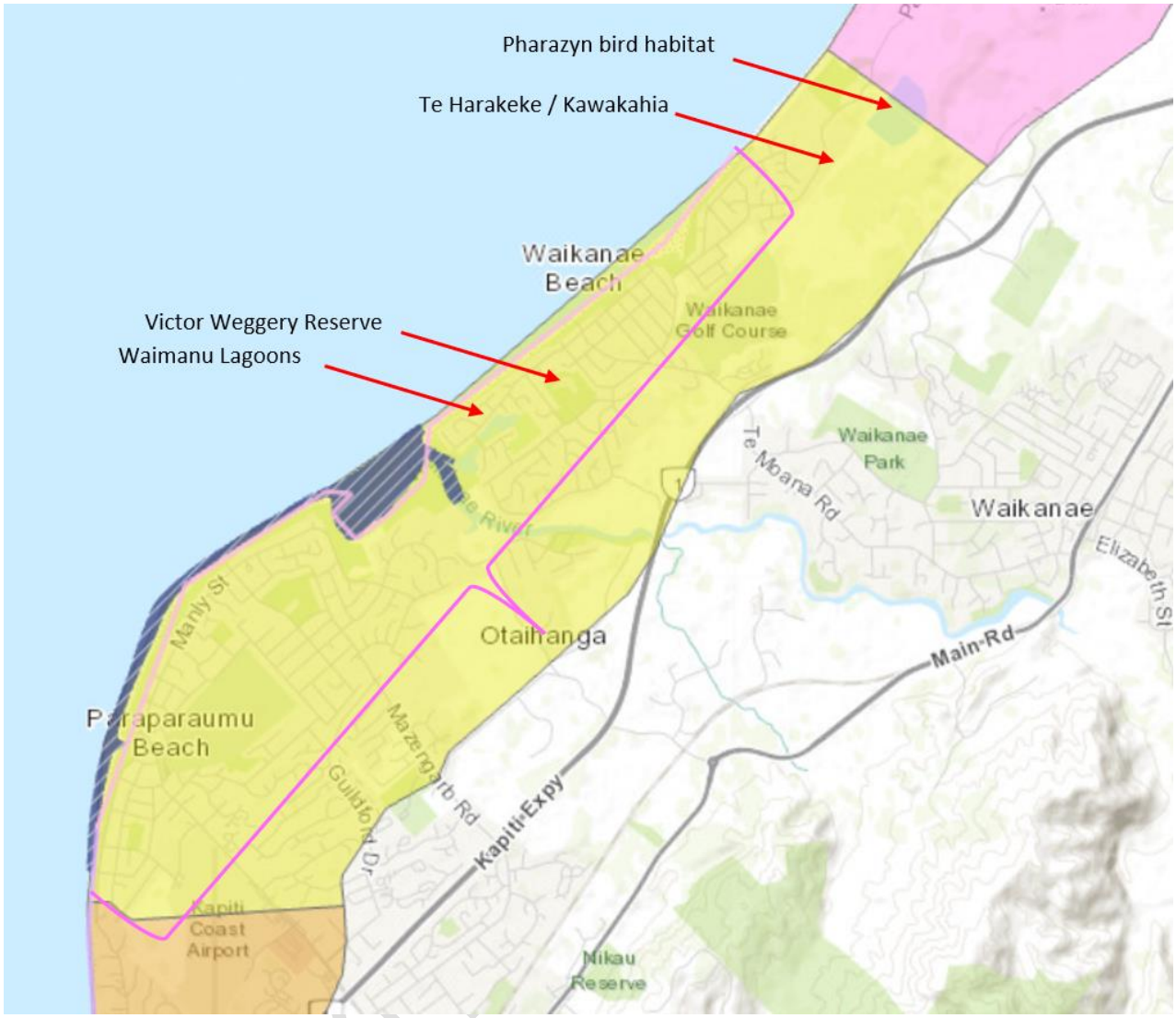

Figure A.3.5: Location of bird surveys within the CAA (pink brackets). GWRC identified two coastal significant bird habitats; one at the Waikanae Estuary, and the other along the Paraparaumu Beach.

Waikanae Estuary supports breeding populations of banded dotterel, North Island fernbird, dabchick, variable oystercatcher, pied stilt and pied shag. It also provides important non-breeding habitat for a range of migratory shorebirds such as NZ pied oystercatcher and bar-tailed godwit. This site also provides seasonal or core habitat for Australasian bittern, spotless crake, royal spoonbill, black shag, little black shag, black-billed gull, red-billed gull, white-fronted tern, black-fronted tern and Caspian tern. This site is one of only two sites in the Wellington Region to support a breeding population of North Island fernbird and is one of only two mainland sites in the Wellington region where brown teal are regularly recorded.

Paraparaumu Beach provides seasonal or core habitat for variable oystercatcher, red-billed gull, Caspian tern and white-fronted tern.

Te Harakeke is the largest dune swale wetland remaining in a relatively natural state on the coastal plain of the Foxton Ecological District and second largest area of raupo flaxland wetland remaining in Greater Wellington area. Kawakahia wetland includes a small area of kahikatea-dominated semi-coastal remnant swamp forest. These two adjacent areas provide habitat for the Threatened-Nationally Critical Australasian Bittern and the At Risk-Declining North Island fernbird as well as a range of more common wetland and forest birds.

Pharazyn Reserve includes a constructed (old sewage pond) but it is in the process of being naturalized and has breeding and roosting populations of a number of At Risk species and Waimanu Lagoons and Victor Weggery Reserve although highly modified have a rich bird population including At Risk and some Threatened species.

A.3.6.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion ▪ Erosion is affecting the beaches, estuaries and adjacent dune systems that provide foraging, roosting and nesting habitat for birds. ▪ Erosion is not affecting the more inland lagoons and wetlands or the old sewage treatment pond. ▪ Overall exposure - moderate	Future exposure: ▪ **2050:** Effects on beach, dune and estuary bird habitat increase; especially the northwestern part of the Waikanae Estuary saltmarsh is likely to experience flow on effects from the erosion of the dunes bordering the estuary. There are no inland wetlands exposed to coastal erosion. ▪ **2070:** Effects on beach, dune and estuary bird habitat increase; erosions and increased storm surges may change the salinity and food availability in Waikanae Estuary saltmarsh. There are no inland wetlands exposed to coastal erosion. ▪ **2130:** It is likely that erosion will open up the northwestern part of the Waikanae Estuary saltmarsh (part of an outstanding wetland system) and more inland portionsof the Waikanae River to more frequent saline water penetration. This will change plant and animal species composition and reduce/change the habitat and food availability for birds. Ongoing erosion of the beaches and dunes will also reduce bird habitat, especially given the effects on the wider Kāpiti Coast limiting alternative habitat to move to. There are no inland wetlands exposed to coastal erosion
Currently exposed to coastal flooding ▪ >95% of the GWRC mapped bird habitat (see map above) is exposed to coastal flooding hazards and the lowland margins of the Waikanae River are flooded. ▪ Te Harakeke Wetland outflow will be restricted and 80% of the Waikanae Estuary saltmarsh floods, 100% flooded -Waimanu Lagoons and Waimeha Lagoon in Victor Weggery Reserve. ▪ Overall exposure on areas that provide foraging, roosting and nesting habitat for birds - High	Future exposure: 2050: ▪ The lower Waikanae River floodplain, Waikanae Estuary saltmarsh and adjacent lagoons experience more frequent and greater depth of flooding. ▪ Flows back up in at least half of Te Harakeke Wetland and 90% of the Waikanae Estuary saltmarsh floods ▪ 100% flooded - Waimanu Lagoons and Waimeha Lagoon in Victor Weggery Reserve. ▪ Reduced availability of areas that provide foraging, roosting and nesting habitat for birds. 2070: ▪ The lower Waikanae River floodplain, Waikanae Estuary saltmarsh and adjacent lagoons experience more frequent and greater depth of flooding. ▪ Flows back up in at least half of Te Harakeke Wetland and 100% of the Waikanae Estuary saltmarsh floods and floods into adjacent areas ▪ 100% flooded - Waimanu Lagoons and Waimeha Lagoon in Victor Weggery Reserve ▪ Other wetlands: 100% flooded Waikanae Oxbow and floods into adjacent areas 2130:

Details of exposure	
	▪ The lower Waikanae River floodplain, Waikanae Estuary saltmarsh and adjacent lagoons experience more frequent and greater depth of flooding. ▪ Te Harakeke Wetland 100% flooded and 100% of the Waikanae Estuary saltmarsh floods and floods into adjacent areas. ▪ 100% flooded - Waimanu Lagoons and Waimeha Lagoon in Victor Weggery Reserve and floods into adjacent areas.

Hazard	Present	2050	2070	2130
Coastal Erosion	M	M	H	E
Coastal Flooding	H	H	E	E

Note:

- There may be inland areas where wetlands could be planted, or established after flooding or other bird habitat created. This could moderate some of the effects.
- Changes to salinity and duration and depth of flooding will change plant species composition. This will have knock-on effects on fauna and bird habitat types.

Erosion

- Estimated as the proportion of the identified bird habitat affected by erosion.
- The current risk is high to extreme exposure for coastal beaches, dunes and estuaries, but low for inland wetland bird habitats. The coastal systems and the species living in them are somewhat adapted to erosion processes. Hence moderate overall.
- Erosion could result in seawater penetrating further inland in groundwater systems and changing salinity of other bird habiats.
- The risk increases to high in 2070 as all coastal bird habitat will be affected to some extent.
- Increases to extreme in 2130 due to opening the northwestern part of the Waikanae Estuary saltmarsh (Outstanding Wetland) to the sea with consequent effects on bird habitat.

Flooding

- Estimated as the proportion of the bird habitats affected by flooding. Includes flooding of adjacent areas as this may increase the area of wetland bird habitat over time.
- Current flooding risk is high, as flooding of the coastal and saline bird habitats occurs already (and is expected), but it is likely that the entire Kāpiti coastline will be experiencing similar effects, reducing the availability of possible alternative habitat.
- Flood risk increases to extreme from 2070 on as low-lying areas adjacent to the bird habitat also flood and the frequency and depth of flooding continues to increase. This would severly limit bird habitat availability and could affect bird populations and potentially even local extinctions. Flooding may result in additional areas of wet land which could provide alternative bird habitat, but this would need to be secured through planting, (legal) protection, and predator control.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	H	E
Coastal Flooding	H	H	E	E

Note: Ministry for the Environment (2020a) identifies that that degree of sensitivity for migratory, coastal and river-nesting birds will be largely dictated by environmental factors rather than physiological and behavioural senstivities with pressure on seabird and river-nestiving birds from human disturbance and other changes in landscape likely to increase aswell as climate change.

One of the problems is that is it likely that the bird habitat in CAA will be affected as well as a much larger area, potentially even areas outside of the Kāpiti Coast for NZ migrants and international migrants. Hence

bird population will be experiencing multiple reductions in habitat area with cumulative effects on bird populations. The frequency of such events will likely also increase that will further undermine the ability of bird populations to recover.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	Low	▪ Waikanae Estuary has long been a habitable bird environment and has continued to adjust and accommodate for changes in sea level and erosion of intertidal and sand banks to support local bird populations and nesting habitats. ▪ There is a limited degree of adaptive capacity that can be expected for most bird populations due to the high pressure they already experience from predation, habitat loss and human disturbance. ▪ Migratory and dispersal ability can be high however the ability to adapt to climate induced hazards is limited by the number of available and suitable alternative habitats, feeding areas and breeding sites (Ministry for the Environment, 2020). Alternative areas will likely decrease in size/suitability over increasingly larger areas.
Coastal Flooding	Very Low	▪ A limited degree of adaptive capacity can be expected for most bird populations, with nationwide shorebird and wetland bird counts showing populations already declining (Lukies, Gaskin & Whitehead, 2021). ▪ Human activities such as harvesting, habitat clearance and fragmentation have already substantially reduced the amount of bird habitat available and opportunities for indigenous species to move to other suitable habitat. ▪ Human infrastructure limits the 'migration' or expansion of bird habitat. This will not be easily remedied and will require concerted effort and financial input to create other suitable habitats.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	M	H	E	L	M	M	H	E
Flooding	H	H	E	E	VL	E	E	E	E

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	M	M	H	E	M	M	H	E	M	M	H	E
Risk from Flooding	H	H	E	E	E	E	E	E	E	E	E	E

A.3.6.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion ▪ Erosion is affecting the beaches, estuaries and adjacent dune systems that provide foraging, roosting and nesting habitat for birds. ▪ Erosion is not affecting the more inland lagoons and wetlands or the old sewage treatment pond. ▪ Overall exposure - moderate	Future exposure: ▪ **2050:** Effects on beach, dune and estuary bird habitat increase; especially the northwestern part of the Waikanae Estuary saltmarsh is likely to experience flow on effects from the erosion of the dunes bordering the estuary. There are no inland wetlands exposed to coastal erosion. ▪ **2070:** Effects on beach, dune and estuary bird habitat increase; erosions and increased storm surges may change the salinity and food availability in Waikanae Estuary saltmarsh. One of the Waikanae Estuary lagoons is likely to be breached and opened to the sea. There are no inland wetlands exposed to coastal erosion. ▪ **2130:** Erosion will open up the northwestern part of the Waikanae Estuary saltmarsh (part of an outstanding wetland system) and more inland portionsof the Waikanae River to more frequent saline water penetration. This will change plant and animal species composition and reduce/change the habitat and food availability for birds. Ongoing erosion of the beaches and dunes will also reduce bird habitat, especially given the effects on the wider Kāpiti Coast limiting alternative habitat to move to. There are no inland wetlands exposed to coastal erosion
Currently exposed to coastal flooding ▪ >95% of the GWRC mapped bird habitat (see map above) is exposed to coastal flooding hazards and the lowland margins of the Waikanae River are flooded. ▪ Te Harakeke Wetland outflow will be restricted and 80% of the Waikanae Estuary saltmarsh floods ▪ 100% flooded -Waimanu Lagoons and Waimeha Lagoon in Victor Weggery Reserve. ▪ Overall exposure on areas that provide foraging, roosting and nesting habitat for birds - high	Future exposure: **2050:** The lower Waikanae River floodplain, Waikanae Estuary saltmarsh and adjacent lagoons experience more frequent and greater depth of flooding. - Flows back up in at least half of Te Harakeke Wetland and 90% of the Waikanae Estuary saltmarsh floods - 100% flooded - Waimanu Lagoons and Waimeha Lagoon in Victor Weggery Reserve. - Reduced availability of areas that provide foraging, roosting and nesting habitat for birds. **2070:** The lower Waikanae River floodplain, Waikanae Estuary saltmarsh and adjacent lagoons experience more frequent and greater depth of flooding. - Flows back up in at least half of Te Harakeke Wetland and 100% of the Waikanae Estuary saltmarsh floods and floods into adjacent areas - 100% flooded - Waimanu Lagoons and Waimeha Lagoon in Victor Weggery Reserve - Other wetlands: 100% flooded Waikanae Oxbow and floods into adjacent areas **2130:** The lower Waikanae River floodplain, Waikanae Estuary saltmarsh and adjacent lagoons experience more frequent and greater depth of flooding. - Te Harakeke Wetland 100% flooded and 100% of the Waikanae Estuary saltmarsh floods and floods into adjacent areas

Details of exposure	
	- 100% flooded - Waimanu Lagoons and Waimeha Lagoon in Victor Weggery Reserve and floods into adjacent areas.

Hazard	Present	2050	2070	2130
Coastal Erosion	M	M	E	E
Coastal Flooding	H	H	E	E

Notes:

- While identified sites on maps do not appear to be experiencing significant erosion, the erosion of spaces behind the habitats and loss of limited space landward of the habitat (due to intensive human occupation and built environment in Paraparaumu and Waikanae), coupled with sea level rise will likely overall reduce the size of habitats as potential habitable space shrinks through time.
- This is based on total exposure percentage of the existing habitats to the hazard. I.e low: 0-25%, moderate: 25-50%, high: 50-75%, extreme: >75%.

- There may be inland areas where wetlands could be planted, or established after flooding or other bird habitat created. This could moderate some of the effects.
- Changes to salinity and duration and depth of flooding will change plant species composition. This will have knock-on effects on fauna and bird habitat types.

Erosion

- Estimated as the proportion of the identified bird habitat affected by erosion.
- The current risk is high to extreme exposure for coastal beaches, dunes and estuaries, but low for inland wetland bird habitats. The coastal systems and the species living in them are somewhat adapted to erosion processes. Hence moderate overall.
- Erosion could result in seawater penetrating further inland in groundwater systems and changing salinity of other bird habiats.
- The risk increased to extreme in 2070 is due to opening the northwestern part of the Waikanae Estuary saltmarsh (Outstanding Wetland) to the sea with consequent effects on bird habitat and because all coastal bird habitat will be affected to some extent.

Flooding

- Estimated as the proportion of the bird habitats affected by flooding. Includes flooding of adjacent areas as this may increase the area of wetland bird habitat over time.
- Current flooding risk is high, as flooding of the coastal and saline bird habitats occurs already (and is expected), but it is likely that the entire Kāpiti coastline will be experiencing similar effects, reducing the availability of possible alternative habitat.
- Flood risk increases to extreme from 2070 on as low-lying areas adjacent to the bird habitat also flood and the frequency and depth of flooding continues to increase. This would severly limit bird habitat availability and could affect bird populations and potentially even local extinctions. Flooding may result in additional areas of wet land which could provide alternative bird habitat, but this would need to be secured through planting, (legal) protection, and predator control.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	E	E
Coastal Flooding	H	H	E	E

Note: Ministry for the Environment (2020a) identifies that that degree of sensitivity for migratory, coastal and river-nesting birds will be largely dictated by environmental factors rather than physiological and behavioural senstivities with pressure on seabird and river-nestiving birds from human disturbance and other changes in landscape likely to increase aswell as climate change.

One of the problems is that is it likely that the bird habitat in CAA will be affected as well as a much larger area, potentially even areas outside of the Kāpiti Coast for NZ migrants and international migrants. Hence bird population will be experiencing multiple reductions in habitat area with cumulative effects on bird populations. The frequency of such events will likely also increase that will further undermine the ability of bird populations to recover.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	▪ Waikanae Estuary has long been a habitable bird environment and has continued to adjust and accommodate for changes in sea level and erosion of intertidal and sand banks to support local bird populations and nesting habitats. ▪ There is a limited degree of adaptive capacity that can be expected for most bird populations due to the high pressure they already experience from predation, habitat loss and human disturbance. ▪ Migratory and dispersal ability can be high however the ability to adapt to climate induced hazards is limited by the number of available and suitable alternative habitats, feeding areas and breeding sites (Ministry for the Environment, 2020). Alternative areas will likely decrease in size/suitability over increasingly larger areas.
Coastal Flooding	VL	▪ A limited degree of adaptive capacity can be expected for most bird populations, with nationwide shorebird and wetland bird counts showing populations already declining (Lukies, Gaskin & Whitehead, 2021). ▪ Human activities such as harvesting, habitat clearance and fragmentation have already substantially reduced the amount of bird habitat available and opportunities for indigenous species to move to other suitable habitat. ▪ Human infrastructure limits the 'migration' or expansion of bird habitat. This will not be easily remedied and will require concerted effort and financial input to create other suitable habitats.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	M	E	E	L	M	M	E	E
Flooding	H	H	E	E	VL	E	E	E	E

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	M	M	E	E	M	M	E	E	M	M	E	E
Risk from Flooding	H	H	E	E	E	E	E	E	E	E	E	E

A.3.7 Fish habitat

Domain	Element at Risk	Overview
Ecological	Fish habitat	Waikanae River Mouth is listed as an outstanding wetland in GWRC Natural Resources Plan Schedule A3: Wetlands with outstanding indigenous biodiversity values. The main-stem stream and all tributaries of the Waikanae River are listed in GWRC Natural Resources Plan Schedule F1: Rivers and lakes with significant indigenous ecosystems. These waterways provide habitat for indigenous Threatened/At Risk fish species and habitat for six or more migratory indigenous fish species. The species include: Threatened-Nationally Vulnerable lamprey and shortjaw kōkopu, At Risk-Naturally Uncommon giant bully, At Risk-Declining bluegill bully, brown mudfish, dwarf galaxias, giant kōkopu, īnanga, koaro, longfin eel, and torrentfish and Not Threatened banded kōkopu, common bully, common smelt, redfin bully, and shortfin eel. The river mouth is also included in Schedule F1b: Known rivers and parts of the coastal marine area with īnanga spawning habitat. Upstream portions are included in Schedule I: Important trout fishery rivers and spawning waters. Schedule F4: Sites with significant indigenous biodiversity values in the coastal marine area as it provides seasonal or core habitat for nine threatened indigenous migratory fish species: longfin eel, giant kōkopu, shortjaw kōkopu, kōaro, īnanga, redfin bully, bluegill bully, torrentfish and lamprey Waimeha Stream (Ngarara Stream) and all tributaries is listed in Schedule F1: Rivers and lakes with significant indigenous ecosystems. The species include: At Risk-Naturally Uncommon giant bully, At Risk-Declining, giant kōkopu, īnanga, longfin eel, and Not Threatened banded kōkopu, common bully, Cran's bully, redfin bully, and shortfin eel. The stream is also included in Schedule F1b: Known rivers and parts of the coastal marine area with īnanga spawning habitat and Schedule F4: Sites with significant indigenous biodiversity values in the coastal marine area. Waimeha provides seasonal or core habitat for four threatened indigenous fish species: longfin eel, giant kōkopu, īnanga, and redfin bully.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	▪ Coastal erosion could alter the habitat, including any saline wetlands, within the waterway mouths and make it less appropriate habitat for indigenous fish species. ▪ It could alter how the waterways connect to more upstream portions (e.g. fish passage barriers). ▪ Rapid erosion could at times temporarily block the stream with sediment. ▪ The estuaries cannot re-establish upstream due to existing human infrastructure. ▪ Increased sediment in the waterways (from coastal erosion or upstream erosion) reduces the quality of fish habitat through reduced oxygen levels, reduced visibility (some fish hunt by sight), reduced prey items (poorer quality water supports a smaller array of invertebrate species), and sediment deposition on spawning areas (vegetation and gravels) and resting areas (gravel substrates and side eddies). ▪ Increasing sea level rise, coupled with erosion is likely to cause increased coastal squeeze for these coastal habitats as erosion inland reduces the amount of space available for habitats to extend into due to infrastructure and dense residential areas on the landward sides.
Coastal Flooding	▪ Salt water would penetrate further upstream and could potentially kill freshwater species (especially plants). These could be areas where īnanga spawn. ▪ The depth of the water in the estuaries and waterways would be progressively deeper from present day to the 2130 modelling.

Hazard	Description of Consequence (note any cascading impacts)
	▪ The current could be so strong that species are unable to swim upstream or are swept out to sea (depending on which flood-flow was strongest). ▪ Areas beside the waterways would be flooded creating additional temporary habitat for freshwater fish which are known to 'graze' flooded paddocks and sometimes also spawn. ▪ Flooding may result in additional areas of wetland that could provide limited (or more permanent habitat for fish).

Opportunities

Hazard	Opportunities
Coastal Erosion	▪ The ongoing management of the Waikanae Estuary seeks to restore the ecosystems and includes intensive pest program. This effort should be continued. The Waikanae Estuary Care Group also undertakes planting to enhance the stability of the salt marshes and the bordering ecosystems to prevent further erosion inland into residential dwellings. ▪ Where possible, plant the banks of the waterways with suitable indigenous plant species, including the floodplain. This will strengthen the stream banks and reduce erosion of the banks. It would also create habitat for indigenous species.
Coastal Flooding	▪ The ongoing management of the Waikanae Estuary seeks to restore the ecosystems and includes intensive pest program. This effort should be continued. The Waikanae Estuary Care Group also undertakes planting to enhance the stability of the salt marshes and the bordering ecosystems to prevent further erosion inland into residential dwellings. ▪ Where possible, plant the banks of the waterways with suitable indigenous plant species, including the floodplain. This will strengthen the stream banks and reduce erosion of the banks. It would also create habitat for indigenous species. ▪ The salt wedge (the location where sea water flowing upstream meets freshwater coming down stream at highest tides) is likely to move upstream as sea-levels increase and flooding progressively moves upstream. Īnanga (At Risk-Declining) lay eggs (spawn) on vegetation draping into the stream or just above flood height on the banks of waterways within the salt wedge. There is an opportunity to revegetate the banks of the waterways with suitable indigenous species to create spawning habitat for īnanga (which is the largest portion of whitebait). This could be further enhanced by creating a series of spoon-shaped 'ponds' on the banks, such that the 'handle' of the 'spoon' connects to the stream and enables the salt wedge to enter the 'bowl' during higher tides. ▪ Consider establishing additional areas of wetland (including deeper trenches) in future flood-prone areas to maintain or even increase habitat for indigenous fish. ▪ Look into options to manage vehicle damage in the estuary to better protect fish habitat. Current access is technically restricted, however difficult to enforce and vehicles are often used irresponsibly in the areas. ▪ Minimising the effects of the flood gates on the Waikanae Estuary and artificial opening of the river mouth on the higher quality estuarine areas to the north of the river mouth would also help minimize any potential adverse effects on the estuarine uses and values.

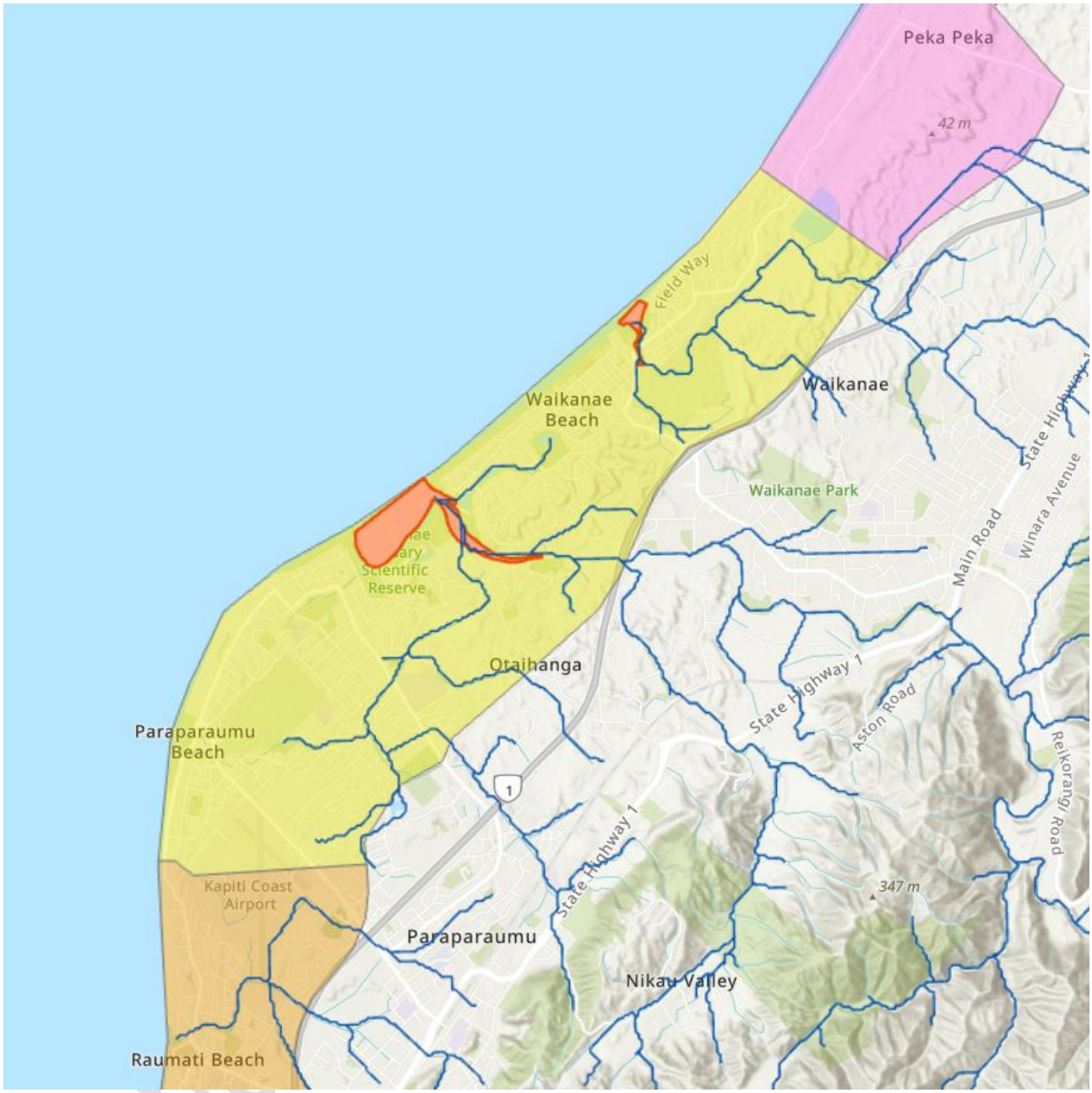

Figure A.3.6: Orange areas are important fish habitats and blue lines are waterways important fish habitat.

A.3.7.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Erosion – present-day average coastal erosion measured as metres from current seaward beach edge: ▪ Waikanae River 20 m ▪ Waimeha Stream 290 m upstream to Field Way	▪ 2050: Waikanae River 140 m, Waimeha Stream 290 m. ▪ 2070: Waikanae River 160 m, Waimeha Stream 290 m. ▪ 2130: Waikanae River 190 m, Waimeha Stream 290 m.
▪ Present day flooding penetrates inland up the main-stems and tributaries of the Waikanae River and the Waimeha Stream. Note: Flooding is measured as metres from current seaward beach edge to the most inland modelled penetration of flood events up the two waterways. ▪ Waikanae River 5930 m ▪ Waimeha Stream 3116 m	▪ 2050: Waikanae River 6480 m, Waimeha Stream 3382 m and greater floodplain area for both. ▪ 2070: Waikanae River 7430 m, Waimeha Stream 3486 m and greater floodplain area for both. ▪ 2130: Waikanae River 9195 m, Waimeha Stream 4242 m and greater floodplain area for both.

Hazard	Present	2050	2070	2130
Coastal Erosion	M	M	M	H
Coastal Flooding	H	E	E	E

Note:

- The Waikanae River mouth can be cut (reshaped) as a permitted activity under GWRC NRP Rule R214 when the channel outlet within the coastal marine area migrates (erodes) either 500m south or 200m north of a projected line parallel to the centerline of the groyne to the south bank of the river and/or when the water level increases 300mm or more above the normal river levels (flooding) at the Otaihanga footbridge.
- The Waimeha Stream mouth can be cut (reshaped) as a permitted activity under GWRC NRP Rule R214 when the channel outlet within the coastal marine area is either 250m south or 150m north of a centerline determined by the training wall adjacent to Field Way or the channel outlet creates a vertical scarp in the sand dunes which exceeds 2m in height and/or when the water level increases 300mm or more above normal river levels as measured at the Field Way road bridge.
- Therefore, fish habitat within the waterway mouths already experiences occasional perturbations.

Erosion:

- Erosion was estimated by measuring inland from the seaward edge of the beach (from outer edge of inundation hazard which is presumed to be outer edge of beach as shown on the topographic base map) to the inland edge of the various hazard modelling lines (present day, 2050, 2070, and 2130) for both Waikanae River and the Waimeha Stream.
- It is assumed that erosion could undermine up- and downstream connectivity for fish and cause deterioration of in-stream habitat and stream bank habitat, especially if any culverts are left perched above the in- or outflow (fish need connected wet surfaces, a sudden drop or waterfall is an obstacle for many species).
- The present-day hazard has been set at moderate as erosion already extents inland from the beach indicating that fish habitat may already be deteriorating, especially so at Waimeha Stream mouth.
- The increase to high in 2130 is due to the more rapid erosion than previous periods.

Flooding:

- Flooding was estimated by measuring inland from the seaward edge of the beach (from outer edge of inundation hazard which is presumed to be outer edge of beach as shown on the topographic base map) to the inland edge of the various flood hazard modelling lines (present day, 2050, 2070, and 2130) along the mainstem and main tributaries for both Waikanae River and the Waimeha Stream.
- Flooding could be benefical to indigenous fish species as it could provide additional areas of flooded habitat for feeding and spawning.
- Flooding could also be detrimental to indigenous fish species due to rapid changes in salinity, increased turbidity, reduced in-stream prey, preventing fish from swimming upstream or downstream ((temporary) loss of connectivity), washing fish out to sea, and salinity killing vegetation.
- Therefore flooding was set as high for the current scenario and extreme for 2050 on.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	M	M
Coastal Flooding	M	M	M	M

Note:

- Many fish species rely on relatively stable banks and stream beds for habitat. They can move, but upstream habitat may already be occupied by other individuals or not suitable. Changes the the bed of the waterway, increased flow, sediment smothering the waterway bed and plants and increased sediment in the water column can reduce habitat suitability. For flooding the effects are offset by temporary additional habitat in flooded parts of the floodplain.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	M	▪ Many fish species rely on relatively stable banks and stream beds for habitat. They can move, but upstream habitat may already be occupied by other individuals or not suitable.
Coastal Flooding	M	▪ Many fish species rely on relatively stable banks and stream beds for habitat. They can move, but upstream habitat may already be occupied by other individuals or not suitable. For flooding the effects are offset by temporary additional habitat in flooded parts of the floodplain

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	M	M	M	M	M	M	M	M
Flooding	M	M	M	M	M	M	M	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130

	Exposure				Vulnerability				Risk			
Risk from Erosion	M	M	M	H	M	M	M	M	M	M	M	M
Risk from Flooding	H	E	E	E	M	M	M	M	M	H	H	H

A.3.7.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Erosion – present-day average coastal erosion measured as metres from current seaward beach edge: ▪ Waikanae River 20 m ▪ Waimeha Stream 290 m upstream to Field Way	▪ 2050: Waikanae River 140 m, Waimeha Stream 290 m. ▪ 2070: Waikanae River 160 m, Waimeha Stream 290 m. ▪ 2130: Waikanae River 190 m, Waimeha Stream 290 m.
▪ Present day flooding penetrates inland up the main-stems and tributaries of the Waikanae River and the Waimeha Stream. Note: Flooding is measured as metres from current seaward beach edge to the most inland modelled penetration of flood events up the two waterways. ▪ Waikanae River 5930 m ▪ Waimeha Stream 3116 m	▪ 2050: Waikanae River 6480 m, Waimeha Stream 3382 m and greater floodplain area for both. ▪ 2070: Waikanae River 8004 m, Waimeha Stream 3629 m and greater floodplain area for both. ▪ 2130: Waikanae River 10427 m, Waimeha Stream 4316 m and greater floodplain area for both.

Hazard	Present	2050	2070	2130
Coastal Erosion	M	M	M	H
Coastal Flooding	H	E	E	E

Note:

- The Waikanae River mouth can be cut (reshaped) as a permitted activity under GWRC NRP Rule R214 when the channel outlet within the coastal marine area migrates (erodes) either 500m south or 200m north of a projected line parallel to the centerline of the groyne to the south bank of the river and/or when the water level increases 300mm or more above the normal river levels (flooding) at the Otaihanga footbridge.
- The Waimeha Stream mouth can be cut (reshaped) as a permitted activity under GWRC NRP Rule R214 when the channel outlet within the coastal marine area is either 250m south or 150m north of a centerline determined by the training wall adjacent to Field Way or the channel outlet creates a vertical scarp in the sand dunes which exceeds 2m in height and/or when the water level increases 300mm or more above normal river levels as measured at the Field Way road bridge.
- Therefore, fish habitat within the waterway mouths already experiences occasional perturbations.

Erosion:

- Erosion was estimated by measuring inland from the seaward edge of the beach (from outer edge of inundation hazard which is presumed to be outer edge of beach as shown on the topographic base map) to the inland edge of the various hazard modelling lines (present day, 2050, 2070, and 2130) for both Waikanae River and the Waimeha Stream.
- It is assumed that erosion could undermine up- and downstream connectivity for fish and cause deterioration of in-stream habitat and stream bank habitat, especially if any culverts are left perched above the in- or outflow (fish need connected wet surfaces, a sudden drop or waterfall is an obstacle for many species).
- The present-day hazard has been set at moderate as erosion already extents inland from the beach indicating that fish habitat may already be deteriorating, especially so at Waimeha Stream mouth.
- The increase to high in 2130 is due to the more rapid erosion than previous periods and consequent changes to the waterway mouths.

Flooding:

- Flooding was estimated by measuring inland from the seaward edge of the beach (from outer edge of inundation hazard which is presumed to be outer edge of beach as shown on the topographic base map) to the inland edge of the various flood hazard modelling lines (present day, 2050, 2070, and 2130) along the mainstem and main tributaries for both Waikanae River and the Waimeha Stream.
- Flooding could be benefical to indigenous fish species as it could provide additional areas of flooded habitat for feeding and spawning.
- Flooding could also be detrimental to indigenous fish species due to rapid changes in salinity, increased turbidity, reduced in-stream prey, preventing fish from swimming upstream or downstream ((temporary) loss of connectivity), washing fish out to sea, and salinity killing vegetation.
- Therefore flooding was set as high for the current scenario and extreme for 2050 on.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	M	M
Coastal Flooding	M	M	M	M

Note:

- Many fish species rely on relatively stable banks and stream beds for habitat. They can move, but upstream habitat may already be occupied by other individuals or not suitable. Changes the the bed of the waterway, increased flow, sediment smothering the waterway bed and plants and increased sediment in the water column can reduce habitat suitability. For flooding the effects are offset by temporary additional habitat in flooded parts of the floodplain.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	Moderate	▪ Many fish species rely on relatively stable banks and stream beds for habitat. They can move, but upstream habitat may already be occupied by other individuals or not suitable.
Coastal Flooding	Moderate	▪ Many fish species rely on relatively stable banks and stream beds for habitat. They can move, but upstream habitat may already be occupied by other individuals or not suitable. For flooding the effects are offset by temporary additional habitat in flooded parts of the floodplain

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	M	M	M	M	M	M	M	M
Flooding	M	M	M	M	M	M	M	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130

	Exposure				Vulnerability				Risk			
Risk from Erosion	M	M	M	H	M	M	M	M	M	M	M	M
Risk from Flooding	H	E	E	E	M	M	M	M	M	H	H	H

A.3.8 Coastal indigenous biodiversity

Domain	Element at Risk	Overview
Ecological	Coastal indigenous biodiversity	As identified in GWRC Natural Resources Plan Schedule F4: Sites with significant indigenous biodiversity values in the coastal marine area: ▪ Waikanae Estuary provides a corridor for animals moving between river, sea, land; habitat for estuarine birds; longfin eel, giant kōkopu, shortjaw kōkopu, kōaro, īnanga, redfin bully, bluegill bully, torrentfish; lamprey; sea sedge; swamp buttercup. ▪ Kāpiti Island Marine Reserve includes a wide range of marine habitats and ecosystems; connectivity to Waikanae Estuary; outstanding underwater scenery; Bryozoan and Rhodolith beds; habitat for little blue penguin, black shag, variable oyster catcher, caspian tern; NZ fur seal haulout. Kāpiti Island Marine Reserve will not be considered further, although erosion and flooding of the CAA may have consequent effects on this area. ▪ Waimeha stream provides seasonal or core habitat for four threatened indigenous fish species: longfin eel, giant kōkopu, īnanga, and redfin bully.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	▪ Erosion can affect beaches causing them to lower and providing less foraging and roosting space at high tide for shore birds. ▪ Coastal erosion could alter the habitat, including any saline wetlands, within the waterway mouths and make it less appropriate habitat for indigenous fish, bird and plant species and too deep to be suitable for shorebirds and wading birds. ▪ Erosion would widen the mouth of the waterways and more exposed to waves and tides and currents. This will make it less suitable for fish, shorebirds and wading birds. ▪ Erosion will affect some of the dunes which could affect bird roosting or nesting habitat and loss of indigenous plant species. ▪ Erosion is likely to affect the waterway estuaries (especially the Waikanae Estuary) and result in a loss of intertidal feeding areas for shorebirds. ▪ Erosion could alter the near-shore environment resulting in reduction of food supplies which could adversely affect bird populations, putting them at greater risk of (local or more wide-spread) extinction. Erosion could also bury in-shore benthic food sources (buried invertebrates in the sand), reducing food for the birds. ▪ Increasing sea level rise, coupled with erosion is likely to cause increased coastal squeeze for these coastal habitats as erosion inland reduces the amount of space available for bird habitats to 'migrate' due to human infrastructure and dense residential areas on the landward sides.
Coastal Flooding	▪ More frequent and extensive flooding of indigenous bird and fish habitats will cause changes in the food availability due to increased diving depth, plants and habitats dying due to flooding, changes in waterflow patterns, and increased water velocity and sedimentation smothering benthic food sources (buried invertebrates in the sand). These changes will likely affect the prey species available in rivers, lagoons and coastal marine areas, reducing food availability for birds and fish. ▪ Salt water would penetrate further upstream and could potentially kill freshwater species (especially plants). These could be areas where īnanga spawn. ▪ The depth of the water in the estuaries and waterways would be progressively deeper from present day to the 2130 modelling. ▪ Higher and more extensive flooding could drown indigenous plants, lizards, invertebrates and nests and burrows of species that nest adjacent or on waterways. This will have cascading effects on the size and genetic diversity of the affected populations. ▪ Flooding can scour waterway beds resulting in altered river flows and loss or flooding of any islands. This would reduce areas of safer (less disturbance by humans and their pets)

Hazard	Description of Consequence (note any cascading impacts)
	nesting and foraging areas. Such losses will reduce breeding and feeding success and will likely result in a decline in the populations of the affected species. ▪ Inundation due to sea level rise will reduce tidal foraging area available to bird species especially because this habitat cannot 'migrate' inland due to surrounding topography and human infrastructure (such as sea walls, stormwater infrastructure, roading and bridges). ▪ Flooding may result in additional areas of wetland in more inland habitat allowing some species to extend their range, but only if these newly wetted areas are retained and protected as wildlife habitat.

Opportunities

Hazard	Opportunities
Coastal Erosion	▪ The ongoing management of the Waikanae Estuary seeks to restore the ecosystems and includes intensive pest program. This effort should be continued. The Waikanae Estuary Care Group also undertakes planting to enhance the stability of the salt marshes and the bordering ecosystems to prevent further erosion inland into residential dwellings. ▪ Where possible, plant the banks of the waterways with suitable indigenous plant species, including the floodplain. This will strengthen the stream banks and reduce erosion of the banks. It would also create habitat for indigenous species.
Coastal Flooding	▪ The ongoing management of the Waikanae Estuary seeks to restore the ecosystems and includes intensive pest program. This effort should be continued. The Waikanae Estuary Care Group also undertakes planting to enhance the stability of the salt marshes and the bordering ecosystems to prevent further erosion inland into residential dwellings. ▪ Where possible, plant the banks of the waterways with suitable indigenous plant species, including the floodplain. This will strengthen the stream banks and reduce erosion of the banks. It would also create habitat for indigenous species. ▪ The salt wedge (the location where sea water flowing upstream meets freshwater coming down stream at highest tides) is likely to move upstream as sea-levels increase and flooding progressively moves upstream. Īnanga (At Risk-Declining) lay eggs (spawn) on vegetation draping into the stream or just above flood height on the banks of waterways within the salt wedge. There is an opportunity to revegetate the banks of the waterways with suitable indigenous species to create spawning habitat for īnanga (which is the largest portion of whitebait). This could be further enhanced by creating a series of spoon-shaped 'ponds' on the banks, such that the 'handle' of the 'spoon' connects to the stream and enables the salt wedge to enter the 'bowl' during higher tides. ▪ Consider establishing additional areas of wetland (including deeper trenches) in future flood-prone areas to maintain or even increase habitat for indigenous fish. ▪ Look into options to manage vehicle damage in the estuary to better protect habitat. Current access is technically restricted, however difficult to enforce and vehicles are often used irresponsibly in the areas. ▪ Minimising the effects of the flood gates on the Waikanae Estuary and artificial opening of the river mouth on the higher quality estuarine areas to the north of the river mouth would also help minimize any potential adverse effects on the estuarine uses and values.

A.3.8.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion ▪ Erosion can affect the beach, estuary and more inland wetted areas of both the Waikanae Estuary and the Waimeha Stream. ▪ This may result in the shrinking of these habitats. ▪ 100% for Waimeha Stream and about 80% for Waikanae Estuary. ▪ Current risk high	Future exposure: ▪ **2050:** Similar risk of erosion for both coastal biodiversity areas - high. ▪ **2070:** Similar risk of erosion for both coastal biodiversity areas - high. ▪ **2130:** Similar risk of erosion for Waimeha Stream coastal biodiversity areas, but increased erosion within the Waikanae Estuary increases significantly - extreme.
Currently exposed to coastal flooding ▪ >95% of the coastal biodiveristy areas area currently exposed to coastal flooding hazards across both habitats ▪ However, these systems are habituated to some degree of flooding (tidal after all). ▪ Hence present day is set to moderate.	Future exposure: ▪ **2050:** >95% of the element is exposed to coastal flooding hazards across both habitats ▪ **2070:** >95% of the element is exposed to coastal flooding hazards across both habitats ▪ **2130:** >95% of the element is exposed to coastal flooding hazards across both habitats

Hazard	Present	2050	2070	2130
Coastal Erosion	H	H	H	E
Coastal Flooding	M	M	H	E

Notes:

- Mapping how much of the feature was affected by erosion or flooding was not informative as pretty much all of the feature was affected in all of the scenarios.

Erosion:

- Landward shift - how far inland the erosion scenario is compared to the innermost part of the mapped estuary. Set as 0m for present day scenario. Measured in linear metres.
- Narrowest width of estuarine mouth - measured from the 'shoulders' of the innermost erosion area for each of the scenarios.
- In combination these two elements illustrate that the estuary bays become more shallow (less bay-shaped) over progressive scenarios.
- Present-day risk set to high as some erosion is already occurring. This shifts to extreme in 2130 because the estuaries become a more 'shallow bay' in shape, which will likely be less favourable habitat for fauna.

Flooding:

- Compare the area flooded in the present day with future flood scenarios and identify the increased area flooded.
- However, these systems are habituated to some degree of flooding (tidal after all).
- Present-day risk set to moderate as flooding is already occuring. This shifts to high in 2070 and extreme in 2130 due to the greater depth of flooding and the additional areas flooded.
- However, these additional areas may also convey some benefits in providing additional (temporary) habitat for fauna.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	H	H	H	E
Coastal Flooding	M	M	H	E

Notes:

- Waikanae Estuary is a very important area of coastal indigenous biodiversity and also links with the Kāpiti Island Marine Reserve. The range and rarity of the species and habitats that occur here make it an especially sensitive area.
- Species become used to where they can go to obtain food or hang out. The frequent the pertubations are, the more likely species will avoid an area. Additionally, habitat along the entire Kāpiti Coast will be affected by similar climatic changes, reducing althernative habitat for species.
- Hence sensitivity has been assessed to follow the same rank as the hazard assessment.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	VL	▪ Once the estuary has been eroded it will be very difficult to re-establish due to low coastal sand availability. Species will stop using an area if it has frequent perturbations or becomes unsuitable habitat.
Coastal Flooding	L	▪ Flooding can be a more temporary perturbation; however, an estuary provides relatively shallow habitat and flooding would increase the depth of the water. Once that happens it will be less suitable fauna habitat. Additional flooded areas may offset some of these effects.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	H	H	H	E	VL	E	E	E	E
Flooding	M	M	H	E	L	M	M	H	E

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	H	H	H	E	E	E	E	E	E	E	E	E
Risk from Flooding	M	M	H	E	M	M	H	E	M	M	H	E

A.3.8.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion ▪ Erosion can affect the beach, estuary and more inland wetted areas of both the Waikanae Estuary and the Waimeha Stream. ▪ This may result in the shrinking of these habitats. ▪ 100% for Waimeha Stream and about 80% for Waikanae Estuary. ▪ Current exposure is high	Future exposure: ▪ **2050:** Similar risk of erosion for both coastal biodiversity areas - high. ▪ **2070:** Similar risk of erosion for both coastal biodiversity areas - high. ▪ **2130:** Similar risk of erosion for Waimeha Stream coastal biodiversity areas, but increased erosion within the Waikanae Estuary increases significantly - extreme.
Currently exposed to coastal flooding ▪ >95% of the coastal biodiveristy areas area currently exposed to coastal flooding hazards across both habitats ▪ However, these systems are habituated to some degree of flooding (tidal after all). ▪ Hence present day is set to moderate.	Future exposure: ▪ **2050:** >95% of the element is exposed to coastal flooding hazards across both habitats ▪ **2070:** >95% of the element is exposed to coastal flooding hazards across both habitats ▪ **2130:** >95% of the element is exposed to coastal flooding hazards across both habitats

Hazard	Present	2050	2070	2130
Coastal Erosion	H	H	H	E
Coastal Flooding	M	M	H	E

Notes:

- Mapping how much of the feature was affected by erosion or flooding was not informative as pretty much all of the feature was affected in all of the scenarios.

Erosion:

- Landward shift - how far inland the erosion scenario is compared to the innermost part of the mapped estuary. Set as 0m for present day scenario. Measured in linear metres.
- Narrowest width of estuarine mouth - measured from the 'shoulders' of the innermost erosion area for each of the scenarios.
- In combination these two elements illustrate that the estuary bays become more shallow (less bay-shaped) over progressive scenarios.
- Present-day risk set to high as some erosion is already occurring. This shifts to extreme in 2130 because the estuaries become a more 'shallow bay' in shape, which will likely be less favourable habitat for fauna.

Flooding:

- Compare the area flooded in the present day with future flood scenarios and identify the increased area flooded.
- However, these systems are habituated to some degree of flooding (tidal after all).
- Present-day risk set to moderate as flooding is already occuring. This shifts to high in 2070 and extreme in 2130 due to the greater depth of flooding and the additional areas flooded.
- However, these additional areas may also convey some benefits in providing additional (temporary) habitat for fauna.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	H	H	H	E
Coastal Flooding	M	M	H	E

Notes:

- Waikanae Estuary is a very important area of coastal indigenous biodiversity and also links with the Kāpiti Island Marine Reserve. The range and rarity of the species and habitats that occur here make it an especially sensitive area.
- Species become used to where they can go to obtain food or hang out. The frequent the pertubations are, the more likely species will avoid an area. Additionally, habitat along the entire Kāpiti Coast will be affected by similar climatic changes, reducing althernative habitat for species.
- Hence sensitivity has been assessed to follow the same rank as the hazard assessment.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	VL	▪ Once the estuary has been eroded it will be very difficult to re-establish due to low coastal sand availability. Species will stop using an area if it has frequent perturbations or becomes unsuitable habitat.
Coastal Flooding	L	▪ Flooding can be a more temporary perturbation; however, an estuary provides relatively shallow habitat and flooding would increase the depth of the water. Once that happens it will be less suitable fauna habitat. Additional flooded areas may offset some of these effects.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	H	H	H	E	VL	E	E	E	E
Flooding	M	M	H	E	L	M	M	H	E

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	H	H	H	E	E	E	E	E	E	E	E	E
Risk from Flooding	M	M	H	E	M	M	H	E	M	M	H	E

A.4 Natural Character Risk Assessment Templates

A.4.1 CMA A. Innershelf and nearshore marine (Coastal Marine Area)

Note: This is included for Information only as this area falls outside the Adaption Area. Direct or indirect effects within the CMA on the natural character have not been identified or assessed.

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☒

Domain	Element at Risk	Overview
Natural Character	CMA A. Innershelf and nearshore marine: Coastal Marine Area	For the most part, the CMA adjoining Kāpiti is exposed to oceanic conditions. Nearshore inter-tidal and shallow sub-tidal rocky reefs are virtually absent, as are visible structures. The seafloor is predominantly sand which gradually slopes down and transitions to mud at a depth of approximately 35 meters, between approximately 3 and 5.5km offshore. The regional tidal range is up to approximately 2.0 m. Bedforms (e.g. sand ripples) are likely in the nearshore and innershelf from the prevailing ocean swells and currents. Ocean currents transport coastal waters southward around the South Taranaki Bight through to Cook Strait. Transport of oceanic and river-modified coastal water is routinely evident on the innershelf, inshore of Kāpiti Island. The broader inner shelf has received relatively limited commercial bottom-trawling effort, however parts of the shoreline are subjected to frequent shore-based recreational harvesting of shellfish, paddle crabs and shallow water fishes, particularly in summer months. Demersal fish species diversity is predicted to be average at a national scale. Through the CAA the wave shadow of Kāpiti Island is clearly apparent alongside the tapered form of the Cuspate Foreland. Several stormwater pipes extend into the MHWS along areas adjoining the Central Adaptation Area and MHWS springs coincides or comes close to seawalls and rock revetment in two areas. This area of coastal environment reflects a **moderate** level of natural character overall.

A.4.2 CTA2: Paraparaumu and Waikanae

Domain	Element at Risk	Overview
Natural Character	Part of CTA2: Waikanae and Paraparaumu: Coastal Terrestrial Area (NB: assessment of effects occurs within Central Adaptation Area)	**Coastal Terrestrial Area 2: Waikanae and Paraparaumu** extends south from Ngawhakangutu Reserve and encompasses the cuspate (tapering) foreland which extends outwards at Paraparaumu Beach and creates the sweeping form of Waikanae and Raumati Beaches. Due to adjoining residential settlements of Paraparaumu Beach and Waikanae Beach, the dune systems which comprise this coastal environment have largely been modified to accommodate housing and urban development. Nevertheless, the cuspate foreland and areas of natural duneland provide natural elements which remain apparent within this Coastal Terrestrial Area beyond which the coastal environment has typically been defined along a legible residential edge which reduces the significance of coastal processes, influences or qualities. The dunes which remain throughout the CAA vary in age. Peka Peka Beach is dominated by a mixture of Waitarere-Motuiti dunes. The Motuiti dunes contain a large amount of Taupo Pumice lapilli which is likely to have accumulated at the time of the Taupo eruption approximately 1,800 years ago. More recent dunes have resulted from accretion near the apex of the Cuspate Foreland. Historically, the Waikanae and Paraparaumu coastal terrestrial area would have been vegetated in native duneland and wetland species with lowland podocarp/broadleaf forest in dune slacks. Today little native vegetation remains because of extensive land use changes (farming and subsequently residential development). Dune vegetation is largely dominated by exotic marram grass and other exotic weed species with pockets of native vegetation retained and/or restored in some areas, including components of Waikanae Estuary and Peka Peka Dunes, both of which have been recognised as high natural character. Duneland adjoins the CMA along broad sandy beaches, with several stormwater pipes and built influences including nighttime lighting from adjoining settlement as well as vehicle activity, including enabling watercraft access to the CMA. The broader terrestrial coastal environment encompasses the most populated area in Kāpiti Coast's Coastal Environment and adjoining Coastal Context and is assessed as having **low-moderate** level of natural character overall within which components of high natural character have been identified encompassing parts of the Peka Peka Dunes which extends into the Northern Adaptation Area and much of Waikanae Estuary, described in more detail as separate elements below.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	In this area, coastal erosion impacts existing duneland areas and begins to extend inland into more modified areas of coastal settlement. Duneland impacted by erosion includes much of the Peka Peka and Waikanae Natural Duneland and parts of the more modified Paraparaumu Natural Duneland, particularly immediately south-west of Waikanae Estuary. Erosion also increases to the south of Paraparaumu Beach within an area subject to existing erosion protection as well as the inherently more dynamic mouths of Waimeha and Tikotu Streams and parts of the Waikanae Estuary. The proximity to existing settlement and impacts of built coastal protection and associated human induced changes has resulted in lower levels of existing natural character in this

Hazard	Description of Consequence (note any cascading impacts)
	terrestrial area. Existing modification also includes responses to existing coastal erosion in some areas, typically through the establishment of rock revetment and built elements which characterise and foreshorten adjoining beach areas. Such modification has potential to adversely impact natural elements, patterns and processes, including the formations of dunes and beaches and therefore reduce natural character.
Coastal Flooding	Outside of the existing river mouths and estuaries currently subjected to frequent inundation, relatively limited flooding occurs within the context of the current extent of the coastal environment. The existing coastal environment typically encompasses a more elevated sequence of duneland along which coastal development has been established and along which the inland extent of the coastal environment used to inform an assessment of natural character has been defined. Coastal flooding increasingly extends inland of the identified coastal environment, including more modified areas containing coastal settlement and consequently more limited levels of natural character. As the risk of coastal flooding increases, this increases the risk that the measures to address coastal flooding will further modify natural character as potential for more significant coastal elements, patterns and processes associated with coastal flooding extends inland.

Opportunities

Hazard	Opportunities
Coastal Erosion	Reinforce and restore native vegetation along riparian margins and within natural dunelands. Identify and maintain natural patterns and processes within areas impacted by natural hazards, including room to maintain dynamic dune areas. Ensure built development and modification is sympathetic to and supports underlying natural characteristics and qualities. Develop and utilise nature-based solutions which preserve and restore natural character.
Coastal Flooding	Reinforce indigenous margins and associated habitat opportunities at the mouths of streams, including to reduce or remedy slumping. Limit built influences which may otherwise impact the natural character along active streams, riverbeds and their margins. Identify opportunities to enhance and restore ecological connectivity between the coastal environment and its context / catchment. Develop and utilise nature-based solutions which restore natural character where possible.

A.4.2.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion: • Areas of beach berm and foredune along PekaPeka, Waikanae Beach and Pararparaumu natural dunelands • The mouths of Waimeha Stream, Waikanae River and, to a lesser extent, Tikotu Creek.	Future exposure: 2050: • Erosion is expected to impact the existing beach berm and foredunes along the Peka Peka Beach Natural Duneland (up to 10m) and Waikanae Beach Natural Duneland (up to 11m) within the increasing context of and modification associated with adjoining residential development which has reduced existing levels of natural character • Erosion of Paraparaumu Natural Duneland extends up to 26m the south of Waikanae Estuary but remains more limited near the apex of the Cuspate Foreland where part of the more modified existing duneland will remain relatively intact • Erosion to the south of Paraparaumu primarily occurs within the context of existing rock revetment adjoining mown grass and amenity planting along and encroaches into adjoining residential development with more limited existing levels of natural character • More substantial areas of erosion occur at the inherently more dynamic mouths of rivers and streams, as follows: o Waimeha Stream - 100m o Waikanae River - 60m o Tikotu Creek - 65m 2070: • There is slight increase in erosion of the Peka Peka Dunes and Waikanae Beach Natural Dunelands (~2m). • Further erosion (~12m) occurs within parts of the remaining Paraparaumu Natural Dunelands to the south of Waikanae Estuary such that some remaining areas of duneland are lost • Erosion remains more limited near the apex of the Cuspate Foreland where part of the existing duneland remains relatively intact • Erosion to the south of Paraparaumu Beach continues inland and north of existing rock revetment and settlement and into areas with more limited existing natural character • Minimal increased erosion at stream mouths. 2130: • Coastal erosion continues to impact natural duneland at Waikanae Beach (11m) such that parts of the remaining duneland are lost • Substantial coastal erosion continues inland of the Paraparaumu Natural Duneland to the south of Waikanae Estuary accommodating existing coastal settlement

Details of exposure	
	• Erosion remains more limited near the apex of the Cuspate Foreland where part of the existing duneland remains relatively intact • Erosion to the south of Paraparaumu Beach continues north of existing rock revetment and into areas of settlement with more limited existing natural character • Erosion to the south of Paraparaumu Beach continues inland and north of existing rock revetment with more limited existing natural character • More significant erosion occurs to the south of the Waikanae Estuary (up to 100 m)
Currently exposed to coastal flooding: • Parts of the coastal environment adjoining Waikanae Estuary and upstream areas including some lower lying tributaries and lagoons • Parts of the Waimeha Stream, including tributaries and lower lying areas inland of the Coastal Environment and primarily within Waikanae Golf Course	2050: • Within the coastal environment, coastal flooding primarily occurs in association with the lower lying and inherently more dynamic Waikanae Estuary and Waimeha Stream. • Coastal Inundation extends inland of the coastal environment including tributaries and lagoons surrounding Waikanae Estuary and inland from Waimeha Stream through the existing Waikanae Golf Course. 2070: • Some additional flooding occurs within the context of established coastal settlement beyond the identified coastal environment 2130: • Additional flooding occurs within the context of established coastal settlement beyond the identified coastal environment

Hazard	Present	2050	2070	2130
Coastal Erosion	M	H	E	E
Coastal Flooding	M	M	M	H

Note:

The exposure to natural hazard typically impacts more modified areas of the coastal environment and increasingly extends inland of the current delineation of this area. Notwithstanding this, the ability for this section of coastal environment to preserve natural character is increasingly impacted by the removal of remaining pockets of natural duneland and the more limited existing structures apparent along the coastal edge.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	H	H
Coastal Flooding	M	M	H	H

Notes:

Through the CAA, the hazards created by coastal erosion and inundation begin to increasingly impact more modified areas of coastal environment including areas of existing settlement which has resulted in a reduction in natural character. More often it is the resultant human response to coastal hazards that has the greatest sensitivity to natural character effects. Change to more modified elements, patterns and processes

may also provide opportunities to restore natural character and the trajectory of such change influences the sensitivity.

To preserve natural character, responses should seek to ensure that natural elements, patterns and processes will continue to operate through appropriate human intervention and management. As areas of higher natural character are exposed to more frequent and greater coastal hazards, sensitivity to ensuring appropriate responses will increase. Conversely, there may be opportunities to restore natural character where coastal hazards interact with element, patterns and processes which currently have lower levels of natural character.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	M	• Coastal erosion increasingly impacts more modified areas which contribute to lower existing levels of natural character • The ability for dunes to remain dynamic and migrate inland is limited by the proximity of adjoining coastal settlement at Waikanae Beach and Paraparaumu Beach. • The rate of accretion means there is more limited erosion occurring at the apex of the cuspate foreland.
Coastal Flooding	M	• Within the coastal environment, most coastal flooding occurs in the context of mouths of streams which it is assumed periodic inundation may be accommodated • Coastal flooding increasingly extends into back dunes and along swales beyond the costal environment. Such areas reflect limited existing levels of natural character resulting from increasing modification associated with coastal settlement.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	M	H	H	M	M	M	M	M
Flooding	M	M	H	H	M	M	M	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	M	H	E	E	M	M	M	M	M	M	H	H
Risk from Flooding	M	M	M	H	M	M	M	M	M	M	M	M

A.4.2.2 SSP5-8.5

Exposure

Details of exposure	
Currently exposed to coastal erosion: • Areas of beach berm and foredune along PekaPeka, Waikanae Beach and Pararparaumu natural dunelands • The mouths of Waimeha Stream, Waikanae River and, to a lesser extent, Tikotu Creek.	Future exposure: 2050: • Erosion is expected to impact the existing beach berm and foredunes along the Peka Peka Beach Natural Duneland (up to 10m) and Waikanae Beach Natural Duneland (up to 11m) within the increasing context of existing modification associated with adjoining residential development and the associated reduction in natural character • Erosion of Paraparaumu Natural Duneland extends up to 26m the south of Waikanae Estuary but remains more limited near the apex of the Cuspate Foreland where part of the more modified existing duneland remains relatively intact • Erosion to the south of Paraparaumu primarily occurs within the context of existing rock revetment with more limited existing natural character and extends into adjoining residential development • More substantial areas of erosion occur at the inherently more dynamic mouths of rivers and streams, as follows: o Waimeha Stream - 100m o Waikanae River - 60m o Tikotu Creek - 65m 2070: • There is an increase in erosion of the Peka Peka Dunes and Waikanae Beach Natural Dunelands (up to 10m). In places this results in the almost complete removal of existing dunes. • There is a further increase in erosion along parts of the Paraparaumu Natural Dunelands (16m) to the south of Waikanae Estuary such that part of the remaining areas of duneland are lost • The extent of dunelands at the apex of the Cuspate Foreland remain relatively stable and contribute to part of the existing overall low-moderate natural character. • Erosion to the south of Paraparaumu Beach continues in the context of existing rock revetment adjoining Marine Parade with more limited existing natural character • Minimal increased erosion at stream mouths. 2130: • Substantial coastal erosion impact natural duneland at Peka Peka and along Waikanae Beach such that it encroaches on adjoining residential development and parts of the remaining duneland are lost • Substantial coastal erosion continues within the Waikanae Estuary (up to 100 m) and along Paraparaumu Duneland to the south of Waikanae Estuary including inland of the existing duneland extent • Erosion to the south of Paraparaumu Beach continues in the context of existing rock revetment adjoining Marine Parade with more limited existing natural character

Details of exposure

Currently exposed to coastal flooding:

- Parts of the coastal environment adjoining Waikanae Estuary and upstream areas including some lower lying tributaries and lagoons
- Parts of the Waimeha Stream, including tributaries and lower lying areas inland of the Coastal Environment and primarily within Waikanae Golf Course

2050:

- Within the coastal environment, coastal flooding primarily occurs in association with the lower lying and inherently more dynamic Waikanae Estuary and Waimeha Stream.
- Coastal Inundation extends inland of the coastal environment including tributaries and lagoons surrounding Waikanae Estuary and inland from Waimeha Stream through the existing Waikanae Golf Course.

2070:

- Coastal flooding remains limited within the context of the current coastal environment.
- Flooding extends inland of the identified coastal environment and generally occurs within the context of established coastal settlement, particularly adjoining the lagoons surrounding Waikanae Estuary and inland from Waimeha Stream through the existing Waikanae Golf Course.

2130:

- Additional flooding becomes more extensive inland of the current coastal environment and has potential to increase the presence of natural patterns and processes which influence natural character within the inland extent of the coastal environment.

Hazard	Present	2050	2070	2130
Coastal Erosion	M	H	E	E
Coastal Flooding	M	M	M	H

Note:

The exposure to natural hazard typically impacts more modified areas of the coastal environment and increasingly extends inland of the current coastal environment as defined. Notwithstanding this, the ability for this section of coastal environment to preserve natural character is increasingly impacted by the removal of remaining pockets of natural duneland and the more limited existing structures apparent along the coastal edge.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	H	H
Coastal Flooding	M	M	H	H

Notes:

Through the CAA, the hazards created by coastal erosion and inundation begin to increasingly impact more modified areas of coastal environment including areas of existing settlement which has resulted in a reduction in natural character. More often it is the resultant human response to coastal hazards that has the greatest sensitivity to natural character effects. Change to more modified elements, patterns and processes may also provide opportunities to restore natural character and the trajectory of such change influences the sensitivity.

To preserve natural character, responses should seek to ensure that natural elements, patterns and processes will continue to operate through appropriate human intervention and management. As areas of higher natural character are exposed to more frequent and greater coastal hazards, sensitivity to ensuring appropriate responses will increase. Conversely, there may be opportunities to restore natural character where coastal hazards interact with element, patterns and processes which currently have lower levels of natural character.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	M	• Coastal erosion increasingly impacts more modified areas which contribute to lower existing levels of natural character. • The ability for dunes to remain dynamic and migrate inland is limited by the proximity of adjoining coastal settlement at Waikanae Beach and Paraparaumu Beach.
Coastal Flooding	M	• Within the coastal environment, most coastal flooding occurs in the context of mouths of streams which it is assumed periodic inundation may be accommodated. • Coastal flooding increasingly extends into modified back dunes and along tributaries beyond the current coastal environment as defined. Such areas reflect limited existing levels of natural character resulting from increasing modification associated with coastal settlement.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	M	H	H	M	M	M	M	M
Flooding	M	M	M	H	M	M	M	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	M	H	E	E	M	M	M	M	M	M	H	H
Risk from Flooding	M	M	M	H	M	M	M	M	M	M	M	M

A.4.3 Peka Peka Dunes (South)

Domain	Element at Risk	Overview
Natural Character	Peka Peka Dunes (South)	A component of high natural character is recognised along part of the southern Peka Peka Dunes. This predominantly encompass Pharazyn Reserve within the CAA. Recorded characteristics are (Boffa Miskell, 2024): • *Largely intact coastal dunes containing Taupo Pumice lapilli* • *Native vegetation cover reduced but present* • *Peka Peka beach provides opportunities for swimming, walking, blow-carting, boating, and surfing in a relatively open and undeveloped context* • *Expansive views of Kāpiti Island and the Rauoterangi Channel*

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Coastal erosion will primarily impact areas of beach berm and foredune within Pharazyn Reserve. Formed by a mixture of Waitarere-Motuiti dunes, these contain a large amount of Taupo Pumice lapilli and support populations of native duneland vegetation including spinifex and pingao amongst a broader area of dunes comprising some re-established native dune species interspersed with colonizing exotic grasses and scrub. Cascading impacts may include increased built coastal protection and associated human induced changes in response to coastal erosion which has potential to impact natural elements, patterns and processes and resultant levels of natural character.
Coastal Flooding	Coastal flooding typically introduces impacts within existing ponds and dune swales in Pharazyn Reserve with more limited natural character impacts in these dynamic coastal elements in this context. As risks of coastal flooding increases this extends beyond the existing coastal environment which encompasses Pharazyn Reserve. Cascading impacts which result in the introduction of increasing structures and modification in responses to flood hazard and potential construction of built flood defences has potential to reduce natural character.

Opportunities

Hazard	Opportunities
Coastal Erosion	Reinforce and restore native vegetation along dunes planting. Maintain natural patterns and processes within areas impacted by natural hazards, including space to maintain dynamic dune areas. Ensure built development and modification is sympathetic to and supports underlying natural characteristics and qualities. Develop and utilise nature-based solutions which preserve and restore natural character.
Coastal Flooding	Reinforce indigenous margins and associated habitat opportunities to support and define areas of increased coastal inundation. Limit and remove built influences which may otherwise impact the natural character along active streams, riverbeds and their margins.

Hazard	Opportunities
	Identify opportunities to enhance and restore ecological connectivity between the coastal environment and its context / catchment.

A.4.3.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion: • Areas of beach berm and foredune at Peka Peka Beach adjoining Pharazyn Reserve.	Future exposure: 2050: • Erosion is expected to impact the existing beach berm and foredunes by up to 14m, broadly consistent with the existing situation. 2070: • There is a very slight increase in erosion of predominantly foredunes (2m). 2130: • Erosion continues to impact areas of dune land (up to 12m). Within the CAA this remains within the context of Pharazyn Reserve.
Currently exposed to coastal flooding: • Parts of the existing beach berm and foredune and within the context of the inherently more dynamic mouth of Te Kowhai Stream.	Future exposure: 2050: • A slight increase in coastal flooding occurs within dune slacks forming ponds in Pharazyn Reserve and comprising inherently more dynamic areas of the costal environment. 2070: • A slight increase in coastal flooding occurs within dune slacks forming ponds in Pharazyn Reserve and comprising inherently more dynamic areas of the costal environment. 2130: • A further slight increase in flooding occurs within the existing dune slacks forming ponds in Pharazyn Reserve. • More substantial additional flooding occurs beyond dunes which retain high natural character, including in close proximity of adjoining settlement.

Hazard	Present	2050	2070	2130
Coastal Erosion	M	M	M	M
Coastal Flooding	M	M	M	M

Note:

The Peka Peka Dunes High Natural Character only encompasses Pharazyn Reserve within the Central Adaptation Area.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	M	M
Coastal Flooding	M	M	M	M

Notes:

The hazards created by coastal erosion and inundation also express natural processes which will continue to shape the characteristics and qualities of the coastal environment and therefore contribute to natural character. Such processes are not therefore sensitive to natural hazards per se. More often it is the human response to coastal hazards that sensitivity to natural character occurs. To preserve natural character, responses should ensure that natural elements, patterns and processes will continue to operate through appropriate human intervention and management. As a larger area of dynamic duneland, Pharazyn Reserve expresses inherently less sensitivity in this context, with the ability for dunes to migrate inland.

The trajectory of change is an important aspect to consider when assessing sensitivity, i.e. whether natural character is decreasing or increasing as a result of broader changes in land management practices which encompass the characteristics and qualities of the broader coastal environment.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	H	• The beach berm and foredune form a dynamic edge adjoining a wider established dune sequence with greater potential adaptive capacity in the context of Pharazyn Reserve.
Coastal Flooding	M	• Most coastal flooding occurs in the context of dynamic aspects of foredunes. • Flooding extends beyond areas of less modified duneland and areas which often reduce natural character within the coastal environment.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	M	M	M	H	L	L	L	L
Flooding	M	M	M	M	M	M	M	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	M	M	M	M	L	L	L	L	L	L	L	L
Risk from Flooding	M	M	M	M	M	M	M	M	M	M	M	M

A.4.3.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion: • Areas of beach berm and foredune at Peka Peka Beach adjoining Pharazyn Reserve.	Future exposure: 2050: • Erosion is expected to impact the existing beach berm and foredunes by up to 14m. 2070: • There is a slight increase in erosion of predominantly foredunes (7m). 2130: • Erosion continues to impact areas of dune land (up to 35m). Within the CAA this remains within the context of Pharazyn Reserve.
Currently exposed to coastal flooding: • Parts of the existing beach berm and foredune and within the context of the inherently more dynamic mouth of Te Kowhai Stream.	Future exposure: 2050: • A slight increase in coastal flooding occurs within dune slacks forming ponds in Pharazyn Reserve and comprising inherently more dynamic areas of the costal environment. 2070: • A slight increase in coastal flooding occurs within dune slacks forming ponds in Pharazyn Reserve and comprising inherently more dynamic areas of the costal environment. 2130: • A further slight increase in flooding occurs within the existing dune slacks forming ponds in Pharazyn Reserve. • More substantial additional flooding occurs beyond dunes which retain high natural character, including in close proximity of adjoining settlement and encompassing the existing Oxidation Ponds.

Hazard	Present	2050	2070	2130
Coastal Erosion	M	M	M	M
Coastal Flooding	M	M	M	H

Note:

The Peka Peka Dunes High Natural Character encompasses Pharazyn Reserve within the Central Adaptation Area, with the balance of high natural character extending north into the Northern Adaption Area.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	M	M
Coastal Flooding	M	M	M	H

Notes:

The hazards created by coastal erosion and inundation also express natural processes which will continue to shape the characteristics and qualities of the coastal environment and therefore contribute to natural character. Such processes are not therefore sensitive to natural hazards per se. More often it is the human response to coastal hazards that sensitivity to natural character occurs. To preserve natural character, responses should ensure that natural elements, patterns and processes will continue to operate through appropriate human intervention and management. As a larger area of dynamic duneland, Pharazyn Reserve expresses inherently less sensitivity in this context, with the ability for dunes to migrate inland.

The trajectory of change is an important aspect to consider when assessing sensitivity, i.e. whether natural character is decreasing or increasing as a result of broader changes in land management practices which encompass the characteristics and qualities of the broader coastal environment. As flooding encompassing the Oxidation Ponds, the sensitivity of the adjoining dunes in Pharazyn Reserve is expected to increase

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	H	• The beach berm and foredune form a dynamic edge adjoining a wider established dune sequence with greater potential adaptive capacity in the context of Pharazyn Reserve.
Coastal Flooding	M	• Most coastal flooding occurs in the context of dynamic aspects of foredunes. • Some flooding begins to extend into back dune areas and coastal development including the Oxidation Ponds and therefore more limited adaption capacity.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	M	M	M	H	L	L	L	L
Flooding	M	M	M	H	M	M	M	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	M	M	M	M	L	L	L	L	L	L	L	L
Risk from Flooding	M	M	M	H	M	M	M	M	M	M	M	M

A.4.4 Waikanae Estuary

Domain	Element at Risk	Overview
Natural Character	Waikanae Estuary	The Waikanae Estuary as been recognised as a component of high natural character along the Kāpiti Coast. The following characteristics and qualities have been explicitly identified (Boffa Miskell, 2024): • *Mouth of the estuary contains a dynamic sandspit associated with cuspate foreland* • *Sustains a representative native freshwater fishery* • *There remains a functional intertidal foraging, breeding and/or high tide roost for a high diversity of coastal and seabird species* • *Opportunities for walking and birdwatching in a relatively unbuilt and dynamic coastal environment*

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	As an estuary, the dynamic nature of this aspect of the coastal environment remains inherently susceptible to ongoing coastal erosion. An expansion of erosion within the estuary will modify some existing coastal vegetation and associated habitats which also maintain a natural buffer and separates the estuary from adjoining built elements including residential development. The lack of obvious built influences within the estuary contrasts with its surrounding urban context and contributes to its high natural character. The introduction of built coastal protection in response to coastal erosion has potential to adversely impact natural elements, patterns and processes and therefore reduce natural character.
Coastal Flooding	An inherent quality of the estuary is exposure to inundation. Sea level rise may also have implications on intertidal habitats and water depth including loss of opportunities for existing natural elements and process which rely on exposed sand banks during low tides. Changes in salinity, sedimentation and introduction of pest species may also increase the apparent level of modification and has potential to reduce natural character. Coastal flooding extends inland of the existing coastal environment and impacts the margins of the Waikanae River and tributaries which extend inland of the Waikanae Estuary. The responses to flood hazard and potential construction of flood defences with increased presence of built form also has potential to reduce natural character.

Opportunities

Hazard	Opportunities
Coastal Erosion	Recognise and maintain the inherently dynamic nature of the estuary and sandspit. Maintain natural patterns and processes within areas impacted by inundation, including intertidal areas and associated lagoon areas. Support restoration of coastal habitats and biodiversity through which further inland areas accommodate dynamic elements, patterns and processes. Ensure built development and modification is sympathetic to and supports underlying natural characteristics and qualities. Develop and utilise nature-based solutions which preserve and restore natural character.

Hazard	Opportunities
Coastal Flooding	Support connectivity between the coast and inland areas becoming increasingly susceptible to coastal flooding. Maintain natural patterns and processes within areas impacted by inundation, including intertidal areas and associated lagoon areas. Extend coastal habitat which supports dynamic coastal processes including saline inundation. Develop and utilise nature-based solutions which restore natural character where possible.

A.4.4.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion: • The existing estuary remains relatively dynamic including mobile coastal elements including the existing sandspit at the mouth of the Waikanae Estuary	Future exposure: 2050: • The estuary and sandspit is expected to remain inherently dynamic including periodic erosion. • There is an increase in erosion to the south of the estuary up to approximately 70 meters adjoining more elevated residential development along elevated land along Taranui Way. 2070: • There is limited additional erosion (~5m) to the south of the estuary in the context of the existing dynamic nature of the estuary 2130: • Erosion continues to impact areas of the estuary and approximately 100 metres to the south-west in the vicinity of Manly Street.
Currently exposed to coastal flooding: • As an estuary, this area of high natural character is inherently exposed to coastal flooding which will continue. • Coastal flooding is largely contained within the current coastal environment and beyond the area of high natural character recognised within the estuary.	Future exposure: 2050: • The estuary will remain inherently subjected to inundation which will have direct impacts on natural elements and processes which contribute to its existing high natural character. • A slight increase in coastal flooding occurs within the coastal environment and begins to extend beyond the coastal environment along adjoining tributaries and lagoons. 2070: • A further slight increase in coastal flooding occurs within and beyond the coastal environment currently containing the estuary, typically along adjoining tributaries and lagoons and into more some more modified urban areas. 2130: • A further increase in coastal flooding occurs within and beyond the coastal environment currently containing adjoining tributaries and lagoons and into more modified urban areas.

Hazard	Present	2050	2070	2130
Coastal Erosion	M	M	M	H
Coastal Flooding	H	E	E	E

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	M	H

	Present	2050	2070	2130
Coastal Flooding	M	M	H	H

Notes:

- As a dynamic estuary, natural elements and patterns express natural character through the continued operation of natural processes which may encompass times of flooding and erosion.
- The trajectory of change will be an important aspect to consider when assessing longer term sensitivity. As the estuary is subjected more frequent coastal erosion in the future, its sensitivity is likely to increase as a natural character is decreasing or increasing as a result of changes in land management practices.
- The proximity between the estuary and adjoining residential development as expected to increase the sensitivity of the estuary in terms of ensuring responses support existing natural elements, patterns and processes.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	M	Coastal erosion will continue to incur in a dynamic coastal environment The ability for erosion to continue inland is restricted by the proximity of adjoining development
Coastal Flooding	M	The processes of the estuary will remain subjected to coastal inundation and remain inherently dynamic. The ability for inundation to continue inland becomes increasingly restricted by the proximity of adjoining development

Notes:

- The natural adaptive capacity of natural character within an area can be impacted by the availability of space within which natural elements, patterns and processes can operate.
- Increased built modification may reduce natural character and therefore restrict any adaptive natural character capacity.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	M	M	H	M	M	M	M	M
Flooding	M	M	H	H	M	M	M	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130

	Exposure				Vulnerability				Risk			
Risk from Erosion	M	M	M	H	M	M	M	M	M	M	M	M
Risk from Flooding	H	E	E	E	M	M	M	M	M	H	H	H

A.4.4.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion: • The existing estuary remains relatively dynamic including mobile coastal elements including the existing sandspit at the mouth of the Waikanae Estuary	Future exposure: 2050: • The estuary and sandspit is expected to remain inherently dynamic including periodic erosion. • There is an increase in erosion to the south of the estuary up to approximately 70 meters in the vicinity of residential development along elevated land along Taranui Way. 2070: • There is limited additional erosion (~8m) to the south of the estuary in the context of the existing dynamic nature of the estuary. 2130: • Erosion continues to impact areas of the estuary and approximately 100 metres to the south-west in the vicinity of Manly Street.
Currently exposed to coastal flooding: • As an estuary, this area of high natural character is inherently exposed to coastal flooding which will continue. • Coastal flooding is largely contained within the current coastal environment and beyond the area of high natural character recognised within the estuary.	Future exposure: 2050: • The estuary will remain inherently subjected to inundation which will have direct impacts on natural elements and processes which contribute to its existing high natural character. • A slight increase in coastal flooding occurs within the coastal environment and begins to extend beyond the coastal environment along adjoining tributaries and lagoons. 2070: • A further slight increase in coastal flooding occurs within and beyond the coastal environment currently containing the estuary, typically along adjoining tributaries and lagoons. 2130: • A more substantial increase in coastal flooding occurs within and beyond the coastal environment currently containing adjoining tributaries and lagoons and into more modified urban areas.

Hazard	Present	2050	2070	2130
Coastal Erosion	M	M	M	H
Coastal Flooding	H	E	E	E

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	M	H
Coastal Flooding	M	M	H	H

Notes:

- As a dynamic estuary, natural elements and patterns express natural character through the continued operation of natural processes which may encompass times of flooding and erosion.
- The trajectory of change will be an important aspect to consider when assessing longer term sensitivity. As the estuary is subjected more frequent coastal erosion in the future, its sensitivity is likely to increase as a natural character is decreasing or increasing as a result of changes in land management practices.
- The proximity between the estuary and adjoining residential development as expected to increase the sensitivity of the estuary in terms of ensuring responses support existing natural elements, patterns and processes.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	M	Coastal erosion will continue to incur in a dynamic coastal environment The ability for erosion to continue inland is restricted by the proximity of adjoining development
Coastal Flooding	M	The processes of the estuary will remain subjected to coastal inundation and remain inherently dynamic. The ability for inundation to continue inland becomes increasingly restricted by the proximity of adjoining development

Notes:

- The natural adaptive capacity of natural character within an area can be impacted by the availability of space within which natural elements, patterns and processes can operate.
- Increased built modification may reduce natural character and therefore restrict any adaptive natural character capacity.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	M	M	H	M	M	M	M	M
Flooding	M	M	H	H	M	M	M	M	M

Overall Risk Score

	Exposure				Vulnerability				Risk			
	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130
Risk from Erosion	M	M	M	H	M	M	M	M	M	M	M	M

	Exposure				Vulnerability					Risk		
Risk from Flooding	H	E	E	E	M	M	M	M	M	H	H	H

A.5 Cultural Risk Assessment Templates

A risk assessment for the Cultural domain in relation to coastal hazard is still to be undertaken with Mana Whenua, and will be added to this document prior to being finalised.

Appendix B Complete Risk Matrices

Element	Coastal Erosion Hazard																											
	SSP2-4.5																SSP5-8.5											
	Exposure				Sensitivity				Adaptive Capacity	Vulnerability				Risk			Exposure				Sensitivity				Adaptive Capacity	Vulnerability				Risk		
	Present	2050	2070	2130	Present	2050	2070	2130		Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130		Present	2050	2070	2130	Present	2050	2070	2130
Built Environment																																
Properties	L	L	L	L	L	E	E	E	L	L	E	E	E	L	M	M	M	L	L	L	L	L	E	E	E	L	L	E	E	E	L	M	M	M
Properties (Waikanae)	L	L	L	L	L	E	E	E	L	L	E	E	E	L	M	M	M	L	L	L	H	L	E	E	E	L	L	E	E	E	L	M	M	E
Properties (Otaihanga)	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Properties (Paraparaumu)	L	L	L	L	L	H	E	E	L	L	H	E	E	L	L	M	M	L	L	L	M	L	H	E	E	L	L	H	E	E	L	L	M	H
Water Supply Infrastructure	L	L	L	L	L	H	H	H	L	L	H	H	H	L	L	L	L	L	L	L	L	L	H	H	E	L	L	H	H	E	L	L	L	M
Wastewater Infrastructure	L	L	L	L	E	E	E	E	L	E	E	E	E	M	M	M	M	L	L	L	L	E	E	E	E	L	E	E	E	E	M	M	M	M
Stormwater Infrastructure	L	L	M	M	M	M	M	H	L	M	M	M	H	L	L	M	M	L	L	M	H	M	M	M	H	L	M	M	M	H	L	L	M	H
Roads and Bridges	L	L	L	L	M	H	H	H	L	M	H	H	H	L	L	L	L	L	L	L	L	M	H	H	E	L	M	H	H	E	L	L	L	M
Electrical transmission and supply infrastructure	L	L	L	L	L	E	E	E	L	L	E	E	E	L	M	M	M	L	L	L	L	L	E	E	E	L	L	E	E	E	L	M	M	M
Natural gas supply mains	L	L	L	L	L	E	E	E	L	L	E	E	E	L	M	M	M	L	L	L	L	L	E	E	E	L	L	E	E	E	L	M	M	M
Ecological																																
Coastal Dunelands	M	M	M	M	M	H	H	H	L	M	H	H	H	M	M	M	M	M	M	H	H	M	H	H	E	L	M	H	H	E	M	M	H	E
Wetlands	L	M	M	H	L	M	M	H	L	L	M	M	H	L	M	M	H	L	M	H	H	L	M	H	H	L	L	M	H	H	L	M	H	H
Mapped Ecological Sites	L	M	H	H	L	M	H	E	VL	M	H	E	E	L	M	E	E	L	M	H	H	L	M	H	E	VL	M	H	E	E	L	M	E	E
Indigenous Trees	No Exposure																No Exposure															
Rare and threatened species	M	M	H	H	M	H	H	E	L	M	H	H	E	M	M	H	E	M	M	H	E	M	M	H	E	L	M	M	H	E	M	M	H	E
Bird Habitat	M	M	H	E	M	M	H	E	L	M	M	H	E	M	M	H	E	M	M	E	E	M	M	E	E	L	M	M	E	E	M	M	E	E
Fish Habitat	M	M	M	H	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	H	M	M	M	M	M	M	M	M	M	M	M	M	M
Coastal indigenous biodiversity	H	H	H	E	H	H	H	E	VL	E	E	E	E	E	E	E	E	H	H	H	E	H	H	H	E	VL	E	E	E	E	E	E	E	E
Human																																
Human health	L	L	L	L	M	M	M	M	M	M	M	M	M	L	L	L	L	L	L	L	L	M	M	M	M	M	M	M	M	M	L	L	L	L
Mental health and identity	L	L	M	M	H	H	H	H	L	H	H	H	H	L	L	M	M	L	L	M	M	H	H	H	H	L	H	H	H	H	L	L	M	M
Conflict, disruption and loss of trust in government	L	L	L	L	M	H	H	H	M	M	M	M	M	L	L	L	L	L	L	L	M	M	H	H	E	M	M	M	M	H	L	L	L	M

	Coastal Erosion Hazard																											
	SSP2-4.5																SSP5-8.5											
	Exposure				Sensitivity				Adaptive Capacity	Vulnerability				Risk				Exposure				Sensitivity				Adaptive Capacity	Vulnerability				Risk			
Element	Present	2050	2070	2130	Present	2050	2070	2130		Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130		Present	2050	2070	2130	Present	2050	2070	2130
Exacerbating inequities	L	L	L	M	H	H	H	H	L	H	H	H	H	L	L	L	M	L	L	L	M	H	H	H	H	L	H	H	H	H	L	L	L	M
Community cohesion and social wellbeing	L	L	L	L	M	H	H	H	L	M	H	H	H	L	L	L	L	L	L	L	M	M	H	H	H	L	M	H	H	H	L	L	L	M
Social infrastructure and amenity	L	L	L	L	H	H	H	H	M	M	M	M	M	L	L	L	L	L	L	L	L	H	H	H	H	M	M	M	M	M	L	L	L	L
Natural Character																																		
CTA2: Paraparaumu and Waikanae	M	H	E	E	M	M	H	H	M	M	M	M	M	M	M	H	H	M	H	E	E	M	M	H	H	M	M	M	M	M	M	M	H	H
Peka Peka Dunes (South) - High Natural Character	M	M	M	M	M	M	M	M	H	L	L	L	L	L	L	L	L	M	M	M	M	M	M	M	M	H	L	L	L	L	L	L	L	L
Waikanae Estuary - High Natural Character	M	M	M	H	M	M	M	H	M	M	M	M	M	M	M	M	M	M	M	M	H	M	M	M	H	M	M	M	M	M	M	M	M	M
Cultural																																		
A risk assessment for the Cultural domain in relation to coastal hazard is still to be undertaken with Mana Whenua, and will be added to this document prior to being finalised.																																		

	Coastal Flood Hazard																													
	SSP2-4.5																SSP5-8.5													
	Exposure				Sensitivity				Adaptive Capacity	Vulnerability				Risk				Exposure				Sensitivity				Adaptive Capacity	Vulnerability				Risk			
Element	Present	2050	2070	2130	Present	2050	2070	2130		Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130		Present	2050	2070	2130	Present	2050	2070	2130
Built Environment																																	
Properties	L	L	L	L	M	M	H	H	L	M	M	H	H	L	L	L	L	L	L	L	M	M	M	H	H	L	M	M	H	H	L	L	L	M
Properties (Waikanae)	L	L	L	M	M	M	M	M	L	M	M	M	M	L	L	L	M	L	L	L	M	M	M	M	H	L	M	M	M	H	L	L	L	M
Properties (Otaihanga)	L	M	M	M	M	H	H	H	L	M	H	H	H	L	M	M	M	L	M	M	H	M	H	H	E	L	M	H	H	E	L	M	M	E
Properties (Paraparaumu)	L	L	L	L	L	M	M	H	L	L	M	M	H	L	L	L	L	L	L	L	M	L	M	M	H	L	L	M	M	H	L	L	L	M
Water Supply Infrastructure	L	L	L	L	L	L	L	M	M	L	L	L	M	L	L	L	L	L	L	L	M	L	L	L	H	M	L	L	L	M	L	L	L	M
Wastewater Infrastructure	L	L	L	M	L	L	L	M	M	L	L	L	M	L	L	L	M	L	L	L	M	L	L	L	H	M	L	L	L	M	L	L	L	M
Stormwater Infrastructure	L	L	M	H	L	L	M	H	M	L	L	M	M	L	L	M	M	L	L	M	H	L	L	H	H	M	L	L	M	M	L	L	M	M
Roads and Bridges	L	M	M	H	L	H	H	E	L	L	H	H	E	L	M	M	E	L	M	M	E	L	H	E	E	L	L	H	E	E	L	M	H	E
Electrical transmission and supply infrastructure	L	L	L	M	L	L	L	H	M	L	L	L	M	L	L	L	M	L	L	L	M	L	L	H	H	M	L	L	M	M	L	L	L	M
Natural gas supply mains	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Ecological																																	
Coastal Dunelands	L	L	L	M	L	L	L	M	M	L	L	L	M	L	L	L	M	L	L	L	M	L	L	L	M	M	L	L	L	M	L	L	L	M
Wetlands	M	M	H	H	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	H	H	M	M	M	H	L	M	M	M	H	M	M	M	H
Mapped Ecological Sites	M	H	H	E	M	M	H	H	L	M	M	H	H	M	M	H	E	M	H	H	E	M	M	H	E	L	M	M	H	E	M	M	H	E
Indigenous Trees	L	L	M	M	L	L	M	M	L	L	L	M	M	L	L	M	M	L	L	M	H	L	L	M	H	L	L	L	M	H	L	L	M	H
Rare and threatened species	M	H	H	E	M	H	H	E	L	M	H	H	E	M	H	H	E	M	H	H	E	M	H	H	E	L	M	H	H	E	M	H	H	E
Bird Habitat	H	H	E	E	H	H	E	E	VL	E	E	E	E	E	E	E	E	H	H	E	E	H	H	E	E	VL	E	E	E	E	E	E	E	E
Fish Habitat	H	E	E	E	M	M	M	M	M	M	M	M	M	M	H	H	H	H	E	E	E	M	M	M	M	M	M	M	M	M	M	H	H	H
Coastal indigenous biodiversity	M	M	H	E	M	M	H	E	L	M	M	H	E	M	M	H	E	M	M	H	E	M	M	H	E	VL	M	M	H	E	M	M	H	E
Human																																	
Human health	L	M	M	H	H	H	H	H	M	M	M	M	M	L	M	M	M	L	M	M	H	H	H	H	H	M	M	M	M	M	L	M	M	M
Mental health and identity	L	M	M	H	H	H	H	H	M	M	M	M	M	L	M	M	M	M	M	H	H	H	H	H	H	M	M	M	M	M	M	M	M	M
Conflict, disruption and loss of trust in government	L	L	M	H	M	H	H	E	M	M	M	M	H	L	L	M	H	L	L	M	H	M	H	H	E	M	M	M	M	H	L	L	M	H
Exacerbating inequities	L	L	M	H	H	H	H	H	L	H	H	H	H	L	L	M	H	L	L	M	E	H	H	H	H	L	H	H	H	H	L	L	M	E

	Coastal Flood Hazard																											
	SSP2-4.5																SSP5-8.5											
	Exposure				Sensitivity				Adaptive Capacity	Vulnerability				Risk				Exposure				Sensitivity				Adaptive Capacity	Vulnerability				Risk			
Element	Present	2050	2070	2130	Present	2050	2070	2130		Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130	Present	2050	2070	2130		Present	2050	2070	2130	Present	2050	2070	2130
Community cohesion and social wellbeing	M	M	H	H	M	H	H	H	L	M	H	H	H	M	M	H	H	M	M	H	E	M	H	H	H	L	M	H	H	H	M	M	H	E
Social infrastructure and amenity	M	M	M	H	H	H	H	H	M	M	M	M	M	M	M	M	M	M	M	M	H	H	H	H	H	M	M	M	M	M	M	M	M	M
Natural Character																																		
CTA2: Paraparaumu and Waikanae	M	M	M	H	M	M	H	H	M	M	M	M	M	M	M	M	M	M	M	M	H	M	M	H	H	M	M	M	M	M	M	M	M	M
Peka Peka Dunes (South) - High Natural Character	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	H	M	M	M	H	M	M	M	M	M	M	M	M	M
Waikanae Estuary - High Natural Character	H	E	E	E	M	M	H	H	M	M	M	M	M	M	H	H	H	H	E	E	E	M	M	H	H	M	M	M	M	M	M	H	H	H
Cultural																																		
A risk assessment for the Cultural domain in relation to coastal hazard is still to be undertaken with Mana Whenua, and will be added to this document prior to being finalised.																																		