Paekākāriki Adaptation Area Risk Assessment

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Kāpiti Coast District Council

Takutai Kāpiti
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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 **Paekākāriki Adaptation Area (PAA)** from projected coastal hazards over the next 100 years (i.e. to 2130) if no future adaptation is undertaken. In the PAA, this assumes that in the future, once current protection structures fail, they are not replaced, and natural shoreline erosion will occur. 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, Central and Raumati 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).

With the PAA, the risks from coastal erosion across all domains are higher than the risks from coastal inundation over both SLR scenarios out to 2130 as a result in the difference in exposure across the two hazards. The PAA is potentially very exposed to coastal erosion hazards at present and through to 2130. This is a result of this area having a low sediment supply as alongshore sediment transport into the district from the north is deposited updrift of Paekākāriki around the Paraparaumu headland in the wave-shadow of Kapiti Island. As a result of this higher exposure in the past, and lack of ability for the shoreline to recover post-storm, the shoreline throughout Paekākāriki consists largely of seawalls to provide protection. Conversely, the land elevations in Paekākāriki are generally above the future storm tide levels, and future coastal flooding is confined to the low-lying areas around the Wainui and Waikākāriki Streams.

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 PAA communities, such as transport (roads), three waters, and electrical supply. It also includes private properties, for which these services are built and maintained to service.

- The highest risks to coastal erosion within the built domain are to beachfront properties, which in an extreme storm at present would be considered high risk, increasing to extreme risk by 2070 under both assessed SLR scenarios. However, when considering erosion risk to private properties across the whole adaptation area, the risk is moderate, and increases to high only in the SSP5-8.5 2130 SLR scenario.

- The risks ratings for coastal erosion to infrastructure (e.g. roads, bridges, three waters etc) is largely driven by an assessment of impacts of service to the entire PAA. Higher risk ratings were applied when erosion could impact the supply of these services to a broader network of properties that were not directly impacted by erosion itself. In most cases, the infrastructure will be impacted at a similar timeframe as the direct impacts to private properties that the infrastructure is servicing (e.g. roads, water supply) – hence, while there is a high exposure of some infrastructure to future coastal erosion, these services may no

longer be required if the existing dwellings are no longer present.

- Water supply infrastructure is considered to become high risk to coastal erosion by 2070 across both SLR scenarios; and roads and bridges are considered to become high risk by 2130. Electrical transmission and supply infrastructure is also anticipated to become high risk by 2130, but only under the higher SSP5-8.5 SLR scenario.

- Storm water infrastructure is considered to be low risk from coastal erosion across all timeframes and scenarios assessed. There is no public wastewater infrastructure or natural gas supply infrastructure located within the PAA, and therefore these elements have not been assessed.

- As a result of the relatively low exposure of the built environment to coastal inundation within the PAA due to the high land elevations, the risk is considered to be low for all elements across both SLR scenarios and all timeframes.

Human Domain

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

- The risks to the human domain elements are heavily tied to the risks to both private property (and therefore people's homes), and water supply infrastructure from the built domains. Over the next 30 years, risks to all human domain elements from coastal erosion are considered to be low to moderate.

- Under the lower SSP2-4.5 scenario, the risks of conflict, disruption and loss of trust in government increases to high by 2130 as a result of the increase in exposure of properties to coastal erosion over this timeframe. It is probable that those residents of beachfront properties will favour hard protection structures that protect their investment, which may not be universally accepted by the wider community. Conflict may arise as discussions occur about who pays for adaptation and the perceived "winners" and "losers" of various approaches.

- Under the higher SSP5-8.5 scenario, risks from coastal erosion remain low-moderate until 2070, where the risks to mental health and wellbeing, and of conflict, disruption and loss of trust in government both increase to high, then extreme by 2130. By 2130 under this scenario, there is also an increase to high risk for exacerbating inequities.

- The risk to all elements in the human domain from coastal flooding is low across all timeframes and SLR scenarios. This is a result of the exposure to coastal flooding in the PAA being generally very low; people generally have warning on inundation events and are able to evacuate when/if events occur. During extreme events in the future, only a small number of individual properties would be inundated, and access to main transport routes and community services would still be possible.

Ecological Domain

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

- Risks to ecological elements from coastal erosion, as a result of the high exposure of the PAA to this hazard, are generally moderate to 2070, and then increase to high-extreme by 2130 under both SLR scenarios.

- Bird habitats are the earliest element to become high risk by 2050, and increase to extreme risk by 2130 across both SLR scenarios. The increase to high risk by 2050 is due to the potential effects on northern blue penguin and the rapid loss of coastal habitats. The increase to extreme risk in 2130 reflects the significant loss of coastal habitat within the PAA, but also that other habitat up and down the coast will also have deteriorated, having a potentially very large effect on northern blue penguins.

- Indigenous biodiversity is currently at moderate risk to coastal erosion, and increases to being at extreme risk from coastal erosion by 2070 across both SLR scenarios. This is due to the extreme exposure of the Wainui Estuary to erosion from 2070 onwards, and the very low adaptive capacity of the indigenous biodiversity, as once the estuary has been eroded it will be very difficult to re-establish due to low coastal sand availability, and species may stop using an area if it has frequent perturbations or becomes unsuitable habitat.

- Ecological sites become high risk from coastal erosion by 2130 under the SSP2-4.5 scenario, and extreme risk in the same timeframe under the higher SSP5-8.5 scenario, as the projected erosion will likely result in loss of habitat of native fauna including northern blue penguin nesting areas, and resting and feeding areas of coastal and seabirds such as pied shag, red-billed gulls. With higher sea levels, more advanced erosion would also affect vegetation types of dry dune habitats including the flora and fauna associated with these sites.

- Rare and threatened species become high risk by 2130 under the higher SSP5-8.5 scenario, and wetlands become high risk by 2130 under both SLR scenarios. Risks to the two coastal dune areas in the PAA increases from moderate to high by 2130 under the SSP2-4.5 scenario; however becomes high risk by 2070 under the SSP5-8.5 scenario due to the higher level of exposure and likely inability to recover. This risk increases to being extreme under the SSP5-8.5 scenario by 2130.

- Risks to elements within the ecological domain from coastal flooding are generally low to moderate across both SLR scenarios and all timeframes through to 2130. The exception to this is coastal indigenous biodiversity (in estuaries), which becomes high risk by 2070, and extreme risk by 2130 under both SLR scenarios. This increase in risk is a result of the increase in exposure (both extent and water depth) by 2070 and 2130 during an extreme event; as significant flooding could alter the water depths and morphology or the usually shallow estuarine environment at Wainui Stream, which may result in it becoming less suitable for fauna habitat.

Natural Character Domain

- The Natural Character domain considers the risks to the preservation of the natural character of the coastal environment. Two elements have been assessed for the PAA – CTA3: Paekākāriki; and Queen Elizabeth Park (Part of). The PAA is included within the wider 'CTA 3: Paekākāriki', which is considered to have moderate natural character. Part of the Queen Elizabeth Park area, which is ranked as having high natural character, also borders the northern boundary of the PAA, north of Wainui Stream.

- Under both SLR scenarios, both elements of natural character assessed (CTA3: Paekākāriki; and part of Queen Elizabeth Park) are considered to be at low risk to coastal erosion through to 2070, and increase to being at moderate risk at 2130. The low-moderate risk rating is a result of the coastal environment already being heavily modified, including existing sea walls, rock revetments and flood defences which border established areas of the existing settlement, and therefore have a more limited level of natural character in front of the Paekākāriki settlement. In the high natural character area in Queen Elizabeth Park included in the PAA, while exposure may be high and increase over time, coastal erosion also expresses natural processes which will continue to shape the characteristics and qualities of the coastal environment and therefore contribute to natural character, and hence the risk in this area (where these is space for the dune to migrate) is considered to be low.

- For coastal flooding, the risks to both natural character elements are considered to be low across both SLR scenarios and all timeframes. This low risk is generally a reflection of the low exposure throughout the PAA to coastal inundation, and the low sensitivity of natural character to temporary coastal flooding in an extreme storm event.

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	M	M	M	M	M	H	L	L	L	L	L	L
Beachfront Properties only*	H	H	E	E	E	E	-	-	-	-	-	-
Water Supply Infrastructure	L	L	H	H	H	H	L	L	L	L	L	L
Stormwater Infrastructure	L	L	L	L	L	L	L	L	L	L	L	L
Roads and Bridges	L	L	M	H	M	H	L	L	L	L	L	L
Electrical Transmission and supply infrastructure	L	L	L	M	M	H	L	L	L	L	L	L
Wastewater Infrastructure**	No Exposure						No Exposure					
Natural Gas Supply**	No Exposure						No Exposure					
Human												
Physical Health	L	L	L	L	L	M	L	L	L	L	L	L
Mental Health and Wellbeing	L	L	M	M	H	E	L	L	L	L	L	L
Social Infrastructure and Amenity	L	L	M	M	M	M	L	L	L	L	L	L
Exacerbating Inequalities	L	L	M	M	M	H	L	L	L	L	L	L
Social Cohesion and Community Wellbeing	L	L	M	M	M	M	L	L	L	L	L	L
Conflict, Disruption, and Loss of Trust in Government	L	M	M	H	H	E	L	L	L	L	L	L
Ecological												
Coastal dunelands	M	M	M	H	H	E	L	L	L	L	L	M
Wetlands	L	M	M	H	M	H	L	M	M	M	M	M
Mapped ecological sites	L	M	M	H	M	E	L	M	M	M	M	M
Indigenous trees***	No Exposure						No Exposure					
Rare and threatened species	M	M	M	M	M	H	M	M	M	M	M	M
Bird habitat	M	H	H	E	H	E	M	M	M	M	M	M
Fish habitat	M	M	M	M	M	M	M	M	M	M	M	M
Indigenous biodiversity (coastal)	M	M	E	E	E	E	M	M	H	E	H	E
Natural Character												
CTA3: Paekākāriki	L	L	L	M	L	M	L	L	L	L	L	L
Queen Elizabeth Park (Part of)	L	L	L	L	L	L	L	L	L	L	L	L
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.												

**Beachfront only' for coastal flooding is not assessed for consistency with other Adaptation Area Risk Assessments.
**There is no public wastewater infrastructure or natural gas supply mains in the PAA, however for completeness with other adaptation areas (where this element has been assessed) it has been included.
***There are no Key Indigenous Trees nor Notable Trees identified in within the Operative Kapiti Coast District plan that are located within the PAA, and therefore there is no identified risk, however for completeness with other adaptation areas (where this element has been assessed) it has been included.

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 Paekākāriki 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; 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.

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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 (this report) 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.
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.
KCDC	Kāpiti Coast District Council
NZILA	New Zealand Institute of Landscape Architects
Paekākāriki Adaptation Area	The Paekākāriki Adaptation Area is located between the southern district boundary, and Queen Elizabeth Park.
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 includes 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)."

The purpose of this report is to present the methodology and results of the risk assessment for the **Paekākāriki Adaptation Area** (PAA), 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 the risk of coastal hazards in the future. This assessment assumes that once existing shoreline protection structures fail, they are not replaced and natural shoreline erosion will resume. The presence of current seawalls in the Paekakariki Adaptation Area have been accounted for within the modelling of the coastal erosion hazard, with residual life of structures being based on Tonkin and Taylor (2016) [5]. Adaptation options can be tested against this scenario through the decision-making processes to evaluate the effectiveness of an adaptation pathway in lowering the risk across multiple domains. It will be used to inform recommendations made by the CAP, and can be drawn on by Council to assist their future decisions around adaptation to have a holistic view of risk and mitigation. This assessment follows the

[1] Jacobs (2021). 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] Tonkin and Taylor (2016) Condition Assessment of Coastal Structures.

guidance provided by Ministry for the Environment (2021)[6] which encourages the assessment of risk to be undertaken across a range of domains.

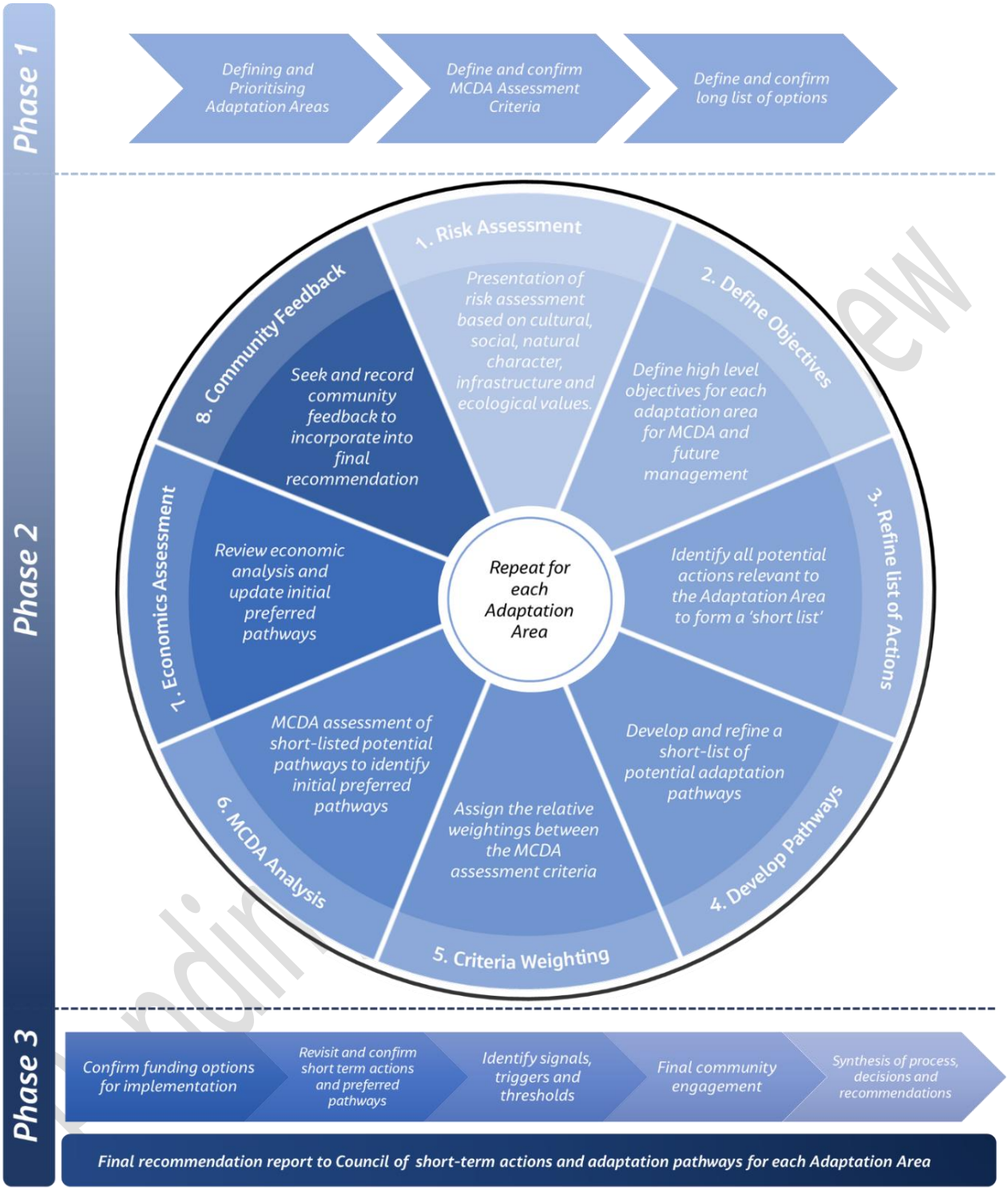

Figure 1.1: Decision Making Framework for the Community Assessment Panel (Jacobs, 2022).

[6] Ministry for the Environment (2021). He kupu ārahi mō te aromatawai tūraru huringa āhuarangi ā-rohe / A guide to local climate change risk assessments. Wellington: Ministry for the Environment

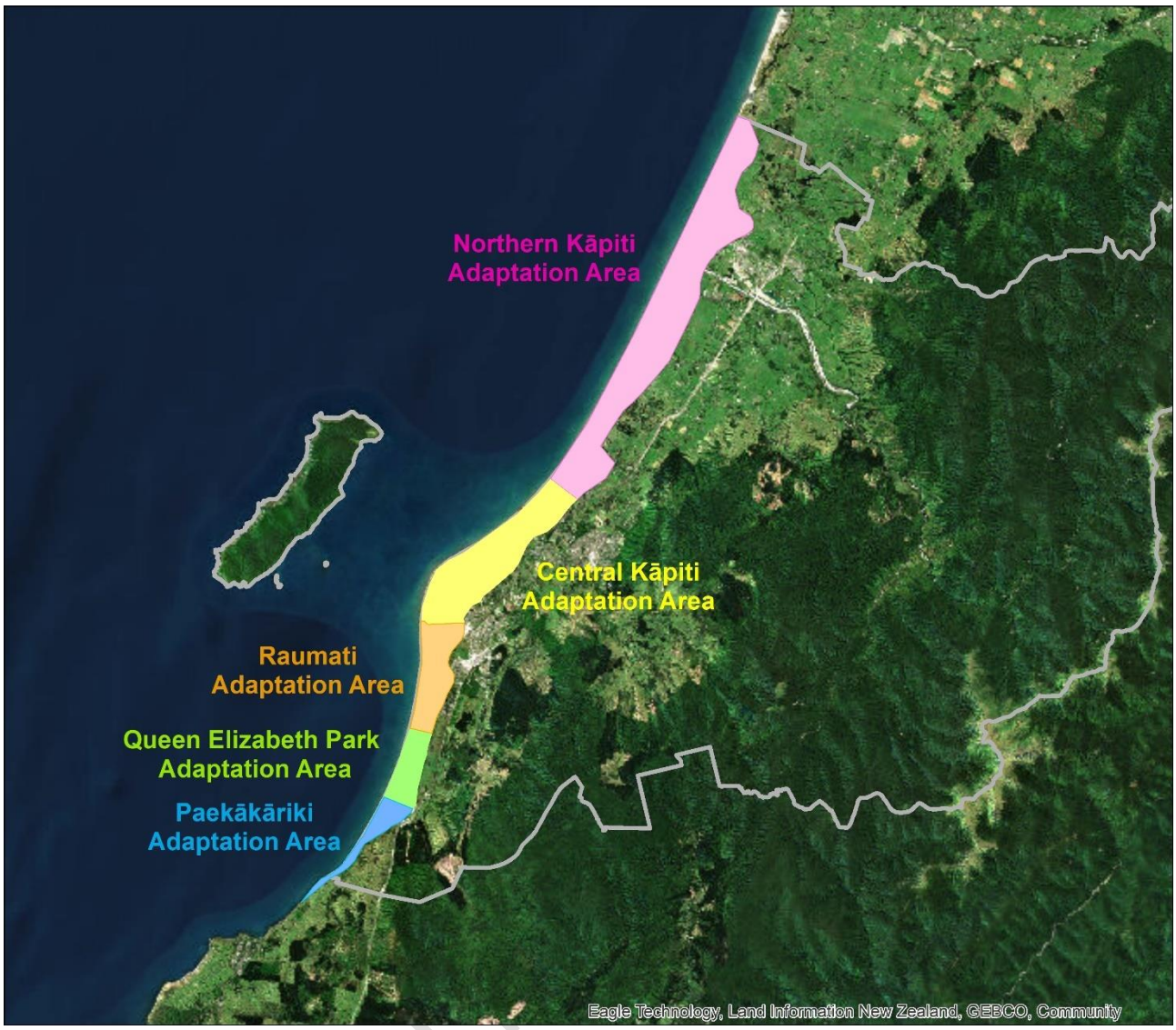

Figure 1.2: Takutai Kāpiti Adaptation Areas. The inland extent of the adaptation areas are determined by the inland extent at which either coastal inundation occurs, or where the interaction from SLR and groundwater ends. The long-shore boundaries of the adaptation areas are based on a combination of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

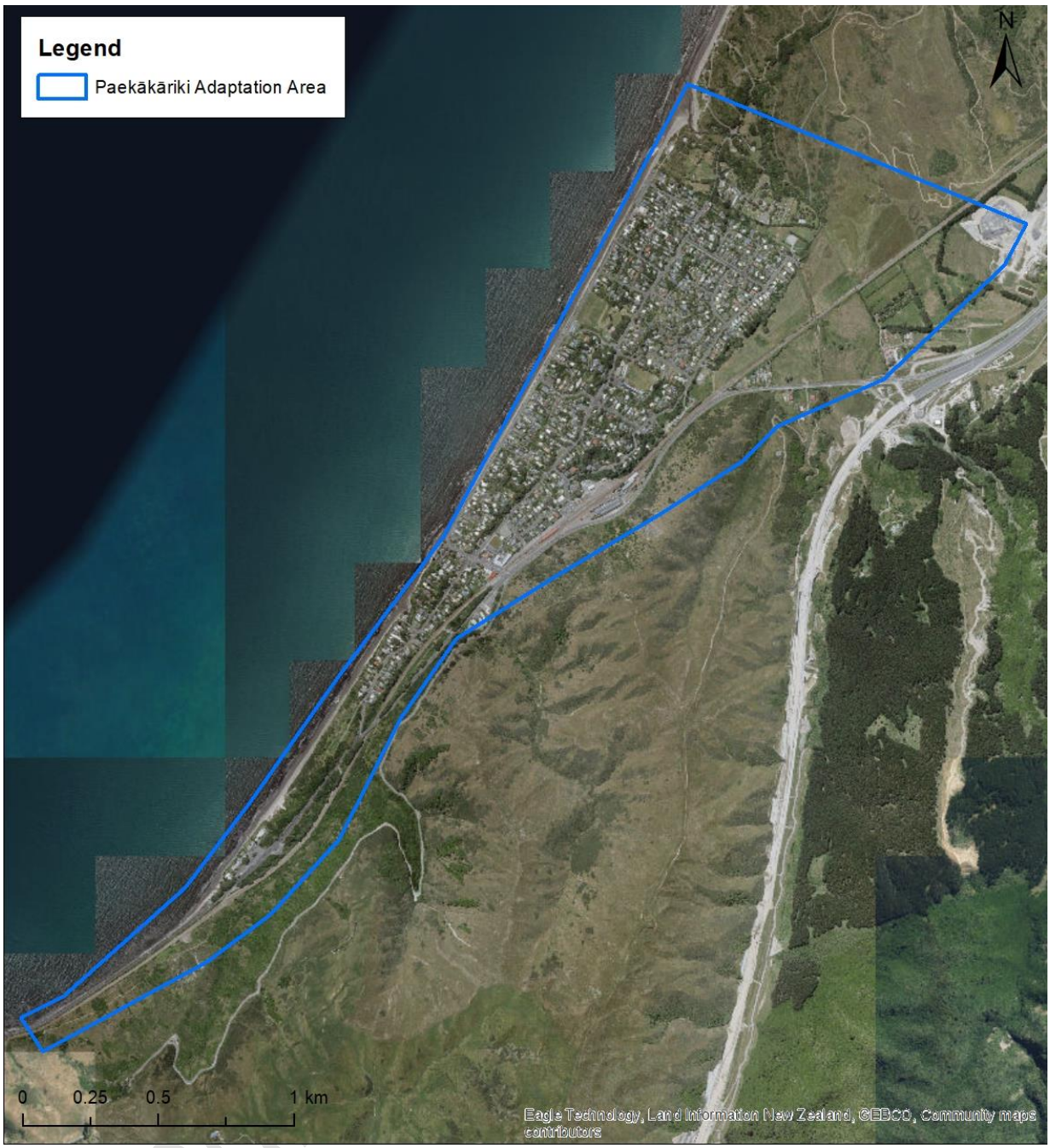

Figure 1.3: Extent and location of the Paekākāriki Adaptation Area

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[7]. The use of these scenarios is consistent with the MfE (2021) ,MfE (2022a)[8], and MfE (2024)[9] guidance for climate change risk assessments and adaptation planning.

This risk assessment presents a summary of the risk for each of the elements assessed within each domain, however is not an exhaustive assessment of all possible elements present along the Paekākāriki 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 PAA, some elements 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 Takutai Kapiti 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.

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

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

[9] 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)[10] *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 desk-top 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 the 2017 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)[11] 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 "*the 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 Paekākāriki adaptation area risk assessment report is considered to be a 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)[12] *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

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

[11] 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.

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

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)[13], 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)[14] provided an update to 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 Kapiti 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 Kapiti (this report).

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.

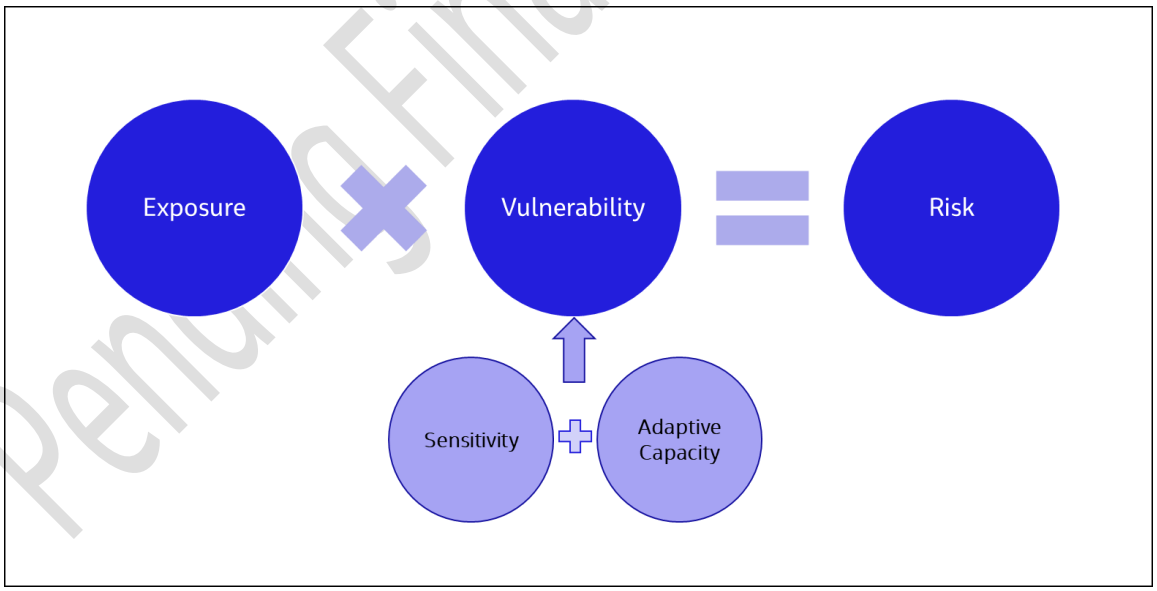

Figure 2.1: Risk equation used for this assessment from MfE (2021) Guidance for climate change risk assessments.

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

[14] Jacobs (2024) Comparison of Relative Sea Level Rise projections presented in the Kapiti 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.

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.

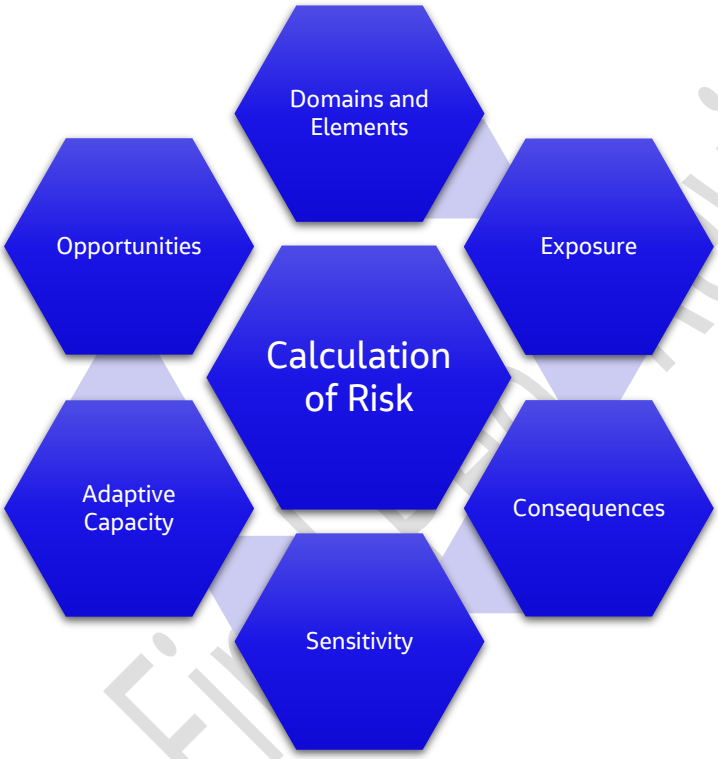

Figure 2.2: Steps for calculating risk.

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

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
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	▪ Coastal Terrestrial Area 3: Paekākāriki ▪ Queen Elizabeth Park
Cultural	▪ *To be completed with Mana Whenua*

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[15] , 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, and 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 there is a 1% annual exceedance probability (AEP) – equivalent to a 10% chance of occurrence over a 10-

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

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 from 2020 in both cases)		
2070 (50 years)	SSP2-4.5 (0.35 m RSLR from 2020) SSP5-8.5 (0.45 m RSLR from 2020		
2130 (110 years)	SSP2-4.5 (0.85 m RSLR from 2020) SSP5-8.5 (1.25 m RSLR from 2020)		

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 Kapiti Coast from NZ SeaRise data (Jacobs, 2024)[16].

A summary of the coastal erosion distances calculated from the updated mapping is as follows for the PAA:

- 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) if the existing protection structures failed) would most likely be in the range of 7 to 22 m along the coastline.
- By 2050, it is projected on average there could be up to an average of 16 m erosion.
- By 2070, there could be on average 23 m of erosion under the lower SSP2-4.5 scenario; and 32 m under the higher SSP5-8.5 scenario.
- By 2130, coastal erosion could be in the order of 55 m under the lower SSP2-4.5 scenario; and 82 m under the higher SSP5-8.5 scenario.

There is varying residual lifetimes of the existing seawalls along the Paekākāriki coast – mainly from 10-30 years[17]. The existence of these structures has been taken into account in the modelling to account for current protection until a point in time in the future when the wall is no longer effective, and erosion processes continue.

This assessment of risk from coastal erosion relies upon the assumptions used in the Jacobs (2022a) hazard assessment, being:

- For longer term projections of future shoreline position, the extent of the coastal erosion hazard is based on the assumption that when an existing wall is at the end of its current residual life, it fails and is not replaced[17].
- The present day exposure to erosion is based on the assumption that existing protection would fail in the design extreme storm event (1% AEP (annual exceedance probability) event), resulting in erosion behind the current wall position. This erosion estimate is based on the 5 m erosion that was experienced along the Paekākāriki coastline following the failure of protection structures in the 1976 extreme storm event (0.5

[16] Jacobs (2024) Comparison of Relative Sea Level Rise projections presented in the Kapiti 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.

[17] Information of structure residual life taken from condition assessment completed by Tonkin and Taylor in 2016.

to 1% AEP joint storm tide and wave event), as well as additional erosion as the dune stabilises post-event.

- The risk to coastal erosion assumes no adaptation or mitigation is undertaken to prevent seawall failure, and therefore risks could be different if measures were put in place to change these underlying assumptions.

For coastal flooding, current pathways for coastal flooding in Paekākāriki are along the Wainui and Waikākāriki Streams. The stormwater drainage network in Paekākāriki is generally raised well above the highest extreme sea level considered in this assessment. Future flood hazards out to 2070 with RSLR are generally well contained to the mouths of Wainui and Waikākāriki Streams. By 2130, the flooding is still mostly localized around the two stream mouths, with the mapping showing some localized depressions within the Paekākāriki settlement, which could be susceptible to flooding from stormwater outfalls, but are generally protected by higher surrounding ground levels. There is a small area around both stream mouths where there could be additional flooding caused by wave run-up.

For coastal flooding, the extent of flooding has been modelled using a "bathtub mapping approach" with the assumption that the current level of natural protection (i.e. current coastal dune morphology preventing direct inundation from the sea) continues into the future. It is recognised that this may not be the case if the projected erosion is allowed to occur in the absence of further adaptation and structures failing, as this will remove the existing high dune and infrastructure along the coastline.

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 similar 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 rating (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 rating 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 rating 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 rating. For example, when assessing the sensitivity of private properties to coastal erosion, consideration was given for where the erosion reached on the property in relation to 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 property, 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) can have a higher 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 may require upgrading prior to being exposed, therefore taking the opportunity to relocate this infrastructure as part of the upgrade and away from the hazard 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 2.2.5), 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 that provides a service to the PAA communities, such as transport (roads), electricity, three waters, gas supply, and electrical supply. It also includes private properties, for which the aforementioned infrastructure is built and maintained to service. The risk to the elements assessed under the built environment domain will most likely result in cascading impacts the human domain.

The following outlines the information used to assess the risks to the built environment in the PAA, 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 potentially exposed an element is to coastal hazards, and 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, and therefore properties that privately manage their wastewater or water supply 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.1.

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 PAA**. 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. This data is from December 2022.
Private properties (beachfront only)	**Risks to private properties by settlements.** The PAA is representative of the Paekākāriki settlement, and therefore the adaptation area has not been further split into smaller settlements areas for assessment, such as how it has in other adaptation areas. However, for consistency of measurement with the risk assessments for other adaptation areas, an assessment of risk to erosion for beachfront properties only (i.e., the most seaward line of properties) has been undertaken. Risk to coastal flooding for beachfront properties, as a result of the method employed in other adaptation areas, is the same as the risk to the whole adaptation area.	Private property boundary outlines provided by KCDC. This data is from December 2022. 'Beachfront' properties were extracted from the property data supplied by KCDC, and only includes the most landward line of properties.
Roads and Bridges	**Risk to roads and bridges in the PAA** that could disrupt access to individual properties 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) with verification using aerial imagery and Google maps street view.

Element	Description	Representative Data
Wastewater services	**Risk to wastewater services** has been assessed in other adaptation areas, however public wastewater infrastructure is not installed in Paekākāriki, and wastewater is privately managed. **Therefore, wastewater services are not assessed for this adaptation area.**	**There is no public wastewater infrastructure in the PAA.**
Water supply services	**Risk to public water supply infrastructure in the PAA** which supports the supply, treatment and distribution of water to private properties. This includes: ▪ Water supply pipe network ▪ Public water supply bores.	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.
Stormwater services	**Risk to public stormwater infrastructure** that manages stormwater in extreme 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 PAA.** 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** has been assessed in other adaptation areas, however gas supply mains or services do not currently exist in the PAA. **Therefore gas supply and transmission services are not assessed for this adaptation area.**	**There is no natural gas supply and transmission infrastructure located in the PAA.**

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	M	M	M	M	M	H	L	L	L	L	L	L
Beachfront Properties only**	H	H	E	E	E	E	-	-	-	-	-	-
Water Supply Infrastructure	L	L	H	H	H	H	L	L	L	L	L	L
Stormwater Infrastructure	L	L	L	L	L	L	L	L	L	L	L	L
Roads and Bridges	L	L	M	H	M	H	L	L	L	L	L	L
Electrical Transmission and Supply Infrastructure	L	L	L	M	M	H	L	L	L	L	L	L
Wastewater infrastructure*	No exposure						No exposure					
Natural Gas Supply*	No exposure						No exposure					

*Public wastewater and natural gas supply infrastructure are not present within the PAA, however for completeness with other adaptation areas (where this element has been assessed) it has been included.
**Beachfront only for coastal flooding is not assessed for consistency with other Adaptation Area Risk Assessments.

3.3 Built Environment Risk Summary

3.3.1 Risks from coastal erosion

This assessment of risk relies upon the assumptions used in the Jacobs (2022a) hazard assessment, where for longer term projections of future shoreline position, the coastal erosion hazard is assessed based on the assumption that when an existing wall is at the end of its current residual life, it fails and is not replaced. For majority of the Paekākāriki shoreline, the assumption is that current sea walls will have a residual life of 10-30 years[18], following which erosion processes will resume.

Present day exposure to erosion is based on the assumption that existing protection would fail in an extreme storm event (i.e. 1% AEP event). This erosion estimate is based on the 5 m storm cut that was experienced along the coastline in 1976 in an extreme storm event (close to a 1% annual exceedance probability event) which caused protection structures to fail and subsequent large scale erosion to occur, followed by dune re-stability which can result in an addition 5-10 m of erosion in some areas. The risk to coastal erosion assumes no adaptation or mitigation is undertaken, and therefore the risks could be different if measures were put in place to change these underlying assumptions.

Although the erosion distances calculated for the SSP 5-8.5 scenarios by 2130 are in the order of 20-30 m greater than for the SSP2-4.5 scenario, this does not trigger an increase in the risk rating for any of the elements.

Private Property

There are 761 private properties located within the PAA, with 44 properties (6%) being potentially exposed to coastal erosion at the present time if an extreme storm were to occur and result in seawall failure. By 2050, this increases to 48 properties being potentially exposed to erosion under both SLR scenarios. By 2070, 122 properties (16%) (SSP2-4.5) to 149 properties (20%) (SSP5-8.5) could be potentially exposed to coastal erosion; increasing to 166 properties (22%) (SSP2-4.5) to 225 properties (30%) (SSP5-8.5) by 2130. The sensitivity of the properties being potentially exposed to coastal erosion is considered to be extreme, as across all timeframes impacted properties would result in both loss of land and loss of dwellings on the properties, which would have a cascading effect on the human domain, and an individual's ability to reside on their property. Risk to private property across the whole adaptation area is moderate at present through to 2130 under the SSP2-4.5 scenario, but increases to high risk by 2130 under the higher SSP5-8.5 SLR scenario.

For most of the Paekākāriki settlement, private properties are separated from the coastline by a road (The Parade) which provides access to the private properties. At these properties, access will be impacted before the properties themselves are directly exposed to coastal erosion.

When the assessment of risk from coastal erosion is considered for beachfront properties only, the risk is much more imminent. At present the risk to beach front properties is high, with 35 properties (28%) of the 127 beachfront properties located in the PAA being potentially exposed to coastal erosion if the existing wall structure fails. These properties are generally located south of The Parade along Ames Street, where the property boundaries extend directly to the coast, with no road buffer in between the properties and the sea. The risk continues to be high out to 2050, with only a small increase in exposure to 44 beachfront properties (35%). The risk increases to extreme by 2070 under both SLR scenarios, where 97 (76%) beach front properties are potentially exposed under SSP2-4.5 SLR scenario, and 123 (97%) private beachfront properties under SSP5-8.5. By 2130, under both SLR scenarios, 100% of beachfront properties are projected to be potentially exposed to coastal erosion.

Roads

The 15.3 km of roads located within the PAA are considered to be at low risk across both SLR scenarios up to 2050; and increasing to moderate in 2070; and to high risk in 2130. Around 1.2km of road length (8% of total in PAA) along The Parade and SH59 at the southern end of the adaptation area could be potentially exposed to coastal erosion if the seawalls were to fail in a present day extreme storm event. A similar length of road is calculated to be potentially exposed to coastal erosion out to 2050, resulting in loss of access to

[18] Tonkin and Taylor (2016) Condition Assessment of Coastal Structures.

private properties located along The Parade, as well as potential loss of access at the southern boundary of the district to Porirua.

By 2070 road exposure increases to 2.4 km (16%) under the SSP2-4.5 scenario, and to 2.7 km (18%) under the SSP5-8.5 scenario. The roads impacted are generally providing access to properties which simultaneously are also being impacted by erosion hazards – however as a result of most properties being located landward of The Parade, access to properties would be lost before the properties themselves would become directly impacted. Access out of the Paekākāriki settlement to the wider district via Beach Road or Ames Street is still available in this timeframe.

By 2130, access to the broader district via Ames Street could become compromised, as well as access to properties that are located on the landward side of Ames Street. Roads that run perpendicular to the coastline (Beach Road, Ocean Road, Pingau Street, Paneta Street, Tangahoe Street, and Henare Street) become potentially exposed to coastal erosion, with 3.3 km (21%) (SSP2-4.5) to 4.1 km (27%) (SSP5-8.5) of road becoming potentially exposed to erosion, and resulting in potentially wider-spread access issues than only to the properties immediately impacted by coastal erosion.

Three waters infrastructure

Water supply infrastructure is considered to be low risk at present through to 2050, and becomes high risk in 2070 through to 2130 under both SLR scenarios. There is an extensive water supply pipe network throughout the PAA, which follows the same locations as the roading network. The consequences of loss of water supply could have cascading impacts on the human domain, and health and safety of the community. Up to 400 m of water supply pipes (2% of total network in PAA) are potentially exposed to erosion in the present day and up to 2050 m if existing seawalls were to fail. As The Parade and adjacent properties become more exposed to erosion in 2070, there is also an increase in the order of 2 km of pipes being potentially exposed across both SLR scenarios. This increases in 2130 to 3.6 km (SSP2-4.5) and 5 km (SSP5-8.5) of water supply pipes being potentially exposed, as well exposure of the only public water supply bore in Paekākāriki under the higher SSP5-8.5 SLR scenario in this timeframe.

Due to the lower flood risk in the PAA relative to other adaptation areas, there is a smaller amount of stormwater infrastructure, with most stormwater pipes running along the road network that runs perpendicular to the coastline. While stormwater outfalls will be increasingly exposed to the coastal erosion hazard over time, the stormwater pipes perpendicular to the coast connecting to these outfalls can be shortened in response to the erosion hazard. Overall, across all timeframes and SLR scenarios, the risk to stormwater infrastructure is considered to be low, as a result of the relatively low exposure to the hazard across the adaptation area, and the moderate sensitivity to exposure, as there is only a small amount of stormwater network that runs parallel to the coast along the Parade (approx. 110m) between Ocean Road and Pingau Street which becomes potentially exposed in 2070.

As noted in previous sections, there is no public wastewater infrastructure located within the PAA, and wastewater is managed privately. It is assumed that as properties are impacted by coastal erosion, this will also impact the private wastewater systems that service the property. Exposure of these systems to erosion could have consequences resulting in discharge of untreated wastewater into the environment, as well as cascading impacts onto the health and safety of the community. The risk to this infrastructure has not been assessed as currently there is no available data on the private wastewater systems located in the PAA to be included in this assessment.

Electrical supply and transmission

The risk to electrical supply is different across both SLR scenarios as a result of when underground transmission lines and distribution transformers become potentially exposed to coastal erosion. Under the lower SSP2-4.5 SLR scenario, electrical supply and transmission infrastructure is not projected to become exposed to coastal erosion until 2130, where 3 of the 22 distribution transformers within the PAA and 0.2 km of the 4.4 km network of underground transmission lines become potentially exposed. The sensitivity of exposed transmission lines is considered to be extreme, and could have significant consequences on health and safety. Therefore when these become exposed under this timeframe, the risk increases from low in 2070 to moderate in 2130.

Under the higher SLR scenario (SSP5-8.5), the risk is considered to be low at present through to 2050 due to no infrastructure being exposed, and increase to moderate in 2070 when a short 10 m section of underground transmission lines is potentially exposed (due to the sensitivity increasing to extreme as a result of high consequences of exposure). By 2130, 4 distribution transformers are potentially exposed to erosion, and 0.6 km of underground transmission lines are potentially exposed to erosion. The risk over this period

increases to high, due to the potentially significant consequences for power supply to a larger number of properties of the exposure of these transmission lines and distribution transformers to coastal erosion.

3.3.2 Risks from coastal inundation

Overall, the risks to all elements assessed in the built environment domain within the PAA are considered to be low across all timeframes and SLR scenarios. The exposure to coastal flooding in the PAA is generally very low and limited to elements located directly on the coastline as a result of the higher elevation of the land behind. There is only one small stream (Wainui Stream) located in the PAA, however this is located at the southern entry to Queen Elizabeth Park and generally away from infrastructure.

Private Properties

Currently, 32 properties are potentially exposed to coastal inundation in a 1% AEP coastal flooding event, which increases to 53 properties by 2130 under the highest SLR scenario (SSP5-8.5). Most of the properties that are potentially exposed to coastal inundation is a result of their property boundary extending into the coastal area, which could be inundated in regular high tides or high frequency storm events (as shown in Figure 3.1). The flooding on properties, even under the longest timeframe and highest SLR scenario, is generally shallow and not a risk to dwellings, meaning that overall there is low sensitivity and low exposure, resulting in low risk to properties in the PAA from flooding.

Figure 3.1: Example of Property boundaries extending into the coastal area in the PAA.

Roads

Roads are also at low risk to coastal inundation as a result of the extremely low exposure to the flood hazard. Roads are generally not exposed to coastal flooding until the 2130 timeframe under the highest SLR scenario, where 50 m of road becomes potentially exposed to shallow flooding along Wellington Road at the Entrance to Queen Elizabeth Park. However, this will not impact access to any properties, or evacuation routes for properties in the PAA.

Three waters infrastructure

All types of stormwater infrastructure located within the PAA are considered to be resilient to coastal inundation (e.g. stormwater pipes, stormwater outfalls), and there are no stormwater pump stations in the

PAA. Therefore, risk to stormwater infrastructure is considered to be low across all SLR scenarios and timeframes assessed in the future.

There is one water supply bore located within the PAA, which is not exposed to coastal flooding under any future timeframe and SLR scenario assessed; and therefore the risk to water supply from coastal flooding is low.

As mentioned in previous sections, public wastewater infrastructure and gas supply infrastructure are not present in the PAA, and therefore are considered to be at 'no' risk to coastal flooding.

Electrical supply and transmission

For electrical transmission and supply infrastructure, of the 22 distribution transformers located in the PAA, only one becomes potentially exposed to coastal inundation in 2130 under the highest RSLR scenario (SSP5-8.5). Flooding at the exposed distribution transformer is shallow (<0.3m), and therefore overall the risk to electrical transmission and supply infrastructure is considered to be low across all SLR scenarios and timeframes assessed.

4. Human Domain

The 'Human' Domain refers to physical and mental health of those who live, work, or recreate in the PAA. 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 PAA, 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 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. There is no public wastewater infrastructure in the PAA, hence it has not been assessed as it has in other areas.
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	Private property boundary outlines provided by KCDC. This data is from December 2022. 'Beachfront' properties were extracted from the 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.

Element	Description	Representative Data
	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.	Paekākāriki Adaptation Area Values Summary (Kāpiti Coast District Council, 2024) 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, 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	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
	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 Paekākāriki Adaptation Area Values Summary (Kāpiti Coast District Council, 2024) 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 – 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 A.

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	M	L	L	L	L	L	L
Mental Health and Wellbeing	L	L	M	M	H	E	L	L	L	L	L	L
Social Infrastructure and Amenity	L	L	M	M	M	M	L	L	L	L	L	L
Exacerbating Inequalities	L	L	M	M	M	H	L	L	L	L	L	L
Social Cohesion and Community Wellbeing	L	L	M	M	M	M	L	L	L	L	L	L
Conflict, Disruption, and Loss of Trust in Government	L	M	M	H	H	E	L	L	L	L	L	L

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 exposure to coastal erosion within the PAA is low, with 6% (44 properties) in the PAA currently potentially exposed to coastal erosion but increasing to 22-30% of properties by 2130. Water supply infrastructure is currently potentially exposed and becomes increasing exposed over time with SLR. A detailed breakdown of properties and infrastructure exposed is provided in Section 3 above.

Physical Health

The risk to physical health is assessed based on the number of private properties (as a proxy for people) that could be impacted in an extreme storm event, resulting in potential injury, illness, or death. Until 2050 the percentage of the overall number of properties potentially exposed to coastal erosion is small compared to the total number of properties in the adaptation area and the overall exposure is considered to be low. However, this number increases with subsequent time steps and by 2070 the exposure is considered to be moderate under both SSP2-4.5 and SSP5-8.5.

Storm warnings enable people to evacuate prior to events that could cause significant coastal erosion. There is no risk to people provided they have proactively evacuated and therefore the overall vulnerability is low across all time periods. Under SSP2-4.5 the risk of coastal erosion is considered low over all time periods. Under SSP5-8.5 the risk is considered low through to 2130 when it increases to moderate due to the increase of properties potentially exposed.

Mental Health and Wellbeing

The beach within the PAA is eroding which may over time impact those who derive identity and wellbeing from the beach. Individuals may experience ongoing stress, anxiety, depression, grief, feelings of powerlessness, and an altered sense of belonging as the risk increases. 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.

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. Financial barriers to adaptation or relocation may cause significant stress or place an individual in the position of needing to remain in a continually affected location.

Under SSP2-4.5 the exposure to erosion is considered low in the present day and 2050, increasing to moderate in 2070 and 2130. Due to the high personal connections to place the vulnerability is considered high. This results in an overall risk rating of low under the present day and 2050 and moderate in 2070 and 2130.

Under SSP5-8.5 the exposure to erosion is considered low in the present day and 2050, increasing to high and extreme in 2070 and 2130 respectively. Due to the high personal connections to place the vulnerability is considered high increasing to extreme in 2130. This results in an overall risk rating of low under the present day and 2050, increasing to high in 2070, and extreme in 2130.

Social Infrastructure and Amenity

No schools, medical practices or places of worship are exposed in any timeframe under either scenario.

Under SSP2-4.5 eight beach access points are within the present-day erosion line. This increases to nine beach access points by 2130. Eight parks and reserves are potentially exposed to erosion in all timeframes and one parcel of DOC land is affected in the present day increasing to two parcels of DOC land in 2130. Public transport routes around The Parade and SH59 are currently potentially exposed to erosion. SH59 leads to Plimmerton and Pukerua Bay and although this is not the only route to these areas, erosion of SH59

could have a flow on impact to use and enjoyment of amenities and facilities in these places, as people have to travel for longer to reach them.

Under SSP2-4.5, by 2050 walking tracks around Wainui Stream are impacted, and this becomes more extensive over time. Likewise, exposure of public transportation routes and SH59 increases to the point that the entire portion of SH59 south of Fisherman's Table subject to erosion by 2130, and the railway is also potentially exposed. The Fisherman's Table restaurant is potentially exposed to erosion by 2050, and by 2130 Industrial Optics business is also potentially exposed. The Paekākāriki Memorial Hall (a heritage place) is potentially exposed to erosion by 2050, and by 2130 the Surf Lifeguards Building is at risk.

Under the SSP5-8.5 scenario, the exposure is similar except by 2070 a greater portion of the Paekākāriki Memorial Hall (a heritage place) is potentially exposed to erosion than under SSP2-4.5, and by 2070 the Surf Lifeguards Building is at risk.

There is limited ability to adapt as the beach and parks are constrained by the adjoining properties and SH59 is backed by steep terrain. Under both scenarios the exposure to erosion is considered low in the present day and 2050, increasing to moderate in 2070 and 2130. Given the inability to adapt the vulnerability is considered high. This results in an overall risk rating of low under the present day and 2050 and moderate in 2070 and 2130.

Exacerbating Inequalities

As properties are impacted by erosion, people are likely to lose their ability to insure against loss, experience decreasing house prices, or experience a reduction in services as the community reduces in size and there is less investment in the area. This may result in those with fewer means being forced to remain in the area. 6% of private properties are currently potentially exposed to coastal erosion increasing to 22-30% by 2130. Under SSP2-4.5 the exposure to erosion is considered low in the present day and 2050, increasing to moderate in 2070 and high in 2130. Under SSP5-8.5 the exposure to erosion is considered low in the present day and 2050, increasing to high to extreme in 2070 and 2130 respectively.

Based on 2018 census data (StatsNZ), the median income in the adaptation area was approximately $35,000 which is slightly higher than the national median personal income ($31,800) for 2018. However, of the total population in the adaptation area, 24% earn under $20,000 per annum. These people may face financial inequities that increase their sensitivity to coastal erosion and inundation. Additionally, the population of the PAA is diverse, containing groups (such as Māori, Pacific peoples, disabled, and older peoples) that have traditionally been shown to face barriers when applying for rental properties and often occupy the lower end of the rental and property market. These groups may end up occupying properties that have devalued in erosion and inundation areas. Those with less financial resources, disabilities or the elderly who rely more heavily on public transport networks may face greater travel costs and times.

Given those with fewer means may have difficulty moving away from hazard-prone areas the adaptive capacity is considered low. This results in an overall risk rating of low under the present day and 2050 and moderate in 2070 for both scenarios. In 2130 under SSP5-8.5 this increases to high due to the increased exposure under this scenario.

Social Cohesion and Community Wellbeing

Given the relatively small number of properties currently affected by coastal erosion there is considered to be minimal impact to social cohesion. As the number of properties affected increases people are likely to move either within the same community or further afield. An impact on social cohesion is possible as the composition of the community changes. Conflict between different elements of the community may emerge due to the change in social norms and disagreement over what to do about ongoing physical, social, and economic changes.

Based on the 2018 census, 40% of residents had lived at the location for less than 5 years, which means that there is a reasonable population turnover. It is, however, also worth noting that 22% of the population in the adaptation area have resided there 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 associated and challenges associated with social cohesion.

The ability for people to adapt is considered low as 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.

Under SSP2-4.5 the exposure to erosion is considered low in the present day and 2050, increasing to moderate in 2070 and 2130. Due to the high personal connections to place the vulnerability is considered moderate. This results in an overall risk rating of low under the present day and 2050, and moderate in 2070 and 2130.

Under SSP5-8.5 the exposure to erosion is considered low in the present day and 2050, increasing to high in 2070 and 2130. Due to the high personal connections to place the vulnerability is considered moderate across all time periods. This results in an overall risk rating of low under the present day and 2050 and moderate in 2070 and 2130.

Conflict, Disruption, and Loss of Trust in Government

It is probable that those residents of beachfront properties will favour hard protection structures that protect their investment. This may not be universally accepted by the wider community. Conflict may arise as discussions occur about who pays for adaptation and the perceived "winners" and "losers" of various approaches.

Under SSP2-4.5 the exposure is considered low in the present day, increasing to moderate in 2050 and high in 2070 and 2130 as the need to adapt increases. Due to the high personal connection to place the vulnerability is considered moderate through to where it increases to high due to the increasing sensitivity. This results in an overall risk rating of low under the present day, moderate in 2050 and 2070, and increasing to high in 2130.

Under SSP5-8.5 the exposure is considered low in the present day, increasing to high in 2050 and 2070, and increasing to extreme by 2130 as the need to adapt increases. Due to the high personal connection to place the vulnerability is considered moderate through to 2070 where it increases to high due to the increasing sensitivity. This results in an overall risk rating of low under the present day, moderate in 2050, high in 2070, and extreme in 2130.

4.3.2 Risks from coastal inundation

The risk to all elements assessed in the Human Domain within the PAA are low across all timeframes and SLR scenarios. The exposure to coastal flooding in the PAA is generally very low; people generally have warning of inundation events and are able to evacuate when/if events occur.

Physical Health

Only a small number of properties are potentially exposed to coastal inundation under both scenarios and floodwater is anticipated to be shallow. Warning of flood events is generally able to be provided and people can evacuate the area prior to any anticipated inundation event.

Many people in the area use the beach for swimming, fishing, and surfing which increases the potential for people to come into contact with contaminated waters. Warnings of potential contamination can be provided allowing people to avoid contact with contaminated water.

Given the number of people who may be exposed to inundation is low, and that people are able to avoid being in area when flooding or contamination is likely the overall risk is considered low.

Mental Health and Wellbeing

Inundation of private properties can cause stress for residents and recurrent inundation may lead to financial loss due to repair costs or insurance withdrawal. Mental health and wellbeing may be impacted by the inability to access flood affected areas for recreation.

Given the low exposure to coastal inundation the overall risk is considered low.

Social Infrastructure and Amenity

At present, four parks and reserves, one parcel of DOC land, and one walkway near Wainui Stream are potentially exposed to coastal flooding. Inundation has a relatively small impact on social infrastructure and amenity into the future within the PAA, with five parks and reserves, one parcel of DOC land, and one track in Queen Elizabeth Park potentially exposed to coastal inundation in 2050, 2070, and 2130.

There is limited ability to adapt as the beach and parks are constrained by the adjoining properties and SH59 is backed by steep terrain. Under both scenarios the exposure to inundation is considered low in all time periods. Given the limited ability to adapt the vulnerability is considered high. This results in an overall risk rating of low under both scenarios in all time periods.

Exacerbating Inequalities

Only a very small number of properties are impacted by coastal inundation (up to 7% under SSP5-8.5 in 2130). As a result, the exacerbation of existing inequities or the creation of new ones are considered low.

Social Cohesion and Community Wellbeing

Minimal impacts to social cohesion are anticipated due to limited exposure of properties. As properties are impacted by periodic inundation people may move either within the same community or further afield. An impact on social cohesion is possible if the composition of the community changes.

Under both scenarios the risk is considered low due to the low exposure to coastal inundation.

Conflict, Disruption, and Loss of Trust in Government

Currently the number of properties exposed to coastal inundation is low. As the number of properties affected increases, there is a risk of conflict between community members as adaptation approaches are discussed including who should pay for a particular response.

Under both scenarios the risk is considered low due to the low exposure to coastal inundation.

5. Ecological Domain

The 'Ecological' domain refers to the plants, animals and their habitats from the coast inland. This assessment looks at the risks of losing plant or animal species, or areas considered to be of ecological importance. It does not include the open coast marine environment, but does include the coastal marine area in estuaries and stream mouths. The risk to the elements assessed under the Ecological domain will likely result in cascading impacts on the Human, Natural Character, and Cultural domains in the PAA.

The coastal area along the Kāpiti Coast District is part of the Foxton Ecological District. This Ecological District contains the most extensive sand-dune system in the country and is a long belt of Holocene sand-dune country extending from Paekākāriki to Patea. In the Kāpiti Coast District dunelands extend as far inland as the old SH1 route. Before human settlement, the habitats consisted of dune forest on the ridges and various types of wetlands between the dunes. The dune landscape is easily visible on aerial imagery, where shadows cast by the dunes can be seen across the area. This Foxton Ecological District still includes several estuaries, wetlands and lagoons, although the vegetation on this dune system is severely modified. Soils in the area are sandy soils of various ages depending on the age of the sand dunes and the height of the water table (McEwen 1987[19]).

The coastline within the PAA consists of ad hoc public and private coastal protection structures (seawalls) that have been constructed since at least the1950's. There are two areas of dunes within the PAA, being at the northern boundary (Queen Elizabeth Park) and near the southern boundary (Ames Street Reserve). Within the urban areas there is little opportunity for coastal indigenous species and their habitat, however the dune areas and associated beaches are known to provide better habitat and for a range of species. Two streams flow through the PAA which also provided potential habitat environments; Wainui Stream through Queen Elizabeth Park and Waikākāriki Stream which exits to the sea halfway along Ames Street (not within Ames Street Reserve).

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

5.1 Ecological Elements

The risk assessment primarily relies on spatial information, and expert knowledge, to establish how exposed an element is to coastal hazards, and also 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 Paekākāriki Adaptation Area 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 Kapiti Coast District Plan 2021 includes maps of Ecological Sites, and Key Indigenous Trees across the district (Figure 7) and four schedules identifying important ecological values:

[19] McEwen W.M., (Ed.) 1987. Booklet to accompany SHEET 2: descriptions of Districts in the central North Island, from Meremere to Eastern Hawkes Bay. Ecological Regions and Districts of New Zealand. Wellington, Department of Conservation. 92 pp.

- 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, Inanga 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 organisations. 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 is one QEII National Trust covenant within the PAA. 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.3.

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

Element	Description	Representative Data
Coastal dunelands	**Risks to any coastal dunelands in the total PAA**. 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. The Queen Elizabeth Park dune system extends south into the PAA and there is another area of dunes south of Paekākāriki township.	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 Ecological Sites schedule. 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 PAA** 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,	KCDC District Plan Schedule 1- Ecological Sites Queen Elizabeth II covenants map (29/09/2023) DOC managed reserves and Conservation covenants

Element	Description	Representative Data
	Regional Parks, Managed Open Space, and Community Environmental Projects.	GWRC Regional Parks, Managed Open Space, and Community Environmental Projects
Key indigenous tree species	**Risks to trees identified as being significant within the PAA.** This information is obtained from the KCDC operative plan and assesses whether these trees would be lost or adversely affected by exposure to coastal hazards.	KCDC 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 PAA.** Some species may be able to move to other areas, but other species could be restricted because there are no other areas available, or potential habitat is too far away. The focus is on Threatened and At Risk[20] 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.	The main data source used is KCDC Rare and Threatened Vegetation Species (Schedule 3) Other data referred to include: ▪ 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 Inanga 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) within river/stream mouths and estuaries 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)

5.2 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.

[20] 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 dunes	M	M	M	H	H	E	L	L	L	L	L	M
Wetlands	L	M	M	H	M	H	L	M	M	M	M	M
Mapped Ecological sites	L	M	M	H	M	E	L	M	M	M	M	M
Indigenous trees*												
Rare and threatened species	M	M	M	M	M	H	M	M	M	M	M	M
Bird habitat	M	H	H	E	H	E	M	M	M	M	M	M
Fish habitat	M	M	M	M	M	M	M	M	M	M	M	M
Indigenous biodiversity (coastal)	M	M	E	E	E	E	M	M	H	E	H	E

*There are no Key Indigenous Trees nor Notable Trees identified in within the Operative Kapiti Coast District plan that are located within the PAA, and therefore there is no identified risk, however for completeness with other adaptation areas (where this element has been assessed) it has been included.

5.3 Ecological Risk Summary

5.3.1 Risks from coastal erosion

The risks to elements assessed in the ecological domain are generally considered to be low-moderate over the next 30 years, however, increase to high-extreme for a number of elements over the next 50-100 years, particularly under the SSP5-8.5 scenario. This is generally a result of the high to extreme exposure to erosion of the coastal habitats in which flora and fauna reside – including both the coastal dunes and the Wainui Stream Estuary where indigenous biodiversity is located.

Coastal dunes

There are two areas of defined coastal dunelands as mapped by GWRC within the PAA:

- The Queen Elizabeth Park duneland system, which is located at the northern part of the PAA (*c.* 40,100m^2). This dune system is wholly within Queen Elizabeth Park.
- Fisherman's Table dunelands south of Ames Street and west of SH59 (c. 54,830 m^2). This duneland is wholly within KCDC Ecological Site K110 Fisherman's Table. The northern 1.8 hectares (18,000m^2) is within Ames Street Reserve, Paekākāriki, which is mapped as managed open space by GWRC. The area is managed primarily for Environmental and Heritage purposes with secondary purpose of Informal Recreation & Leisure.

Both the Ames Street dunes and the Queen Elizabeth Park dunes are known to provide habitat for a range of dune species as well as nesting locations for At Risk-Declining northern blue penguins.

Under present day sea levels, the risk to coastal dunes from erosion in the wider PAA is considered to be moderate, as the toes of the dunes are already subject to erosion during storm events and long-term erosion, but these dunes are generally less modified with a greater quantity of lesser unmodified dune inland. In an unmodified duneland, the ecological function of eroded foredunes would be taken over by more inland dunes – i.e. the more inland dunes would become the foredunes. However, built infrastructure on more inland dunes at Ames Street precludes this, so areas with less human infrastructure could be more resilient (e.g. the Queen Elizabeth Park dunelands).

Under the lower SSP2-4.5 scenario, the risk to the coastal dunes remains moderate until 2130, where the risk increases to high. However, under the higher SSP5-8.5 scenario, coastal dunes become high risk by 2070, and at extreme risk by 2130. The high and extreme risk ratings are a result of the eventual near total loss of the existing dunelands in the PAA as a result of future erosion with SLR, which would therefore result in the loss of habitat for dune dwelling flora and fauna. Under the lower SSP2-4.5 scenario, in 2130 57% of the Queen Elizabeth Park dunes within the PAA could be eroded, and 77% of the Fisherman's Table dunes could be eroded. This increases under the higher SSP5-8.5 scenario to 71% and 90% respectively.

Wetlands

Within the PAA, there is one known area of wetland at the mouth of the Wainui Stream. This small estuarine wetland is currently not at risk of coastal erosion, and therefore the present-day risk is low. For both SLR scenarios, the risk remains moderate through to 2070 under, then increases to high risk in 2130 as the amount of erosion increases, significantly reducing the area of wetland (including complete removal) by 2130. The adaptive capacity of wetlands is considered to be moderate, as some wetland elements and plants could be retained throughout the different SLR scenarios, enabling additional areas of estuarine wetland to be created or retained downstream of Queen Elizabeth Park Road; however, the wetland could not be established upstream of Queen Elizabeth Road due to the existing vegetation and relatively steep banks.

Mapped Ecological Sites

Within the PAA there are (parts of) nine mapped ecological areas, including seven areas that have ecological values[21] [22]. Currently, three of these sites could be exposed to coastal erosion in a present day extreme coastal storm event, with a total of 7% of the area of mapped ecological sites potentially being impacted. Under the lower SSP2-4.5 SLR scenario, over time this percentage of area impacted increases to on average 16% potentially exposed by 2050, 18% by 2070; and 32% by 2130. Under the higher SSP5-8.5 scenario, this increases to an average of 45% by 2130 overall. Some ecological sites are more impacted than others, particularly K110 Fishermans Table, of which 90% of the mapped area is potentially exposed to erosion by 2130 (SSP5-8.5); and 97% of the mapped K109 Queen Elizabeth Park dune area within the PAA.

Erosion of the ecological sites noted above could result in loss of habitat of native fauna including At Risk-Declining northern blue penguin nesting areas, and resting and feeding areas of coastal and seabirds such as At Risk-Recovering pied shag and At Risk-Declining red-billed gull. With higher sea levels, more accelerated erosion would also affect vegetation types of dry dune habitats including the flora and fauna associated with these. Higher 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.

In summary, the risk to mapped ecological sites over time increases progressively from low risk at present day, to moderate risk in 2050 and 2070; to high risk in 2130 under the lower SSP2-4.5 scenario; and extreme risk under the higher SSP5-8.5 scenario.

Indigenous trees

The survey for Key indigenous Trees (KCDC Schedule 2) is restricted to urban allotments, of which Paekākāriki was not included due to lack of connectivity to a serviced sewerage system. Hence, there are no Key Indigenous Trees identified in the PAA. There are Notable Trees (KCDC Schedule 8) within the PAA but these comprise mostly exotic (Norfolk pine planted in 1830, and cork oak) or indigenous trees that are not native to the area (pohutukawa, kauri, puriri). One large cabbage tree is noted on the inland side of SH59 opposite Ames Street Reserve, however this tree is not at risk under any future SLR scenario out to 2130.

Rare and threatened species

At lower tides the beach provides feeding and resting habitat for a range of seabirds and shore birds including At Risk-Declining red-billed gull. Some At Risk-Declining lizard species have been reported in the PAA[23], as well as nesting and breeding by Northern blue penguins (Korora) There are no Nationally and Regionally Rare and Threatened Species populations listed for PAA in Schedule 3 of the Operative Kapiti Coast District Plan. There are no records of indigenous or native Threatened or At Risk plant species, but it is possible that Sand Dune Kanuka (*Kunzea amathicola*; Threatened – Nationally Vulnerable) could still be present.

Due to the highly modified nature of the landscape, if rare and threatened species do occur then they are likely to be in relatively low numbers and mostly on private property in people's gardens. To estimate the potential effects on rare and threatened species it was assumed that their habitat (people's gardens) would disappear at the same rate as has been used for loss of private property.

Given that coastal erosion will affect more of the Kāpiti Coast coastline than just within the PAA, alternative coastal habitat may be significantly reduced even for mobile species. Hence the risk for rare and threatened species at present is considered to be a moderate risk.

Overall risk to rare and threatened species under the lower SSP2-4.5 scenario is considered to be remain moderate through to 2130, as a result of both moderate sensitivity, moderate to high exposure, and moderate adaptive capacity. Under the higher SSP5-8.5 scenario, risk increases from moderate to high in 2130 as a result of the increase to extreme exposure due to a significant increase in the percentage of property eroded (72%), the loss of dunes, and the potential significant changes of the Wainui Stream mouth.

Bird habitat

[21] Murray Hill Point and Campbell Park are Informal Recreation/Leisure and Organised Sports/Activities areas respectively and are not included in this assessment.

[22] KCDC Ecological Site K110 Fisherman's Table and Ames Street Reserve Managed Open Space areas are essentially the same, so only K110 Fisherman's Table will be included in the calculations.

[23] Lizards and the habitats of lizards are protected under the Wildlife Act 1977

The beach from Paekākāriki to McKay's Crossing (Queen Elizabeth Park foreshore) provides seasonal or core habitat for variable oystercatcher, while Wainui Stream mouth provides seasonal or core habitat for pied stilt, banded dotterel and variable oystercatcher. At Risk-Declining northern blue penguins are known to nest along in the dunes of Ames Street Reserve and are also likely to nest along the Queen Elizabeth Park dunes. At lower tides the beach provides feeding and resting habitat for a range of seabirds including At Risk-Declining species such as red-billed Gull (Tarāpunga), black-billed gull (Tarāpuka), and At Risk-Recovering pied shag (Kāruhiruhi). At Risk-Relict fluttering shearwater (Pakahā) might occasionally rest on the beach but are more often sea floating in large groups just off the coast.

The reduction of dune environments or alterations to the Wainui Stream mouth due to coastal erosion could result in the loss of habitat for bird species. The issue will be that the whole or much of the coastline will be similarly affected, which will not only reduce the local habitat within the PAA, but also reduce the potential habitat areas for birds to move to. Erosion could potentially bury in-shore benthic food sources, resulting in reduction of bird food supplies. Loss of coastal bird habitat might result in greater human vs bird conflict/interaction if birds seek alternative locations to rest, nest and feed such as sports fields, roof tops, trees in gardens and parks, local ponds and amenity features.

The present-day risk to bird habitat is moderate, as potential erosion in an extreme storm could erode inland the beach system, indicating that bird habitat may already be deteriorating. Under both future sea level rise scenarios, the risk increases to high in 2050 and 2070, then extreme by 2130. The increase to high in 2050 is due to the potential effects on At Risk-Declining northern blue penguin and the rapid loss of coastal habitats. The increase to extreme in 2130 reflects the significant loss of coastal habitat within the PAA, but also that other habitat up and down the coast will also have deteriorated, having a potential very large effect on At Risk-Declining northern blue penguins.

Fish habitat

The main-stem stream and all tributaries of the Wainui Stream are listed in GWRC Natural Resources Plan Schedule F1: Rivers and lakes with significant indigenous ecosystems[24]. These waterways provide habitat for indigenous Threatened/At Risk fish species and habitat for six or more migratory indigenous fish species. The species include; Banded kokopu, common bully, giant kokopu (At Risk-Declining), koaro (At Risk-Declining), longfin eel (At Risk-Declining), redfin bully (At Risk-Declining), shortfin eel and torrentfish (At Risk-Declining). Wainui Estuary is listed in Schedule F4: Sites with significant indigenous biodiversity values in the coastal marine area as it provides seasonal or core habitat for five threatened indigenous migratory fish species: longfin eel, giant kōkopu, kōaro, redfin bully and torrentfish.

Coastal erosion could alter the habitat, including the saline wetland, within the Wainui Stream mouth and make it a less appropriate habitat for indigenous fish species, and it could also alter how the stream connects to more upstream portions (e.g. fish passage barriers). It is unlikely that the estuary could re-establish upstream of Queen Elizabeth Park Road in the future due to the steep banks present in this area. Any increased sediment in the stream (from coastal erosion or upstream erosion) is likely to reduce 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).

The risk to fish habitat is considered to be moderate at present, as the erosion hazard already extends into the Wainui Stream Estuary indicating that fish habitat may already be deteriorating. The risk remains moderate across both SLR scenarios through to 2130, largely due to the moderate adaptive capacity of fish habitats as fish may be able to move upstream if the habitat is not already occupied by other individuals and is suitable.

Indigenous biodiversity coastal

Wainui Estuary is mapped by GWRC in the NRP Schedule f4: Sites with significant indigenous biodiversity values in the coastal marine area. This estuary provides seasonal or core habitat for five threatened indigenous migratory fish At Risk-Declining species: longfin eel, giant kōkopu, kōaro, redfin bully and torrentfish

[24] The Waikākāriki Stream is not included in GWRC schedules, and there is no date available for this stream in the NZ Freshwater fish database curated by NIWA.

Coastal erosion could potentially widen the mouth of the stream, and it could be more exposed to waves and tides. This could make it less suitable for fish and other species due to greater exposure to the sea. Erosion may also result in bank scour and could result in significant in-stream altitude changes which may reduce connectivity to inland parts of the Wainui Stream. The estuary could develop further upstream, however, this is largely constrained by the Queen Elizabeth Park/Paekākāriki Entrance Road crossing over the stream and the upstream steep vegetated banks and will result in a smaller estuary.

Changes to the estuary could result in fewer fish species using this habitat and/or reduced food availability. Present-day risk is considered to be moderate as some erosion could result from extreme storm occurring and changing the natural habitat for these species. Under both SLR scenarios, the risk remains moderate in 2050, and increases to extreme by 2070 and 2130. This extreme risk is in large due to the extreme exposure of the Wainui estuary due to erosion from 2070 onwards, and the very low adaptive capacity of the indigenous biodiversity, as once the estuary has been eroded it will be very difficult to re-establish due to low coastal sand availability, and species may stop using an area if it has frequent perturbations or becomes unsuitable habitat.

5.3.2 Risks from coastal inundation

Due to the relatively low exposure to coastal flooding within the PAA, the risks to elements assessed within the ecological domain most remain low-moderate through to 2130 under both SLR scenarios.

Coastal Dunes

Generally, the exposure to the PAA is lower to coastal inundation hazards (compared to coastal erosion) as a result of the high land elevations throughout the area. The highest exposure to coastal flooding is generally along the Wainui Stream and lower lying surrounding areas. For coastal dunes, as a result of the high dune crests at both Queen Elizabeth Park and Ames Street, the risk remains low through to 2130 under the lower SSP2-4.5 scenario. Under the higher SSP5-8.5 SLR scenario, the risk to coastal dunes from inundation becomes moderate in 2130 as a result of the gradual increase in exposure with sea level rise during large events, and cascading impacts of foreshore erosion during these large events.

Wetlands

There is one known area of wetland at the mouth of the Wainui Stream that could be affected by flooding over time with SLR. Present day coastal flooding could affect c. 3,335m^2 area downstream of Queen Elizabeth Road/Paekākāriki Entrance Road. The effects will depend on the frequency of flooding and water residency time - prolonged or very frequent flooding may kill some or all of the wetland plants.

Across both future SLR scenarios, extensive flooding in an extreme storm in 2130 could create additional areas of wetland and estuarine wetland. The risk of losing the wetland from flooding changes is low risk at present-day, and increases to being at moderate risk during 2050 & 2070 while most of the flooding occurs within the stream corridor. In 2130, the risk remains moderate as more area may become available for estuarine habitat than in the previous time periods, hence exposure is retained at moderate.

Mapped Ecological Sites

Of the nine mapped areas within the PAA, two are currently potentially exposed to coastal flooding in an extreme storm event (K109 Queen Elizabeth Park, and Queen Elizabeth Park). The exposure of these sites increases over time as SLR increases, with 29% of K109 Queen Elizabeth Park site within the PAA being inundated by 2130 under the SSP2-4.5 scenario; and 32% under the higher SSP5-8.5 scenario.

Flooding at these sites could increase the rate of sand removal accelerating coastal erosion, and could scour out the streams, flooding associated wetlands. Any flooding would affect any low-lying penguin burrows possibly killing chicks and make access more difficult for the adults, potentially resulting in nest abandonment. Any birds nesting in low lying areas would also be affected, as could lizards, skinks and invertebrates.

Coastal flood risk to mapped ecological sites within the PAA is currently low, however under both SLR scenarios increases to moderate by 2050 and continues to be at moderate risk through to 2130 because the effects on the wetland, penguins, and other flora and fauna remains relatively constant over this time frame even with SLR.

Key indigenous trees

As noted in the previous sections, there are no surveyed Key Indigenous Trees located in the PAA. There are Notable Trees (KCDC Schedule 8) within the PAA, but these comprise mostly exotic (Norfolk pine planted in 1830, and cork oak) or indigenous trees that are not native to the area (pohutukawa, kauri, puriri). One large cabbage tree is noted on the inland side of SH59 opposite Ames Street Reserve, however this tree is not at risk to coastal flooding in any future SLR scenario.

Rare and threatened species

Coastal flooding could result in the loss of habitat (possibly temporary) for rare and threatened species, especially with alterations to the Wainui Stream mouth and remnant dune habitat. This will be a more significant adverse effect for species with less mobility such as lizards and plants. Due to the highly modified nature of the 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, to create new habitat. However, given that coastal flooding will likely affect more of the coastline than just within the PAA, alternative coastal habitat may be significantly reduced even for mobile species. The current risk to rare and threatened species from coastal flooding is considered to be moderate and remain moderate through to 2130 under both SLR scenarios.

Bird habitat

It is acknowledged that increased flooding is likely to result in greater sediment input into waterways, smothering in-shore benthic food sources (buried invertebrates in the sand) reducing of food supplies which could adversely affect bird populations. However due to the higher dune elevations in the PAA and that the present-day hazard already extents inland from the beach, coastal flood risk to bird habitat remains moderate for the present day through to 2130 under both SLR scenarios, which is a result of mostly the impact on nesting sites and temporary loss of habitat. Fish habitat is considered to have moderate adaptive capacity to flooding, as the impacts of coastal flooding could be offset by the additional temporary habitat created in exposed parts of the floodplain.

Fish habitat

The main-stem stream and all tributaries of the Wainui Stream have significant indigenous ecosystems. which provide habitat for indigenous Threatened/At Risk fish species and habitat for six or more migratory indigenous fish species. The species include; Banded kokopu, common bully, giant kokopu (At Risk-Declining), koaro (At Risk-Declining), longfin eel (At Risk-Declining), redfin bully (At Risk-Declining), shortfin eel and torrentfish (At Risk-Declining). Wainui Estuary provides seasonal or core habitat for five threatened indigenous migratory fish species: longfin eel, giant kōkopu, kōaro, redfin bully and torrentfish.

Flooding may result in additional areas of wetland that could potentially be beneficial to indigenous fish species as it could provide additional areas of flooded habitat for feeding and spawning. Areas beside the stream would be flooded creating additional temporary habitat for freshwater fish which are known to 'graze' flooded paddocks and sometimes also spawn. 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.

Risks to fish habitat in the PAA is considered to be moderate at present and is assessed to continue to be at moderate risk through to 2130 under both SLR scenarios. This is largely due to the flood events being of a temporary nature, and therefore fish habitats having a moderate adaptive capacity by offsetting the effects of flooding by using temporary additional habitat in flooded parts of the floodplain.

Indigenous biodiversity coastal

Wainui Estuary is mapped by GWRC in the NRP Schedule f4: Sites with significant indigenous biodiversity values in the coastal marine area. This estuary provides seasonal or core habitat for five threatened indigenous migratory fish At Risk-Declining species: longfin eel, giant kōkopu, kōaro, redfin bully and torrentfish

The effects on these fish species during extreme floods are similar to those listed above, with fish potentially being washed inland, and potentially left to dry in temporary flooded areas. However, additional low-lying areas of flooding can provide temporary or more permanent habitat for fish, including the potential expansion of the estuary.

For indigenous biodiversity, the adaptive capacity is considered to be low, although the flooding is considered to be a temporary event, an estuary provides relatively shallow habitat and flooding would increase the depth of the water. Once that happens, it will be less suitable for fauna habitat.

The risk at present is considered to be moderate. Under both SLR scenarios it remains moderate in 2050, increasing to high in 2070 and extreme in 2130, as over time both the flood exposure and the sensitivity to flooding increases, with key indigenous habitats being completely flooded.

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 (New Zealand Institute of Landscape Architects) 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 Paekākāriki Adaptation Area Risk Assessment Report and the PAA natural character domain risk assessments, the natural character rating and description of coastal environment are from the Kāpiti Coast Natural Character Evaluation (Boffa Miskell, Final Draft 2024) report and not the Operative Kapiti Coast District Plan 2021.

The Paekākāriki area was recently assessed as part of the Kāpiti Coast Natural Character Evaluation (Boffa Miskell, Final Draft 2024). Within this study, Paekākāriki forms part of the **Coastal Terrestrial Area 3: Paekākāriki** with an overall **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.

Within the PAA, only a small area within the southern part of Queen Elizabeth (QE) Park has been identified as high natural character, with modification of natural elements, patterns and processes evident across the remainder of the adaptation area to the extent that natural character is no longer high. Notwithstanding this, 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[25] when considering the effects of coastal erosion and inundation on coastal natural character. 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.

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

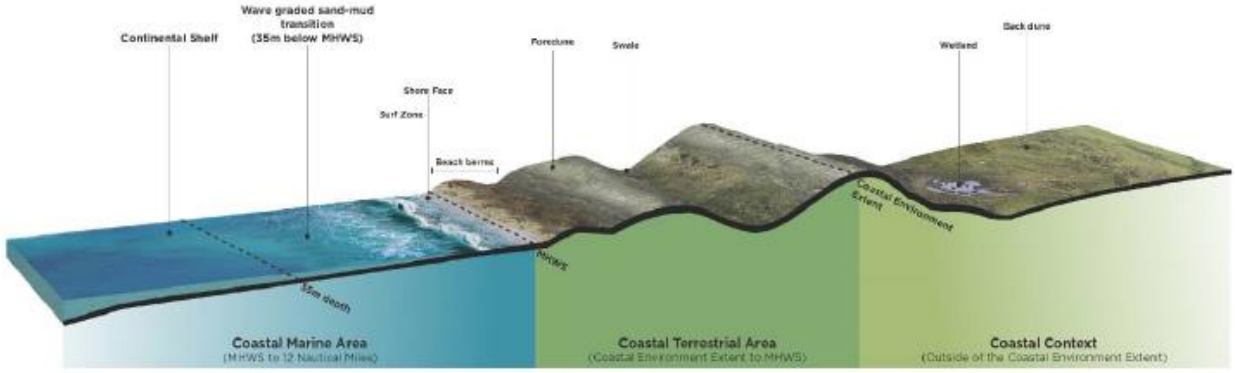

Figure 6.1: Typical transect through Kapiti Coast duneland (from Boffa Miskell, 2024)

The following outlines the information used to assess the risks to the Natural Character domain in the PAA, 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 6.1 provides a summary of the elements assessed within the natural character domain, and what spatial information was used to inform the assessment of risk.

Two elements have been assessed for the PAA – CTA3: Paekākāriki; and Queen Elizabeth Park (Part of). The coastal terrestrial area (CTA) is representative of the broader coastal environment. The PAA is included within the wider 'CTA 3: Paekākāriki', which is considered to have moderate natural character. Part of the Queen Elizabeth Park area, which is ranked as having high natural character, also boarders the norther boundary of the PAA, north of Wainui Stream.

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.4.

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

Element	Description	Representative Data
Section of CTA3: Paekākāriki – Coastal Terrestrial Area.	**Risks to the natural character of the Paekākāriki Coastal Terrestrial Area, which has a 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 Paekākāriki CTA has moderate natural character primarily on account of the settlement of Paekākāriki expressing a comparatively higher level of modification.	Spatial overlays of the identified coastal terrestrial area completed by Boffa Miskell for GWRC and KCDC.

Element	Description	Representative Data
Queen Elizabeth Park (Part of)	**Risks to Queen Elizabeth Park (where the southern boundary of the park adjoins the northern boundary of the PAA), which has high natural character.**	Spatial overlays of the identified coastal terrestrial area 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
CTA3: Paekākāriki	L	L	L	M	L	M	L	L	L	L	L	L
Queen Elizabeth Park (Part of)	L	L	L	L	L	L	L	L	L	L	L	L

6.3 Natural Character Risk Summary

6.3.1 Risks from coastal erosion

Under both sea level rise scenarios, the risks to the natural character of CTA3: Paekākāriki from coastal erosion is considered to be low until 2130, when it increases to moderate. The increase from low to moderate risk is a result of the increase to high exposure of the CTA3: Paekākāriki in 2130, where erosion continues in the context of both existing modified areas of coastline supporting established settlement, and in the context of the more naturalised areas at Ames Street Reserve and part of Queen Elizabeth Park. The exposure to the coastal terrestrial area within the PAA increases over the 100-year period with SLR, however the impacts of erosion are generally in more highly modified areas of the coastal environment, including existing sea walls, rock revetments and flood defences which border established areas of existing settlement, and therefore have a more limited level of natural character.

Under both SLR scenarios, the overall risk to the part of Queen Elizabeth Park that is included in the PAA (around Wainui Stream) is considered to be at low risk to coastal erosion from the present day through to 2130. The exposure to the high natural character in Queen Elizabeth Park that is considered within the PAA is low at present but could increase to moderate exposure from 2050 through to 2130. However, the sensitivity of the area to coastal erosion is considered to be moderate across all timeframes, as hazards created by coastal erosion 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.

While the risks are generally low to natural character, there are likely to be opportunities to restore natural character by reinforcing and restoring native vegetation along riparian margins and within natural dunelands to provide co-benefits of increasing the resilience of these systems.

6.3.2 Risks from coastal inundation

Risks from coastal inundation to both natural character elements are considered to be low at present and through to 2130 under both SLR scenarios assessed. This low risk is generally a reflection of the low exposure throughout the PAA to coastal inundation, and the low sensitivity of natural character to temporary coastal flooding in significant events. Similar to the risk of the coastal erosion, the exposure of the CTA3 and Queen Elizabeth Park area within the PAA to coastal flooding is primarily within areas that are modified due to residential development. Areas that are less modified within the PAA, such as Ames Street Reserve and Queen Elizabeth Park, are generally at elevations that are not exposed to coastal inundation hazards, and therefore will be at low risk.

7. Cultural Domain

A risk assessment for the Cultural domain in relation to coastal hazard is still being 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 'rating' (low/moderate/high/extreme)
- A sensitivity 'rating' (low/moderate/high/extreme)
- A description of the elements' adaptive capacity and its 'rating' (very low/low/moderate/high)
- A calculated vulnerability score based on sensitivity and adaptive capacity ratings (low/moderate/high/extreme)
- A calculated overall risk score based on combined exposure and vulnerability ratings (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 PAA, of which there is 761 private properties. Properties are assessed as the property boundaries of private parcels, supplied by KCDC.

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 property.
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 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.

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 there are 44 (6%) properties exposed to short term storm erosion	Future exposure: 2050: 48 private properties (6%) 2070: 122 private properties (16%) 2130: 166 private properties (22%)
Currently exposed to coastal flooding - Currently there are 32 (4%) private properties exposed to coastal inundation – These are generally coastal properties south of the Esplanade where the property boundary extends into the coastal area.	Future exposure: 2050: 35 private properties are exposed (5%) 2070: 36 private properties are exposed (5%) 2130: 45 private properties are exposed (6%)

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 PAA (761).
- It is noted that exposure to erosion in the present day is based on the estimated erosion that could occur when there is failure of an existing structure during an extreme storm event. This erosion estimate is based on the 5 m erosion that was experienced along the coastline in 1976 in an extreme storm event (close to a 1% annual exceedance probability event) which occurred following structure failure, as well as a varying dune stability factor along the coastline dependent on the land elevation behind the failed structure. This assessment assumes that all walls would fail in an significant storm event, and this level of erosion would occur. The risk to coastal erosion would be low-moderate if walls were designed to withstand this extreme storm event, and were maintained to this level of protection over the 100 year period.
- Exposure of properties to coastal inundation is generally beachfront properties south of the Parade, where the property boundary extends out onto the beach, where water would usually be in high tides. Only over higher SLR scenarios and long term timeframes to properties set back from the coast become exposed due to small depressions in the land elevations in historical dune swale areas.

Sensitivity

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

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 of those exposed, it is considered to be 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 low-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 = Moderate sensitivity (up to a depth of 0.5 m above typical floor level in which a significant 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	E	E	E	E	L	E	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	E	E	E	E	M	M	M	M
Risk from Flooding	L	L	L	L	L	L	L	L	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 there are 44 (6%) properties exposed to short term storm erosion	Future exposure: - 2050: 48 private properties (6%) - 2070: 149 private properties (20%) - 2130: 225 private properties (30%)
Currently exposed to coastal flooding - Currently there are 32 (4%) private properties exposed to coastal inundation – These are generally coastal properties south of the Esplanade where the property boundary extends into the coastal area.	Future exposure: - 2050: 35 private properties are exposed (5%) - 2070: 36 private properties are exposed (5%) - 2130: 53 private properties are exposed (7%)

Hazard	Present	2050	2070	2130
Coastal Erosion	L	L	L	M
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 PAA (761).
- It is noted that exposure to erosion in the present day is based on the estimated erosion that could occur when there is failure of an existing structure during an extreme storm event. This erosion estimate is based on the 5 m erosion that was experienced along the coastline in 1976 in an extreme storm event (close to a 1% annual exceedance probability event) which occurred following structure failure, as well as a varying dune stability factor along the coastline dependent on the land elevation behind the failed structure. This assessment assumes that all walls would fail in an extreme storm event, and this level of erosion would occur. The risk to coastal erosion would be low-moderate if walls were designed to withstand this extreme storm event, and were maintained to this level of protection over the 100 year period.
- Exposure of properties to coastal inundation is generally beachfront properties south of the Esplanade, where the property boundary extends out onto the beach, where water would usually be in high tides. Only over higher SLR scenarios and long term timeframes to properties set back from the coast become exposed due to small depressions in the land elevations in historical dune swale areas.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	E	E	E	E
Coastal Flooding	L	L	L	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 of those exposed, it is considered to be 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 low-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 = Moderate sensitivity (up to a depth of 0.5 m above typical floor level in which a significant 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. Increase to moderate risk as approximately 10 properties under SSP8.5 2130.

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	E	E	E	E	L	E	E	E	E
Flooding	L	L	L	M	L	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	M	E	E	E	E	M	M	M	H
Risk from Flooding	L	L	L	L	L	L	L	M	L	L	L	L

A.1.2 Private Property (Beachfront – Erosion Only)

Domain	Element at Risk	Overview
Built Environment	Private property (Beachfront property only)	Private beachfront land parcels within the PAA, of which there is 127 private properties. Properties are assessed as the property boundaries of private parcels, supplied by KCDC. This only looks at the risk of erosion to beachfront properties to be consistent with other adaptation areas, where larger adaptation areas are split into smaller management units based on settlement boundaries.

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 property.

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.

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 - Currently there are 35 (28%) properties exposed to short term storm erosion	Future exposure: 2050: 44 private properties (35%) 2070: 97 private properties (76%) 2130: 127 private properties (100%)

Hazard	Present	2050	2070	2130
Coastal Erosion	M	M	E	E

Note:

- For both coastal erosion and coastal flooding, exposure is calculated based on the percentage of private beach front land parcels affected relative to the total number of private beachfront land parcels in the PAA (127).
- It is noted that exposure to erosion in the present day is based on the estimated erosion that could occur when there is failure of an existing structure during an extreme storm event. This erosion estimate is based on the 5 m erosion that was experienced along the coastline in 1976 in an extreme storm event (close to a 1% annual exceedance probability event) which occurred following structure failure, as well as a varying dune stability factor along the coastline dependent on the land elevation behind the failed structure. This assessment assumes that all walls would fail in an extreme storm event, and this level of erosion would

occur. The risk to coastal erosion would be low-moderate if walls were designed to withstand this extreme storm event, and were maintained to this level of protection over the 100 year period.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	E	E	E	E

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 of those exposed, it is considered to be 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 low-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.

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.

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

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	E	E	E	E	H	H	E	E

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 - Currently there are 35 (28%) properties exposed to short term storm erosion	Future exposure: 2050: 44 private properties (35%) 2070: 123 private properties (97%) 2130: 127 private properties (100%)

Hazard	Present	2050	2070	2130
Coastal Erosion	M	M	E	E

Note:

- For both coastal erosion and coastal flooding, exposure is calculated based on the percentage of private beach front land parcels affected relative to the total number of private beachfront land parcels in the PAA (127).
- It is noted that exposure to erosion in the present day is based on the estimated erosion that could occur when there is failure of an existing structure during an extreme storm event. This erosion estimate is based on the 5 m erosion that was experienced along the coastline in 1976 in an extreme storm event (close to a 1% annual exceedance probability event) which occurred following structure failure, as well as a varying dune stability factor along the coastline dependent on the land elevation behind the failed structure. This assessment assumes that all walls would fail in an extreme storm event, and this level of erosion would occur. The risk to coastal erosion would be low-moderate if walls were designed to withstand this extreme storm event, and were maintained to this level of protection over the 100 year period.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	E	E	E	E

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 of those exposed, it is considered to be 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 low-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.

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.

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

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	E	E	E	E	H	H	E	E

A.1.3 Roads and Bridges

Domain	Element at Risk	Overview
Built Environment	Roads and Bridges	All roads and bridges in the PAA. Roads include unsealed and sealed roads as per the LINZ Roads Centreline dataset from LINZ Data service. In the PAA there is 15.3 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 PAA there are two bridges – one on Queen Elizabeth Road at the entrance to Queen Elizabeth Park, and the other at the intersection of Ames Street and SH59 at the rail overbridge. Included in the Paekākāriki Adaptation Area is an approximately 800m coastal stretch of SH59, which is one of two main transport routes from Kāpiti to Wellington.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Properties located in Paekākāriki are generally accessed off SH59 by Ames Street or Beach Road, which act as the key evacuation roads for this settlement. Ames Street, The Parade, and Wellington Road run parallel to the coast, and are key access for smaller adjoining roads. Included in the Paekākāriki Adaptation Area is SH59, which is one of two main transport routes from Kāpiti to Wellington. This road is currently protected and maintained by Waka Kotahi, however loss of this road would reduce access to Porirua and Wellington, and would increase traffic on SH1 (Transmission Gully). Closure/loss of the access roads (Ames Street or Beach Road) would lead to significant disruption to the local communities with limited alternative routes. Access or evacuation for the broader settlement would currently not be possible with loss of key access roads. 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. Cascading impacts of loss of key access routes would include primarily health and safety issues for evacuation by vehicle in a significant event, as well as reduced access for emergency services. More broadly, there would be impacts to local tourism (e.g. access to the Te Araroa trail which runs through Paekākāriki), and access to education within the district. The consequence of erosion reaching a bridge/culvert structure would likely result in undermining of the structure and cause failure. The small bridge at the entrance to QE Park is the only access route from the southern end of the park, and would therefore restrict access to the park.
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 main roads which provide inland routes 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.1.3.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion - 1.2 km (8%) of road exposed – sections of the Parade and SH59 would be exposed if existing structures were to fail. - 0 Bridges	Future exposure: - 2050: 1.2 km of road (8%) – the Parade and SH59. - 2070: 2.4 km of road (16%) – the Parade and SH59 - 2130: 3.3 km km of road (21%) – the Parade, SH59, parts of Ames Street, and sections of perpendicular roads within the Paekākāriki settlement (Beach Road, Ocean Road, Pingau Street, Paneta Street, Tangahoe Street, Henare Street)
Currently exposed to coastal flooding - 0 km of road (<1%) - 1 bridge – Entrance to QE Park	Future exposure: - 2050: 0 km of road (<1%), 1 bridge - 2070: 0 km of road (<1%), 1 bridge - 2130: 0 km of road (<1%), 1 bridge

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

Note:

- Exposure ratings for Coastal Erosion is calculated as a percentage of the effected road length of the total road length (15.3 km) in the PAA, with consideration of erosion impacts on key access roads providing access to properties, as well as SH59 and the broader district. More weighting is placed on roads which provide access to a high percentage of houses within the settlement.
- Exposure rating for Coastal Flooding additionally considers loss of access inland or isolation of sections of the community.

Sensitivity

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

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 PAA, other key access roads include those that run parallel to the shoreline (the Parade, Ames Street, Wellington Street) and the ones which provide access to SH59 (Ames Street and Beach Road).
- High sensitivity is representative of loss of access to individual homes, generaly through the loss of roads that run parallel to the coast but only service a small number of localised properties, and extreme sensitivity is widespread loss of roading network – generally through loss of roads that run parallel with the coastline and those that provide critcal access to the broader roading network.
- While the erosion of The Parade will cause extreme disruption to residents that live along this road, it only services the houses that will also be directly impacted by erosion, and therefore is considered to be highly sensitive, but not extremely sensitive, as it will not cause widespread disruption to the wider network and wider community.
- SH59 could be impacted in erosion across all SLR scenarios if the existing structures fail. This road is maintained by Waka Kotahi and it is assumed that ownship and maintenance of this road will remain with

that authority. While loss of this road would cause disruption to access between Kāpiti and Wellington, there is alternative access via SH1 (Transmission Gully), and no private property access would be directly impacted by this loss.

- 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 = Moderate 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/moderate/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 'moderate' 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	H	H	E	E	L	H	H	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	M	H	H	E	E	L	L	M	H
Risk from Flooding	L	L	L	L	L	L	L	L	L	L	L	L

A.1.3.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion - 1.2 km (8%) of road exposed – sections of the Parade and SH59 would be exposed if existing structures were to fail. - 0 Bridges	Future exposure: - 2050: 1.2 km of road (8%) – the Parade and SH59. - 2070: 2.7 km of road (18%) – the Parade and SH59 - 2130: 4.1 km km of road (27%) – the Parade, SH59, parts of Ames Street, and sections of perpendicular roads within the Paekākāriki settlement (Beach Road, Ocean Road, Pingau Street, Paneta Street, Tangahoe Street, Henare Street)
Currently exposed to coastal flooding - 0 km of road (<1%) - 1 bridge – Entrance to QE Park	Future exposure: - 2050: 0 km of road (<1%), 1 bridge - 2070: 0 km of road (<1%), 1 bridge - 2130: 0.05 km of road (<1%), 1 bridge

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

Note:

- Exposure ratings for Coastal Erosion is calculated as a percentage of the effected road length of the total road length (15.3 km) in the PAA, with consideration of erosion of key access roads providing connection to SH59 and the broader district. More weighting is placed on roads which provide access to a high percentage of houses within the settlement.
- Exposure rating for Coastal Flooding additionally considers loss of access inland or isolation of sections of the community.

Sensitivity

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

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 PAA, other key access roads include those that run parallel to the shoreline (the Parade, Ames Street, Wellington Street) and the ones which provide access to SH59 (Ames Street and Beach Road).
- High sensitivity is representative of loss of access to individual homes, generaly through the loss of roads that run parallel to the coast but only service a small number of localised properties, and extreme sensitivity is widespread loss of roading network – generally through loss of roads that run parallel with the coastline and those that provide critcal access to the broader roading network.
- While the erosion of The Parade will cause extreme disruption to residents that live along this road, it only services the houses that will also be directly impacted by erosion, and therefore is considered to be highly sensitive, but not extremely sensitive, as it will not cause widespread disruption to the wider network and wider community.
- SH59 could be impacted in erosion across all SLR scenarios if the existing structures fail. This road is maintained by Waka Kotahi and it is assumed that ownship and maintenance of this road will remain with

that authority. While loss of this road would cause disruption to access between Kāpiti and Wellington, there is alternative access via SH1 (Transmission Gully), and no private property access would be directly impacted by this loss.

- 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 = Moderate 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/moderate/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 'moderate' 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	H	H	E	E	L	H	H	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	M	H	H	E	E	L	L	M	H
Risk from Flooding	L	L	L	L	L	L	L	L	L	L	L	L

A.1.4 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. Land elevations are high in Paekākāriki, and therefore the flood risk is lower than other adaptation areas, hence less stormwater infrastructure exists in the PAA relative to other adaptation areas. Within the PAA there is 5.9 km of stormwater network pipes, 15 stormwater outfalls (direct to the coast), and no stormwater pumpstations. 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, it could have a cascading impact on the flood hazard if the outfall is unable to efficiently discharge the stormwater to the sea. Stormwater network pipes which are undermined by erosion will require cutback of the pipes, and additional protection around the outfall to protect from further scour at the coast. Consequences are greater to stormwater pipes that are eroded which run parallel to the shoreline, as erosion would cause the pipes to be undermined and fail, and due to being within the network and not at the ends of the network (i.e. discharging at an outfall) there is wider-spread impacts to the network.
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 control systems 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.1.4.1 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 (4%) of stormwater pipe currently exposed to storm erosion. - 15 (100%) Stormwater outfalls exposed.	Future exposure: 2050 - 0.2 km (4%) of stormwater pipe - - 15 (100%) stormwater outfalls exposed 2070: - 0.5 km (8%) of stormwater pipe - 15 (100%) stormwater outfalls exposed 2130: - 0.7 km (12%) of stormwater pipe - 15 (100%) stormwater outfalls exposed
Currently exposed to coastal flooding - There are no pump stations located in the PAA	Future exposure: - 2050: None - 2070: None - 2130: None

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

Note:

- Exposure rating for coastal erosion is based on total pipe length within the PAA. However, it is noted that stormwater outfall pipes are particularly exposed now due to their locality on the coast, and in the future.
- Exposure rating for coastal flooding only considers stormwater pumpstations, and there are none of these located in the PAA, therefore exposure is low.

Sensitivity

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

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. When stormwater pipes run perpendicular to the shoreline, it is assumed that these pipes could be cut back to still discharge to the sea and function. However, when stormwater pipes running parallel to the shoreline become impacted there could be wider-scale implications on the PAA stormwater network, with cascading impacts on the flood hazard.
- For coastal flooding, sensitivity considers the potential depth of flooding at pump stations if flooded 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	M	L	M	M	M	M
Flooding	L	L	L	L	M	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	M	M	M	M	L	L	L	L
Risk from Flooding	L	L	L	L	L	L	L	L	L	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 - 0.2 km (4%) of stormwater pipe currently exposed to storm erosion. - 15 (100%) Stormwater outfalls exposed.	Future exposure: 2050: - 0.2 km (4%) of stormwater pipe - - 15 (100%) stormwater outfalls exposed 2070: - 0.5 km (9%) of stormwater pipe - 15 (100%) stormwater outfalls exposed 2130: - 1 km (16%) of stormwater pipe - 15 (100%) stormwater outfalls exposed
Currently exposed to coastal flooding - There are no pump stations located in the PAA	Future exposure: - 2050: None - 2070: None - 2130: None

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

Note:

- Exposure rating for coastal erosion is based on total pipe length within the PAA. However, it is noted that stormwater outfall pipes are particularly exposed now due to their locality on the coast, and in the future.
- Exposure rating for coastal flooding only considers stormwater pumpstations, and there are none of these located in the PAA, therefore exposure is low.

Sensitivity

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

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. When stormwater pipes run perpendicular to the shoreline, it is assumed that these pipes could be cut back to still discharge to the sea and function. However, when stormwater pipes running parallel to the shoreline become impacted there will be wide-scale implications on the PAA stormwater network, with cascading impacts on the flood hazard.
- For coastal flooding, sensitivity considers the potential depth of flooding at pump stations if flooded 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	M	L	M	M	M	M
Flooding	L	L	L	L	M	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	M	M	M	M	L	L	L	L
Risk from Flooding	L	L	L	L	L	L	L	L	L	L	L	L

A.1.5 Wastewater Infrastructure

There is no mapped public wastewater infrastructure located within the PAA, and therefore this has not been assessed for the PAA. Wastewater is privately managed at these properties, however due to data availability the risk to privately managed wastewater has not been assessed for PAA.

Similar to communities assessed in the Northern Adaptation Area, it is assumed that if a property is impacted by erosion, then the private wastewater infrastructure servicing that property will also be impacted.

A.1.6 Water Supply Infrastructure

Domain	Element at Risk	Overview
Built Environment	Water Supply Infrastructure	Water supply infrastructure in the PAA 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 PAA. In the PAA there is: - 23.3 km of water supply pipes - 1 water supply bore Nearby reservoirs and pump stations are generally located landward of SH1 outside of the PAA.

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 PAA, and could cause disruption to the wider network if pipes were damaged at critical points (i.e. along sections which connected the total network). Loss of water supply will affect individual properties and would likely lead to cascading effects on community 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 seaward of private properties, and therefore erosion would result in loss of water supply to a property before the property itself is impacted.
Coastal Flooding	Water supply pipes are generally resilient to flooding provided pressure is maintained in the network. Bore supplies may be contaminated by flood water. Power supply and controls at pump stations can be damaged by flooding resulting in interruption of supply and repair or replacement, and consequent loss of network pressure can result in contamination of supply from flood water. However, there are no pump stations located in the PAA, and this is therefore not applicable here.

Opportunities

Hazard	Opportunities
Coastal Erosion	Many of the most seaward coastal water supply pipes were installed in 1960's (cement asbestos) and therefore are likely to need upgrading at some time in the future. There is an opportunity for the network to be realigned and/or incorporate in the 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.1.6.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion - 0.4 km water supply pipes (2%) – the Parade - 0 water supply bores (0%) -	Future exposure: 2050: - 0.4 km water supply pipes (2%) – the Parade - 0 water supply bores (0%) 2070: - 2 km water supply pipes (9%) – the Parade - 0 water supply bores (0%) 2130: - 3.6 km water supply pipes (15%) – the Parade and pipes exntending into roads perpendicular to the coast. - 0 water supply bores (0%)
Currently exposed to coastal flooding - 0 water supply bores (0%)	Future exposure: - 2050: 0 water supply bore (0%) - 2070: 0 water supply bore (0%) - 2130: 0 water supply bores (0%)

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

Note:

- For exposure to coastal erosion is the combined exposure on water supply bores and water supply pipes, and consideration of disruption to the wider water supply network (i.e. number of properties impacted by loss of supply).
- 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 PAA and therefore are not assessed.

Sensitivity

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

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. The sensitivity increases as the exposure of the network increases, which could result in wide-spread disruption to the local water supply network as water supply pipes that run parallel to the shoreline are impacted. It is noted that at present and in 2050, some areas of the pipe network that run parallel to the shoreline are impacted, however significantly more so in the 2070-2130 timeframes.
- 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	Bores could be easily floodproofed if required.

Vulnerability Score

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

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 - 0.4 km water supply pipes (2%) – the Parade - 0 water supply bores (0%)	Future exposure: 2050: - 0.4 km water supply pipes (2%) – the Parade - 0 water supply bores (0%) 2070: - 2.2 km water supply pipes (9%) – the Parade - 0 water supply bores (0%) 2130: - 5 km water supply pipes (21%) – the Parade and pipes extending into roads perpendicular to the coast. - 1 water supply bores (100%)
Currently exposed to coastal flooding - 0 water supply bores (0%)	Future exposure: - 2050: 0 water supply bore (0%) - 2070: 0 water supply bore (0%) - 2130: 0 water supply bores (0%)

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

Notes:

- For exposure to coastal erosion is the combined exposure on water supply bores and water supply pipes, and consideration of disruption to the wider water supply network (i.e. number of properties impacted by damage).
- 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 PAA and therefore are not assessed.

Sensitivity

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

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. The sensitivity increases as the exposure of the network increases, which could result in wide-spread disruption to the local water supply network as water supply pipes that run parallel to the shoreline are impacted. It is noted that at present and in 2050, some small areas of the pipe network that run parallel to the shoreline are impacted, however significantly more so in the 2070-2130 timeframes.

- 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	Bores could be easily floodproofed if required.

Vulnerability Score

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

A.1.7 Natural Gas Supply Mains

There is no mapped gas supply or distribution mains infrastructure located within the PAA, and therefore this has not been assessed for the PAA.

A.1.8 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 PAA there is: - 22 distribution transformers (which convert electricity from 11kV to 230 V for distribution to all households) – generally, approximately 30% of these are ground mounted and the remainder are pole mounted. - 4.4 km of underground lines (11kV) - 4.6 km of overhead lines (11kV) Data was also obtained for the location of substations, of which there is one substation one on at Tilley Road near Tarawa Street, however it is not exposed to any hazards over any timeframes.

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.

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.
Coastal Flooding	Routine upgrade of equipment can include floodproofing measures.

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: - No distribution transformers are exposed; - No underground transmission lines are exposed.	Future exposure: 2050: - No distribution transformers are exposed; - No underground transmission lines are exposed; and 2070: - No distribution transformers are exposed; - No underground transmission lines are exposed; and 2130: - 3 distribution transformers are exposed (14%); - 0.2 km (5%) underground transmission 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: 0 ground mounted distribution transformers

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

Sensitivity

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

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	L	L	E	L	L	L	L	E
Flooding	L	L	L	L	M	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	L	L	E	L	L	L	M
Risk from Flooding	L	L	L	L	L	L	L	L	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: - No distribution transformers are exposed; - No underground transmission lines are exposed.	Future exposure: 2050: - No distribution transformers are exposed; - No underground transmission lines are exposed; and 2070: - No distribution transformers are exposed; - 0.01 km underground transmission lines are exposed; and 2130: - 4 distribution transformers are exposed (19%); - 0.6 km (14%) underground transmission 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: 1 ground mounted distribution transformer

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

Note:

- Increase to moderate exposure in 2130 due to combined consideration of percentage for both transmission lines and distribution transformers.

Sensitivity

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

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	L	E	E	L	L	L	E	E
Flooding	L	L	L	L	M	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	M	L	L	E	E	L	L	M	H
Risk from Flooding	L	L	L	L	L	L	L	L	L	L	L	L

A.2 Human Risk Assessment Templates

A.2.1 Risk to physical human health

Domain	Element at Risk	Overview
Human	Risks to 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.

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 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 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: ▪ 6% of properties (n= 44) in the adaptation area are exposed to coastal 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 ▪ At present, there are a number of water service pipes and points and stormwater pipes and points exposed to coastal erosion, primarily along The Parade	Future exposure ▪ By 2050 6% of properties (n= 48) 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 ▪ By 2070 the % of properties at risk (n=122) increases to 16% ▪ By 2130 the % of properties at risk (n=166) increases to 22% Increasing amounts of water service pipes and points, stormwater pipes and points, and wastewater pipes and points are exposed to coastal erosion as time progresses. By 2070, for example, the water service pipe and points along The Parade (supplying the first line of beachfront properties) is totally eroded, and by 2130, there is significant impact to the network, and especially water service pipes and points and wastewater pipes and points along The Parade, Ames Reserve, Pingao Street, and Tangahoe Street.
Currently exposed to coastal inundation/flooding: ▪ 4% of properties (n= 32) 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 risks to a small number of stormwater points in the coastal area, plus a length of stormwater channel around Ames Street, with potential risks for recreational users of these areas (e.g swimmers and those walking on the track beside the stream).	Future exposure: ▪ By 2050 5% of properties (n=35) 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. ▪ By 2070 the % of properties at risk (n=36) remains at 5% ▪ By 2130 the % of properties at risk (n=45) increases to 6% Risks to stormwater points in the coastal area persist and areas around The Parade, and over time the stormwater channel in the vicinity of Wainui Stream becomes inundated at progressively higher levels, as does the stormwater channels around Ames Street.

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

Notes:

Until 2050 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, this number increases with subsequent time steps. In particular, the exposure covers beachfront property.

Coastal inundation exposure changes only a few percent at a time.

Sensitivity

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

Notes:

Sensitivity is related to the impact of exposure to pathogens and contaminants in water or danergous buildings which may result in sickness, injury or death.

Older and younger residents are likely to be more sensitive to harm because of their physiology. In this adaptation area 15% of residents are aged over 65, which is on par with the national average (EHINZ 2018), and 4% are below the age of 5, which is 3.5% below the national average (Stats NZ infoshare 2018 data). Many people in the area use the beach for swimming, fishing, and surfing, which increases potential for people to come into contact with contaminated waters.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	H	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
Coastal Flooding	H	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	H	L	L	L	L
Flooding	M	M	M	M	H	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	M	M	L	L	L	L	L	L	L	L
Risk from Flooding	L	L	L	L	L	L	L	L	L	L	L	L

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: ▪ 6% of properties (n=44) in the adaptation area are exposed to coastal 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 ▪ At present, there are a number of water service pipes and points and stormwater pipes and points exposed to coastal erosion, primarily along The Parade	Future exposure: ▪ By 2050 6 % of properties (n=48) 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 ▪ By 2070 the % of properties at risk (n=149) increases to 20% ▪ By 2130 the % of properties at risk (n=225) increases to 30% Increasing amounts of water service pipes and points, stormwater pipes and points, and wastewater pipes and points are exposed to coastal erosion as time progresses. By 2070, for example, the water service pipe and points and stormwater pipe and points along The Parade (servicing the first line of beachfront properties and around) is totally eroded, and by 2130, there is significant impact to the network, and especially water service pipes and points and wastewater pipes and points along The Parade, Ames Reserve, Pingao Street, and Tangahoe Street.
Currently exposed to coastal inundation/flooding: ▪ 4% of properties (n=32) 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 risks to a small number of stormwater points in the coastal area plus a length of stormwater channel around Ames Street, with potential risks for recreational users of these areas (e.g swimmers and those walking on the track beside the stream).	Future exposure: ▪ By 2050 5 % of properties (n=35) 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. ▪ By 2070 the % of properties at risk (n=36) remains at 5% ▪ By 2130 the % of properties at risk (n=53) increases to 7% Risks to stormwater points in the coastal area persist and areas around The Parade, and over time the stormwater channel in the vicinity of Wainui Stream becomes inundated at progressively higher levels, as does the stormwater channels around Ames Street.

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

Note:

Until 2050 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, this number increases with subsequent time steps with exposure at 30% of properties in the adaptation area by 2130. In particular, the exposure covers beachfront property. Coastal inundation exposure changes only a few percent at a time.

Sensitivity

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

Notes:

Sensitivity is related to the impact of exposure to pathogens and contaminants in water or danergous buildings which may result in sickness, injury or death.

Older and younger residents are likely to be more sensitive to harm because of their physiology. In this adaptation area 15% of residents are aged over 65, which is on par with the national average (EHINZ 2018), and 4% are below the age of 5, which is 3.5% below the national average (Stats NZ infoshare 2018 data). Many people in the area use the beach for swimming, fishing, and surfing, which increases potential for people to come into contact with contaminated waters.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	H	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 defence/council warnings) the hazard could be avoided
Coastal Flooding	H	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 defence 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	H	L	L	L	L
Flooding	M	M	M	M	H	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	M	H	H	L	L	L	L	L	L	M
Risk from Flooding	L	L	L	L	L	L	L	L	L	L	L	L

A.2.2 Risks to 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 actions 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 areas), or under take particular activities (e.g. needing to stay away from erosion-prone areas of the coast).
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 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 along 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 ▪ 6% of properties (n=44) in the adaptation area are currently exposed to coastal erosion and could be lost or damaged. ▪ Beach and periphery of Campbell Park is currently experiencing erosion	Future exposure ▪ By 2050 6% of properties (n=48) in the adaptation area are at risk of erosion and could be lost or damaged. ▪ By 2070 the % increases to 16% of the total properties(n=122) in the adaptation area ▪ By 2130 the % increases to 22% of the total properties (n=166) in the adaptaion area 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 (e.g. Ames Street Reserve and Campbell Park) and a sense of identity (e.g. the heritage sites around Campbell Park and Queen Elizabeth Park are also at risk from erosion
Currently exposed to coastal flooding ▪ 4% of properties (n=32) in the adaptation area are at risk of coastal inundation and could be lost or damaged ▪ Few areas are inundated during events at present, mostly just the beach area.	Future exposure ▪ By 2050, 5% of properties (n=35) within the adaptation area will experience coastal inundation and could be lost or damaged. ▪ By 2070 the % remains at 5% (n=36) ▪ By 2130 the % increases to 6% (n=45) By 2130 coastal inundation reaches further inland, periodically flooding low-lying areas mainly around the beach. Inundation affects a few beach-front properties. Other areas that may provide for residents' mental wellbeing (e.g. walking tracks around Wainui Stream) are at risk of inundation

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

Notes:

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) is likely due to their connection with the coast.

Sensitivity

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

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 Paekākāriki given that the Paekākāriki Adaptation Area Values Engagement Summary (Kāpiti Coast District Council, 2024) demonstrates that people within the community have a strong emotional affiliation to the area, particularly the beach and coastline.

Adaptive Capacity

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

	Exposure				Vulnerability				Risk			
Risk from Flooding	L	L	L	L	M	M	M	M	L	L	L	L

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: ▪ 6% of properties (n=44) in the adaptation area are currently exposed to coastal erosion and could be lost or damaged. ▪ Beach and periphery of Campbell Park is currently experiencing erosion	Future exposure: ▪ By 2050 6% of properties (n=48) in the adaptation area are at risk of erosion and could be lost or damaged. ▪ By 2070 the % increases to 20% of the total properties (n=149) in the adaptation area ▪ By 2130 the % increases to 30% of the total properties (n=225) in the adaptaion area 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 (e.g. Ames Park Reserve and Campbell Park) and a sense of identity (e.g. the heritage sites around Campbell Park and Queen Elizabeth Park are also ar risk from erosion
Currently exposed to coastal flooding ▪ 4% of properties (n=32) in the adaptation area are at risk of coastal inundation and could be lost or damaged ▪ Few areas are inundated during events at present, mostly just the beach area.	Future exposure: ▪ By 2050, 5% of properties (n=35) within the adaptation area will experience coastal inundation and could be lost or damaged. ▪ By 2070 the % remains at 5% (n=36) ▪ By 2130 the % increases to 7% (n=53) By 2130 coastal inundation reaches further inland, periodically flooding low-lying areas mainly around the beach. Inundation affects a few beach-front properties. Other areas that may provide for residents' mental wellbeing (e.g. walking tracks around Wainui Stream) are at risk of inundation

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

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) is likely due to their connection with the coast.

Sensitivity

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

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 Paekākāriki given that the Paekākāriki Adaptation Area Values Engagement Summary (Kāpiti Coast District Council, 2024) demonstrates that people within the community have a strong emotional affiliation to the area, particularly the beach and coastline.

Adaptive Capacity

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

	Exposure				Vulnerability				Risk			
Risk from Flooding	L	L	L	L	M	M	M	M	L	L	L	L

References cited:

Bell, S. L., Phoenix, C., Lovell, R., & Wheeler, B. W. (2015). Seeking everyday wellbeing: The coast as a therapeutic landscape. Social Science & Medicine (1982), 142, 56–67. https://doi.org/10.1016/j.socscimed.2015.08.011

Bryce, R., Irvine, K. N., Church, A., Fish, R., Ranger, S., & Kenter, J. O. (2016). Subjective well-being indicators for large-scale assessment of cultural ecosystem services. Ecosystem Services, 21, 258–269. https://doi.org/10.1016/j.ecoser.2016.07.015

Chen, Z., Ryan, C., & Zhang, Y. (2021). Transgenerational place attachment in a New Zealand seaside destination. Tourism Management, 82, 104196. https://doi.org/10.1016/j.tourman.2020.104196

Collins, D., & Kearns, R. (2010). "It's a gestalt experience": Landscape values and development pressure in Hawke's Bay, New Zealand. Geoforum, 41(3), 435–446. https://doi.org/10.1016/j.geoforum.2009.11.010

Collins, D., & Kearns, R. (2013). Place attachment and community activism at the coast: The case of Ngunguru, Northland. New Zealand Geographer, 69(1), 39–51. https://doi.org/10.1111/nzg.12005

Cosgriff, M. (2023). Tuning in: Using photo-talk approaches to explore young people's everyday relations with local beaches. Sport, Education and Society, 28(6), 629–640. https://doi.org/10.1080/13573322.2023.2170345

Floyd, M. A. (2023). Narratives of place and identity on the West Coast of the South Island, Aotearoa New Zealand [Thesis, University of Otago]. https://ourarchive.otago.ac.nz/handle/10523/14833

Foley, R., Kearns, R., Kistemann, T., & Wheeler, B. (2019). Blue Space, Health and Wellbeing: Hydrophilia Unbounded. Routledge.

Foley, R., & Kistemann, T. (2015). Blue space geographies: Enabling health in place. Health & Place, 35, 157–165. https://doi.org/10.1016/j.healthplace.2015.07.003

Kāpiti Coast District Council. (2024). Coastal Advisory Panel Engagement: Paekākāriki Adaptation Area Summary (p. 28).

Murton, B. (2006). "Toheroa Wars": Cultural politics and everyday resistance on a northern New Zealand beach. New Zealand Geographer, 62(1), 25–38. https://doi.org/10.1111/j.1745-7939.2006.00046.x

Panelli, R., Allen, D., Ellison, B., Kelly, A., John, A., & Tipa, G. (2008). Beyond Bluff oysters? Place identity and ethnicity in a peripheral coastal setting. Journal of Rural Studies, 24(1), 41–55. https://doi.org/10.1016/j.jrurstud.2007.05.008

Panelli, R., & Tipa, G. (2007). Placing Well-Being: A Māori Case Study of Cultural and Environmental Specificity. EcoHealth, 4(4), 445–460. https://doi.org/10.1007/s10393-007-0133-1

Schneider, P., Glavovic, B., & Farrelly, T. (2017). So Close Yet So Far Apart: Contrasting Climate Change Perceptions in Two "Neighboring" Coastal Communities on Aotearoa New Zealand's Coromandel Peninsula. Environments, 4(3), 28. https://doi.org/10.3390/environments4030065

Waiti, J. T. A., & Awatere, S. (2019). Kaihekengaru: Māori Surfers' and a Sense of Place. Journal of Coastal Research, 87(SI), 35–43. https://doi.org/10.2112/SI87-004.1

Wheaton, B., Waiti, J., Cosgriff, M., & Burrows, L. (2020). Coastal blue space and wellbeing research: Looking beyond western tides. Leisure Studies, 39(1), 83–95. https://doi.org/10.1080/02614367.2019.1640774

Widener, P. (2018). Coastal people dispute offshore oil exploration: Toward a study of embedded seascapes, submersible knowledge, sacrifice, and marine justice. Environmental Sociology, 4(4), 405–418. https://doi.org/10.1080/23251042.2018.1441590

A.2.3 Risk to 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 utilize, 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 8 beach access points within the current day hazard line. ▪ A total of 8 parks and reserves are exposed, and one parcel of DOC land. ▪ Public transportation routes around The Parade and SH59 are currently exposed to erosion. SH59 leads to Plimmerton and Pukerua Bay and although this is not the only route to these areas, erosion of SH59 could have a flow on impact to use and enjoyment of amenities and facilities in these places, as people have to travel for longer to reach them, which may prevent them from making the trip. ▪ No other social infrastructure is exposed	Future exposure ▪ The exposure of beach access points, parks and reserves stays at the current level under all future time stamps, with the exception being that two parcels of DOC land are affected by 2130, and a ninth beach access point is impacted by 2130. ▪ By 2050 walking tracks around Wainui Stream are impacted, and this becomes more extensive over time. Likewise, exposure of public transportation routes and SH59 increases to the point that the entire portion of SH59 south of Fisherman's Table is in an erosion area by 2130 and the railway is also exposed. ▪ By 2050 the Fisherman's Table restaurant is exposed to erosion, and by 2130 Industrial Optics business is also exposed. ▪ By 2070 the Paekakariki Memorial hall (a heritage place) is exposed to erosion, and by 2130 the Surf lifeguards building is at risk.
Present exposure – Coastal inundation ▪ At present, 4 parks and reserves, one parcel of DOC land, and one walkway near Wainui Stream are exposed to coastal flooding	Future exposure ▪ Coastal inundation has a relatively small impact on social infrastructure and amenity into the future, with five parks and reserves, one parcel of DOC land, and one track in Queen Elizabeth Park exposed to coastal inundation in 2050, 2070, and 2130. ▪ No other social infrastructure is exposed

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

Notes:

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	L	Limited options to adapt because the beach and parks are constrained by adjoining private properties and SH59 is backed by steep-sided terrain. Although walking tracks and bus routes could be re-routed away from erosion hazard (e.g. buses take alternative roads), it could prove difficult and costly to re-route the railway since this is a fixed structure).
Coastal Flooding	M	Limited options to adapt because the beach and parks are constrained by adjoining private properties, but walking tracks 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	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	L	L	L	L	M	M	M	M	L	L	L	L

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 8 beach access points within the current day hazard line. ▪ A total of 8 parks and reserves are exposed, and one parcel of DOC land. ▪ Public transportation routes around The Parade and SH59 are currently exposed to erosion. SH59 leads to Plimmerton and Pukaerua Bay and although this is not the only route to these areas, erosion of SH59 could have a flow on impact to use and enjoyment of amenities and facilities in these places, as people have to travel for longer to reach them, which may prevent them from making the trip. No other social infrastructure is exposed	Future exposure: ▪ The exposure of beach access points, parks and reserves stays at the current level under all future time stamps, with the exception being that two parcels of DOC land are affected by 2130, and a ninth beach access point is impacted by 2130. ▪ By 2050 walking tracks around Wainui Stream are impacted, and this becomes more extensive over time. Likewise, exposure of public transportation routes and SH59 increases to the point that the entire portion of SH59 south of Fisherman's Table is in an erosion area by 2070 and the railway is also exposed. ▪ By 2050 the Fisherman's Table restaurant is exposed to erosion, and by 2130 Industrial Optics business is also exposed. ▪ By 2070 a greater portion of the Paekakariki Memorial hall (a heritage place) is exposed to erosion than under SSP2-4.5, and by 2070 the Surf lifeguards building is at risk.
Present exposure – Coastal inundation: ▪ At present, 4 parks and reserves, one parcel of DOC land, and one walkway near Wainui Stream are exposed to coastal flooding	Future exposure: ▪ Coastal inundation has a relatively small impact on social infrastructure and amenity into the future, with five parks and reserves, one parcel of DOC land, and one track in Queen Elizabeth Park exposed to coastal inundation in 2050, 2070, and 2130. ▪ No other social infrastructure is exposed

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

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

Notes:

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

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Limited options to adapt because the beach and parks are constrained by adjoining private properties and SH59 is backed by

Domain	Adaptive Capacity	Key Assumptions
		steep-sided terrain. Although walking tracks and bus routes could be re-routed away from erosion hazard (e.g. buses take alternative roads), it could prove difficult and costly to re-route the railway since this is a fixed structure.
Coastal Flooding	M	Limited options to adapt because the beach and parks are constrained by adjoining private properties, but walking tracks 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	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	L	L	L	L	M	M	M	M	L	L	L	L

A.2.4 Risk of 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 pronounced over time, the value of affected properties will decrease. Decreasing values mean it is likely these properties will be 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. The competition for "safe" land and homes within the community (away from erosion areas) will increase, meaning that those with the financial resources will be able to secure properties in low-risk areas 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. 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. Access to insurance for affected properties may be reduced over time leading to further inequities within the community.
Coastal Flooding	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 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 exacerbate existing health inequities that are associated with low-income and other marginalized groups. The competition for "safe" land and homes within the community will increase meaning that those with the financial resources will be able to secure properties in low-risk areas while others 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. 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. Access to insurance for affected properties may be reduced over time leading to further inequities within the community.

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.2.4.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion ▪ 6% of private properties (n=44) are currently exposed to coastal erosion. As a result, the exacerbation 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 perceived 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 obtained from insurance companies. ▪ Public transportation routes around The Parade and SH59 are currently exposed to erosion. SH59 leads to Plimmerton and Pukaerua Bay and although this is not the only route to these areas, erosion of SH59 could have a flow on impact for ease and cost of travel.	Future exposure ▪ By 2050 6% of properties (n=48) in the adaptation area are at risk of erosion and could be lost or damaged. ▪ By 2070 the % increases to 16% of the total properties (n=122) in the adaptation area ▪ By 2130 the % increases to 22% of the total properties (n=166) in the adaptation area As these properties are impacted, people are likely to lose their ability to insure against loss, they may either sell their property or remain in place as long as possible (and expereince a slow worsening of living conditions). New inequities may be created and experienced by property owners. Properties that are sold for progressively lower value, or become a low-value rental will exacerbate existing socio-economic and health inequities. Reduction of services may occur as the community reduces in size and there is less investment in the area because of the known hazards. This can lead to "hollowing out" of communities – people with fewer means are effectively trapped in a place with few opportunities to access services, resources, employment, and social connections. Conflict between different elements of the community may emerge over change in social norms and disagreement over what to do about ongoing physical social and economic change. By 2050 exposure of public transportation routes and SH59 increases to the point that the entire portion of SH59 south of Fisherman's Table is in an erosion area by 2130 and the railway is also exposed.
Currently exposed to coastal inundation ▪ 4% of properties in the adaptation area (n=32) are at risk of coastal inundation. As a result, the exacerbation of existing inequities or the creation of new ones are low.	Future exposure ▪ By 2050, 5% of properties within the adaptation area (n=35) will experience coastal inundation and could be lost or damaged. ▪ By 2070 the % will remain at 5% (n=36) ▪ By 2130 the % increases to 6% (n=45) As these properties are impacted, people are likely to move, either within the same community or further afield. An impact on social cohesion is possible if the composition of the community changes. Conversely, some residents may not be able to leave because of financial constraints. Simultaneously, properties affected by semi-permanent inundation may devalue, and the areas affected may largely become home to households of lesser economic means. Reduction of services may occur as the community reduces in size and there is less investment in the area because of the known hazards. This can lead to "hollowing out" of communities – people with fewer means are effectively

Details of exposure	
	trapped in a place with few opportunities to access services, resources, employment, and social connections. Conflict between different elements of the community may emerge over change in social norms and disagreement over what to do about ongoing physical social and economic change.

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

Notes:

The total number of properties within the adaptation area have been assessed rather than just the beach front properties.

Sensitivity

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

Notes:

Based on 2018 census data (StatsNZ), the median income in the adaptation area was approximately $35,000 which is slightly higher than the national median personal income ($31,800) for 2018. However, of the total population in the adaptation area, 24% earn under $20,000 per annum. These people may face financial inequities that increase their sensitivity to coastal erosion and inundation. 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 when applying for rental properties 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). These groups may end up occupying properties that have devalued in erosion and inundation areas. Additionally, 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). Those with less finacical resources, disabilities or the elderly who rely more heavily on public transport networks may face greater travel costs and times.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	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 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. Public transport networks like bus routes could be re-routed away from erosion hazard. However, SH59 is backed by steep-sided terrain and may have limited options. Residents who depend on public transport (e.g., less finanicaly able, older and those with disabilities) will have little choice but to pay more for services that take longer to arrive at their destination.

Domain	Adaptive Capacity	Key Assumptions
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. 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	M	M	M	M	L	M	M	M	M
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	M	H	M	M	M	M	L	L	M	M
Risk from Flooding	L	L	L	L	M	M	M	M	L	L	L	L

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 ▪ 6% of private properties (n=44) are currently exposed to coastal erosion. As a result, the exacerbation of existing inequities or the creation of new ones are low. ▪ However, there 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 6% of properties in the adaptation area (n=48) are at risk of erosion and could be lost or damaged. ▪ By 2070 the % increases to 20% of the total properties (n=149) in the adaptation area ▪ By 2130 the % increases to 30% of the total properties (n=225) in the adaptation area As these properties are impacted, people are likely to lose their ability to insure against loss, they may either sell their property or remain in place as long as possible (and expereince a slow worsening of living conditions). New inequities may be created and experienced by property owners. Properties that are sold for progressively lower value, or become a low-value rental will exacerbate existing socio-economic and health inequities. Reduction of services may occur as the community reduces in size and there is less investment in the area because of the known hazards. This can lead to "hollowing out" of communities – people with fewer means are effectively trapped in a place with few opportunities to access services, resources, employment, and social connections. Conflict between different elements of the community may emerge over change in social norms and disagreement over what to do about ongoing physical social and economic change. By 2050 exposure of public transportation routes and SH59 increases to the point that the entire portion of SH59 south of Fisherman's Table is in an erosion area by 2070 and the railway is also exposed.
Currently exposed to coastal inundation ▪ 4% of properties (n=32) in the adaptation area are at risk of coastal inundation. As a result, the exacerbation of existing inequities or the creation of new ones are low.	Future exposure ▪ By 2050, 5% of properties (n=35) within the adaptation area will experience coastal inundation and could be lost or damaged. ▪ By 2070 the % remains at 5% (n=36) ▪ By 2130 the % increases to 7% (n=53) As these properties are impacted, people are likely to move, either within the same community or further afield. An impact on social cohesion is possible if the composition of the community changes. Conversely, some residents may not be able to leave because of financial constraints. Simultaneously, properties affected by semi-permanent inundation may devalue, and the areas affected may largely become home to households of lesser economic means. Reduction of services may occur as the community reduces in size and there is less investment in the area because of the known hazards. This can lead to "hollowing out" of communities – people with fewer means are effectively

Details of exposure	
	trapped in a place with few opportunities to access services, resources, employment, and social connections. Conflict between different elements of the community may emerge over change in social norms and disagreement over what to do about ongoing physical social and economic change.

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

Note:

The total number of properties within the adaptation area have been assessed rather than just the beach front properties, or areas adjacent to a waterway or drain.

Sensitivity

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

Notes:

Based on 2018 census data (StatsNZ), the median income in the adaptation area was approximately $35,000 which is slightly higher than the national median personal income ($31,800) for 2018. However, of the total population in the adaptation area, 24% earn under $20,000 per annum. These people may face financial inequities that increase their sensitivity to coastal erosion and inundation. 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 when applying for rental properties 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). These groups may end up occupying properties that have devalued in erosion and inundation areas. Additionally, 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). Those with less finacical resources, disabilities or the elderly who rely more heavily on public transport networks may face greater travel costs and times.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	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 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. Public transport networks like bus routes could be re-routed away from erosion hazard. However, SH59 is backed by steep-sided terrain and may have limited options. Residents who depend on public transport (e.g., less finanicaly able, older and those with disabilities) will have little choice but to pay more for services that take longer to arrive at their destination.

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

Vulnerability Score

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

A.2.5 Risk to 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 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' 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. A few households at a time

Hazard	Description of Consequence (note any cascading impacts)
	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, 2019; Boege, 2018).

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.2.5.1 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 limited exposure of properties (6%) and other community services. ▪ However, there is no data to indicate people may be moving due to the perceived risks	Future exposure ▪ By 2050, 6% of properties (n=48) in the adaptation area are in erosion areas that could be lost or damaged. ▪ By 2070 the % increases to 16% (n=122) ▪ By 2130 the % increases to 22% (n=166) As these properties are impacted, people are likely to move either within the same community or further afield. An impact on social cohesion is possible as if the composition of the community changes. Hollowing out of services may occur as the community reduces in size and there is less investment in the area because of the known hazards. Conflict between different elements of the community may emerge over change in social norms and disagreement over what to do about ongoing physical, social, and economic change.
Current exposure to coastal inundation: ▪ Minimal impacts to social cohesion due to limited exposure of 32 properties (4%) and other community services. ▪ However, there is no data to indicate people may be moving due to the perceived risks	Future exposure ▪ By 2050, 5% of properties (n=35) will experience coastal inundation and could be lost or damaged ▪ By 2070, the % remans at 5% (n=36) ▪ By 2130 the % increases to 6% (n=45) As these properties are impacted people are likely to move either within the same community or further afield. An impact on social cohesion is possible if the composition of the community changes. Conversely, some residents may not be able to leave because of financial constraints. Simultaneously properties affected by periodic inundation may devalue and the areas affected become home to households with lesser economic means. Hollowing out of services may occur as the community reduces in size and there is less investment in the area because of the known hazards. Conflict between different elements of the community may emerge over change in social norms and disagreement over what to do about ongoing physical, social, and economic change.

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

Notes:

Exposure for the total properties in the adaptation area is considered, rather than just a focus on the beach front properties.

Sensitivity

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

Notes:

Based on the 2018 census 40% of residents had lived at the location for less than 5 years, which means that there is a reasonable population turnover. It is, however, also worth noting that 22% of the population in the adaptation area have resided there 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 associated and challenges associated with social cohesion.

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	M	M	M	L	M	M	M	M
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	M	M	M	M	M	M	L	L	M	M
Risk from Flooding	L	L	L	L	L	L	L	L	L	L	L	L

A.2.5.2 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 limited exposure of properties (6%) and other community services. ▪ However, there is no data to indicate people may be moving due to the perceived risks	Future exposure ▪ By 2050, 6% of properties (n=48) in the adaptation area are in erosion areas that could be lost or damaged. ▪ By 2070 the % increases to 20% (n=149) ▪ By 2130 the % increases to 30% (n=225) As these properties are impacted, people are likely to move either within the same community or further afield. An impact on social cohesion is possible as if the composition of the community changes. Hollowing out of services may occur as the community reduces in size and there is less investment in the area because of the known hazards. Conflict between different elements of the community may emerge over change in social norms and disagreement over what to do about ongoing physical, social, and economic change.
Current exposure to coastal inundation ▪ Minimal impacts to social cohesion due to limited exposure of 32 properties (4%) and other community services. ▪ However, there is no data to indicate people may be moving due to the perceived risks	Future exposure ▪ By 2050, 5% of properties (n=35) will experience periodic coastal inundation and could be lost or damaged ▪ By 2070, the % remains at 5% (n=36) ▪ By 2130 the % increases to 7% (n=53) As these properties are impacted people are likely to move either within the same community or further afield. An impact on social cohesion is possible if the composition of the community changes. Conversely, some residents may not be able to leave because of financial constraints. Simultaneously properties affected by periodic inundation may devalue and the areas affected become home to households with lesser economic means. Hollowing out of services may occur as the community reduces in size and there is less investment in the area because of the known hazards. Conflict between different elements of the community may emerge over change in social norms and disagreement over what to do about ongoing physical, social, and economic change.

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

Note:

Exposure for the total properties in the adaptation area is considered, rather than just a focus on the beach front properties.

Sensitivity

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

Notes:

Based on the 2018 census 40% of residents had lived at the location for less than 5 years, which means that there is a reasonable population turnover. It is, however, also worth noting that 22% of the population in the adaptation area have resided there 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 associated and challenges associated with social cohesion.

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	M	M	M	L	M	M	M	M
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	H	H	M	M	M	M	L	L	M	M
Risk from Flooding	L	L	L	L	L	L	L	L	L	L	L	L

A.2.6 Risk of 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.2.6.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Currently exposed to coastal erosion ▪ 6% of properties (n=44) in the adaptation area are currently exposed to coastal erosion and could be lost or damaged. ▪ 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.	Future exposure ▪ By 2050 6% of properties (n=48) in the adaptation area are at risk of erosion and could be lost or damaged. ▪ By 2070 the % increases to 16% (n=122) of the total properties in the adaptation area ▪ By 2130 the % increases to 22% (n=166) of the total properties in the adaptation area Increasing erosion of public spaces along the coastal strips including parks, reserves, and beach access points, businesses, and transportation networks 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=32) in the adaptation area are at risk of coastal inundation and could be lost or damaged ▪ Periodic flooding is mostly confined to the beach.	Future exposure ▪ By 2050, 5% of properties (n=35) within the adaptation area will experience coastal inundation and could be lost or damaged ▪ By 2070 the % remains at 5% (n=36) ▪ By 2130 the % increases to 6% (n=45) There is some increase to flooding of public spaces along the coastal strip including parks, reserves, 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	M	H	H
Coastal Flooding	L	L	L	L

Notes:

Depending on how the impacts of the hazards unfold and the decision made regarding what action (if any) are taken, a large number of residents within the adaptation area may be at risk of conflict. In particular, the conflict arsing from the percieved "winners" and "losers" of various courses of action. The erosion hazard rises 10% between 2050 and 2070 which may begin to cause significant concern within the community and drive conflict. Certain portions of the community (primarily low income households) will not be able to compete for safe land and will face little choice but to live in hazardous locations, or leave the area.

Sensitivity

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

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 Paekākāriki, especially since there is evidence that residents have strong feelings of attachment to their community, and particularly the beach (Kāpiti Coast District Council, 2024). 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 Paekākāriki Adaptation Area Values Engagement Summary (Kāpiti Coast District Council, 2024) 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 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 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

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
Erosion	H	H	H	E	M	M	M	M	H
Flooding	L	L	L	L	M	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	M	H	H	M	M	M	H	L	M	M	H
Risk from Flooding	L	L	L	L	L	L	L	L	L	L	L	L

A.2.6.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion 6% of properties (n=44) in the adapation area are currently exposed to coastal erosion and could be lost or damaged. 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.	Future exposure - By 2050 6% of properties (n=48) in the adaptation area are at risk of erosion and could be lost or damaged. - By 2070 the % increases to 20% (n=149) of the total properties in the adaptation area - By 2130 the % increases to 30% (n=225) of the total properties in the adaptaion area 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=32) in the adaptation area are at risk of coastal inundation and could be lost or damaged Periodic inundation is mostly confined to the beach	Future exposure - By 2050, 5% of properties (n=35) within the adaptation area will experience coastal inundation and could be lost or damaged, principally around Wharemauku Stream - By 2070 the % remains at 5% (n=36) - By 2130 the % increases to 7% (n=53) Increased incidence of flooding of public spaces along the coastal strips including parks, reserves, 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	H	H	E
Coastal Flooding	L	L	L	L

Note:

Depending on how the impacts of the hazards unfold and the decision made regarding what action (if any) are taken, a large number of residents within the adaptation area may be at risk of conflict. In particular, the conflict arsing from the percieved "winners" and "losers" of various courses of action. The erosion hazard rises quickly between from 2050, with high exposure (30% of properties) in the early stages of next centurary which will generate significant concern within the community and drive conflict. Certain portions of the community (primarily low income households) will not be able to compete for safe land and will face little choice but to live in hazardous locations, or leave the area.

Sensitivity

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

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 Paekākāriki, especially since there is evidence that residents have strong feelings of attachment to their community, and particularly the beach (Kāpiti Coast District Council, 2024). 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 Paekākāriki Adaptation Area Values Engagement Summary (Kāpiti Coast District Council, 2024) 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 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. 24% of the Paekākāriki community has a personal income of less than $20,000 per annum. 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	H	H	E	E	M	M	M	H	H
Flooding	M	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	H	H	E	M	M	H	H	L	M	H	E
Risk from Flooding	L	L	L	L	M	M	M	M	L	L	L	L

References cited

Gesing, F. (2017). Whose Beach, Which Nature? Coproducing Coastal Naturecultures and Erosion Control in Aotearoa New Zealand. In E. Dürr & A. Pascht (Eds.), Environmental Transformations and Cultural Responses: Ontologies, Discourses, and Practices in Oceania (pp. 125–156). Palgrave Macmillan US. https://doi.org/10.1057/978-1-137-53349-4_6

Gesing, F. (2019). The politics of artificial dunes: Sustainable coastal protection measures and contested socio-natural objects. DIE ERDE – Journal of the Geographical Society of Berlin, 150(3), Article 3. https://doi.org/10.12854/erde-2019-423

Gesing, F. (2021). Towards a more-than-human political ecology of coastal protection: Coast Care practices in Aotearoa New Zealand. Environment and Planning E: Nature and Space, 4(2), 208–229. https://doi.org/10.1177/2514848619860751

Hayward, B. (2008). "Nowhere Far From the Sea": Political Challenges of Coastal Adaptation To Climate Change in New Zealand. Political Science, 60(1), 47–59. https://doi.org/10.1177/003231870806000105

Kāpiti Coast District Council. (2024). Coastal Advisory Panel Engagement: Paekākāriki Adaptation Area Summary (p. 28).

Rouse, H., Bell, R., Lundquist, C., Blackett, P., Hicks, D., & King, D. N. (2016). Coastal adaptation to climate change in Aotearoa-New Zealand. New Zealand Journal of Marine and Freshwater Research, 51(2), 183–222. https://doi.org/10.1080/00288330.2016.1185736

Scouller, A. (2011). The Challenges of Coastal Setbacks in New Zealand [Thesis, University of Otago]. https://ourarchive.otago.ac.nz/handle/10523/1677

A.3 Ecological Risk Assessment Templates

A.3.1 Coastal dunelands

Domain	Element at Risk	Overview
Ecological	Coastal dunelands	Areas of duneland as mapped by GWRC. There are two areas of defined coastal dunelands within the PAA (as shown in Figure A.3.1): 1) The Queen Elizabeth Park duneland system continues into the northern part of the PAA (*c.* 40,100m^2). This dune system is wholly within Queen Elizabeth Park and includes foredunes and mid-dunes. 2) Fisherman's Table dunelands south of Ames Street and west of SH59 (c. 54,830 m^2). This duneland is wholly within KCDC Ecological Site K110 Fisherman's Table and the northern part is within Ames Street Reserve which is managed primarily for Environmental and Heritage purposes with secondary purpose of Informal Recreation & Leisure. Potential effects on the beach within the PAA are also considered.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Seawalls occur along the Ames Street Reserve (northern) part of the Ames Street Dunes and are expected to last 10-50 years. There are no (or few) protective structures north of the northern end of The Parade and the dunes within Queen Elizabeth Park are largely not protected. Seawalls can exacerbate erosion by scouring at the ends of the walls, and the erosion patterns will change if the seawall fails. The beach in front of the seawalls could lower 0.8 to 2.6m over the next 30 years as a result of relative sea level rise (RSLR), which could cause the seawalls to fail. Removal of sand from the beach, would result in 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. 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. This could happen with both dune systems to some extent but there also is human infrastructure on more inland dunes that would limit this progression. Thus, there is a risk that coastal foredunes would be completely eroded and not replaced. Wainui Stream flows through the Queen Elizabeth Park dunes and increased stream flooding could speed up erosion of coastal dunes. Both the Ames Street dunes and the Queen Elizabeth Park dunes are known to provide habitat for a range of dune species as well as nesting locations for northern blue penguins[26]. Dunes help protect human infrastructure as well as providing habitat for plants and animals. Therefore, erosion of the dunes would result substantial loss of breeding and nesting habitat and reduction in level of protection for nearby human infrastructure.
Coastal Flooding	Due to the high land elevations in Paekākāriki, the present-day flood hazard is very minimal and localized to the Wainui Stream and Waikākāriki Stream mouths (exits to the sea halfway along Ames Street). Because dunes are a feature with somewhat higher elevation (i.e. small hills) and therefore less prone to flooding. Due to the lower land elevations around the Wainui Stream, the Queen Elizabeth dunes would be impacted by flooding earlier than the southern Ames Street Dunes section. Flooding could increase the rate of sand removal through scour and subsequent dune collapse accelerating coastal erosion, would flood any low-lying penguin burrows possibly killing chicks and make access more difficult for the adults potentially resulting in nest abandonment.

[26] https://www.kapiticoast.govt.nz/explore-kapiti/recreation/parks-and-reserves/parks/ames-street-reserve/ ; https://paekakariki.nz/listings/penguin-park-walk/; https://www.kapitibiodiversity.org.nz/korora;

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. 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	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.

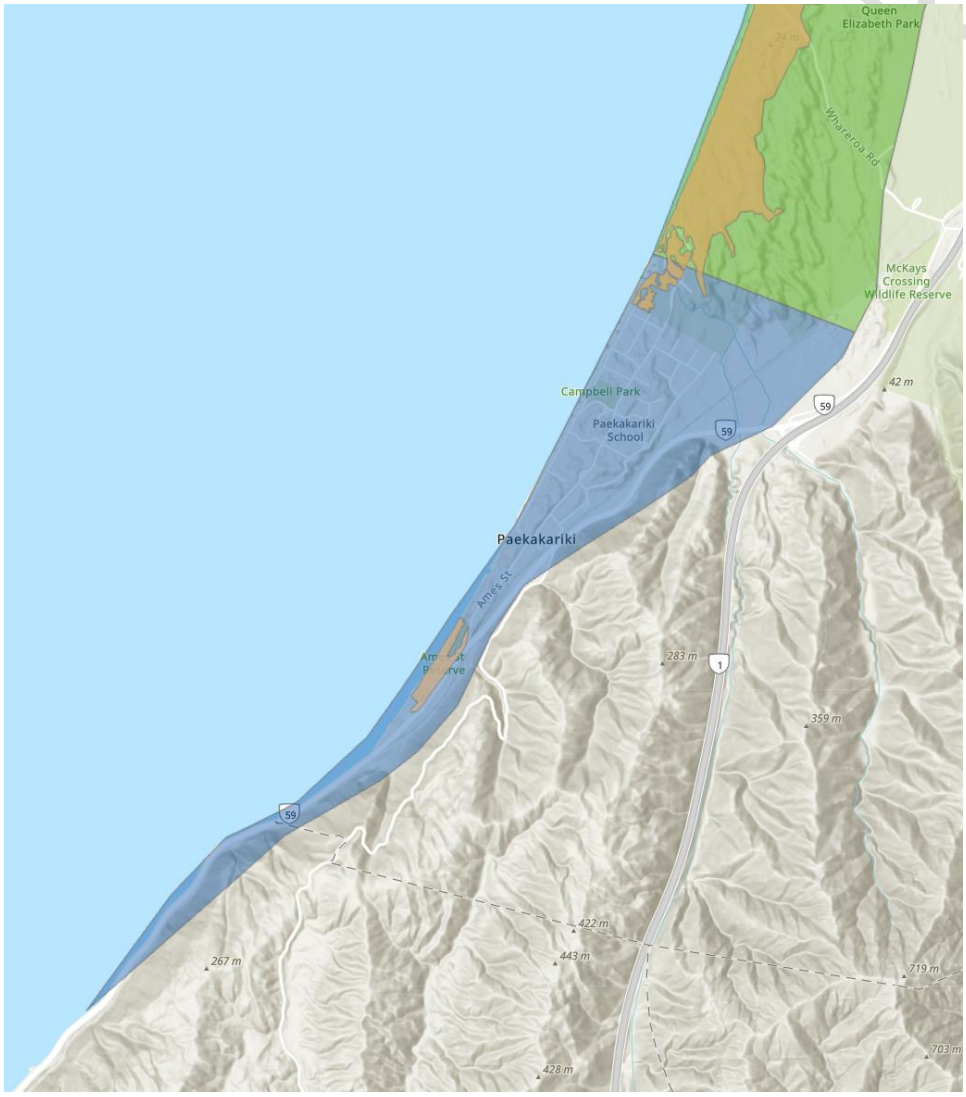

Figure A.3.1: Two areas of defined coastal dunelands within the PAA (brown areas).

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:
- Currently there are two areas of dune exposed to short term storm erosion:
  o Queen Elizabeth Park dunes and
  o Fisherman's Table dunelands
- Present day erosion could affect 10% of Queen Elizabeth Park dunes and 43% of Fisherman's Table dunes
	Future exposure:
	- 2050: 27% of Queen Elizabeth Park dunes and 51% of Fisherman's Table dunes
	- 2070: 29% of Queen Elizabeth Park dunes and 55% of Fisherman's Table dunes
	- 2130: 57% of Queen Elizabeth Park dunes and 77% of Fisherman's Table dunes
	Over the two areas the erosion increases from a present-day average of 29% - 41% to 44% - 69% in 2130

Currently exposed to coastal flooding: - Currently there are two areas of dune exposed to potential flooding. - Queen Elizabeth Park dunes and - Fisherman's Table dunelands - Present day flooding could affect 5% of Queen Elizabeth Park dunes and 8% of Fisherman's Table dunes	Future exposure: - 2050: 16% of Queen Elizabeth Park dunes and 7% of Fisherman's Table dunes - 2070: 18% of Queen Elizabeth Park dunes and 7% of Fisherman's Table dunes - 2130: 21% of Queen Elizabeth Park dunes and 13% of Fisherman's Table dunes Over the two areas the flooding risk increases from a present-day average of 8% -11% to 12% - 17% in 2130

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

Notes:

- Due to the shape of the coast, there is a reduced sediment supply to the Paekākāriki foreshore.
- This means that the beach and dune systems are not replenished and move inland with erosion.
- Ad hoc public and private coastal protection structures (seawalls) have been constructed since at least the 1950s.
- Hard structures can cause waves to deflect, so erosion can occur in two directions, one from the sea and the other from deflected waves.
- The Kāpiti Coast is subsiding due to tectonic movement and this has been considered for effects on dunes.

Erosion:

- Measured from the toe of the dunes to the highest modelled erosion line.
- Erosion is more significant for the Fisherman's Table dunes because these are a long linear feature, so although erosion does not penetrate as far inland as for the Queen Elizabeth Park dunes, the total area eroded is greater (up to 77% versus 57% in 2130).
- Erosion for the Queen Elizabeth Park dunes is along the Wainui Stream as well as parallel to the shore.
- Present day erosion risk is already moderate and this is expected to increase progressively to high in 2130.

Flooding:

- Measured as the area of dune affected by the modelled flooding.
- Due to the high land elevations in Paekākāriki, the present-day flood hazard is very minimal.
- The Queen Elizabeth Park dunes are more susceptible to flooding due to floods travelling up the Wainui Stream.
- Present-day flood risk is low, and although this does increase over the various scenarios it does not exceed 25% overall and therefore remains low.

Sensitivity

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

Notes:

- Due to low sand supply to the Paekākāriki foreshore it may be difficult for damaged dunes to re-establish. 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 both dune areas (Queen Elizabeth Park more so than Fisherman's Table) 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.
- Both dunes already have very steep seaward facing slopes, which increases the risk of slope collapse.
- 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, limited room for the dune re-establish inland, and lack of coastal sand input.
- From 2070 on the sensitivity has been increased to high because the Ames Street Reserve seawall (protecting Fisherman's Table dunes) is near the end of its projected life, and because of the steep seaward foredune faces.

Flooding:

- Present-day sensitivity to flood events is ranked as low as both areas 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	Low volume of sand supply. Dunes can move progressively inland to some extent, but there are inland human infrastructures that will limit such movement. Storm surge and more frequent flood events lowering beach profile, and tectonic subsidence, allowing storm surge to move further inland and causing greater erosion. Very steep foredune faces. Pest plants resulting in less stable dunes. But significant areas of indigenous vegetation that help stabilise current dunes.
Coastal Flooding	L	The dunes could be eroded from 1) storm surge, 2) Wainui Stream flood events, 3) deflected waves from hard structures. If this happens then the dunes will disappear and make the area more sensitive to flooding. Due to low sand input and limited opportunity of dunes to move progressively inland there is low adaptive capacity. However, the area is generally more elevated and therefore flooding may not be as frequent or severe as in other parts of the Kāpiti Coast.

Vulnerability Score

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

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
Erosion	M	M	H	H	L	M	M	H	H
Flooding	L	L	L	M	L	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	H	M	M	H	H	M	M	M	H
Risk from Flooding	L	L	L	L	L	L	L	M	L	L	L	L

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 - Currently there are two areas of dune exposed to short term storm erosion: - Queen Elizabeth Park dunes and - Fisherman's Table dunelands Present day erosion could affect 10% of Queen Elisabeth Park dunes and 43% of Fisherman's Table dunes	Future exposure: - 2050: 27% of Queen Elizabeth Park dunes and 51% of Fisherman's Table dunes - 2070: 29% of Queen Elizabeth Park dunes and 59% of Fisherman's Table dunes - 2130: 71% of Queen Elizabeth Park dunes and 90% of Fisherman's Table dunes
Currently exposed to coastal flooding - Currently there are two areas of dune exposed to potential flooding. - Queen Elizabeth Park dunes and - Fisherman's Table dunelands Present day flooding could affect 5% of Queen Elizabeth Park dunes and 8% of Fisherman's Table dunes	Future exposure: - 2050: 16% of Queen Elizabeth Park dunes and 7% of Fisherman's Table dunes - 2070: 19% of Queen Elizabeth Park dunes and 8% of Fisherman's Table dunes - 2130: 25% of Queen Elizabeth Park dunes and 17% of Fisherman's Table dunes Over the two areas the flooding risk increases from a present-day average of 8% -11% to 12% - 20% in 2130

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

Notes:

- Due to the shape of the coast, there is a reduced sediment supply to the Paekākāriki foreshore.
- This means that the beach and dune systems are not replenished and move inland with erosion.
- Ad hoc public and private coastal protection structures (seawalls) have been constructed since at least the1950s.
- Hard structures can cause waves to deflect, so erosion can occur in two directions, one from the sea and the other from deflected waves.
- The Kāpiti Coast is subsiding due to tectonic movement and this has been considered for effects on dunes.

Erosion:

- Measured from the toe of the dunes to the highest modelled erosion line.
- Erosion is more significant for the Fisherman's Table dunes because these are a long linear feature, so although erosion does not penetrate as far inland as for the Queen Elizabeth Park dunes, the total area eroded is greater (up to 77% versus 57% in 2130).
- Erosion for the Queen Elizabeth Park dunes is along the Wainui Stream as well as parallel to the shore.
- Present day erosion risk is already moderate and this is expted to increase progressively to high in 2070 and to extreme in 2130 due to the significant erosion of the Fisherman's Table dunes.

Flooding:

- Measured as the area of dune affected by the modelled flooding.
- Due to the high land elevations in Paekākāriki, the present-day flood hazard is very minimal.
- The Queen Elizabeth Park dunes are more susceptible to flooding due to floods travelling up the Wainui Stream.

- Present-day flood risk is low, and this increases over the various scenarios. Although it does not exceed 25% overall flooding risk at Queen Elizabeth dunes does reach 25% in 2130 and increased to moderate.

Sensitivity

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

Notes:

- Due to reduced sand supply to the Paekākāriki foreshore is may be difficult for damaged dunes to re-establish. 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 both dune areas (Queen Elizabeth Park more so than Fisherman's Table) 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.
- Both dunes already have very steep seaward facing slopes, which increases the risk of slope collapse.
- 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 succeptible to being underminded, causing dune collapse and further erosion.

Erosion:

- Present day sensitivity has been ranked as moderate due to present day erosion risk, limited room for the dune re-establish inland, and lack of coastal sand input.
- From 2070 on the sensitivity has been increased to high because the Ames Street Reserve seawall protecting Fisherman's Table dunes near the end of its projected life, and because of the steep seaward foredune faces.

Flooding:

- Present-day sensitivity to flood events is ranked as low as both areas are elevated and therefore somewhat resilient 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	Low volume of sand supply. Dunes can move progressively inland to some extent, but there are inland human infrastructures that will limit such movement. Storm surge and more frequent flood events lowering beach profile, and tectonic subsidence, allowing storm surge to move further inland and causing greater erosion. Very steep foredune faces. Pest plants resulting in less stable dunes. But significant areas of indigenous vegetation that help stabilise current dunes.
Coastal Flooding	L	The dunes could be eroded from 1) storm surge, 2) Wainui Stream flood events, 3) deflected waves from hard structures. If this happens then the dunes will disappear and make the area more sensitive to flooding. Due to low sand input and limited opportunity of dunes to move progressively inland there is low adaptive capacity. However, the area is generally more elevated and therefore flooding may not be as frequent or severe as in other parts of the Kāpiti Coast.

Vulnerability Score

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
	Present	2050	2070	2130		Present	2050	2070	2130
Erosion	M	M	H	H	L	M	M	H	H
Flooding	L	L	L	M	L	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	H	E	M	M	H	H	M	M	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	The mouth of the Wainui Stream forms a small tidal stream mouth estuarine system near the southern entrance to Queen Elizabeth Park. The outlet is likely to be occasionally blocked creating the wetland. A small tidal pool has formed behind the beach and passes through the coastal dunes, flanked on the south side by a steep bank. On the true left bank, approximately 100m upstream from the mouth, there is an area of saltmarsh wetland. There are no GWRC Natural Resource Plan Scheduled wetlands (Outstanding nor Significant), but the wetland lies within KCDC Ecological Site K109 Queen Elizabeth Park.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Erosion could wash out the sediment that the plants are rooted in, and eventually completely erode all aspects of the wetland. This may be partially prevented by the built-up of woody debris in the stream mouth. Depending on the rate of erosion (coupled with sea-level rise and increased flooding and storms) it may be that wetland plants and a new wetland will establish further upstream, but if erosion is rapid or involves a large area then this wetland will be lost. Loss of the wetland vegetation can also result in further destabilization of the dunes and streambed leading to more or increased rates of erosion.
Coastal Flooding	Prolonged or very frequent flooding may kill some or all of the wetland plants. Flooding also creates opportunities for wetlands to establish further inland and upstream. The nature of these wetlands could differ from the estuarine and saline wetlands that currently exist to more freshwater, and the vegetation would likely be younger and less established. Some species may be lost.

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. There is limited opportunity to create additional estuarine wetland habitat upstream as much of the stream is already vegetated. Only closer to the Expressway is the stream more exposed, but this would not be suitable for estuarine wetlands.
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. There is limited opportunity to create additional estuarine wetland habitat upstream as much of the stream is already vegetated. Only closer to the Expressway is the stream more exposed, but this would not be suitable for estuarine wetlands. The extent of 2130, flooding may result in additional areas of estuarine, semi-saline wetlands that could be planted or developed.

Figure 15.3. The partially blocked Wainui Stream mouth. The Norfolk Island pine in the saltmarsh wetland (centre rear) is stabilising the environment. *Photo: Matt Todd*.

Figure 15.4. The upper tidal reach of the Wainui Stream is lined with three-square and tall fescue along the margins of the waterway. Harakeke flaxland occupies the wetland at rear. *Photo: Matt Todd*.

Figure A.3.2: Images and description from Todd *et al*. (2016)[27]. The mouth of the Wainui Stream forms a small tidal stream mouth estuarine system near the southern entrance to Queen Elizabeth Park. The outlet is likely to be occasionally blocked creating the wetland. A small tidal pool has formed behind the beach and passes through the coastal dunes, flanked on the south side by a steep bank. On the true left bank, approximately 100 m upstream from the mouth, there is an area of saltmarsh wetland.

[27] Todd, M., Kettles, H., Graeme, C., Sawyer, J., McEwan, A., Adams, L., 2016: Estuarine systems in the lower North Island/Te Ika-a-Māui: rating of significance, current status and future management options. Department of Conservation, Wellington, New Zealand. 400 p.

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 - Currently there is one small area of estuarine wetland at the mouth of the Wainui Stream - Present day erosion would barely affect the wetland	Future exposure: - 2050: *c.* 70% of the length of the stream below Queen Elizabeth Road/ Paekakariki Entrance Road could be eroded - 2070: *c.72*% of the length of the stream below Queen Elizabeth Road/ Paekakariki Entrance Road could be eroded - 2130: *c.93*% of the length of the stream below Queen Elizabeth Road/ Paekakariki Entrance Road could be eroded
Currently exposed to coastal flooding - Currently there is one small area of estuarine wetland at the mouth of the Wainui Stream - Present day flooding could affect a *c.* 3,335m^2 area downstream of Queen Elizabeth Road/Paekākāriki Entrance Road.	Future exposure: - 2050: could affect a *c.* 5,040m^2 area downstream of Queen Elizabeth Road/Paekākāriki Entrance Road - 2070: could affect a *c.* 6,230m^2 area downstream of Queen Elizabeth Road/Paekākāriki Entrance Road - 2130: could affect a *c.* 8,988m^2 area downstream of Queen Elizabeth Road/Paekākāriki Entrance Road

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

Note:

- There are no GWRC Natural Resource Plan Scheduled wetlands (Outstanding nor Significant) but the wetland lies within KCDC Ecological Site K109 Queen Elizabeth Park.
- The Todd *et al.* (2016)[28] report does not include a wetland outline on aerials, the wetland is not easily recognisable on aerials, and the location of the wetland may have changed since 2016, so it was not possible to estimate the area of wetland that could be lost.
- It is assumed that wetland will not be able to establish along the Wainui Stream inland from the Queen Elizabeth Road due to existing vegetation and the relatively steep banks.

Erosion:

- Coastal erosion is measured in straight line metres along the stream from the change in sand to land symbology on the topographic base map to the landward most edge of the erosion boundary where it meets the most inland part of the stream.
- The percentage was calculated as the distance of 'stream wetland' lost as a proportion of the distance from the sand to where Queen Elizabeth Road crosses the Wainui Stream.
- The wetland is currently not at risk of coastal erosion, so present-day risk is low.
- The risk of coastal erosion reducing the area of wetland (including complete removal) increases progressively as the amount of erosion increases to high in 2130.

Flooding:

[28] Todd, M., Kettles, H., Graeme, C., Sawyer, J., McEwan, A., Adams, L., 2016: Estuarine systems in the lower North Island/Te Ika-a-Māui: rating of significance, current status and future management options. Department of Conservation, Wellington, New Zealand. 400 p.

- Coastal flooding was measured from the change in sand to land symbology on the topographic base map and the estuarine area inland from the present day flooding hazard (see small map below) and includes all areas of flooding upstream of that line but downstream of where Queen Elizabeth Road crosses the Wainui Stream.
- The outer edge of flooding was measured and any interior 'unflooded' areas were included as these would have altered hydrology and a higher watertable and would be part of the estuarine wetland sequence (between wet and dry land).
- Refer to second small map – the arrow indicated the edge that was followed during measurements even though there was a small unflooded part nearer the stream in the inundation 2070 (SSP2-4.5) modelling.
- The risk of losing the wetland from flooding changes from present-day low risk to moderate risk during 2050 & 2070 while most of the flooding occurs within the stream corridor. More area may become available from 2130 for estuarine habitat than in the previous scenarios, so despite increased flooding the risk remains moderate.

Sensitivity

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

Notes:

Erosion:

- Present-day sensitivity has been set as moderate as erosion could remove or undermine areas that are presently wetland.
- Some wetland elements may survive/persist in parts of the stream corridor to enable future wetland establishment and/or growth.
- The sensitivity of the wetland to erosion increases to high risk in 2070 due to more than 75% of the length of the stream (downstream of the Queen Elizabeth Road/Paekākāriki Entrance Road) being at risk from erosion.

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 this estuarine wetland. Effects would depend, in part, on the duration of flooding.
- The risk for 2130 flooding remains at moderate as there is potential for estuarine wetland to establish over a greater area.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	M	That some wetland elements and plants would be retained throughout the different scenarios enabling additional areas of estuarine wetland to be created or retained downstream of Queen Elizabeth Road/Paekākāriki Entrance Road. That estuarine wetland cannot establish upstream of Queen Elizabeth Road due to the existing vegetation and relatively steep stream banks.
Coastal Flooding	M	That some wetland elements and plants would be retained throughout the different scenarios enabling additional areas of estuarine wetland to be created or retained downstream of Queen Elizabeth Road/Paekākāriki Entrance Road.

Domain	Adaptive Capacity	Key Assumptions
		That estuarine wetland cannot establish upstream of Queen Elizabeth Road due to the existing vegetation and relatively steep stream banks.

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	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	H	H	E	M	M	M	M	L	M	M	H
Risk from Flooding	L	M	M	M	M	M	M	M	L	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 - Currently there is one small area of estuarine wetland at the mouth of the Wainui Stream - Present day erosion would barely affect the wetland	Future exposure: - 2050: *c.* 70% of the length of the stream below Queen Elizabeth Road could be eroded - 2070: *c.72*% of the length of the stream below Queen Elizabeth Road could be eroded - 2130: *c.97*% of the length of the stream below Queen Elizabeth Road could be eroded
Currently exposed to coastal flooding - Currently there is one small area of estuarine wetland at the mouth of the Wainui Stream - Present day flooding could affect a *c.* 3,335m^2 area downstream of Queen Elizabeth Road/Paekākāriki Entrance Road.	Future exposure: - 2050: could affect a *c.* 5,040m^2 area downstream of Queen Elizabeth Road/Paekākāriki Entrance Road - 2070: could affect a *c.* 6,449m^2 area downstream of Queen Elizabeth Road/Paekākāriki Entrance Road - 2130: could affect a *c.* 12,330m^2 area downstream of Queen Elizabeth Road/Paekākāriki Entrance Road

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

Note:

- There are no GWRC Natural Resource Plan Scheduled wetlands (Outstanding nor Significant), but the wetland lies within KCDC Ecological Site K109 Queen Elizabeth Park.
- The Todd et al. (2016)[29] report does not include a wetland outline on aerials, the wetland is not easily recognisable on aerials, and the location of the wetland may have changed since 2016, so it was not possible to estimate the area of wetland that could be lost.
- It is assumed that wetland will not be able to establish along the Wainui Stream inland from the Queen Elizabeth Road due to existing vegetation and the relatively steep banks.

Erosion:

- Coastal erosion is measured in straight line metres along the stream from the change in sand to land symbology on the topographic base map to the landward most edge of the erosion boundary where it meets the most inland part of the stream.
- The percentage was calculated as the distance of 'stream wetland' lost as a proportion of the distance from the sand to where Queen Elizabeth Road crosses the Wainui Stream.
- The wetland is currently not at risk of coastal erosion, so present-day risk is low.
- The risk of coastal erosion reducing the area of wetland (including complete removal) increases progressively as the amount of erosion increases to extreme in 2130.

Flooding:

- Coastal flooding was measured from the change in sand to land symbology on the topographic base map and the estuarine area inland from the present day flooding hazard (see small map below) and includes all areas of flooding upstream of that line but downstream of where Queen Elizabeth Road crosses the Wainui Stream.

[29] Todd, M., Kettles, H., Graeme, C., Sawyer, J., McEwan, A., Adams, L., 2016: Estuarine systems in the lower North Island/Te Ika-a-Māui: rating of significance, current status and future management options. Department of Conservation, Wellington, New Zealand. 400 p.

- The outer edge of flooding was measured and any interior 'unflooded' areas were included as these would have altered hydrology and a higher watertable and would be part of the estuarine wetland sequence (between wet and dry land).
- The risk of losing the wetland from flooding changes from present-day low risk to moderate risk during 2050 & 2070 while most of the flooding occurs within the stream corridor. More area may become available for estuarine habitat in 2130 than in the previous scenarios, so despite increased flooding the risk remains moderate.

Sensitivity

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

Notes:

Erosion:

- Present-day sensitity has been set as moderate as erosion could remove or undermine areas that are presently wetland.
- Some wetland elements may survive/persist in parts of the stream corridor to enable future wetland establishment and/or growth.
- The sensitivity of the wetland to erosion increases to high risk in 2070 due to more than 75% of the length of the stream (downstream of the Queen Elizabeth Road/Paekākāriki Entrance Road) being at risk from erosion.

Flooding:

- Present-day sensitivity has been set as moderate as flooding could adversly 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 adversly affect this estuarine wetland. Effects would depend, in part, on the duration of flooding.
- The risk for 2130 flooding remains at moderate as there is potential for estuarine wetland to establish over a greater area.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	M	That some wetland elements and plants would be retained throughout the different scenarios enabling additional areas of estuarine wetland to be created or retained downstream of Queen Elizabeth Road/Paekākāriki Entrance Road. That estuarine wetland cannot establish upstream of Queen Elizabeth Road due to the existing vegetation and relatively steep stream banks.
Coastal Flooding	M	That some wetland elements and plants would be retained throughout the different scenarios enabling additional areas of estuarine wetland to be created or retained downstream of Queen Elizabeth Road/Paekākāriki Entrance Road. That estuarine wetland cannot establish upstream of Queen Elizabeth Road due to the existing vegetation and relatively steep stream banks.

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	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	H	E	M	M	M	M	M	M	M	H
Risk from Flooding	L	M	M	M	M	M	M	M	L	M	M	M

A.3.3 Mapped ecological sites

Domain	Element at Risk	Overview
Ecological	Mapped ecological sites	Within the PAA there are (parts of) nine mapped areas, including seven areas that have ecological values. Murray Hill Point and Campbell Park are Informal Recreation/Leisure and Organised Sports/Activities areas respectively and will not be discussed further. KCDC Ecological Site K110 Fisherman's Table and Ames Street Reserve Managed Open Space areas are essentially the same, so only K110 Fisherman's Table will be included in the calculations. The sites with ecological values are: ▪ QEII covenant 5-07-317 – 9% within PAA ▪ K110 Fisherman's Table - 100% within PAA ▪ K221 Paekākāriki escarpment - 49% within PAA (not affected by any of the scenarios so excluded from further discussion) ▪ K135 Pukerua Bay Coastal Scarp- 18% within PAA ▪ K109 Queen Elizabeth Park – 2% within PAA ▪ Queen Elizabeth Park - 5% within PAA

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 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. Loss of the ecological values associated with a dune and wetland landscape. Erosion of habitat of native fauna including northern blue penguin 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. Erosion would also remove some of the human infrastructure such as walking/cycling tracks, and bridges and potentially even undermine roads. This would make predator and pest plant control more difficult and could reduce ecological values.
Coastal Flooding	Due to the high land elevations in Paekākāriki, the present-day flood hazard is very minimal and localized to the Wainui Stream and Waikākāriki Stream mouths (exits to the sea halfway along Ames Street). Dunes are a feature with somewhat higher elevation (i.e. small hills) and therefore less prone to flooding. Due to the lower land elevations around the Wainui Stream, the Queen Elizabeth Dunes would be impacted by flooding earlier than the southern Ames Street Dunes section. Flooding could increase the rate of sand removal through scour and subsequent dune collapse accelerating coastal erosion. It could scour out the streams and flood associated wetlands. Flooding would affect any low-lying penguin burrows possibly killing chicks and make access more difficult for the adults potentially resulting in nest abandonment. Any birds nesting in low lying areas would be affected, as could lizards and skinks and invertebrates.

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. 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	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. Anticipate future flooding and create vegetation types in those areas that are adaptable and also found in wetlands.

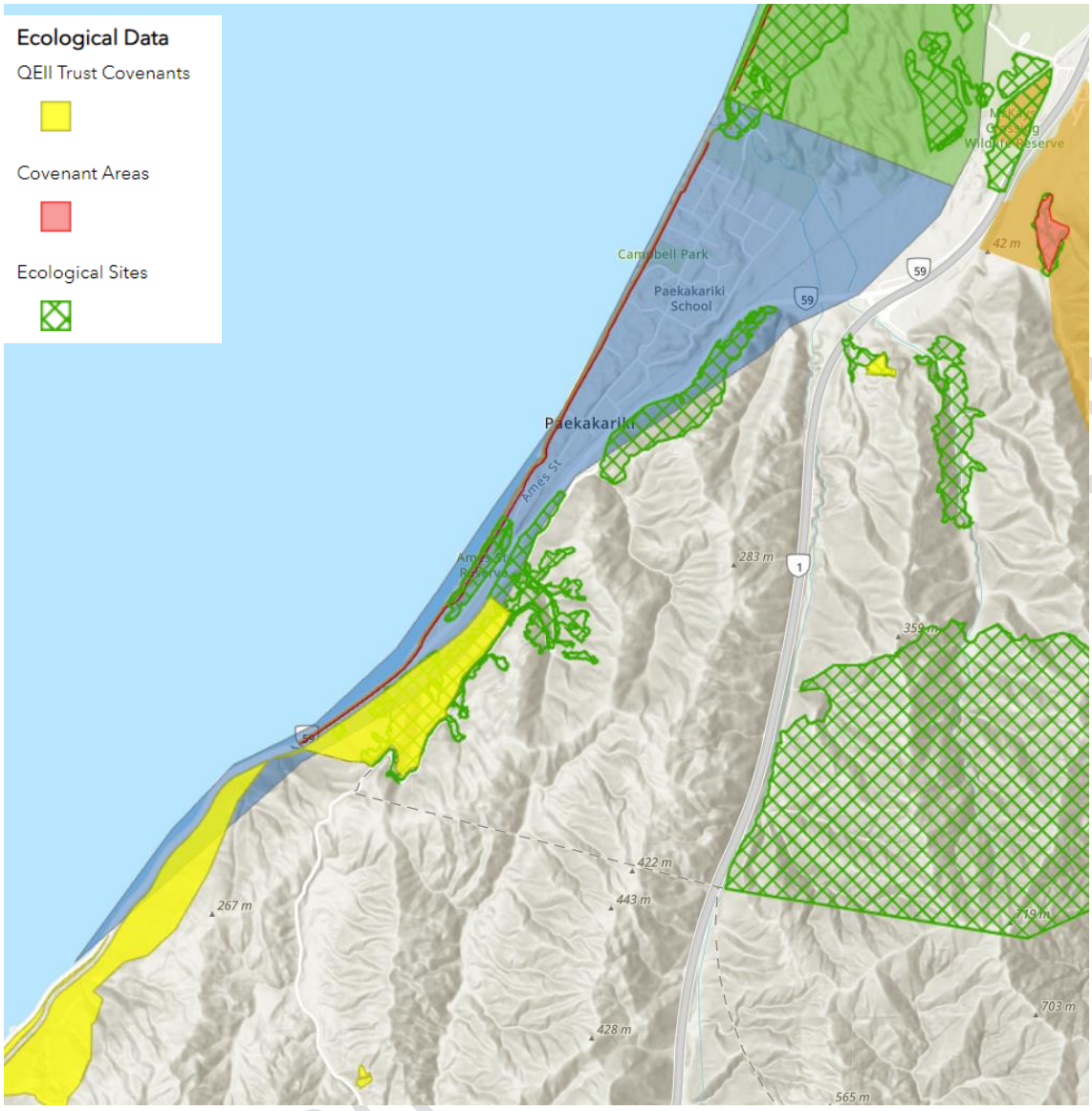

Figure A.3.3: Location of Ecological sites, Covenant Areas, and QE2 Trust Covenants.

Table A.3.1: Queen Elizabeth Trust covenant areas and KCDC Ecological Sites within the PAA

	Total area (m^2)	Area within PAA (m^2)	% of total area
QEII covenant 5-07-317	965338.7	90617.59	9%
K110 Fisherman's Table	52853.75	52861	100%
K221 Paekākāriki escarpment	188218.3	91308	49%
K135 Pukerua Bay Coastal Scarp	394715.6	70371	18%
K109 Queen Elizabeth Park	1095026	24649	2%

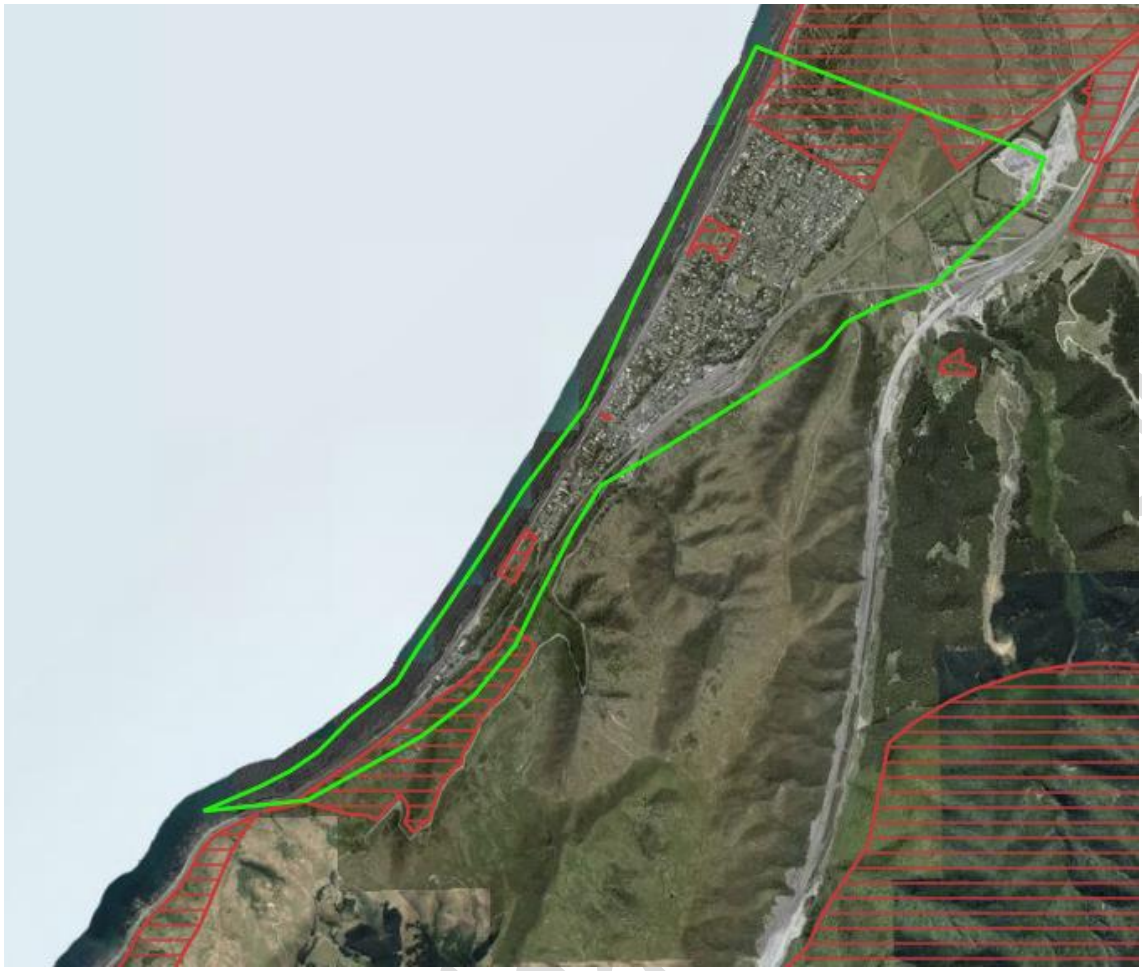

Figure A.3.4: GWRC Managed Open Space Areas within PAA.

Table A.3.2: GWRC Managed Open Space Areas within PAA. Note that there is an overlap between Queen Elizabeth Trust covenants and Managed Open Space. Only non-QEII Trust areas are included in the table below.

	Total area (m^2)	Area within PAA (m^2)	% of total area
Ames Street Reserve, Paekākāriki	18201.3	18204	100%
Queen Elizabeth Park	6511516	299821	5%
Murray Hill Point, Paekākāriki	417.9466	418	100%
Campbell Park, Paekākāriki	23899.82	23903	100%

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 (% of area affected within PAA): ▪ QEII covenant 5-07-317 (0%) ▪ K110 Fishermans Table (27%) ▪ K135 Pukerua Bay Coastal Scarp (0%) ▪ K109 Queen Elizabeth Park (2%) ▪ Queen Elizabeth Park (5%) Present day erosion could affect on average 7% of the area over these five sites	Future exposure: ▪ 2050: Average of 16% with a maximum of 38% for K110 Fishermans Table and 38% for K109 Queen Elizabeth Park. ▪ 2070: Average of 18% with a maximum of 46% for K110 Fishermans Table and 38% for K109 Queen Elizabeth Park. ▪ 2130: Average of 32% with a maximum of 72% for K110 Fishermans Table and 67% for K109 Queen Elizabeth Park.
Currently exposed to coastal flooding ▪ K109 Queen Elizabeth Park (16%) ▪ Queen Elizabeth Park (2%) Present day inundataion could affect on average 4% of the area over these two sites	Future exposure: ▪ 2050: 20% of K109 Queen Elizabeth Park and 2% of Queen Elizabeth Park ▪ 2070: 23% of K109 Queen Elizabeth Park and 3% of Queen Elizabeth Park ▪ 2130: 29% of K109 Queen Elizabeth Park and 4% of Queen Elizabeth Park

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

Note:

- The total approximate area of each of the mapped ecological sites potentially affected by erosion or flooding is measured and expressed as a percentage of the area of the mapped ecological sites within the PAA.
- Some mapped ecological sites occur in more than one Adaptation Area.

Erosion:

- Initially, risk was going to be assessed on the average percentage of area affected over all five sites (only including those that will be affected by erosion). However, this underrepresented the risk of the higher value sites, and therefore exposure risk instead is based on the highest percentage for any site.
- The table below provides more detailed information on erosion risk.

Erosion risk of mapped ecological areas for the SSP2.5-4.5 scenarios:

	Area within PAA (m^2)	% of area	% of area exposed to erosion present day	% of area exposed to erosion 2050	% of area exposed to erosion 2070	% of area exposed to erosion 2130
QEII covenant 5-07-317	90617.59	9%	0%	0%	0%	7%
K110 Fisherman's Table	52861	100 %	27%	38%	46%	72%

K135 Pukerua Bay Coastal Scarp	70371	18 %	0%	0%	0%	2%
K109 Queen Elizabeth Park	24649	2%	9%	38%	38%	67%
Queen Elizabeth Park	299821	5%	0%	4%	4%	10%
	Average	**40 %**	**7%**	**16%**	**18%**	**32%**

- Erosion risk increases progressively according the the percentage of the site most affected.

Flooding:

- Initially, risk was going to be assessed on the average percentage of area affected over both sites (only including those that will be affected by coastal flooding). However, this underrepresented the risk of the higher value site, and therefore exposure risk instead is based on the highest percentage for any site.
- The table below provides more detailed information on erosion risk.

Flooding risk of mapped ecological areas for the SSP2.5-4.5 scenarios:

	Area within PAA (m^2)	% of area	% of area exposed to coastal flooding at present day	% of area exposed to coastal flooding at 2050	% of area exposed to coastal flooding at 2070	% of area exposed to coastal flooding at 2130
K109 Queen Elizabeth Park	24649	2%	16%	20%	23%	29%
Queen Elizabeth Park	299821	5%	2%	2%	3%	4%
	Average	3%	9%	11%	13%	17%

- Flooding risk increases progressively according the the percentage of the site most affected.

Sensitivity

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

Notes:

- Sensitivity is scored on the basis of the mapped Ecological Sites that are most affected.
- 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.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Ecological sites have a low adaptive capacity, as they cannot move to another location, however, only parts of some of the mapped ecological sites are affected, and it may be possible to relocate specific values within an affected site.

Domain	Adaptive Capacity	Key Assumptions
Coastal Flooding	L	Ecological sites have a low adaptive capacity, as they cannot move to another location, however, only parts of some of the mapped ecological sites are affected, and it may be possible to relocate specific values within an affected site.

Vulnerability Score

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

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 (% of area affected within PAA): ▪ QEII covenant 5-07-317 (0%) ▪ K110 Fishermans Table (27%) ▪ K135 Pukerua Bay Coastal Scarp (0%) ▪ K109 Queen Elizabeth Park (2%) ▪ Queen Elizabeth Park (5%) Present day erosion could affect on average 7% of the area over these five sites	Future exposure: ▪ 2050: Average of 16% with a maximum of 38% for K110 Fishermans Table and 38% for K109 Queen Elizabeth Park. ▪ 2070: Average of 19% with a maximum of 50% for K110 Fishermans Table and 37% for K109 Queen Elizabeth Park. ▪ 2130: Average of 45% with a maximum of 90% for K110 Fishermans Table and 97% for K109 Queen Elizabeth Park.
Currently exposed to coastal flooding: ▪ K109 Queen Elizabeth Park (16%) ▪ Queen Elizabeth Park (2%) Present day erosion could affect on average 4% of the area over these two sites	Future exposure: ▪ 2050: 20% of K109 Queen Elizabeth Park and 2% of Queen Elizabeth Park ▪ 2070: 24% of K109 Queen Elizabeth Park and 3% of Queen Elizabeth Park ▪ 2130: 32% of K109 Queen Elizabeth Park and 6% of Queen Elizabeth Park

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

Note:

- The total approximate area of each of the mapped ecological sites potentially affected by erosion or flooding was measured and expressed as a percentage of the area of the mapped ecological sites within the PAA.
- Some mapped ecological sites occur in more than one Adaptation Area.

Erosion:

- Initially, risk was going to be assessed on the average percentage of area affected over all five sites (only including those that will be affected by erosion). However, this underrepresented the risk of the higher value sites, and therefore exposure risk instead is based on the highest percentage for any site.
- The table below provides more detailed information on erosion risk.

Erosion risk of mapped ecological areas for the SSP5–8.5 scenarios

	Area within PAA (m^2)	% of area ecological site	% of area exposed to erosion at present day	% of area exposed to erosion at 2050	% of area exposed to erosion at 2070	% of area exposed to erosion at 2130
QEII covenant 5-07-317	90617.59	9%	0%	0%	0%	27%
K110 Fisherman's Table	52861	100%	27%	38%	50%	90%

K135 Pukerua Bay Coastal Scarp	70371	18%	0%	0%	0%	16%
K109 Queen Elizabeth Park	24649	2%	9%	38%	37%	79%
Queen Elizabeth Park	299821	5%	0%	4%	5%	13%
	Average	27%	7%	16%	19%	45%

- Erosion risk increases progressively according the the percentage of the site most affected.

Flooding:

- Initially, risk was going to be assessed on the average percentage of area affected over both sites (only including those that will be affected by coastal flooding). However, this underrepresented the risk of the higher value site, and therefore exposure risk instead is based on the highest percentage for any site.
- The table below provides more detailed information on erosion risk.

Flooding risk of mapped ecological areas for the SSP2.5-4.5 scenarios

	Area within PAA (m^2)	% of area ecological site	% of area exposed to coastal flooding at present day	% of area exposed to coastal flooding at 2050	% of area exposed to coastal flooding at 2070	% of area exposed to coastal flooding at 2130
K109 Queen Elizabeth Park	24649	2%	16%	20%	24%	32%
Queen Elizabeth Park	299821	5%	2%	2%	3%	6%
	Average	3%	9%	11%	13%	19%

- Flooding risk increases progressively according the the percentage of the site most affected.

Sensitivity

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

Notes:

- Sensitivity is scored on the basis of the mapped Ecological Sites that are most affected.
- 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.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Ecological sites have a low adaptive capacity, as they cannot move to another location, however, only parts of some of the mapped ecological sites are affected, and it may be possible to relocate specific values within an affected site.
Coastal Flooding	L	Ecological sites have a low adaptive capacity, as they cannot move to another location, however, only parts of some of the mapped

Domain	Adaptive Capacity	Key Assumptions
		ecological sites are affected, and it may be possible to relocate specific values within an affected site.

Vulnerability Score

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

A.3.4 Indigenous trees

Domain	Element at Risk	Overview
Ecological	Indigenous trees	The survey for Key Indigenous Trees (KCDC Schedule 2) was restricted to urban allotments. Paekākāriki was not an urban area at the time due to lack of connectivity to a serviced sewerage system. Hence, there are no Key Indigenous Trees in the PAA. There are Notable Trees (KCDC Schedule 8) within the PAA but these comprise mostly exotic (Norfolk pine planted in 1830, and cork oak) or indigenous trees that are not native to the area (pohutukawa, kauri, puriri).

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	No currently mapped Key Indigenous Trees (KCDC Schedule 2) or Notable Trees (KCDC Schedule 8) are at risk of coastal erosion.
Coastal Flooding	No currently mapped Key Indigenous Trees (KCDC Schedule 2) or Notable Trees (KCDC Schedule 8) are at risk of coastal erosion.

Opportunities

Hazard	Opportunities
Coastal Erosion	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. 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.
Coastal Flooding	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.

A.3.4.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Erosion: - No mapped trees	Future exposure: - 2050: No mapped trees affected - 2070: No mapped trees affected - 2130: No mapped trees affected
Flooding: - No mapped trees	Future exposure: - 2050: No mapped trees affected - 2070: No mapped trees affected - 2130: No mapped trees affected

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

A.3.4.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Erosion: - No mapped trees	Future exposure: - 2050: No mapped trees affected - 2070: No mapped trees affected - 2130: No mapped trees affected
Flooding: - No mapped trees	Future exposure: - 2050: No mapped trees affected - 2070: No mapped trees affected - 2130: No mapped trees affected

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

A.3.5 Rare and threatened species

Domain	Element at Risk	Overview
Ecological	Rare and threatened species	Ames Street Reserve is significant breeding location for the northern blue penguin or kororā (Eudyptula minor iredalei; At Risk-Declining)[30]. Within the PAA there are records for bush falcon (Falco novaeseelandiae; Threatened-Nationally Increasing), North Island kaka (Nestor meridionalis septentrionalis; At Risk-Recovering), New Zealand Pied Shag (Phalacrocorax varius; At Risk-Recovering), and Red-billed Gull (Chroicocephalus novaehollandiae scopulinus; At Risk-Declining). At lower tides the beach would provide feeding and resting habitat for a range of seabirds and coastal birds. The areas of taller shrubs and trees would provide nesting habitat for other indigenous bird species. No lizard species have been reported from within the modelled erosion or flood hazard areas. However, this does not mean that they do not occur, merely that they have not been observed, and/or reported and/or occur in low numbers. Within the wider Paekākāriki area there are records for barking gecko (Naultinus punctatus; At Risk-Declining), copper skink (Oligosoma aeneum; At Risk-Declining), Raukawa gecko (Woodworthia maculata; Not Threatened), and northern grass skink (Oligosoma polychroma; Not Threatened). These species could all occur in the available coastal habitat types as well as in people's gardens.

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 Wainui Stream mouth, and dune habitat. This will be a more significant adverse effect for species with less mobility such as lizards and plants. Due to the modified nature of the 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 PAA, alternative coastal habitat may be significantly reduced even for mobile species.
Coastal Flooding	Coastal flooding could result in the loss of habitat (possibly temporary) for rare and threatened species, especially alterations to the Wainui Stream mouth and remnant dune habitat. This will be a more significant adverse effect for species with less mobility such as lizards and plants. Due to the highly modified nature of the 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 coastal flooding will likely affect more of the coastline than just within the PAA, alternative coastal habitat may be significantly reduced even for mobile species.

Opportunities

Hazard	Opportunities
Coastal Erosion	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.

[30] https://www.kapiticoast.govt.nz/explore-kapiti/recreation/parks-and-reserves/parks/ames-street-reserve/; https://www.kapitibiodiversity.org.nz/korora; https://paekakariki.nz/listings/penguin-park-walk/;

Hazard	Opportunities
	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 area.
Coastal Flooding	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 zones.

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 ▪ Currently there are 44 (6%) properties exposed to short term storm erosion ▪ K110 Fishermans Table (14250 m^2 potentially affected which is 27% of the area within the PAA) ▪ Queen Elizabeth Park (750 m^2 potentially affected which is less than 1% of the area within the PAA)	Future exposure: ▪ 2050: 48 private properties (6%); K110 Fishermans Table (38%) & Queen Elizabeth Park (4%) ▪ 2070: 122 private properties (16%); K110 Fishermans Table (46%) & Queen Elizabeth Park (4%) ▪ 2130: 166 private properties (72%); K110 Fishermans Table (38%) & Queen Elizabeth Park (10%)
Currently exposed to coastal flooding ▪ Currently there are 32 (4%) private properties exposed to coastal inundation – these are generally coastal properties south of The Esplanade where the property boundary extends into the coastal area. ▪ Queen Elizabeth Park (5,615 m^2 potentially affected which is 2% of the park within the PAA)	Future exposure: ▪ 2050: 35 private properties are exposed (5%); Queen Elizabeth Park (2%) ▪ 2070: 36 private properties are exposed (5%); Queen Elizabeth Park (3%) ▪ 2130: 45 private properties are exposed (6%); Queen Elizabeth Park (4%)

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

Note:

- There is little information about rare and threatened species 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. To assess the loss of potential habitat of Threatened or At Risk species a proxy was used of the number of properties that could be affected.
- Given the high level of human modification in the PAA it is probably more likely that few rare or threatened species remain in urban areas.
- Ames Street Reserve and Queen Elizabeth Park are known to have higher biodiversity values and therefore dominate the scores.
- Adverse will be greater for species with less mobility such as lizards and plants, rather than seabirds or other birds.
- However, given that coastal flooding will likely affect more of the coastline than just within the PAA, alternative coastal habitat may be significantly reduced even for mobile species.
- Effects to the Wainui Stream mouth and areas of dune elevate the risk of loss of rare or threatened species.

Erosion:

- To estimate the potential effects on rare and threatened species it was assumed that their habitat (people's gardens) would dissapear at the same rate as has been used for loss of private property.
- The rate of loss of reserve areas (K110 Fishermans Table, and Queen Elizabeth Park) is modelled on the loss of Mapped Ecological Sites.

- There is a known population of northern blue penguin residing in the coastal parts of K110 Fishermans Table[31].
- The increase to high in 2130 is due more than 65% of the reserves (K110 Fishermans Table and Queen Elizabeth Park) being affected by erosion.

Flooding:

- To estimate the potential effects on rare and threatened species it was assumed that their habitat (people's gardens) would dissapear at the same rate as has been used for loss of private property. Flooding may only be temporary, which would reduce the effects.
- The rate of loss of reserve areas (Queen Elizabeth Park) is modelled on the loss of Mapped Ecological Sites.
- Risk of flooding in the present-day risk is considered to be moderate and doesn't change during the scenarios due to the dune system that Paekākāriki is built on. It is set to moderate due to potential effects on northern blue penguins.

Sensitivity

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

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 erosion and flooding will likely affect more of the coastline than just within the PAA, alternative coastal habitat may be significantly reduced even for mobile species.
- 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 (people's gardens) would dissapear at the same rate as has been used for loss of private property.
- The rate of loss of reserve areas (K110 Fishermans Table, and Queen Elizabeth Park) is modelled on the loss of Mapped Ecological Sites.
- The increase to high in 2050 is due 46% of K110 Fishermans Table being affected by erosion and the known population of northern blue penguin residing there.

Flooding:

- To estimate the potential effects on rare and threatened species it was assumed that their habitat (people's gardens) would dissapear at the same rate as has been used for loss of private property. Flooding may only be temporary, which would reduce the effects.
- The rate of loss of reserve areas (Queen Elizabeth Park) is modelled on the loss of Mapped Ecological Sites.
- The increase to high in 2130 is due 29% of Queen Elizabeth Park (within the PAA) being affected by flooding and the known range of fauna habitat that will be lost.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	M	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.

[31] https://www.kapiticoast.govt.nz/explore-kapiti/recreation/parks-and-reserves/parks/ames-street-reserve/; https://www.kapitibiodiversity.org.nz/korora; https://paekakariki.nz/listings/penguin-park-walk/;

Domain	Adaptive Capacity	Key Assumptions
Coastal Flooding	M	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.

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	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	H	H	M	M	M	M	M	M	M	M
Risk from Flooding	M	M	M	M	M	M	M	M	M	M	M	M

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 ▪ Currently there are 44 (6%) properties exposed to short term storm erosion ▪ K110 Fishermans Table (14,250 m2 potentially affected which is 27% of the area within the PAA) ▪ Queen Elizabeth Park (750 m2 potentially affected which is less than 1% of the area within the PAA)	Future exposure: ▪ 2050: 48 private properties (6%); K110 Fishermans Table (38%) & Queen Elizabeth Park (4%) ▪ 2070: 122 private properties (16%); K110 Fishermans Table (50%) & Queen Elizabeth Park (5%) ▪ 2130: 166 private properties (72%); K110 Fishermans Table (90%) & Queen Elizabeth Park (13%)
Currently exposed to coastal flooding ▪ Currently there are 32 (4%) private properties exposed to coastal inundation – these are generally coastal properties south of The Esplanade where the property boundary extends into the coastal area. ▪ Queen Elizabeth Park (5,615 m2 potentially affected which is 2% of the park within the PAA)	Future exposure: ▪ 2050: 35 private properties are exposed (5%); Queen Elizabeth Park (2%) ▪ 2070: 36 private properties are exposed (5%); Queen Elizabeth Park (3%) ▪ 2130: 45 private properties are exposed (6%); Queen Elizabeth Park (6%)

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

Note:

- There is little information about rare and threatened species 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. To assess the loss of potential habitat of Threatened or At Risk species a proxy was used of the number of properties that could be affected.
- Given the high level of human modification in the PAA it is probably more likely that few rare or threatened species remain in urban areas.
- Ames Street Reserve and Queen Elizabeth Park are known to have higher biodiversity values and therefore dominate the scores.
- Adverse will be greater for species with less mobility such as lizards and plants, rather than seabirds or other birds.
- However, given that coastal flooding will likely affect more of the coastline than just within the PAA, alternative coastal habitat may be significantly reduced even for mobile species.
- Effects to the Wainui Stream mouth and areas of dune elevate the risk of loss of rare or threatened species.

Erosion:

- To estimate the potential effects on rare and threatened species it was assumed that their habitat (people's gardens) would dissapear at the same rate as has been used for loss of private property.
- The rate of loss of reserve areas (K110 Fishermans Table, and Queen Elizabeth Park) is modelled on the loss of Mapped Ecological Sites.

- There is a known population of At Risk-Declining northern blue penguin residing in the coastal parts of K110 Fishermans Table[32].
- The increase to high in 2070 is due more than 50% of the reserves (K110 Fishermans Table and Queen Elizabeth Park) being affected by erosion.
- The increase to extreme in 2130 is due to more than 90% of K110 Fishermans Table being affected.

Flooding:

- To estimate the potential effects on rare and threatened species it was assumed that their habitat (people's gardens) would dissapear at the same rate as has been used for loss of private property. Flooding may only be temporary, which would reduce the effects.
- The rate of loss of reserve areas (Queen Elizabeth Park) is modelled on the loss of Mapped Ecological Sites.
- Risk of flooding in the present-day risk is considered to be moderate and doesn't change during the scenarios due to the dune system that Paekākāriki is built on. It is set to moderate due to potential effects on At Risk-Declining northern blue penguins.

Sensitivity

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

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 erosion and flooding will likely affect more of the coastline than just within the PAA, alternative coastal habitat may be significantly reduced even for mobile species.
- 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 (people's gardens) would dissapear at the same rate as has been used for loss of private property.
- The rate of loss of reserve areas (K110 Fishermans Table, and Queen Elizabeth Park) is modelled on the loss of Mapped Ecological Sites.
- The increase to high in 2050 is due 46% of K110 Fishermans Table being affected by erosion and the known population of At Risk-Declining northern blue penguin residing there.

Flooding:

- To estimate the potential effects on rare and threatened species it was assumed that their habitat (people's gardens) would dissapear at the same rate as has been used for loss of private property. Flooding may only be temporary, which would reduce the effects.
- The rate of loss of reserve areas (Queen Elizabeth Park) is modelled on the loss of Mapped Ecological Sites.
- The increase to high in 2130 is due 29% of Queen Elizabeth Park (within the PAA) being affected by flooding and the known range of fauna habitat that will be lost.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	M	That less mobile rare or threatened species will not be able to move to alternative habitat and will be lost.

[32] https://www.kapiticoast.govt.nz/explore-kapiti/recreation/parks-and-reserves/parks/ames-street-reserve/; https://www.kapitibiodiversity.org.nz/korora; https://paekakariki.nz/listings/penguin-park-walk/;

Domain	Adaptive Capacity	Key Assumptions
		That mobile species such as birds move to other locations, or inland.
Coastal Flooding	M	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.

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	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	H	E	M	M	M	M	M	M	M	H
Risk from Flooding	M	M	M	M	M	M	M	M	M	M	M	M

A.3.6 Bird habitat

Domain	Element at Risk	Overview
Ecological	Bird habitat	The beach south of Paekākāriki township to Pukerua Bay provides seasonal or core habitat for black shag, pied shag, red-billed gull and white-fronted tern. The beach from Paekākāriki township to McKay's Crossing (Queen Elizabeth Park foreshore) provides seasonal or core habitat for variable oystercatcher. Wainui Stream mouth provides seasonal or core habitat for pied stilt, banded dotterel and variable oystercatcher[33]. At Risk-Declining Northern blue penguins are known to nest along in the dunes of Ames Street Reserve and are also likely to nest along the Queen Elizabeth Park dunes. At lower tides the beach would provide feedings and resting habitat for a range of seabirds including At Risk-Declining species such as red-billed gull (Tarāpunga), black-billed gull (Tarāpuka), At Risk-Recovering pied shag (Kāruhiruhi). At Risk-Relict fluttering shearwater (Pakahā) might occasionally rest on the beach but are more often sea floating in large groups just off the coast. Inland erosion and flooding distances were used as a proxy to measure the potential loss of shoreline bird habitat.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	At Risk-Declining 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 Wainui Stream mouth, and dune habitat. This will be a more significant adverse effect for species with less mobility such as lizards and plants. Due to the modified nature of the 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 PAA, alternative coastal habitat may be significantly reduced even for mobile species. Erosion and sea-level rise could over-deepen the water in the Wainui Stream estuary so that the area is no longer suitable for birds to wade 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. 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.
Coastal Flooding	Flooding could result in the (temporary) loss of habitat for bird species, including alterations to the Wainui Stream mouth, and dune habitat. The issue will be that the whole or much of the coastline will be similarly affected, so not only reducing local habitat within the PAA but also reducing habitat for birds to move too. Increased flooding is likely to result in greater sediment input into waterways, smothering in-shore benthic food sources (buried invertebrates in the sand) reducing of food supplies which

[33] McArthur N., Lawson J. 2014. Coastal and freshwater sites of significance for indigenous birds in the Wellington region, September 2013. Environmental Science Department , Greater Wellington Regional Council, Wellington, No. Publication No. GW/ESCI-T-14/67.

Hazard	Description of Consequence (note any cascading impacts)
	could adversely affect bird populations, putting them at greater risk of (local or more wide-spread) extinction.

Opportunities

Hazard	Opportunities
Coastal Erosion	Predator control program to keep birds safe. 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. Creating and/or maintaining safe bird habitat somewhere away from coastal erosion (e.g. predator control around in Queen Elizabeth Park and Ames Street Reserve, assisting private landowners with predator control around lakes and ponds with high bird values, creating an inland dune lake with beaches as bird habitat).
Coastal Flooding	Predator control program to keep birds safe. 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. Creating and/or maintaining safe bird habitat somewhere away from coastal erosion (e.g. predator control around in Queen Elizabeth Park and Ames Street Reserve, assisting private landowners with predator control around lakes and ponds with high bird values, creating an inland dune lake with beaches as bird habitat).

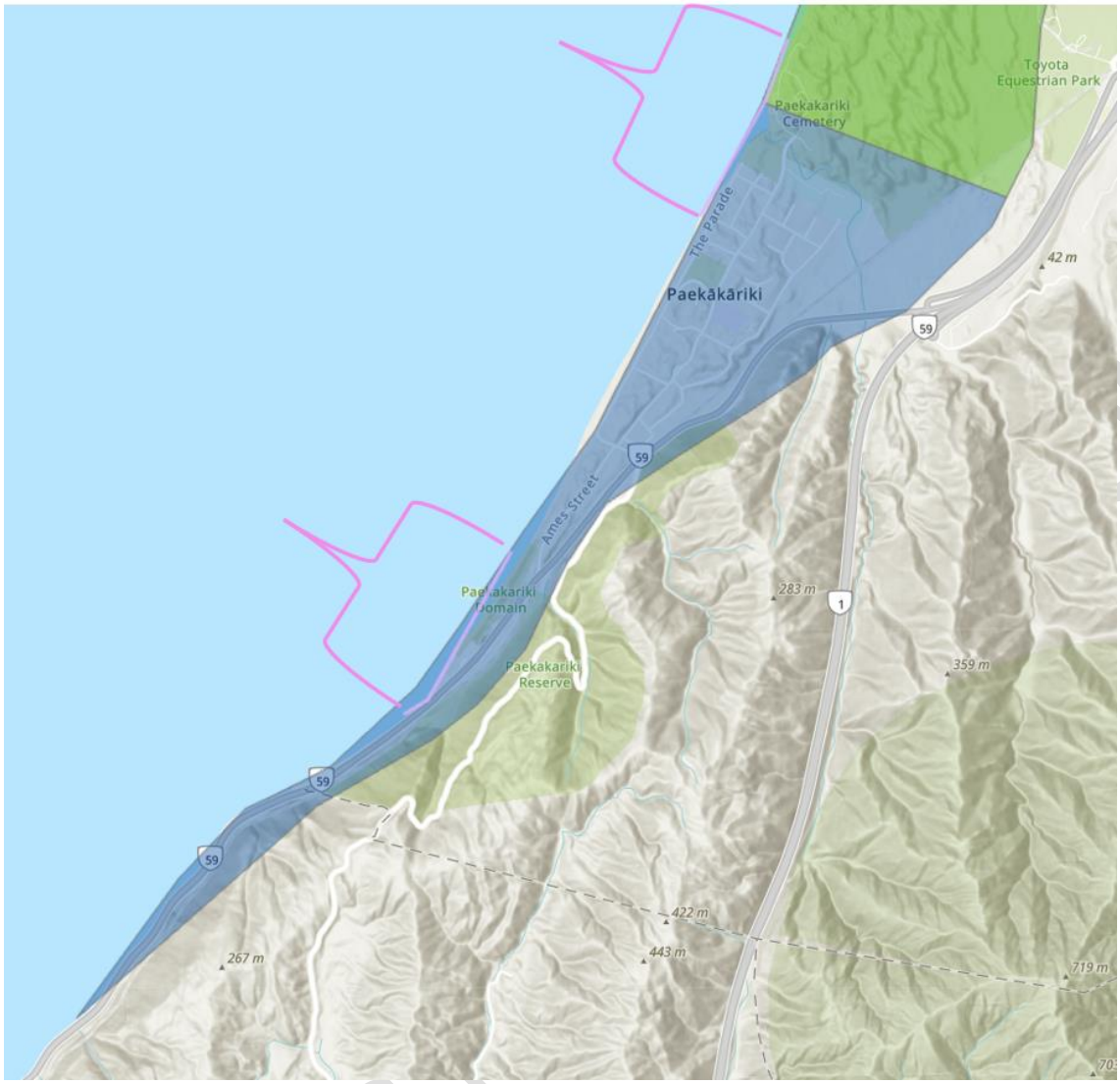

Figure A.3.5: Bird Survey Areas (Pink Brackets).

The PAA was surveyed for birds as indicated by the pink brackets. These areas provide seasonal or core habitat for black shag, pied shag, variable oystercatcher, red-billed gull, and white-fronted tern. Wainui Stream mouth provides seasonal or core habitat for pied stilt, banded dotterel and variable oystercatcher.

A.3.6.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
Erosion: Present-day average coastal erosion 86 m from current seaward beach edge	- 2050 average coastal erosion 124 m from current seaward beach edge - 2070 average coastal erosion 124 m from current seaward beach edge - 2130 average coastal erosion 162 m from current seaward beach edge
Flooding: Present-day average coastal erosion 139 m from current seaward beach edge to inland edge of coastal inundation or first coastal most 'ponding area' if there was one.	- 2050 average coastal erosion 149 m from current seaward beach edge - 2070 average coastal erosion 150 m from current seaward beach edge - 2130 average coastal erosion 156 m from current seaward beach edge

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

Note:

- Bird habitat is a function of:
  - roosting space above high tide, so that birds can rest.
  - lack of disturbance by humans and their pets, and predators (wider beaches are better). Eroded beaches are likely to provide narrower habitat.
  - availability of food; river and stream mouths, and on-shore coastal currents can deliver more food items. Erosion could change coastal currents and alter the location of river and stream mouths.
  - Availability of food – sediment deposition from erosion and/or flooding could also bury in-shore benthic food sources (buried invertebrates in the sand), reducing food for the birds
- The issue will be that the whole or much of the Kāpiti coastline will be similarly affected, so not only reducing local habitat within the PAA but also reducing habitat for birds to move too.
- Changes to stream mouths could make the habitat less suitable for birds (water too deep, edges too steep, too close to human activity).
- Loss of 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.
- An assumption has been made that the eroded beach and foreshore provides poorer quality habitat for birds and put birds in greater conflict with human interaction.

Coastal erosion:

- The present-day hazard has been set at moderate as it already extents inland from the beach indicating that bird habitat may already be deteriorating, and especially affecting penguin burrows.
- Erosion was estimated by measuring inland from the seaward edge of the beach (the outer edge of the inundation hazard as shown on the topographic base map) to the inland edge of the various hazard modelling lines (present day, 2050, 2070, and 2130) at the following locations Wainui Stream, Ocean Road, Beach Road, Waikākāriki Stream, and Ames Street reserve. These estimates were then averaged for the PAA.
- The outer edge of the inundation hazard was used as there was no topographic beach feature available, and inundation implies that there is land to be flooded. The beach is important habitat for birds.

- The increase to high in 2050 is due to effects on At Risk-Declining northern blue penguin a substantial loss of coastal habitats than previous periods.
- The increase to extreme in 2130 reflects the significant loss of coastal habitat within the PAA but also that other habitat up and down the coast will also have deteriorated and the very large effect on At Risk-Declining northern blue penguins.

Coastal flooding:

- The present-day hazard has been set at moderate as it already extents inland from the beach indicating that bird habitat may already be deteriorating.
- Coastal flooding was estimated by measuring inland from the seaward edge of the beach (as shown on the topographic base map) to the inland edge of the various hazard modelling lines (present day, 2050, 2070, and 2130) at the following Wainui Stream, Ocean Road, Beach Road, Waikākāriki Stream, and Ames Street reserve. These estimates were then averaged for the PAA.
- Due to the higher dunes in the PAA flooding risk remains at moderate for all scenarios.

Sensitivity

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

Notes:

Although the birds could potentially move to other locations when their habitat is eroded or flooded (thus a low sensitivity) the issue will be that the whole or much of the coastline will be similarly affected, so not only reducing local habitat within the PAA but also reducing habitat for birds to move too. Hence Sensitivity for the present is set to moderate.

- For erosion, the increase to high in 2050 is to the substantially greater area of bird habitat modelled to be affected. The increase to extreme in 2130 reflects the significant loss of coastal habitat within the PAA but also that other habitat up and down the coast will also have deteriorated and the very large effect on At Risk-Declining northern blue penguins.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Adaptive Capacity would have been set to high on the basis that there is other habitat where the birds can forage for food, and not be disturbed by humans. However, there will be few alternative locations for At Risk-Declining northern blue penguin nesting, and most of the coastal habitat in the Kāpiti District is subject to erosion (and flooding) thus the adaptive capacity was set to low, as there will be very limited places for birds to move to.
Coastal Flooding	L	Adaptive Capacity would have been set to high on the basis that there is other habitat where the birds can forage for food, and not be disturbed by humans. However, there will be few alternative locations for At Risk-Declining northern blue penguin nesting, and most of the coastal habitat in the Kāpiti District is subject to flooding (and erosion) thus the adaptive capacity was set to low, as there will be very limited places for birds to move to.

Vulnerability Score

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

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
Erosion	M	H	H	E	L	M	H	H	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	M	H	H	E	M	H	H	E	M	H	H	E
Risk from Flooding	M	M	M	M	M	M	M	M	M	M	M	M

A.3.6.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Erosion: Present-day average coastal erosion 86 m from current seaward beach edge (outer edge of inundation model)	▪ 2050 average coastal erosion 124 m from current seaward beach edge ▪ 2070 average coastal erosion 132 m from current seaward beach edge ▪ 2130 average coastal erosion 182 m from current seaward beach edge
Flooding: Present-day average coastal erosion 139 m from current seaward beach edge (outer edge of inundation model) to inland edge of coastal inunadtion or first coastal most 'ponding area' if there was one.	▪ 2050 average coastal erosion 149 m from current seaward beach edge ▪ 2070 average coastal erosion 152 m from current seaward beach edge ▪ 2130 average coastal erosion 176 m from current seaward beach edge

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

Note:

- Bird habitat is a function of:
  - roosting space above high tide, so that birds can rest.
  - lack of disturbance by humans and their pets, and predators (wider beaches are better). Eroded beaches are likely to provide narrower habitat.
  - availability of food; river and stream mouths, and on-shore coastal currents can deliver more food items. Erosion could change coastal currents and alter the location of river and stream mouths.
  - Availability of food – sediment deposition from erosion and/or flooding could also bury in-shore benthic food sources (buried invertebrates in the sand), reducing food for the birds
- The issue will be that the whole or much of the Kāpiti coastline will be similarly affected, so not only reducing local habitat within the PAA but also reducing habitat for birds to move too.
- Changes to stream mouths could make the habitat less suitable for birds (water too deep, edges too steep, too close to human activity).
- Loss of 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.
- An assumption has been made that the eroded beach and foreshore provides poorer quality habitat for birds and put birds in greater conflict with human interaction.

Erosion:

- The present-day hazard has been set at moderate as it already extents inland from the beach indicating that bird habitat may already be deteriorating, and especially affecting penguin burrows.
- Erosion was estimated by measuring inland from the seaward edge of the beach (the outer edge of the inundation hazard as shown on the Topographic base map) to the inland edge of the various hazard modelling lines (present day, 2050, 2070, and 2130) at the following locations Wainui Stream, Ocean Road, Beach Road, Waikakariki Stream, and Ames Street reserve. These estimates were then averaged for the PAA.
- The outer edge of the inundation hazard was used as there was no topographic beach feature available, and inundation implies that there is land to be flooded. The beach is important habitat for birds.

- The increase to high in 2050 is due to a substantial loss of coastal habitats than previous periods.
- The increase to extreme in 2130 reflects the significant loss of coastal habitat within the PAA but also that other habitat up and down the coast will also have deteriorated and the very large effect on At Risk-Declining northern blue penguins.

Coastal flooding:

- The present-day hazard has been set at moderate as it already extents inland from the beach indicating that bird habitat may already be deteriorating.
- Coastal flooding was estimated by measuring inland from the seaward edge of the beach (as shown on the Topographic base map) to the inland edge of the various hazard modelling lines (present day, 2050, 2070, and 2130) at the following Wainui Stream, Ocean Road, Beach Road, Waikakariki Stream, and Ames Street reserve. These estimates were then averaged for the PAA.
- Due to the higher dunes in the PAA flooding risk remains at moderate for all scenarios.

Sensitivity

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

Notes:

Although the birds could potentially move to other locations when their habitat is eroded or flooded (thus a low sensitivity) the issue will be that the whole or much of the coastline will be similarly affected, so not only reducing local habitat within the PAA but also reducing habitat for birds to move too. Hence Sensitivity for the present is set to moderate.

- For erosion, the increase to high in 2050 is to the substantially greater area of bird habitat modelled to be affected. The increase to extreme in 2130 reflects the significant loss of coastal habitat within the PAA but also that other habitat up and down the coast will also have deteriorated and the very large effect on At Risk-Declining northern blue penguins.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	Adaptive Capacity would have been set to high on the basis that there is other habitat where the birds can forage for food, and not be disturbed by humans. However, there will be few alternative locations for At Risk-Declining northern blue penguin nesting, and most of the coastal habitat in the Kāpiti District is subject to erosion (and flooding) thus the adaptive capacity was set to low, as there will be very limited places for birds to move to.
Coastal Flooding	L	Adaptive Capacity would have been set to high on the basis that there is other habitat where the birds can forage for food, and not be disturbed by humans. However, there will be few alternative locations for At Risk-Declining northern blue penguin nesting, and most of the coastal habitat in the Kāpiti District is subject to flooding (and erosion) thus the adaptive capacity was set to low, as there will be very limited places for birds to move to.

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

Hazard	Sensitivity				Adaptive Capacity	Vulnerability			
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	M	H	H	E	M	H	H	E	M	H	H	E
Risk from Flooding	M	M	M	M	M	M	M	M	M	M	M	M

A.3.7 Fish habitat

Domain	Element at Risk	Overview
Ecological	Fish habitat	The main-stem stream and all tributaries of the Wainui Stream 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: Banded kokopu, common bully, giant kokopu (At Risk-Declining), koaro (At Risk-Declining), longfin eel (At Risk-Declining), redfin bully (At Risk-Declining), shortfin eel and torrentfish (At Risk-Declining). Wainui Estuary is listed in Schedule F4: Sites with significant indigenous biodiversity values in the coastal marine area as it provides seasonal or core habitat for five threatened indigenous migratory fish species: longfin eel, giant kōkopu, kōaro, redfin bully and torrentfish. The Waikākāriki Stream is not included in GWRC schedules, and there is no data available for this stream in the NZ Freshwater fish database curated by NIWA. The proxy to estimate effects on the stream mouths were distance of inland erosion and area of additional flooding or pooling.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Coastal erosion could alter the habitat, including the saline wetland, within the Wainui Stream mouth and make it less appropriate habitat for indigenous fish species. It could alter how the stream connects to more upstream portions (e.g. fish passage barriers). Rapid erosion could at times temporarily block the stream with sediment. The estuary cannot re-establish upstream of Queen Elizabeth Park Road due to the steep banks. Increased sediment in the stream (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).
Coastal Flooding	Salt water would penetrate further upstream and could potentially kill freshwater species (especially plants). There could be areas for īnanga to spawn. The depth of the water in the estuary and stream would be progressively deeper from present day to the 2130 modelling. 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 stream 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	Where possible, plant the banks of the Wainui Stream and the Waikākāriki Stream 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	Where possible, plant the banks of the Wainui Stream and the Waikākāriki Stream with suitable indigenous plant species, including the floodplain. Planting the floodplain will assist with retaining/slowing water from upstream reaches which could reduce the extent of coastal flooding. Planting will strengthen the stream banks and create habitat for indigenous species.

Hazard	Opportunities
	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 Wainui Stream 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. Wetland restoration is already underway in Queen Elizabeth Park, but most of these wetlands are nearer to the Expressway. Consider establishing additional areas of wetland (including deeper trenches) in future flood-prone areas to maintain or even increase habitat for indigenous fish.

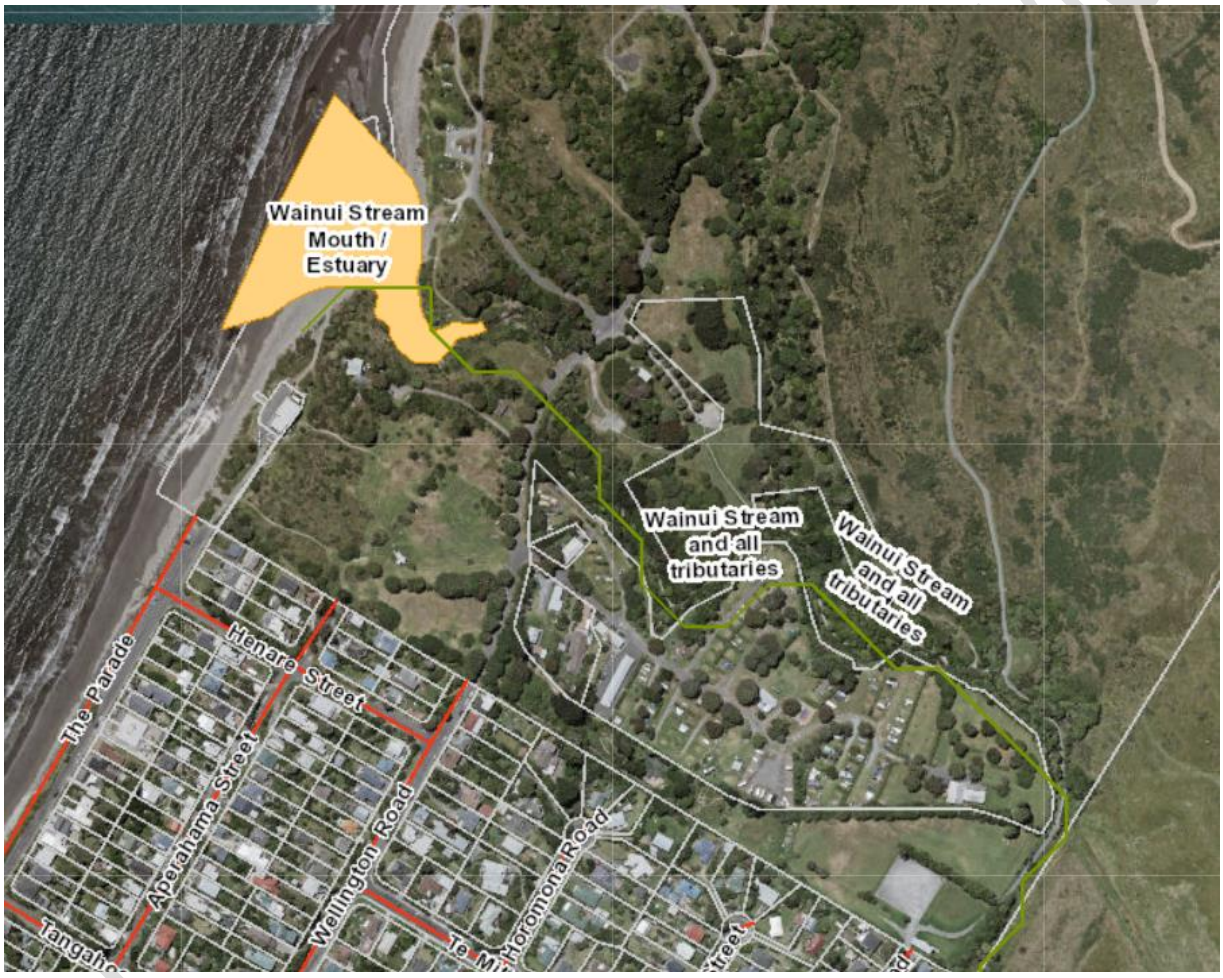

Figure A.3.6: The main-stem stream and all tributaries of the Wainui Stream are listed in GWRC Natural Resources Plan Schedule F1: Rivers and lakes with significant indigenous ecosystems.

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: ▪ Wainui Stream 114 m ▪ Waikākāriki Stream 101 m	▪ 2050: Wainui Stream 233 m, Waikākāriki Stream 106 m. ▪ 2070: Wainui Stream 240 m, Waikākāriki Stream 118 m. ▪ 2130: Wainui Stream 253 m, Waikākāriki Stream 153 m.
Present day flooding really only penetrates inland up the main-stems of the Wainui Stream and the Waikākāriki Stream. - Wainui Stream 370 m - Waikākāriki Stream 115 m .	▪ 2050: Wainui Stream 420 m, Waikākāriki Stream 115 m. ▪ 2070: Wainui Stream 420 m, Waikākāriki Stream 115 m. ▪ 2130: Wainui Stream 444 m, Waikākāriki Stream 119 m.

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

Note:

- The Wainui Stream mouth can be cut (reshaped) as a permitted activity under GWRC NRP Rule R214 when the channel outlet within the coastal marine area migrates either south of or 60m north of the end of the pole retaining structure. And/or when the stream mouth closes or the distance between the timber bridge desk (approximately 50m upstream) is less than 1.5m in normal flow at low tide.
- The Waikākāriki Stream mouth can be cut (reshaped) as a permitted activity under GWRC NRP Rule R214 when the channel outlet within the coastal marine area migrates either south and undermines the protection wall, or north and creates a vertical scarp in the sand dunes which exceeds 1m in height. And/or when the stream mouth closes or becomes blocked with debris and logs or the distance from the top of the right-hand side of the training wall looking landward to the water level is less than 900mm.
- Therefore, fish habitat within the stream 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 Wainui Stream and the Waikākāriki 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.
- The increase to high in 2130 is due to the more rapid erosion than previous periods.

Flooding:

- As there was little inland flooding or areas of pooling, 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 hazard modelling lines (present day, 2050, 2070, and 2130) for both Wainui Stream and the Waikākāriki 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 moderate and maintained at moderate for all scenarios.

Sensitivity

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

Notes:

- 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. Hence, moderate sensitivity. For coastal erosion, sensitivity increased in 2130 due the erosion penetrating considerable further upstream. 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	Fish can move, but upstream habitat may already be occupied by other individuals or not suitable.
Coastal Flooding	M	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
Risk from Erosion	M	M	M	H	M	M	M	M	M	M	M	M
Risk from Flooding	M	M	M	M	M	M	M	M	M	M	M	M

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 ▪ Wainui Stream 114 m ▪ Waikakariki Stream 101 m	▪ 2050: Wainui Stream 233 m, Waikakariki Stream 106 m. ▪ 2070: Wainui Stream 240 m, Waikakariki Stream 123m. ▪ 2130: Wainui Stream 260 m, Waikakariki Stream 178 m.
▪ Present day flooding is really only penetrates inland up the main-stems of the Wainui Stream and the Waikakariki Stream. ▪ Flooding – present-day average coastal erosion measured as metres from current seaward beach edge to the most inland modelled penetration of flood events up the two streams. ▪ Wainui Stream 370 m ▪ Waikakariki Stream 115 m	▪ 2050: Wainui Stream 420 m, Waikakariki Stream 115 m. ▪ 2070: Wainui Stream 427 m, Waikakariki Stream 120 m. ▪ 2130: Wainui Stream 517 m, Waikakariki Stream 138 m.

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

Note:

- The Wainui Stream mouth can be cut (reshaped) as a permitted activity under GWRC NRP Rule R214 when the channel outlet within the coastal marine area migrates either south of or 60m north of the end of the pole retaining structure. And/or when the stream mouth closes or the distance between the timber bridge desk (approximately 50m upstream) is less than 1.5m in normal flow at low tide.
- The Waikākāriki Stream mouth can be cut (reshaped) as a permitted activity under GWRC NRP Rule R214 when the channel outlet within the coastal marine area migrates either south and undermines the protection wall, or north and creates a vertical scarp in the sand dunes which exceeds 1m in height. And/or when the stream mouth closes or becomes blocked with debris and logs or the distance from the top of the right hand side of the training wall looking landward to the water level is less than 900mm.
- Therefore, fish habitat within the stream 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 Wainui Stream and the Waikākāriki 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.
- The increase to high in 2130 is due to the more rapid erosion than previous periods.

Flooding:

- As there was little inland flooding or areas of pooling, 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 hazard modelling lines (present day, 2050, 2070, and 2130) for both Wainui Stream and the Waikākāriki 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 moderate and maintained at moderate for all scenarios.

Sensitivity

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

Notes:

- 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. Hence, moderate sensitivity. For coastal erosion, sensitivity increased in 2130 due the erosion penetrating considerable further upstream. 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	Fish can move, but upstream habitat may already be occupied by other individuals or not suitable.
Coastal Flooding	M	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
Risk from Erosion	M	M	M	H	M	M	M	M	M	M	M	M
Risk from Flooding	M	M	M	M	M	M	M	M	M	M	M	M

A.3.8 Coastal indigenous biodiversity

Domain	Element at Risk	Overview
Ecological	Coastal indigenous biodiversity	Coastal indigenous biodiversity as mapped by GWRC in the NRP Schedule F4: Sites with significant indigenous biodiversity values in the coastal marine area. Wainui Estuary provides seasonal or core habitat for five threatened indigenous migratory fish At Risk-Declining species: longfin eel, giant kōkopu, kōaro, redfin bully and torrentfish. The main-stem stream and all tributaries of the Wainui Stream provide habitat for indigenous Threatened/At Risk fish species and habitat for six or more migratory indigenous fish species including: Banded kokopu, common bully, giant kokopu (At Risk-Declining), koaro (At Risk-Declining), longfin eel (At Risk-Declining), redfin bully (At Risk-Declining), shortfin eel and torrentfish (At Risk-Declining). For erosion the proxy measurements were how far inland the erosion was modelled compared to the innermost part of the mapped estuary and how much wider the estuary mouth would become. For flooding the comparison was increase in area flooded between the present day and future flood scenarios

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Erosion would widen the mouth of the stream and make it less deep (area protected by projecting land) and more exposed to waves and tides and currents. This will make it less suitable for fish and other species (greater exposure). Erosion may also result in scour and can result in significant in-stream altitude changes which may reduce connectivity to inland parts of the Wainui Stream. Or it may require that the estuary to develop more upstream but this is constrained by the Queen Elizabeth Park/Paekākāriki Entrance Road crossing over the stream and the upstream steep vegetated banks and will result in a smaller estuary. Changes to the estuary may result in fewer fish species using this habitat or reduced food availability. Changes to coastal currents resulting in alter food supplies.
Coastal Flooding	Fish species being washed inland, and potentially left to dry on temporary flooded areas. Additional low-lying areas flooding and providing temporary or more permanent habitat for fish, or an expansion of the estuary.

Opportunities

Hazard	Opportunities
Coastal Erosion	Some of the species also occur in freshwater and creating additional upstream habitat may support/enhance the population. Where possible, plant the banks of the Wainui Stream and the Waikākāriki Stream with suitable indigenous plant species, including the floodplain. Planting the floodplain will assist with retaining/slowing water from upstream reaches which could reduce the extent of coastal flooding. Planting will strengthen the stream banks and create habitat for indigenous species.
Coastal Flooding	Some of the species also occur in freshwater and creating additional upstream habitat may support/enhance the population. Where possible, plant the banks of the Wainui Stream and the Waikakariki Stream with suitable indigenous plant species, including the floodplain. Planting the floodplain will assist with

Hazard	Opportunities
	retaining/slowing water from upstream reaches which could reduce the extent of coastal flooding. Planting will strengthen the stream banks and 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 Wainui Stream 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.

Figure A.3.7: Wainui Estuary is listed in Schedule F4: Sites with significant indigenous biodiversity values in the coastal marine area as it provides seasonal or core habitat for five threatened indigenous migratory fish species: longfin eel, giant kōkopu, kōaro, redfin bully and torrentfish.

A.3.8.1 SSP2-4.5

Sea level rise scenario:	
SSP2 4.5 ☒	SSP5 8.5 ☐

Exposure

Details of exposure	
▪ Coastal erosion – present day: - Landward shift (how far inland the erosion scenario is compared to the innermost part of the mapped estuary. Set as 0 for present day scenario - Narrowest width of estuarine mouth -42 m.	2050: - Landward shift – 34 m - Estuarine mouth - 60 m 2070: - Landward shift – 41 m - Estuarine mouth - 107 m 2130: - Landward shift – 47 m - Estuarine mouth - 206 m
▪ Coastal flooding – present day the whole estuary would be flooded. ▪ Area flooded present-day – 3,348 m^2	▪ 2050 – area flooded 3,929 m^2 (17% more) ▪ 2070 – area flooded 4,671 m^2 (40% more) ▪ 2130 – area flooded 6,056 m^2 (81% more)

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

Note:

Erosion:

- Landward shift - how far inland the erosion scenario is compared to the innermost part of the mapped estuary. 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 'bay' becomes more shallow over progressive scenarios.
- Present-day risk set to moderate as some erosion is already occurring. This shifts to high in 2070 and extreme in 2130 because the estuary becomes 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.
- Effects for future scenarios are educated guestimates – more information is required on flood frequency and depth to enable more robust estimates to be made.
- Present-day risk set to moderate as some erosion is already occuring. This shifts to high in 2070 and extreme in 2130 due to the additional area flooded.
- However, these additional areas may also convey some benefits in providing additional (temporary) habitat for fauna.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	H	E

	Present	2050	2070	2130
Coastal Flooding	M	M	H	E

Notes:

- 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. 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	M	M	H	E	VL	H	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	M	M	H	E	H	H	E	E	M	M	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	
Coastal erosion – present day: - Landward shift (how far inland the erosion scenario is compared to the innermost part of the mapped estuary. Set as 0 for present day scenario - Narrowest width of estuarine mouth- 42 m.	2050: - Landward shift – 34 m - Estuarine mouth - 60 m 2070: - Landward shift – 41 m - Estuarine mouth - 207 m 2130: - Landward shift – 57 m - Estuarine mouth - 292 m
▪ Coastal flooding – present day the whole estuary would be flooded. ▪ Area flooded present-day – 3,348 m^2	▪ 2050 – area flooded 3,929 m^2 (17% more) ▪ 2070 – area flooded 4,870 m^2 (45% more) ▪ 2130 – area flooded 6,574 m^2 (96% more) plus an additional area of dunes flooded that may take on some estuarine roles of c. 4,000 m^2

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

Note:

- 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 0 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 'bay' becomes more shallow over progressive scenarios.
- Present-day risk set to moderate as some erosion is already occuring. This shifts to extreme in 2070 because the estuary becomes 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.
- Present-day risk set to moderate as some erosion is already occuring. This shifts to high in 2070 and remains high in 2130 due to the large additional area flooded that may convey some benefits in providing additional (temporary) habitat for fauna.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	E	E

	Present	2050	2070	2130
Coastal Flooding	M	M	H	E

Notes:

- 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. 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	M	M	E	E	VL	H	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	M	M	E	E	H	H	E	E	M	M	E	E
Risk from Flooding	M	M	H	H	M	M	H	E	M	M	H	E

A.4 Natural Character Risk Assessment

A.4.1 CMA A. Inner shelf 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: Inner shelf 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 5.5 km 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. The Paekākāriki Adaption Area is located within the wave shadow of Kāpiti Island south of the Paraparaumu cuspate foreland. The coastal feature is the result of progradation of coastal sediment, restricting the sediment supply further south within the adaptation area. Consequently, erosion within this adaptation area is more common than in northern areas of the district and MHWS springs coincides or comes close to seawalls and rock revetment along the length of this coastline. This area of coastal environment reflects a moderate level of natural character overall.

A.4.2 CTA3: Paekākāriki

Domain	Element at Risk	Overview
Natural Character	Section of CTA3: Paekākāriki – Coastal Terrestrial Area. (NB: Assessment of effects occurs within the Paekākāriki Adaptation Area).	Coastal Terrestrial Area 3: Paekākāriki encompasses the southern extent of the Kāpiti Coast's coastal environment. This broader area extends from the district boundary in the south, to the northern extent of Queen Elizabeth (QE) Park and includes the settlement of Paekākāriki and part of SH59 as it enters the southern end of the district from Porirua. It also includes part of the adjoining Paekākāriki Scarp where this forms an immediate and significant influence along the coastal edge. Within the Paekākāriki Adaptation Area, the underlying dune systems typically reflect parts of the eroded Old Waitarere Dune system and areas of older underlying Foxton soils upon which dunes have formed. This system has been almost completely modified to accommodate established urban development. Inland of existing coastal protection, modification predominantly encompasses residential dwellings and associated transport infrastructure, typically in association with existing coastal protection comprising a combination of rock revetment and seawalls. Notwithstanding this, pockets of remnant dunes and areas of coastal planting remain within the southern extent of QE Park as well as parts of Ames Street Reserve towards the southern end of the Adaptation Area. Like much of the Kāpiti Coast, the CTA3: Paekākāriki Coastal Terrestrial Area would have historically been characterised by extensive dune systems, native sand binders (spinifex and pingao) and coastal plants such as sand daphne and shore bindweed. Whilst parts of these dune systems remain in QE Park, vegetation cover has often been modified as a by-product of urbanization, vegetation clearance and invasion of exotic vegetation. Parts of Paekākāriki escarpment are vegetated in kohekohe, mahoe-akiraho-nikāu forest with areas of grey shrubland as well as exotic pastoral grasses and weed species. Planted Pohutukawa trees are also common along road corridors. Overall, the larger coastal terrestrial area is considered to have a moderate level of natural character overall, primarily on account of the settlement of Paekākāriki expressing a comparatively higher level of modification.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Throughout the Paekākāriki Adaptation Area, coastal erosion predominantly occurs in the context of existing modified areas with consequent reduced levels of natural character. This primarily impacts modified dunes which are currently influenced by existing seawalls and rock revetment designed to protect adjoining coastal settlement. In response to existing erosion, rock revetment also continues to the south of the Paekākāriki Adaptation Area along the edge of State Highway 59. Ongoing erosion within the coastal environment represents an ongoing influence of dynamic natural elements, patterns and processes. In this context, any change in the characteristics and qualities which result also introduces opportunities to restore natural character within this existing more modified coastal environment.
Coastal Flooding	Relatively limited flooding occurs within the context of the current extent of the coastal environment, which is typically elevated on historic dunes. Notwithstanding this, some coastal flooding occurs within lower lying areas adjoining the margins of Wainui Stream in the context of QE Park as well as some very isolated lower lying pockets within modified interdunal hollows. Extremely limited flooding extends inland of the identified coastal environment, within the context of QEII Park along the existing alignment of Wainui Stream.

Opportunities

Hazard	Opportunities
Coastal Erosion	Reinforce and restore native vegetation along riparian margins. 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 including utilizing nature-based solutions where possible.
Coastal Flooding	Reinforce indigenous margins and associated habitat opportunities at the mouths of streams, including developing nature-based solutions which restore natural character where possible. Identify opportunities to enhance and restore ecological connectivity between the coastal environment and its context / catchment.

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: ▪ Existing erosion has generally resulted in seawalls and rock revetment being introduced along the length of The Parade and adjoining residential development accessed along Ames Street. Rock revetment recommences south of Ames Street Reserve adjoining Fishermans Table and continues south along SH59 into Porirua. ▪ Areas of erosion also occur within Ames Street Reserve and the mouth or Wainui Stream within QE Park which includes limited existing erosion protection measures. Here blow outs are also common particularly where tracks through the park come close to the edge of the dunes.	Future exposure: 2050: • Erosion predominantly impacts existing modified seawalls adjoining the Parade and along State Highway 59 as well as beach front properties accessed along Ames Street and at Fishermans Table. These areas generally express higher levels of human modification including existing erosion protection which have been intrdouced and corresponding lower levels of natural character. • Some further erosion occurs at the mouth of Wainui Stream at the southern end of QE Park and within Ames Street Reserve with comparatively higher levels of natural character and in the context of more dynamic and vegetated dunes. 2070: • There is a continuation of erosion along this predominately modified coastal edge. This continues inland of The Parade and into residential properties and playing fields at Campbell Park and further south at Fishermans Table and along part of SH59 which follows the coastline. • Additional, erosion occurs at Wainui Stream and within Ames Street Reserve in the absence of any existing erosion protection. 2130: • Additional substantial erosion continues in the context of both existing modified areas of coastline supporting established settlement and in the context of Ames Street Reserve and part of QE Park. The inland extent of erosion remains confined within the existing extent of the coastal environment.
Currently exposed to coastal flooding: ▪ Parts of the coastal environment adjoining Wainui Stream within QE Park.	2050: • Negligible increase in inundantion beyond the current day hazard and primarily a the mouth of Wainui Stream. 2070: • Negible increase in flooding. 2130:

Details of exposure	
	• Negible increase in flooding with exception of very isolated pockets of flooding within interdunal hollows in context of existing high levels of modification.

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

Notes:

- Whilst the exposure of the coastal environment to erosion increases in this area, this impacts more highly modified areas of the coastal environment with more limited levels of natural character.

Sensitivity

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

Notes:

- Through the Paekākāriki Adaptation Area, the hazards created by coastal erosion generally impact more highly modified areas of coastal environment including existing seawalls, rock revetment and flood defences which border established areas of existing settlement. This uniformly has resulted in lower levels of natural character and corresponding low levels of sensitivity as a consequence. Conversely, ongoing change to modified elements, patterns and processes may also provide opportunities to restore natural character and the trajectory of such change.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	▪ Coastal erosion almost entirely impacts more modified areas which contribute to lower existing levels of natural character and therefore very limited adaptive capacity. ▪ To restore natural character where possible, responses should seek to ensure that natural elements, patterns and processes can continue to operate through appropriate human intervention and management.
Coastal Flooding	L	▪ Very limited coastal flooding occurs, most typically in the context of elevated coastal settlement.

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	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	M	M	H	L	L	L	L	L	L	L	M
Risk from Flooding	L	L	L	L	L	L	L	L	L	L	L	L

A.4.2.2 SSP5-8.5

Sea level rise scenario:	
SSP2 4.5 ☐	SSP5 8.5 ☒

Exposure

Details of exposure	
Currently exposed to coastal erosion: ▪ Existing erosion has generally resulted in seawalls and rock revetment being introduced along the length of The Parade and adjoining residential development accessed along Ames Street. Rock revetment recommences south of Ames Street Reserve adjoining Fishermans Table and continues south along SH59 into Porirua. ▪ Areas of erosion also occur within Ames Street Reserve and the mouth or Wainui Stream within QE Park which includes limited existing erosion protection measures. Here blow outs are also common particularly where tracks through the park come close to the edge of the dunes.	Future exposure: 2050: ▪ Erosion predominantly impacts existing modified seawalls adjoining the Parade and along State Highway 59 as well as beach front properties accessed along Ames Street and at Fishermans Table . These areas generally express higher levels of human modification including existing erosion protection which have been introduced and corresponding lower levels of natural character. ▪ Some further erosion occurs at the mouth of Wainui Stream at the southern end of QE Park and within Ames Street Reserve with compariitively higher levels of natural character and in the context of more intact, dynamic and vegetated dunes. 2070: ▪ There is a continuation of erosion along this predominately modified coastal edge. This continues inland of The Parade and into residential properties and playing fields at Campbell Park and further south at Fishermans Table and along part of SH59 which follows the coastline. ▪ Additional, erosion occurs at Wainui Stream and within Ames Street Reserve in the absence of any existing erosion protection. 2130: ▪ Additional substantial erosion continues in the context of both existing modified areas of coastline supporting established settlement and in the context of Ames Street Reserve and part of QE Park. The inland extent of erosion remains confined within the existing extent of the coastal environment.
Currently exposed to coastal flooding: ▪ Parts of the coastal environment adjoining Wainui Stream within QE Park.	2050: ▪ Negligible increase in inundation beyond the current day hazard and primarily at the mouth of Wainui Stream. 2070: ▪ Negligible increase in flooding. 2130: ▪ Negligible increase in flooding with exception of very isolated pockets of flooding within interdunal hollows in context of existing high levels of modification.

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

Note:

Whilst the exposure of the coastal environment to erosion increases in this area, this impacts more highly modified areas of the coastal environment with more limited levels of natural character.

Sensitivity

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

Notes:

- Through the Paekākāriki Adaptation Area, the hazards created by coastal erosion generally impact more highly modified areas of coastal environment including existing seawalls, rock revetment and flood defences which border established areas of existing settlement. This uniformly has resulted in lower levels of natural character and corresponding low levels of sensitivity. Conversely, ongoing change to modified elements, patterns and processes may also provide opportunities to restore natural character and the trajectory of such change.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	L	▪ Coastal erosion largely impacts more modified areas which contribute to lower existing levels of natural character and therefore very limited adaptive capacity. ▪ To restore natural character where possible, responses should seek to ensure that natural elements, patterns and processes can continue to operate through appropriate human intervention and management.
Coastal Flooding	L	▪ Very limited coastal flooding occurs, most typically in the context of elevated coastal settlement.

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	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	M	M	H	L	L	L	L	L	L	L	M
Risk from Flooding	L	L	L	L	L	L	L	L	L	L	L	L

A.4.3 Queen Elizabeth Park

Domain	Element at Risk	Overview
Natural Character	Queen Elizabeth Park (Part of)	Part of the Queen Elizabeth Park dune fields: ▪ *Extensive area of Older Waitarere - Motuiti dunes formed from rich sea-rafted Taupo Pumice lapilli* ▪ *A mix of native and exotic vegetation supporting ongoing restoration.* ▪ *Queens Elizabeth Park offers numerous recreational activities including walking, biking, and horse ridding* ▪ *Expansive, uncluttered views of Kāpiti Island and the Rauoterangi Channel.* The Whareroa dune field also represents a regionally significant geopreservation site and also provides habitat for a number of At Risk and Threatened species, e.g. sand coprosma, New Zealand pipit, variable oystercatcher, longfin eel.

Consequence

Hazard	Description of Consequence (note any cascading impacts)
Coastal Erosion	Coastal erosion will primarily impact areas of beach berm and foredunes as well as the mouth of Wainui Stream within which a larger component of high natural character has been identified within Queen Elizabeth Park. This area of broader dunelands contain isolated populations of native vegetation, including spinifex and pingao along relatively more dynamic coastal edges with corresponding increased levels of natural character and which remain susceptible to changes in coastal processes including erosion. Built coastal protection and associated human induced changes in response to coastal erosion have potential to adversely impact natural elements, patterns and processes and therefore reduce natural character. Such built influences are presently limited within the context of Queen Elizabeth Park.
Coastal Flooding	Relatively limited flooding occurs within the context of the current extent of the coastal environment, which is typically elevated on historic dunes. Notwithstanding this, some coastal flooding occurs within lower lying areas adjoining the margins of Wainui Stream in the context of QE Park along the existing alignment of Wainui Stream.

Opportunities

Hazard	Opportunities
Coastal Erosion	Reinforce and restore native vegetation along riparian margins and within natural dunelands along which components of high natural character form an integral part. Maintain natural patterns and processes within areas impacted by natural hazards, including dynamic dune areas. Ensure built development and modification is sympathetic to and supports underlying natural characteristics and qualities.
Coastal Flooding	Reinforce indigenous margins and associated habitat opportunities at the mouth of Wainui Stream, including to reduce or remedy slumping. Limit and remove built influences which may otherwise impact the natural character along active streams, riverbeds and their margins and ensure any necessary built development and modification is sympathetic to and supports underlying natural characteristics and qualities. 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 with native vegetation at the mouth of Wainui Stream and support a mosaic of native and exotic vegetation. ▪ The exposed coastline supports expansive views of open ocean to the south of Kāpiti Island and opportunities to experience the sounds and smells of the open ocean with limited structures.	Future exposure: **2050:** ▪ Erosion is expected to impact the existing beach berm and foredunes which commence to the north of Wainui Stream and express high natural character in addition to facilitating recreation access into the southern area of QE Park. ▪ Areas of erosion are focused within the inherently more dynamic mouth of Wainui Stream **2070:** ▪ Erosion is expected to continue to impact the existing beach berm and foredune which continues north of Wainui Stream **2130:** ▪ A further increase in erosion is expected around the mouth of Wainui Stream. This is expected to cover much of the existing foerdune and reshape this existing dynamic area of coastline.
Currently exposed to coastal flooding: ▪ Very isolated parts of the coastal environment within the southern extent of Queen Elizabeth Park adjoining the margins of the Wainui Stream.	Future exposure: **2050:** ▪ Coastal flooding primarily occurs in association with the lower lying and inherently more dynamic mouth of Wainui Stream. **2070:** ▪ A small increase in flooding occurs in association within dune swales adjoining Wainui Stream. **2130:** Additional limited flooding occurs at the mouth of Wainui Stream and continues east of Queen Elizabeth Road outside the current inland extent of the coastal environment.

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

Note:

- The bulk of Queen Elizaeth Park is located outside Paekākāriki Adaptation Area. In this context, natural elements and patterns also express natural character through the continued operation of natural processes which may encompass times of flooding and erosion.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	M	M	M	M

	Present	2050	2070	2130
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 areas within and adjoining areas of high natural character are exposed to more frequent and greater coastal hazards in the future, sensitivity to ensuring appropriate responses and modification occurs in this context expected to increase.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	M	▪ The beach berm and foredune form a dynamic edge adjoining a wider established dune sequence with limited adjoining coastal settlement. ▪ The ability for dunes to migrate at the mouth of Wainui remains largely unconstrained by adjoining settlement.
Coastal Flooding	M	▪ Most coastal flooding occurs in the context of dynamic aspects at the north of Wainui Stream ▪ Additional flooding occurs inland beyond the stream mouth of the Wainui Stream and remains in the context of Queen Elizabeth Park.

Vulnerability Score

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

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 with native vegetation at the mouth of Wainui Stream and support a mosaic of native and exotic vegetation. ▪ The exposed coastline supports expansive views of open ocean to the south of Kāpiti Island and opportunities to experience the sounds and smells of the open ocean with limited structures.	Future exposure: **2050:** ▪ Erosion is expected to impact the existing beach berm and foredunes which commence to the north of Wainui Stream and express high natural character in addition to facilitating recreation access into the southern area of QE Park. ▪ Areas of erosion are focused within the inherently more dynamic mouth of Wainui Stream **2070:** ▪ Erosion is expected to continue to impact the existing beach berm and foredune which continues north of Wainui Stream and impacts access into the northern area of QE Park. **2130:** ▪ A further substantial increase in erosion is expected in the foredune to the north of and around the mouth of Wainui Stream. This is expected to reshape this existing dynamic area of coastline.
Currently exposed to coastal flooding: ▪ Very isolated parts of the coastal environment within the southern estent of Queen Elizabeth Park adjoining the margins of the Wainui Stream.	Future exposure: **2050:** ▪ Coastal flooding primarily occurs in association with the lower lying and inherently more dynamic mouth of Wainui Stream. **2070:** ▪ A small increase in flooding occurs in association within dune swales adjoining Wainui Stream. **2130:** ▪ Additional limited flooding occurs at the mouth of Wainui Stream and continues east of Queen Elizabeth Road outside the current inland extent of the coastal environment.

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

Note:

- The bulk of Queen Elizaeth Park is located outside Paekākāriki Adaptation Area. In this context, natural elements and patterns also express natural character through the continued operation of natural processes which may encompass times of flooding and erosion.

Sensitivity

	Present	2050	2070	2130
Coastal Erosion	L	L	L	L

	Present	2050	2070	2130
Coastal Flooding	L	L	L	L

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 areas within and adjoining areas of high natural character are exposed to more frequent and greater coastal hazards in the future, sensitivity to ensuring appropriate responses and modification occurs in this context expected to increase.

Adaptive Capacity

Domain	Adaptive Capacity	Key Assumptions
Coastal Erosion	M	▪ The beach berm and foredune form a dynamic edge adjoining a wider established dune sequence with limited adjoining coastal settlement. ▪ The ability for dunes to migrate at the mouth of Wainui remains largely unconstrained by adjoining settlement. ▪ Some carparking and existing access arrangement areas will be disrupted.
Coastal Flooding	M	▪ Most coastal flooding occurs in the context of dynamic aspects at the north of Wainui Stream ▪ Additional flooding occurs inland beyond the stream mouth of the Wainui Stream and remains in the context of Queen Elizabeth Park.

Vulnerability Score

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

A.5 Cultural Risk Assessment Templates

The risk assessment of the Cultural domain in relation to coastal hazards is still be undertaken with Mana Whenua. Once completed this document will be updated and finalised.

Appendix B Full 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 - Whole Adaptation Area	L	L	L	L	E	E	E	E	L	E	E	E	E	M	M	M	M		L	L	L	M	E	E	E	E	L	E	E	E	E	M	M	M	H
Beachfront Properties only**	M	M	E	E	E	E	E	E	L	E	E	E	E	H	H	E	E		M	M	E	E	E	E	E	E	L	E	E	E	E	H	H	E	E
Water Supply Infrastructure	L	L	M	M	H	H	E	E	L	H	H	E	E	L	L	H	H		L	L	M	M	H	H	E	E	L	H	H	E	E	L	L	H	H
Stormwater Infrastructure	L	L	L	L	M	M	M	M	L	M	M	M	M	L	L	L	L		L	L	L	L	M	M	M	M	L	M	M	M	M	L	L	L	L
Roads and Bridges	L	L	L	M	H	H	E	E	L	H	H	E	E	L	L	M	H		L	L	L	M	H	H	E	E	L	H	H	E	E	L	L	M	H
Electrical Transmission and supply infrastructure	L	L	L	L	L	L	L	E	L	L	L	L	E	L	L	L	M		L	L	L	M	L	L	E	E	L	L	L	E	E	L	L	M	H
Ecological																																
Coastal dunes	M	M	M	H	M	M	H	H	L	M	M	H	H	M	M	M	H		M	M	H	E	M	M	H	H	L	M	M	H	H	M	M	H	E
Wetlands	L	H	H	E	M	M	H	H	M	M	M	M	M	L	M	M	H		M	M	H	E	M	M	H	H	M	M	M	M	M	M	M	M	H
Mapped ecological sites	L	M	M	H	L	M	M	H	L	L	M	M	H	L	M	M	H		L	M	M	E	L	M	M	E	L	L	M	M	E	L	M	M	E
Indigenous trees*	No Exposure																		No Exposure													
Rare and threatened species	M	M	H	H	M	M	M	H	M	M	M	M	M	M	M	M	M		M	M	H	E	M	M	M	H	M	M	M	M	M	M	M	M	H
Bird habitat	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
Fish habitat	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
Indigenous biodiversity (coastal)	M	M	H	E	M	M	H	E	VL	H	H	E	E	M	M	E	E		M	M	E	E	M	M	E	E	VL	H	H	E	E	M	M	E	E
Human																																
Physical human health	L	L	M	M	M	M	M	M	H	L	L	L	L	L	L	L	L		L	L	M	H	M	M	M	M	H	L	L	L	L	L	L	L	M
Mental health and identity	L	L	M	M	H	H	H	H	L	H	H	H	H	L	L	M	M		L	L	H	E	H	H	H	E	L	H	H	H	E	L	L	H	E
Social infrastructure and amenity	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	M	H	H	H	H	H	E	M	M	M	M	H	L	M	M	H		L	H	H	E	H	H	E	E	M	M	M	H	H	L	M	H	E
Social cohesion and community wellbeing	L	L	M	M	M	M	M	M	L	M	M	M	M	L	L	M	M		L	L	H	H	M	M	M	M	L	M	M	M	M	L	L	M	M
Exacerbating inequities	L	L	M	H	M	M	M	M	L	M	M	M	M	L	L	M	M		L	L	H	E	M	M	M	M	L	M	M	M	M	L	L	M	H
Natural Character																																
CTA3: Paekākāriki	L	M	M	H	L	L	L	L	L	L	L	L	L	L	L	L	M		L	M	M	H	L	L	L	L	L	L	L	L	L	L	L	L	M
Queen Elizabeth Park (Part of)	L	M	M	M	L	L	L	L	M	L	L	L	L	L	L	L	L		L	M	M	M	L	L	L	L	M	L	L	L	L	L	L	L	L

	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 - Whole Adaptation Area	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	M	L	L	L	L	M	L	L	L	L
Beachfront Properties only**	Not Assessed																	Not Assessed															
Water Supply Infrastructure	L	L	L	L	L	L	L	L	M	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	M	L	L	L	L	L	L	L	L
Stormwater Infrastructure	L	L	L	L	L	L	L	L	M	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	M	L	L	L	L	L	L	L	L
Roads and Bridges	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
Electrical Transmission and supply infrastructure	L	L	L	L	L	L	L	L	M	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	M	L	L	L	L	L	L	L	L
Ecological																																
Coastal dunes	L	L	L	L	L	L	L	M	L	L	L	L	M	L	L	L	L	L	L	L	M	L	L	L	M	L	L	L	L	M	L	L	L	M
Wetlands	L	M	M	M	M	M	M	M	M	M	M	M	M	L	M	M	M	L	M	M	M	M	M	M	M	M	M	M	M	M	L	M	M	M
Mapped ecological sites	L	M	M	M	L	M	M	M	L	L	M	M	M	L	M	M	M	L	M	M	M	L	M	M	M	L	L	M	M	M	L	M	M	M
Indigenous trees*	No Exposure																	No Exposure															
Rare and threatened species	M	M	M	M	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
Bird habitat	M	M	M	M	M	M	M	M	L	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	L	M	M	M	M	M	M	M	M
Fish habitat	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Indigenous biodiversity (coastal)	M	M	H	E	M	M	H	E	L	M	M	H	E	M	M	H	E	M	M	H	H	M	M	H	E	L	M	M	H	E	M	M	H	E
Human																																
Physical human health	L	L	L	L	M	M	M	M	H	L	L	L	L	L	L	L	L	L	L	L	L	M	M	M	M	H	L	L	L	L	L	L	L	L
Mental health and identity	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
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
Conflict, disruption and loss of trust in government	L	L	L	L	L	L	L	L	M	L	L	L	L	L	L	L	L	L	L	L	L	M	H	H	H	M	M	M	M	M	L	L	L	L
Social cohesion and community wellbeing	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
Exacerbating inequities	L	L	L	L	M	M	M	M	L	M	M	M	M	L	L	L	L	L	L	L	L	M	M	M	M	L	M	M	M	M	L	L	L	L
Natural Character																																
CTA3: Paekākāriki	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
Queen Elizabeth Park (Part of)	L	L	L	M	L	L	L	L	M	L	L	L	L	L	L	L	L	L	L	L	M	L	L	L	L	M	L	L	L	L	L	L	L	L