REPORT

Tonkin+Taylor

Beachlands South Fast Track Application

Coastal hazard NPS-NH and AUP risk assessment

Prepared for

Beachlands South Ltd Partnership

Prepared by

Tonkin & Taylor Ltd

Date

June 2026

Job Number

1014358.2501 v1.2 CHA

Together we create and sustain a better world

www.tonkintaylor.com

Document control

Title: Beachlands South Fast Track Application – Coastal hazard NPS-NH and AUP risk assessment					
Date	**Version**	**Description**	**Prepared by:**	**Reviewed by:**	**Authorised by:**
8 May 2026	0.1	Draft for internal review	R. Reinen-Hamill	M Thomas	M Thomas
3 June 2026	1.0	Revision including UNIO, SG and RMcV comments	R. Reinen-Hamill		
15 June 2026	1.1	Final	R. Reinen-Hamill		M Thomas
24 June 2026	1.2	Minor revisions	R. Reinen-Hamill		M Thomas

Distribution:

Beachlands South Ltd Partnership 1 electronic copy

Tonkin & Taylor Ltd (FILE) 1 electronic copy

Table of contents

1 Introduction

1.1 Purpose

This report has been prepared in support of a substantive application submitted by Beachlands South Limited Partnership ('BSLP') under the Fast-track Approvals Act ('FTAA'). The Project name is 'Beachlands South' and is included in Schedule 2 of the FTAA as a Listed Project with significant regional or national benefits. The Project location or Site is 110 Jack Lachlan Drive and 620, 712, 758 and 770 Whitford-Maraetai Road, Beachlands (the "Site" or the "project area").

1.2 Description of the project

In summary, the Project will provide for the development of live zoned land at Beachlands (see Figure 1.1) into a comprehensively planned and public transport focussed community to achieve a well-functioning urban environment comprising residential dwellings, a hotel and conference venue, community and commercial activities, protected ecological restoration areas, walking and cycling networks, and community facilities, and enable the potential development of two schools, as well as all associated earthworks and all associated infrastructure including transport facilities, intersection upgrades and roading, telecommunications, power, and water supply, stormwater, and wastewater infrastructure (including any treatment or storage facilities, drainage, pipes, pump stations, outfalls and discharges). A portion of Future Urban zoned land will be used for wastewater management purposes.

Key elements of the Project include:

- Residential activities comprising approximately 2,200 dwellings in a variety of housing types, densities and vacant sites for future residential development;
- Establishment of a commercial local centre supported by employment opportunities within and around the periphery of the local centre and on the Whitford-Maraetai Road frontage comprising approximately 27,000 m^2 of commercial GFA and 30,000 m^2 of light industrial GFA;
- Education facilities comprising the development of both primary and secondary schools;
- Establishment of an Ecological Protected Area Network (EPAN) comprising approximately 75 hectares of land being replanted, restored, maintained and enhanced including preservation of streams and their margins;
- A series of open spaces including a suburban park, neighbourhood parks, the Fairway Reserve, golf course, esplanade reserve and riparian margins;
- Provision of public access to and along the coastal marine area and the creation of a quality coastal pathway;
- Public transport enhancements and integrations including expanded ferry passenger capacity;
- Staged road upgrades including the provision of pedestrian and cycling facilities along Jack Lachlan Drive, the upgrade of Whitford roundabout, a series of intersection upgrades; and
- Establishment of infrastructure to service the project including wastewater, water supply, stormwater, telecommunications and power.

Figure 1.1: Project extent

1.3 Purpose

The purpose of this report is to present coastal hazard information and a risk assessment to support the substantive application with reference to both the National Policy Statement for Natural Hazards (NPS-NH) which came into force on 15 January 2026 and both the operative Auckland Unitary Plan (AUP) and the proposed Plan Change 120 (PC120) provisions.

1.4 Statement of Qualification and Experience

The report has been prepared by Richard Anthony Reinen-Hamill. I am a Chartered Engineer and a Technical Director: Coastal Engineering at Tonkin + Taylor, an environmental and engineering consultancy firm.

I have a BE (Hons) and a ME from the University of Auckland. I also have a certificate of competency in multi-hazard risk assessment from the University of Twente. I have more than 38 years' experience as a coastal engineer. In my role as a consulting engineer, I have authored more than 800 technical assessments, design and review reports and I have 15 published papers and have assisted in the preparation of four regional and national guidance notes.

I am a Fellow of Engineering New Zealand and a lifetime member of the New Zealand Coastal Society.

Relevant project experience to coastal hazard risk assessments carried out for this project include:

- NPS-NH assessment for proposed subdivision and residential development in Viaduct Harbour, Wynyard Quarter and Britomart
- Regional coastal and flood hazard risk assessment to Support Shoreline Adaptation Planning, Auckland Council
- Regional natural hazard exposure assessment, Auckland Transport

- National Climate Change Risk Assessment, Ministry for the Environment
- National coastal hazard exposure assessment, NZTA and KiwiRail
- Makara Coastal Hazard and Climate Change Strategy, Wellington City Council
- Port Phillip Bay Coastal Hazard assessment, Victoria, Department of Environment, Land, Water and Planning
- Christchurch Coastal Hazard Assessment, Christchurch City Council
- Clifton to Tangoio Coastal Hazard Strategy, Hawke's Bay Regional Council, Hastings District Council and Napier City Council
- Northland Regional Erosion Hazard Assessment, Northland Regional Council
- Coastal Erosion Hazard Susceptibility Assessment to develop Area Susceptible to Coastal Instability and/or Erosion (ASCIE) lines, Auckland Council
- State of Victoria coastal hazard mapping, Department of Sustainability and Environment, Victoria
- Coastal hazard Manual, Department of Sustainability and Environment, Victoria
- Hawkes Bay Regional Coastal Hazard Strategy, Hawke's Bay Regional Council
- Tauranga Tsunami Evacuation Study, NZ, Tauranga City
- Wellington Sea Level Rise Hazard Assessment, Wellington City Council
- Victorian coastal hazard guideline, Department of Sustainability and Environment
- Ocean Beach hazard and option assessment, Dunedin City Council

I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court of New Zealand Practice Note 2023 and that I have complied with it when preparing this report. Other than when I state I am relying on the advice of another person, this report is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

2 Hazard summary

This report relies on coastal erosion and coastal inundation information presented in T+T (2021)[1] and is included in Appendix A. The 2021 coastal hazard assessment considered all of the coastline that is part of the current proposal and considered all relevant physical coastal processes and effects over at least the next 100 years in accordance with the Ministry for Environment (MfE, 2024) guidance, the New Zealand Coastal Policy Statement (Policy 24 & 25) (NZCPS) and AUP requirements. The 2021 hazard report used natural hazard information that is still current in the Auckland Council GIS viewer and considered the RCP8.5H+ sea level rise scenario in 2130 taking into account sea level rise of 1.52 m for the erosion hazard assessment and 1 m and 2 m sea level rise for the coastal inundation assessment.

The 2021 erosion hazard assessment used upper bounds of toe erosion rates, a conservative stable angle of repose sea level factors (less than 10% exceedance) applied to the highest point within each cell and a "building block" approach of adding resultants of each hazard driver to derive the final hazard line. Comparisons of this method compared to more probabilistic assessments have shown

[1] T+T (2021) Beachlands South Private Plan Change: Coastal Hazards Assessment, T+T report ref 1014358.v3, December 2021

that the building block approach results in a wider erosion hazard zone than the probabilistic approaches.

The findings of the report identified that all property parcels, key assets and infrastructure (i.e. the sensitive and potentially sensitive activities) are located landward of the 2130 area susceptible to coastal instability and erosion. We have reviewed the proposed development included in the MasterPlan for the Project, which achieves the same outcome.

The 2021 report assessment demonstrates no coastal inundation or tsunami hazard will occur on property parcels, key assets and infrastructure, even with a consideration of 2 m sea level rise. Only beach and salt-marsh areas are susceptible to coastal inundation and are also the most likely to be affected by tsunami. These low-lying areas around the coastal edge have only been considered for recreational amenity and no habitable buildings should be located on these areas.

Since the report was issued, vertical land movement (VLM) information is available for the site that suggests an additional allowance of -1.3 mm ± 2.2 mm/year may occur at this location (Site 1318 Takiwa - Map Page). However, the level of uncertainty (+/-) is greater than the predicted subsidence value which means there is a high degree of uncertainty in this value. Considering vertical land movement as required by PC120 E36 provisions, the projected sea level rise by 2130 for SSP5-8.5p50 (including VLSM) is 1.42 m, compared to 1.25 m excluding VLM and the SSP5-8.5p83 percentile value is 2.07 m. The 50% value is less than the 1.52 m value used for the RCP8.5H+ projection to 2130, meaning that the related ASCIE line for RCP8.5H+ still provides an appropriate and precautionary assessment for erosion hazard extents over the next 100 years and can be used for the entire project area.

3 Natural hazard risk assessments

This section outlines the risk assessment considering the NPS-NH, the Operative AUP and the proposed PC 120 requirements.

3.1 National Policy Statement for Natural Hazards (NPS-NH)

3.1.1 Objective

The objective of the NPS-NH is that "Natural hazard risk to people and property associated with subdivision use and development is managed using a risk-based proportionate approach".

The NPS-NH requires the level of risk associated with subdivision, use or development to be assessed using the risk matrix (Policy 1), with the assessment considering the potential impacts of climate change to at least 100 years into the future (Policy 6) using the best available information (Policy 5). In this instance the best available information is considered to be the coastal erosion and coastal inundation information included in Appendix A.

3.1.2 NPS-NH risk assessment requirements

The NPS-NH requires the level of risk associated with subdivision, use or development to be assessed using the risk matrix (Policy 1), with the assessment considering the potential impacts of climate change to at least 100 years into the future (Policy 6) using the best available information (Policy 5) and to be in accordance with Appendix 1 of the NPS. The hazards required to be considered include:

- Coastal inundation
- Coastal erosion
- Catchment flooding
- Tsunami

- Landslips
- Liquefaction
- Active faults

Catchment flooding is covered in a separate report by Harrison Grierson. The T+T Geotechnical report (June 2026, ref 1014358.3200) addresses landslips, liquefaction and active fault assessments. This report analyses the natural hazards of coastal inundation, coastal erosion and tsunami.

The NPS-NH does not preclude Councils from managing natural hazard risk beyond the application of the NPS, including risks from other natural hazards and activities not otherwise covered, or from applying a more conservative approach to managing the natural hazard risks. The NPS-NH is an additional requirement until local authorities make changes to their regional policy statements or district plans to give effect to the NPS. We note that while PC120 deals with natural hazard risk, it is not a response to the NPS-NH, which was notified later.

3.1.3 NPS-NH risk framework

Natural hazard risk associated with subdivision, use or development must be assessed based on Appendix 1: Risk matrix, likelihood and consequence tables of the NPS-NH using the likelihood of a natural hazard event occurring combined with the consequence of a natural hazard event for both life and property to determine the level of risk. The likelihoods are shown in Table 3.1 and the consequences in Table 3.2.

Table 3.1: NPS-NH Likelihood table (Source: NPS-NH)

Likelihood level	Annual exceedance probability (AEP)	Average recurrence interval (ARI) or 'return period'
Almost Certain	10% or more	Up to and including 10 years
Very Likely	10% to 5%	Over 10 and up to and including 20 years
Likely	5% to 2%	Over 20 and up to and including 50 years
Possible	2% to 1%	Over 50 and up to and including 100 years
Unlikely	1% to 0.2%	Over 100 and up to and including 500 years
Rare	0.2% to 0.02%	Over 500 and up to and including 5,000 years
Very Rare	<0.02%	More than 5,000 years

Table 3.2: Consequence table (Source: NPS-NH)

Consequence level	Damage to property	Potential for injury or fatalities
Catastrophic	Severe damage to land and building(s), potential for collapse or total destruction of structures. Building(s) need to be demolished, rebuilt or relocated.	High threat to life safety, with probable fatalities and/or critical injuries.
Major	Major damage to land and building(s), including structural damage. Loss of use and substantial repair required.	Unsafe for people, with potential for many injuries, or critical injuries and/or fatalities.

Consequence level	Damage to property	Potential for injury or fatalities
Moderate	Some damage to land and non-structural damage to building(s). Limited loss of use, repairs required.	Unsafe for people, with potential for injuries, although expected to be minor.
Minor	Minor damage to land and building(s). No loss of use, minimal repairs required.	Isolated minor injuries possible.
Negligible	No loss of use, no building repairs required	No injury

Risks are graded from low, medium, high or very high with the risk frameworks shown in Figure 3.1 , with a requirement to avoid very high natural risk and avoiding high or medium natural risk or mitigation proportionate to the level of risk, while ensuring creation or increasing natural risk on other sites is avoided or mitigated.

Consequence Level	Likelihood Level	Almost Certain	Very Likely	Likely	Possible	Unlikely	Rare	Very Rare
	ARI (years)	up to 10	10-20	20-50	50-100	100-500	500-5000	> 5000
	AEP	10% or more	10% to 5%	5% to 2%	2% to 1%	1% to 0.2%	0.2% to 0.02%	< 0.02%
	Catastrophic	Very High	Very High	Very High	High	Medium	Medium	Medium
	Major	Very High	Very High	High	High	Medium	Medium	Medium
	Moderate	High	High	High	Medium	Medium	Low	Low
	Minor	Medium	Medium	Medium	Medium	Low	Low	Low
	Negligible	Low	Low	Low	Low	Low	Low	Low

Figure 3.1: Risk matrix (Source: NPS-NH)

When assessing natural hazard risk, consideration must be made of existing and proposed mitigation measures; and residual risk that arises when design thresholds of any existing and proposed mitigation measures are exceeded.

3.1.4 Site specific NPS-NH Risk assessment

All residential and commercial development and associated infrastructure within the Project are situated landward of the ASCIE 2130 RCP8.5+ scenario and above the 1%AEP storm surge + 2 m relative sea level rise. The likelihood of the following hazards affecting the Project over the next 100 years are:

- Coastal erosion: Unlikely
- Coastal inundation: Unlikely
- Tsunami inundation: Rare
- Landslides due to the coastal cliffs: Unlikely to rare

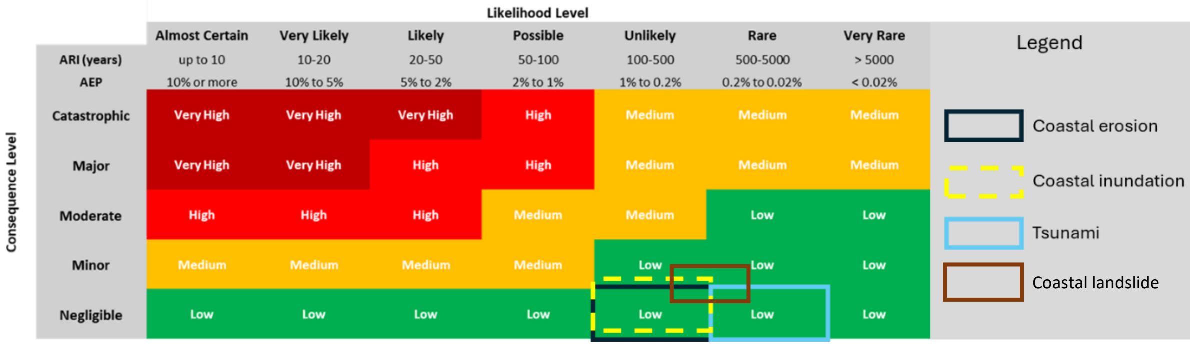
The consequence of the hazard on the Project over the next 100 years is set out in Table 3.3, with explanations of the findings.

Table 3.3: Consequence rating

Hazard	Consequence to property and people	Commentary
Coastal erosion	Negligible	Development set back landward of the 2130 RCP8.5+ hazard line
Coastal inundation	Negligible	Development set above the 1%AEP storm surge + 2 m RSLR
Tsunami	Negligible	Development set above the 1%AEP storm surge + 2 m RSLR
Landslides due to the coastal cliffs	Minor to Negligible	Development set back beyond FOS>1.5 instability zone. Cliff slope instability tends to occur in a gradual manner; i.e. initially affecting the land closest to the cliff, before affecting land set back from the clifftop. In that manner, forewarning of sea cliff related instability can often occur years or decades in advance of any impacts upon infrastructure or buildings within the development area

The resulting risk rating is **low** for all hazards in context of the NPS-NH risk matrix in Appendix 1. (Table 3.4).

Table 3.4: NPS-NH risk rating summary



Consequence Level	Almost Certain	Very Likely	Likely	Possible	Unlikely	Rare	Very Rare
ARI (years)	up to 10	10-20	20-50	50-100	100-500	500-5000	> 5000
AEP	10% or more	10% to 5%	5% to 2%	2% to 1%	1% to 0.2%	0.2% to 0.02%	< 0.02%
Catastrophic	Very High	Very High	Very High	High	Medium	Medium	Medium
Major	Very High	Very High	High	High	Medium	Medium	Medium
Moderate	High	High	High	Medium	Medium	Low	Low
Minor	Medium	Medium	Medium	Medium	Low	Low	Low
Negligible	Low	Low	Low	Low	Low	Low	Low

3.1.5 Assessment against objectives and policies

Table 3.5 provides a summary of the assessment of the Project against the objectives and policies of NPS-NH.

Table 3.5: Assessment against NPS-NH objectives and policies

Objective or policy	Assessment
Objective 1: Natural hazard risk to people and property associated with subdivision use and development is managed using a risk-based proportionate approach.	The Project avoids natural hazard risk to people and property associated with subdivision use and development based on the risk-based approach which concludes all risks are low.
Policy 1: When considering natural hazard risk associated with subdivision, use or development, the risk level must be assessed using the risk matrix.	Risk assessment completed using the risk matrix and risk level is concluded to be low.
Policy 2: Natural hazard risk associated with subdivision, use and development must be managed using an approach that is proportionate to the level of natural hazard risk.	Risk managed proportionate to the natural hazard risk

Objective or policy	Assessment
Policy 3: Where subdivision, use or development is assessed as having very high natural hazard risk, that risk must be avoided.	No aspect of the Project has been assessed as having a very high natural hazard risk
Policy 4: Where subdivision, use or development, including any associated mitigation measures, will create or increase significant natural hazard risk on other sites, that risk must be avoided or mitigated using an approach that is proportionate to the level of natural hazard risk.	With the development both landward of the 2130 ASCIE line and above the coastal inundation hazard level, the development will not result in adverse effects on the coastal hazards, and therefore the Project will not create any natural hazard risk on other sites or increase significant natural hazard risks that may be present on those other sites.
Policy 5: Natural hazard risk assessment and decisions must be based on the best available information and must be made even when that information is uncertain or incomplete.	The assessment uses the site specific coastal hazard report included in Appendix 1 that is considered the best available information.
Policy 6: The potential impacts of climate change to at least 100 years into the future must be considered.	The assessment considers climate change to at least 100 years into the future.

3.1.6 NPS-NH risk summary

The NPS-NH risk assessment approach results for the Project is assessed as low risk for coastal erosion, coastal inundation, tsunami and coastal landslides for the next 100 years for both building damage and life safety as it effectively avoids development in areas of coastal hazard exposure.

3.2 Auckland Unitary Plan (Operative)

Chapter E36 'Natural Hazards and Flooding' of PC120 has immediate legal effect and requires a hazard risk assessment to be undertaken when a subdivision, use or development requiring resource consent is proposed to be undertaken on land which is within an area susceptible to one or more natural hazards. For coastal hazards this risk assessment should also consider the effects of climate change over at least a 100-year timeframe (rounded up here to 2130).

3.2.1 Objectives and policies

The current provisions from the AUP require consideration of coastal erosion, coastal storm inundation and flooding. Objective (E36.2(1)) requires that subdivision, use and development outside urban areas does not occur unless the risk of adverse effects to people, property, infrastructure and the environment from natural hazards has been assessed and significant adverse effects are avoided, taking into account the likely long-term effects of climate change.

Policy E36.3(6) requires avoiding subdivision, use and development in greenfield areas which would result in an increased risk of adverse effects from coastal hazards, taking account of a longer-term rise in sea level.

Special Information Requirement E36.9(2) identifies the requirement for coastal inundation to consider 1% Annual Exceedance Probability (AEP) plus 1 m of sea level rise and for the coastal erosion hazard area to consider at least the next 100 years.

3.2.2 Operative AUP risk assessment

As summarised in Section 2 this report relies on coastal erosion and coastal inundation hazard information presented in T+T (2021)[2] that is included in Appendix A. The 2021 coastal hazard assessment of the site considered the physical coastal processes and effects over at least the next 100 years to provide consistency with NZCPS Policies 24 & 25 and AUP requirements. It relied on natural hazard information included in the GIS viewer and assessed the RCP8.5 and RCP8.5H+ sea level rise scenario in 2080 and 2130. This information is still up-to-date, the best available information and uses conservative and precautionary assessments of the erosion and inundation extents.

The findings of the 2021 report identified that all property parcels, key assets and infrastructure are located landward of the 2130 area susceptible to coastal instability and erosion and therefore are not at risk to these coastal hazards for at least 100 years. No coastal inundation will occur on property parcels, key assets and infrastructure, even with a consideration of 2 m sea level rise. Only beach and salt-marsh areas are susceptible to coastal inundation and are also the most likely to be affected by tsunami. These low-lying areas around the coastal edge have only been considered for recreational amenity and no habitable buildings should be located on these areas.

Therefore, risks of the proposal to coastal erosion and coastal inundation over the next 100 years are negligible.

3.2.3 Assessment against objectives and policies

The following tables assesses the Project against the objectives and policies for the operative AUP for coastal hazard risk of erosion and inundation.

Objective or Policy	Assessment response
Objectives	
E36.2 Objective (1): Subdivision, use and development outside urban areas does not occur unless the risk of adverse effects to people, property, infrastructure and the environment from natural hazards has been assessed and significant adverse effects are avoided, taking into account the likely long-term effects of climate change.	Project meets this objective as risk is negligible due to Project having no infrastructure, residential or commercial development seaward of the ASCIE 2130 (RCP8.5+) or below 1%AEP storm surge + 2 m RSLR.
E36.2 Objective (2): Subdivision, use and development, including redevelopment in urban areas, only occurs where the risks of adverse effects from natural hazards to people, buildings, infrastructure and the environment are not increased overall and where practicable are reduced, taking into account the likely long-term effects of climate change.	Project meets this objective as the Project has no infrastructure, residential or commercial development seaward of the ASCIE 2130 (RCP8.5+) or below 1%AEP storm surge + 2 m RSLR.
E36.2 Objective (3): Subdivision, use and development on rural land for rural uses is managed to ensure that the risks of adverse effects from natural hazards are not increased and where practicable are reduced.	N/A

[2] T+T (2021) Beachlands South Private Plan Change: Coastal Hazards Assessment, T+T report ref 1014358.v3, December 2021

Objective or Policy	Assessment response
E36.2 Objective (4): Where infrastructure has a functional or operational need to locate in a natural hazard area, the risk of adverse effects to other people, property, and the environment shall be assessed and significant adverse effects are sought first to be avoided or, if avoidance is not able to be totally achieved, the residual effects are otherwise mitigated to the extent practicable.	N/A
E36.2 Objective (6): Where appropriate, natural features and buffers are used in preference to hard protection structures to manage natural hazards.	Project meets this objective by locating all subdivision development landward of the 2130 ASCIE (RCP8.5+) line
Policies	
E36.3 Policy (1): Identify land that may be subject to natural hazards, taking into account the likely effects of climate change, including all of the following: 1 coastal hazards (including coastal erosion and coastal storm inundation, excluding tsunami); 2 flood hazards; 3 land instability; and 4 wildfires.	This assessment considers coastal hazards of inundation and erosion.
E36.3 Policy (2): Investigate other natural hazards to assess whether risks to people, property or the environment should be managed through the Plan or otherwise.	These are addressed in other reports
E36.3 Policy (3): Consider all of the following, as part of a risk assessment of proposals to subdivide, use or develop land that is subject to natural hazards: a) the type, frequency and scale of the natural hazard and whether adverse effects on the development will be temporary or permanent; b) the type of activity being undertaken and its vulnerability to natural hazard events; c) the consequences of a natural hazard event in relation to the proposed activity; d) the potential effects on public safety and other property; e) any exacerbation of an existing natural hazard risk or the emergence of natural hazard risks that previously were not present at the location; f) whether any building, structure or activity located on land subject to natural hazards near the coast can be relocated in the event of severe coastal erosion, inundation or shoreline retreat; g) the ability to use non-structural solutions, such as planting or the retention or enhancement of natural landform buffers to avoid, remedy or mitigate hazards, rather than hard protection structures; h) the design and construction of buildings and structures to mitigate the effects of natural hazards;	The hazard assessment considers coastal erosion including RCP8.5H+ considered a precautionary upper bound scenario for at least 100 years (i.e. 2130) and coastal inundation with up to 2 m sea level rise (more than 100 years for the high emission scenario) and the development is located landward of the ASCIE line and above the inundation level, so avoids coastal hazard risk for the activities proposed.

Objective or Policy	Assessment response
i) the effect of structures used to mitigate hazards on landscape values and public access; j) site layout and management to avoid or mitigate the adverse effects of natural hazards, including access and exit during a natural hazard event; and k) the duration of consent and how this may limit the exposure for more or less vulnerable activities to the effects of natural hazards including the likely effects of climate change.	
E36.4 Policy (4): Control subdivision, use and development of land that is subject to natural hazards so that the proposed activity does not increase, and where practicable reduces, risk associated with all of the following adverse effects: a) accelerating or exacerbating the natural hazard and/or its potential impacts b) exposing vulnerable activities to the adverse effects of natural hazards; c) creating a risk to human life; and d) increasing the natural hazard risk to neighbouring properties or infrastructure.	Project meets this policy requirement as the Project is not on land subject to coastal hazards over the next 100 years
E36.4 Policy (5): Ensure that subdivision, use and development on rural land for rural uses and in existing urban areas subject to coastal hazards avoids or mitigates adverse effects resulting from coastal storm inundation, coastal erosion and sea level rise of 1 m through location, design and management.	Project meets this policy requirement as the Project is not on land subject to coastal hazards over the next 100 years
E36.4 Policy (6): Avoid subdivision, use and development in greenfield areas which would result in an increased risk of adverse effects from coastal hazards, taking account of a longer-term rise in sea level.	Project meets this policy requirement as the Project is not on land subject to coastal hazards over the next 100 years using more conservative levels of sea level rise (i.e. 2 m) and a precautionary scenario for coastal erosion (RCP8.5 H+)
E36.4 Policy (7): Ensure that buildings in areas subject to coastal hazards are located and designed to minimise the need for hard protection structures.	Project meets this policy requirement as the Project is not on land subject to coastal hazards over the next 100 years
E36.4 Policy (8): Ensure that when locating any new infrastructure in areas potentially subject to coastal hazards consider, where appropriate, an adaptive management response taking account of a longer-term rise in sea level.	Project meets this policy requirement as the Project is not on land subject to coastal hazards over the next 100 years using more conservative levels of sea level rise (i.e. 2 m) and a precautionary scenario for coastal erosion (RCP8.5 H+)
E36.4 Policy (9): Require habitable areas of new buildings and substantial additions, alterations, modifications or extensions to existing buildings located in coastal storm inundation areas to be above the 1 per cent annual exceedance probability (AEP) coastal storm inundation event including an additional sea level rise of 1 m.	Project meets this policy requirement as the Project is not on land subject to coastal hazards over the next 100 years

Objective or Policy	Assessment response
Defences against coastal hazards	
E36.4 Policy (10): Avoid the modification, alteration or removal of sand dunes and vegetation on sand dunes which would compromise their function as natural defences for an area subject to coastal hazards and ensure adverse effects on wider coastal processes are avoided or mitigated.	No modification or alteration of the existing coastal edge is proposed.
Special information requirements	
E36.9(2): A hazard risk assessment must be undertaken when subdivision, use or development requiring resource consent is proposed to be undertaken on land which may be subject to coastal erosion and coastal inundation for at least 100 years.	A hazard risk assessment is included as Appendix A of this report covering the requirements of this policy

3.3 Auckland Unitary Plan (PC120)

3.3.1 Objectives

Objective (E36.2(3B)) requires that new subdivision, use and development avoids significant risk and only occurs when the risk from natural hazards to people, property, infrastructure and the environment is assessed as being tolerable or acceptable.

Table E36.3.1B.2 identifies that activities sensitive and potentially sensitive to natural hazards are at significant risk in all identified hazard areas. The matrix of hazard exposure and activity sensitivity that is used to characterise risk tolerance for subdivision, use and developments outside existing urbanised areas is shown in **Table 3.6**. Activities sensitive to natural hazards are activities where people are regularly present and often in a vulnerable state because they sleep there, require medical treatment, or require extra assistance to evacuate. This includes residential dwellings and associated activities, healthcare facilities and retirement villages.

Potentially sensitive activities are where people are regularly present and buildings are routinely required to carry out the activity, but people are not usually in a vulnerable state. These include offices, retail, commercial services, entertainment facilities and education facilities without overnight accommodation.

Less sensitive activities are where there are minimal presence of people and buildings and will not create public health or pollution issues. These include park infrastructure, public amenities, informal recreation and buildings for network utilities.

Table 3.6: AUP E36 definitions for different hazard levels and associated risk levels based on activity sensitivity for subdivision, use and development outside of existing urbanised areas

Hazard type		Activity sensitivity to natural hazards		
Coastal erosion	**Coastal inundation**	***Sensitive***	***Potentially sensitive***	***Less sensitive***
ASCIE 2050 (RCP8.5)	1% AEP + 0.5 m RSLR	*Significant*	*Significant*	*Acceptable*
ASCIE 2050 (RCP8.5) – ASCIE 2080 (RCP8.5)	1% AEP + 0.5 - 1 m RSLR	*Significant*	*Significant*	*Acceptable*
ASCIE 2080 (RCP8.5) – ASCIE 2130 (RCP8.5+)	1% AEP + 1 - 1.5 m RSLR	*Significant*	*Significant*	*Acceptable*

3.3.2 AUP Risk assessment

Along the coastal edge of the Project there is an ecological (EPAN) area (less sensitive) backed by sensitive activities comprise standalone residential lots ranging in size from 300 m^2 to 1000 m^2 (see Figure 3.2). All sensitive and potentially sensitive activities of the Project are landward of the ASCIE 2130 (RCP8.5H+) coastal erosion hazard line and above the 1%AEP + 1.5 m RSLR coastal inundation level and in all cases, there is also a strip of ecological land between the hazard zone and the lot boundaries. Therefore, the Project is not within any of the identified hazard overlay areas and avoids significant risk for sensitive and potentially sensitive activities over at least the next 100 years.

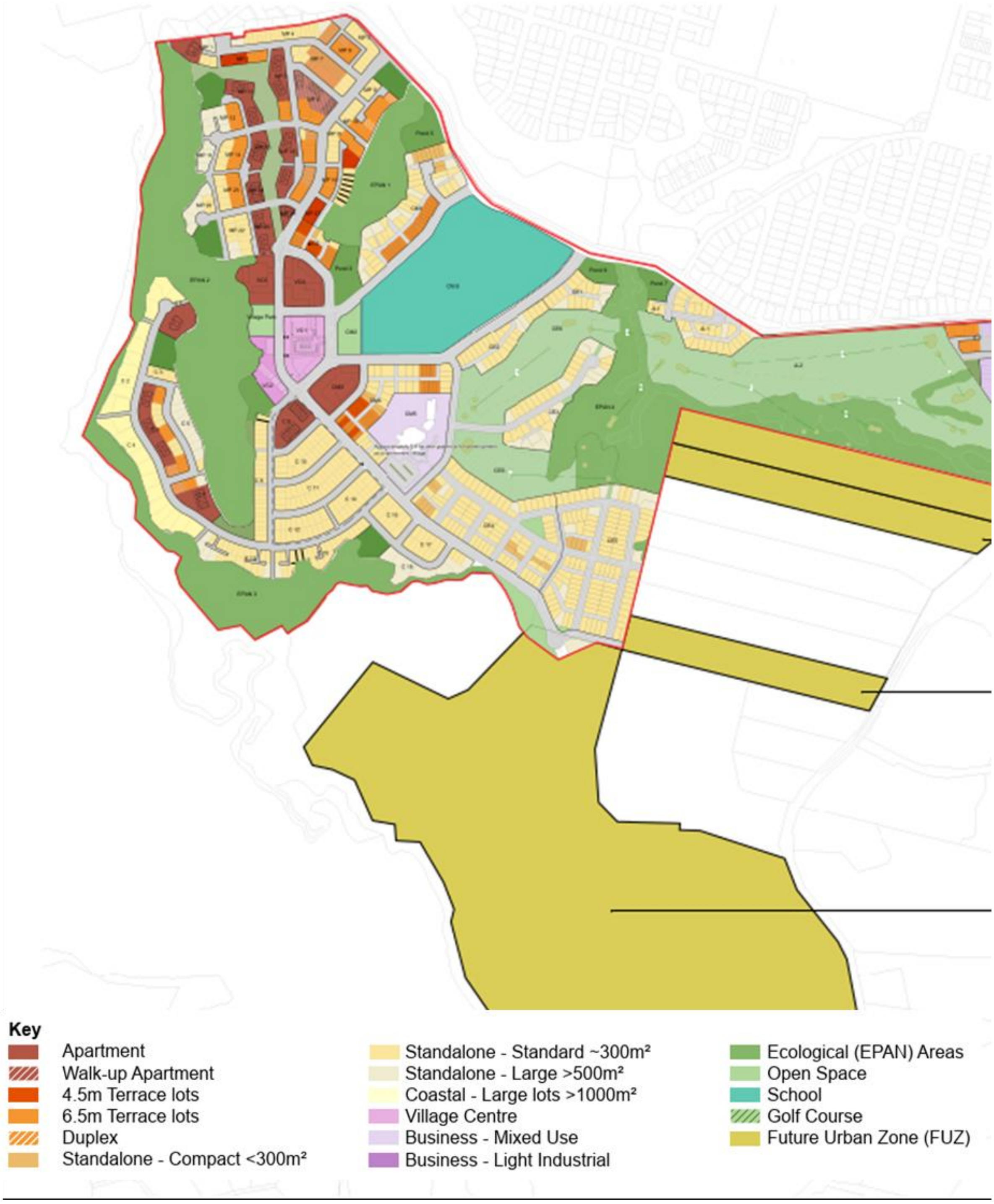


Figure 3.2: Masterplan showing ecological and open space areas fringing the coastal edge with sensitive activities landward of these areas.

In relation to the specific requirements of the both the operative provisions and PC120 Chapter E36 of the AUP, this section summarises the risk assessment covering (E36.3(3)):

- The consequences of the natural hazard in relation to the proposed activity
- Existing and proposed mitigation measures
- Residual risk
- Any relevant management plan, strategy or hazard risk assessment relating to the area.

3.3.2.1 The consequences of the natural hazard in relation to the proposed activity

This item is in reference to E36.3(3)(c) and E36.3(4A) of PC120.

3.3.2.1.1 The type of activity being undertaken and its sensitivity to natural hazard events

The Project complies with the operative AUP requirements of not increasing risk associated with coastal hazards (Policy E36.3(4)), with no sensitive or less sensitive activities seaward of the ASCIE 2130 (RCP8.5+) or below 1%AEP storm surge + 2 m RSLR.

3.3.2.1.2 Creating natural hazard risks that previously were not present at the location (PC120 E36.3(4A)(b))

There are no new coastal hazards at the location as a result of the Project.

3.3.2.1.3 Potential to accelerate or exacerbate the natural hazard and/or its potential impacts (PC120 E36.3(4A)(a))

The natural hazard assessments (coastal erosion and coastal inundation) have not identified any exacerbation of the natural hazard as a result of the Project.

3.3.2.1.4 Creating or increasing the natural hazard risk(s) to people and communities, including long-term impacts from more frequent hazard events (PC120 E36.3(4A)(d))

The Project avoids coastal erosion and coastal inundation over the next 100 years and therefore does not create or increase coastal hazard hazard risks.

3.3.2.1.5 Creating or increasing the natural hazard risk(s) to other properties, infrastructure and the environment (PC120 E36.3(4A)(e))

As the Project is landward of the ASCIE 2130 (RCP8.5+) and above 1%AEP + 2 m RSLR the development does not increase natural hazard risk to other properties, infrastructure and the environment.

3.3.2.1.6 Cultural impacts, including consequences for Māori land, Treaty Settlement, Land, marae, urupā, mana whenua cultural heritage and values (PC120 E36.3(4A)(f))

Cultural impacts have not been assessed as part of this risk assessment. However, based on information contained in the Auckland Council GIS viewer there is no Māori land, treaty settlement areas or land, marae, urupā or other sites identified within the Project area.

3.3.2.2 Existing and proposed mitigation measures (PC120 E36.3(3)(l))

The Project avoids coastal hazard risk due to its location landward of the ASCIE 2130 (RCP8.5+) hazard line and being above the 1%AEP + 2 m RSLR coastal inundation extent. This means that no mitigation measures are required.

3.3.2.3 Residual risk

For sea level rise and erosion, the climate change scenarios considered include high emission scenarios and stress tests that represent a conservative and precautionary scenario (MfE, 2024). The CAT Thermometer | Climate Action Tracker shows we are heading to between a 1.9°C to 2.6°C temperature increase by 2100, however, 3.3°C temperature increases cannot be ruled out. More likely climate scenario projections are SSP2-4.5 (possible temperature range of 2.1 to 3.5°C).

With this scenario sea level rise by 2130 is projected to be between 1 m and 1.51 m (RCP8.5 p50 and p83 values respectively), which is within the range of sea level rise values considered. Therefore, residual risk for over design events is adequately addressed. However, sea level rise will continue for centuries after 2130, even with progress to reduce emissions.

3.3.2.4 Any relevant management plan, strategy or hazard risk assessment relating to the area.

This area is unit 9 in the Highbrook to Whitford Shoreline Adaptation Plan (Highbrook to Whitford Shoreline Adaptation Plan (SAP)) that was endorsed by the local boards in August 2025. The preferred strategy for Council-owned land and assets in this location is “No Action” in the short, medium and long term due to the relative absence of Council owned land and assets.

The approach to avoid natural hazard risk over the next 100 years by setting back development to be landward of the SSP5-8.5H+ hazard extent and above the 1%AEP + 1.5 m coastal inundation level is consistent with the Council approach.

3.3.2.5 Additional matters to be considered

Table 3.7 sets out matters to be considered under the operative AUP Policies E36.3 and our assessment. The additional matters to be considered under Policy E36.3(4B) of PC120 are not applicable as the development avoids the coastal hazards identified for at least the next 100 years. The Project meets both these policy requirements.

Table 3.7: Summary of matters to be considered under operative AUP Policies E36.3

Matters to be considered	Assessment
Policy 4: Control subdivision, use and development of land that is subject to natural hazards so that the proposed activity does not increase, and where practicable reduces, risk associated with all of the following adverse effects: 1 accelerating or exacerbating the natural hazard and/or its potential impacts; 2 exposing vulnerable activities to the adverse effects of natural hazards; 3 creating a risk to human life; and 4 increasing the natural hazard risk to neighbouring properties or infrastructure.	The Project does not increase risk to matters identified in a) to d). The development does not accelerate or exacerbate existing or potential future coastal hazards and the proposed levels and requirements of the adaptation plan avoid exposing vulnerable activities to the adverse effect of natural hazards. Therefore, there is not a risk to human life.
Policy 7: Ensure that buildings in areas subject to coastal hazards are located and designed to minimise the need for hard protection structures.	Sensitive and potentially sensitive activities are set sufficiently landward to minimise the need for hard protection structures

3.3.2.6 AUP Risk summary

The Project complies with the operative AUP requirements of not increasing risk associated with natural hazards (Policy E36.3(4)).

Considering PC120 E36, the Project is situated landward of the ASCIE 2130 (RCP8.5+) and above the 1%AEP + 2 m RSLR coastal inundation extent so avoids coastal hazards over the next 100 years.

4 Applicability

This report has been prepared for the exclusive use of our client Beachlands South Ltd Partnership, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
....	....
Richard Reinen-Hamill	Mark Thomas
Technical Director: Coastal Engineering	Project Director

Richard Reinen-Hamill
p:\1014358\1014358.2501\workingmaterial\natural hazard update\20260615.rrh.coastal risk assessment update.v1.2.docx

Appendix A Coastal Hazard Assessment Report

REPORT

Tonkin+Taylor

Coastal Hazard Assessment

Beachlands South Private Plan Change

Prepared for
Beachlands South Limited Partnership

Prepared by
Tonkin & Taylor Ltd

Date
January 2022

Job Number
1014358.v4

Exceptional thinking together

www.tonkintaylor.co.nz

Document Control

Title: Coastal Hazard Assessment					
Date	**Version**	**Description**	**Prepared by:**	**Reviewed by:**	**Authorised by:**
23/07/2020	1	Client review draft	J. Joubert B. Westgate R. Reinen-Hamill	R. Reinen-Hamill	P. Millar
13/08/2020	2	Revision to include statutory information and clarifications	J. Joubert R. Reinen-Hamill	R. Reinen-Hamill	P. Millar
3/12/2021	3	Planning comments	R. Reinen-Hamill		P. Millar
17/12/2021	4	Minor revisions	R. Reinen-Hamill		P. Millar

Distribution:

Beachlands South Limited Partnership	1 PDF copy
Tonkin & Taylor Ltd (FILE)	1 PDF copy

Table of contents

Executive summary

Beachlands South Limited Partnership (BSLP) is seeking a Private Plan Change (PPC) to re-zone the Formosa Golf Course and an adjacent area of currently rural and private property land in Beachlands, Auckland to facilitate urban development of that area.

BSLP engaged Tonkin & Taylor Ltd (T+T) to undertake a site-specific coastal hazards and issues assessment to inform the structure planning and private plan change.

The PPC area covers approximately 307 ha and consists primarily of two properties, Formosa Golf Resort and 620 Maraetai-Whitford Road (620 site). Several smaller lots between 678 and 770 Whitford-Maraetai Road are also included in the PPC.

The site is generally a cliff coast fronted along the north-west side by a narrow shelly beach and to the south-west by low lying salt marsh and mangrove habitat, some of which has been converted to flood prone paddocks. The area is generally characterised as a low energy sheltered environment with relatively low waves and currents, but susceptible to tropical storm generated waves during high tide.

This study includes a local scale assessment of Areas Susceptible to Coastal Instability and Erosion (ASCIE) of both consolidated (cliff/ terrace) and unconsolidated (beach) shorelines, and an assessment of the inundation hazard of the site based on scenarios supplied by Auckland Council.

For this assessment, present day ASCIE and two future ASCIE (2080 and 2130) were evaluated. Present day ASCIE is based on the current stability of the shoreline and potential erosion to occur after large storm events, and future ASCIE is based on present day values, plus a future long-term regression rate, including a sea level rise component (using the RCP 8.5+ scenario).

All property parcels, key assets and infrastructure are located landward of the 2130 area susceptible to coastal instability and erosion. No coastal inundation or tsunami hazard will occur on property parcels, key assets and infrastructure, even with a consideration of 2 m sea level rise. The AUP framework for addressing natural hazards and climate change will be sufficient for addressing coastal instability and erosion and no specific mitigation is required.

Only beach and salt-marsh areas are susceptible to coastal inundation and are also the most likely to be affected by tsunami. These low-lying areas around the coastal edge have only been considered for recreational amenity and no habitable buildings should be located on these areas. The walkway is situated sufficiently landward and is of an elevation that reduces the risk of inundation to negligible for sea level rise of up to 1.5m. Adaptation responses can be considered to raise or relocate in the long term.

The AUP currently requires a 30 m coastal yard for buildings measured from MHWS under the AUP framework. This yard is for a range of purposes and is considered to be adequate for managing the development of buildings and structures adjacent to this coastal edge but there is no reason from a coastal hazard perspective to change this setback standard.

The assessment meets the requirement of Policy 24 of the NZCPS and the proposed structure plan meets both Objective 5 of the NZCPS ensuring that coastal hazard risks, taking into account of climate change are managed by locating new development away from areas prone to such risks, and Policy 25 by avoiding any increased risk of adverse effects from coastal hazards. By avoiding the setback areas along the coastal edge, the proposal recognises and protects the existing natural defences of vegetated slopes and wetlands, meeting requirements of Policy 26 of the NZCPS.

1 Introduction

1.1 Purpose

Beachlands South Limited Partnership (BSLP) is seeking a Private Plan Change (PPC) to re-zone the Formosa Golf Course and an adjacent area of currently rural and private property land in Beachlands, Auckland to facilitate urban development of that area.

BSLP engaged Tonkin & Taylor Ltd (T T) to undertake a site-specific coastal hazards and issues assessment to inform the structure planning and private plan change.

1.2 Proposed structure plan and Private Plan Change

The PPC area covers approximately 307 ha and consists primarily of two properties, Formosa Golf Resort and 620 Maraetai-Whitford Road (620 site). Several smaller lots between 678 and 770 Whitford-Maraetai Road are also included in the PPC. The Structure Plan proposes a village centre in the northwest of the site, with a central business village centre surrounded by mixed used land and higher density housing, giving way to medium and lower density housing with increasing distance from the centre. Ecological open space areas are proposed throughout the Plan area, generally in gullies, coastal areas and as linkages between key locations. A secondary mixed use area is proposed at the north-eastern corner of the Plan area, adjacent to Whitford Maraetai Road.

1.3 Purpose of this report

This report has been prepared to support the Structure Plan and Plan Change application for Beachlands South, and to assist Auckland Council and decision makers in approving this application.

1.4 Scope

This coastal hazard assessment of the site recognises the issues associated with physical coastal processes and effects over at least the next 100 years to provide consistency with the New Zealand Coastal Policy Statement (NZCPS) and Auckland Unitary Plan (AUP) requirements. These policies encourage redevelopment, or change in land use, where that would reduce the risk ofadverse effects from coastal hazard and to encourage the location of infrastructure away from areasof hazard risk where practicable.

The coastal hazard assessment was largely by a desktop study providing information on the present day and future erosion and inundation risk based on existing published information. It includes information on published tsunami inundation mapping used for civil defence, but also provides additional information and context on this data.

1.5 Report outline

The statutory and physical settings are described in Section 2 to 4. Section 2 provides the base framework for the assessment and Sections 3 and 4 describe the physical environment that contributes to the hazard assessment. Sections 5 to 7 describe the hazards and the assessment of the impact of these hazards on the proposal. Section 5 describes the coastal erosion hazard assessment; Section 6 describes the coastal inundation hazard assessment and Section 7 describes tsunami. Section 7 and 8 include the summary and conclusion.

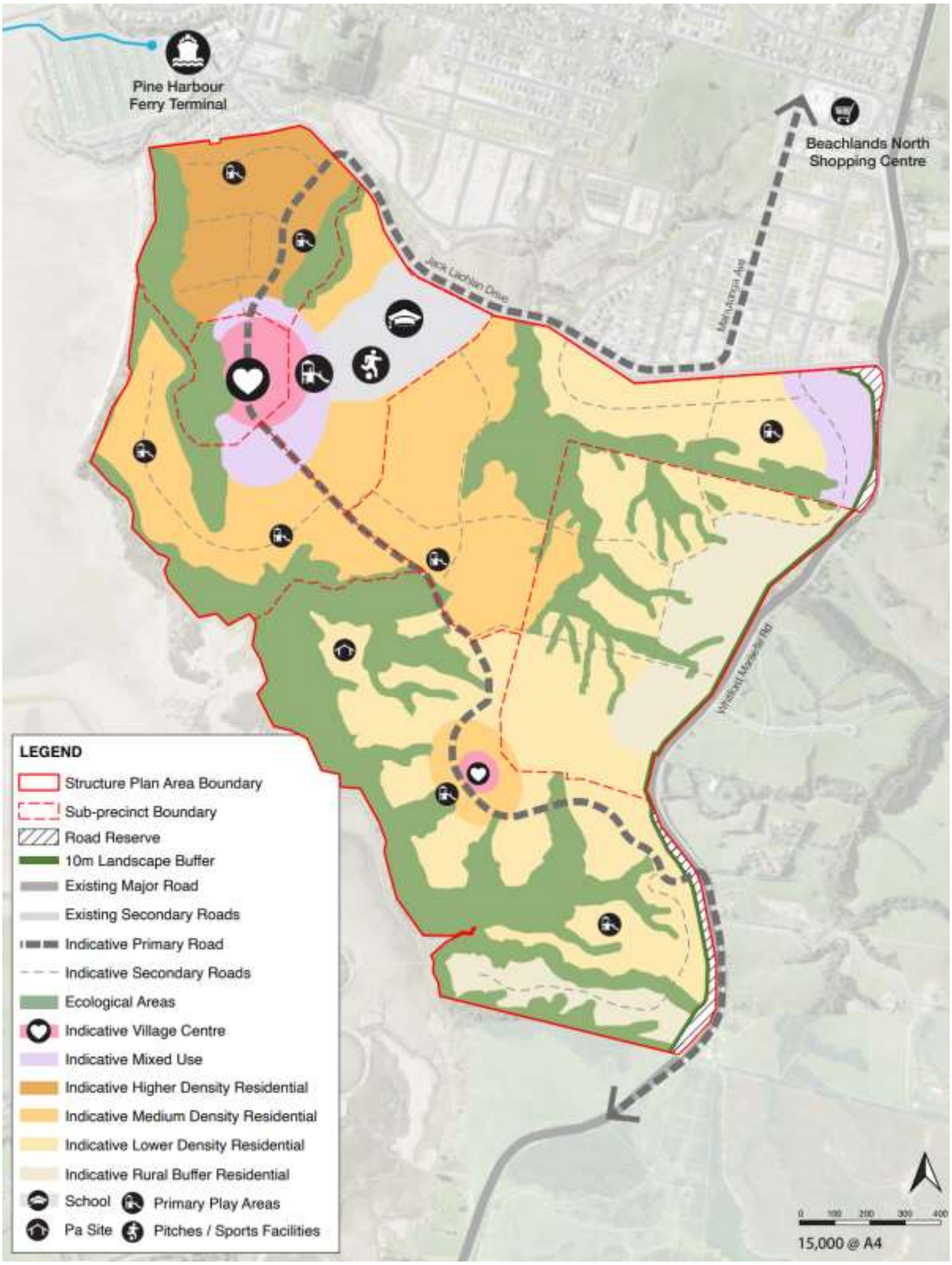


Figure 1-1: Structure Plan map (Source: Unio Environmental, 2021)

2 Statutory setting

This section sets out the various statutory documents that require consideration of coastal hazards including the Resource Management Act, the New Zealand Coastal Policy Statement and the Auckland Unitary Plan.

2.1 Resource Management Act

The purpose of the Resource Management Act 1991 (RMA) is to promote the sustainable management of natural and physical resources (Section 5). It provides that the functions of district and regional councils include controlling the use of land for the purpose of avoiding or mitigating natural hazards[1]. One method by which this is achieved is through the use of objectives, policies and rules in district and regional plans (and unitary plans in the case of Auckland).

In developing provisions in plans to address natural hazards in the form of coastal erosion, the process requires technical assessment of the erosion hazard susceptibility and the risk posed by any such identified hazards, and a robust process for developing and testing plan provisions. Drafting provisions that help to achieve the sustainable management purpose of the RMA requires consideration of how to manage the hazard risk and provide for the social, economic and cultural wellbeing needs of the community.

2.2 New Zealand Coastal Policy Statement

The New Zealand Coastal Policy Statement 2010 (NZCPS, 2010), prepared by the Minister of Conservation, sets out objectives and policies in order to achieve the purpose of the RMA with regard to the coastal environment of New Zealand. It contains objectives and policies that include those aimed at safeguarding the integrity, form, functioning and resilience of the coastal environment and sustaining its ecosystems, and preserving the natural character of the coastal environment. Local authorities are required by the RMA to give effect to the NZCPS through plans and policy statements. Of relevance to this assessment are Objective 5, Policy 24, Policy 25 and Policy 26. These are set out below.

Objective 5:To ensure that coastal hazard risks, taking account of climate change, are managed by:

- *locating new development away from areas prone to such risks*;
- *considering responses, including managed retreat, for existing development in this situation; and*
- *protecting or restoring natural defences to coastal hazards."*

Policy 24: the identification of areas that are potentially affected by coastal hazards:

> *''Identify areas in the coastal environment that are potentially affected by coastal hazards (including tsunami), giving priority to the identification of areas at high risk of being affected. Hazard risks, overat least 100 years, are to be assessed having regard to:*

physical drivers and processes that cause coastal change including sea level rise;

short-term and long-term natural dynamic fluctuations of erosion and accretion;

[1] Section 30 sets out the functions of regional councils, including section 30(c) which is *"the control of the use of land for the purpose of...(iv) The avoidance or mitigation of natural hazards"*. Section 31 sets out the functions of territorial authorities which includes (b) "*the control of any actual or potential effects of the use, development, or protection of land,including for the purpose of avoidance or mitigation of natural hazards …"*

geomorphological character;

the potential for inundation of the coastal environment, taking into account potential sources, inundation pathways and overland extent;

cumulative effects of sea level rise, storm surge and wave height under storm conditions;

influences that humans have had or are having on the coast;

the extent and permanence of built development; and

the effects of climate change on:

i. *matters (a) to (g) above;*

ii. *storm frequency, intensity and surges; and*

iii. *coastal sediment dynamics;*

taking into account national guidance and the best available information on the likely effects ofclimate change on the region or district.''

Policy 25: subdivision, use, and development in areas of coastal hazard risk

In areas potentially affected by coastal hazards over at least the next 100 years:

a *avoid increasing the risk[10] of social, environmental and economic harm from coastal hazards;*

avoid redevelopment, or change in land use, that would increase the risk of adverse effectsfrom coastal hazards;

encourage redevelopment, or change in land use, where that would reduce the risk of adverse effects from coastal hazards, including managed retreat by relocation or removal ofexisting structures or their abandonment in extreme circumstances, and designing for relocatability or recoverability from hazard events;

encourage the location of infrastructure away from areas of hazard risk where practicable;

discourage hard protection structures and promote the use of alternatives to them, includingnatural defences; and

consider the potential effects of tsunami and how to avoid or mitigate them.

Policy 26: Natural defences against coastal hazards

1 Provide where appropriate for the protection, restoration or enhancement of natural defences that protect coastal land uses, or sites of significant biodiversity, cultural or historic heritage or geological value, from coastal hazards.

2 Recognise that such natural defences include beaches, estuaries, wetlands, intertidal areas, coastal vegetation, dunes and barrier islands.

2.3 Auckland Unitary Plan

The Auckland Unitary Plan – Operative in part (2016) (AUP) combines Auckland's regional policy statement (RPS) and district, regional, and regional coastal plans. Together, these set out the objectives, policies and methods that allow Auckland Council to meet its obligations under the RMA, including its functions specified in Sections 30 and 31 of the RMA. As noted in the previous section, these functions include the avoidance or mitigation of natural hazards.

Objectives and policies in the RPS (Chapter B of the AUP) set strong directives to manage the risk of coastal hazards (Chapters B8 and B10). Subdivision, use and development in areas potentially affected by coastal hazards must not increase the risk of social, environmental and economic harm (Objective B3.1(7)), and the effects of climate change on natural hazards (including the effects of sea level rise and on the frequency and severity of storm events) are to be recognised and provided for (Objective B10.2.1(4)). This is supported particularly by the regional and district plan provisions in

Chapters E36 (Natural Hazards and Flooding) and Chapter F (Coastal) of the AUP which require resource consents for certain activities and for coastal hazard risks to be assessed and managed.

Chapter E36 of the AUP includes rules for activities on land in the “coastal erosion hazard area”. E36.9 requires that a hazard risk assessment is undertaken when subdivision, use or development requiring a resource consent is to be undertaken on land that may be subject to natural hazards. It states that an assessment of coastal hazards should include consideration of the effects of climate change over at least a 100-year timeframe and cover storm inundation of the 1 percent annual exceedance probability (AEP) plus 1 m of sea level rise.

3 Setting

3.1 Location

The site is located south of the Pine Harbour marina, on the western coastline of the Beachlands suburb in Auckland (Figure 3-1) and follows the length of the Jack Lachlan Esplanade Reserve. The northern end of the site is separated from the Pine Harbour marina by a small unnamed tributary (hereby referred to in this report as Stream A). The shoreline is inter-tidal with estuarine/ mudstone flats seaward and can be characterised by the following sections.

- Approx. 0.8 km long section of high tide beach/chenier ridge backed by consolidated terrace of varying width (5 to 60 m) with high cliff sections landward, leading up to the Formosa Golf Club course.
- Approx. 0.3 km long section of cliff headland backed by the Formosa Golf Club.
- Approx. 0.8 km long section of salt marsh of varying width (90 to 180 m) backed by farmland extending to Whitford-Maraetai Road.
- Approx. 0.6 km long section of mangrove forests protecting vegetated cliff/embankment shoreline seaward of farmland extending to Whitford-Maraetai Road.

Figure 3-1: Location map of the site

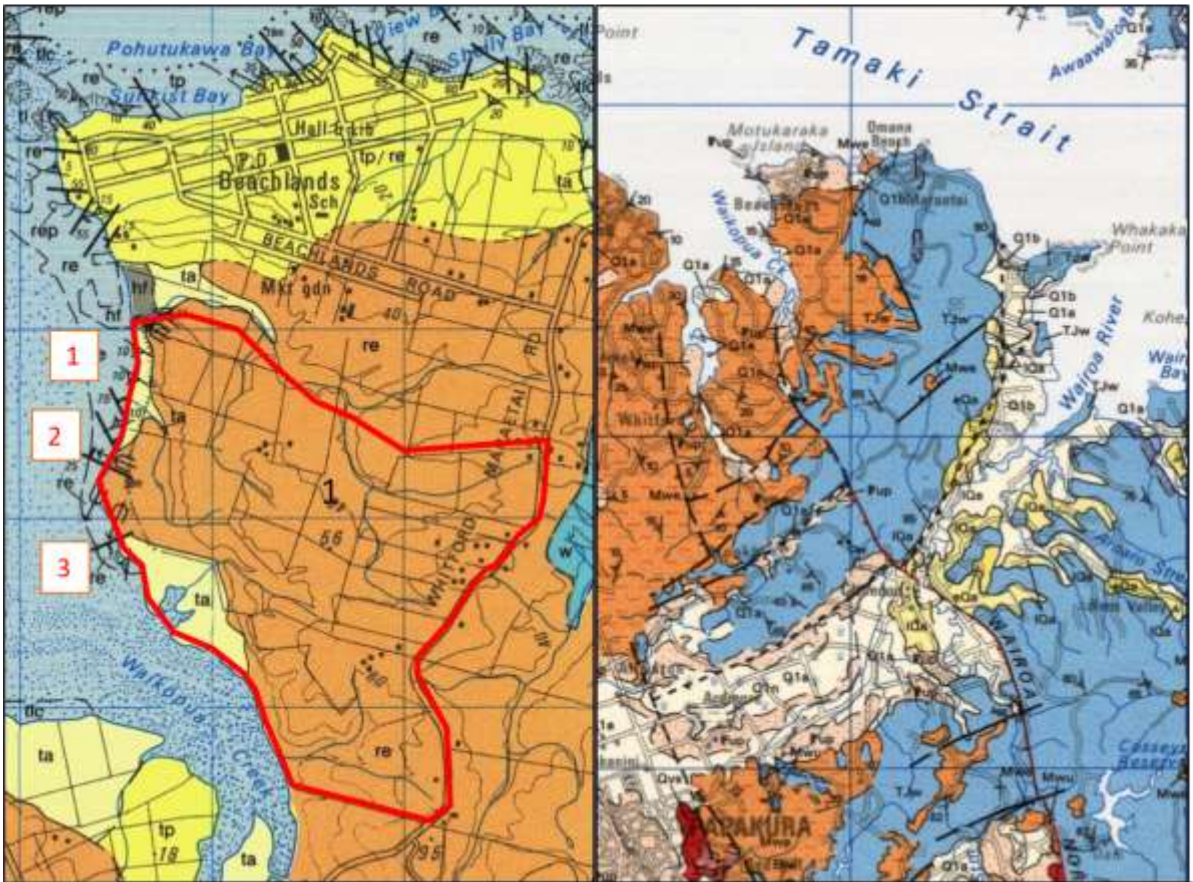
3.2 Geology

3.2.1 Regional geological review

As shown on the geological maps shown in Figure 3-2, the site is expected to be generally underlain by East Coast Bays Formation flysch, consisting of alternating beds of greyish grey, muddy sandstone and siltstones East Coast Bays Formation with occasional undifferentiated Tauranga Group alluvium comprising mud, sand and gravel located along the coast, and within the stream channels across the site (T+T, 2021). No argillite or greywacke is expected at the location of the site, the nearest expression of Waipapa Group greywacke on the eastern side of the Whitford – Maraetai Road. Inactive faults have been mapped to the east and south of the site. There are four faults shown on the geological map which are described as, from north to south:

1. two normal fault dipping 70º to the northeast into the coastal slope (striking NW-SE).
2. a reverse fault with 38m throw (displacement) dipping 25º to the North, perpendicular to the coastal slope (striking E-W).
3. a normal fault dipping 25º to the southeast, perpendicular to the coastal slope (striking NE-SW).

The nearest known active fault is the Wairoa North fault, approximately 6.5 km to the south.



ta	Holocene Tauranga Group, undifferentiated alluvium
re	Miocene Waitemata Group, East Coast Bays Formation, flysch
w / TJw	Jurassic Waipapa Group, massive to thin-bedded, lithic volcaniclastic sandstone and argillite

Figure 3-2: Published geological maps of the location (site outlined in red).
Left: *1:50,000 scale map showing general geology of the site.* ***Right:*** *1:250,000 scale map showing regional geology and proximity to faults. Source: IGNS[iii].*

3.2.2 Site walkover

The site walkover observations confirm the regional geological review. The northern section of coastline is protected by an accretion sand and shell spit, with an area of angular to sub rounded cobbles and boulders over and underlain by shell layers (shown as 1 on **Error! Reference source not found.**, and Figure 3-3). The origin and depositional timing of this material is unclear due to the shell layers. This area is backed by ECBF slopes which are generally very weak to weak thin to thickly bedded light yellow brown sandstones with very weak very thin to thinly bedded yellow brown to grey mudstones. Thesurface of the ECBF has decomposed on exposure to the atmosphere and weathering events and isfriable to the touch.

Further south, the ECBF varies between very thin (6-20 mm) to very thick (>2 m) beds of cyclic mudstone and sandstone. The thinner beds are dominated by the exceptionally weak to weak mudstones units, generally between 6 to 40 mm, with very weak to weak sandstone beds from20 mm to 2 m, as shown in Figure 3-3.

The ECBF is variable along the coastal section due to the reported faulting. These were confirmed on the site walkover. In these locations the faults and faulted material act as large land drains and can be traced landwards through the topography (Faults 2 and 3 above, as shown in Figure 3.5). They have been eroded out and therefore pose a hazard to surface construction with the potential for washout voids.

A progression south along the coastline there are a series of debris fans or colluvium which has been washed out of the streams and stormwater channels and built up on the salt marshes. These areas do not represent the toe of the slope and will be removed with a rise in sea level. There are two locations of coastal instability, shown on **Error! Reference source not found.** as X1 and X2.

Figure 3-3: Shell layers above and below a heterogenous conglomerate. Shown as 1 in ***Error! Reference source not found.***

*Figure 3-4: ECBF bedded mudstones and sandstones, dipping 06/180. Shown as 2 in **Error! Reference source not found.***

*Figure 3-5: Two faults, within the coastline as shown in **Error! Reference source not found.***

3.3 Beach sediments

Between the marina and the headlands to the south, observations on site note that the beach sediments primarily consist of calcium carbonate (shell) overlying fine sand (Figure 3-6), which is typical of sheltered estuarine sites within the inner Hauraki Gulf (Klinac, 2002). Some sections were noted to have a scattering of rocks, possibly from embankment erosion. Mudstone flats extend seaward from the beach toe. South of the headlands, muddy fine sand is more abundant, with some shell deposits forming ridges in front of the vegetated shoreline (Figure 3-7).

Figure 3-6: Beach section north of headland

Figure 3-7: Chenier ridge seaward of salt marsh south of headlands

3.4 Topography and bathymetry

Topographic information is available from a 2016 LiDAR survey conducted by Auckland Council, from which topographic contours have been generated and is shown in Figure 3.8. Contours shown in grey are at 2 m increments. Major contours (0, 5, 10, 20 and 50 m AVD46 (hereby referred to in this report as m RL)) are shown as red lines. Another major contour line is shown at 1.5 m RL (approximately MHWS) in blue. Levels within the bay, along the intertidal flats, range from around -1 m to 1 m.

The 2016 LiDAR survey captured the intertidal area down to at least -0.5 m RL. On the northern end of the site, the nearshore slope (between 0.7 and 1.5 m RL contours) is around 1(V):10(H) and the intertidal area (between -0.5 and 0.5 m RL contours) is around 1(V):300(H).

The bathymetry offshore from Beachlands is shown in Appendix E and is based of levels from chart NZ 532 published in 1975.

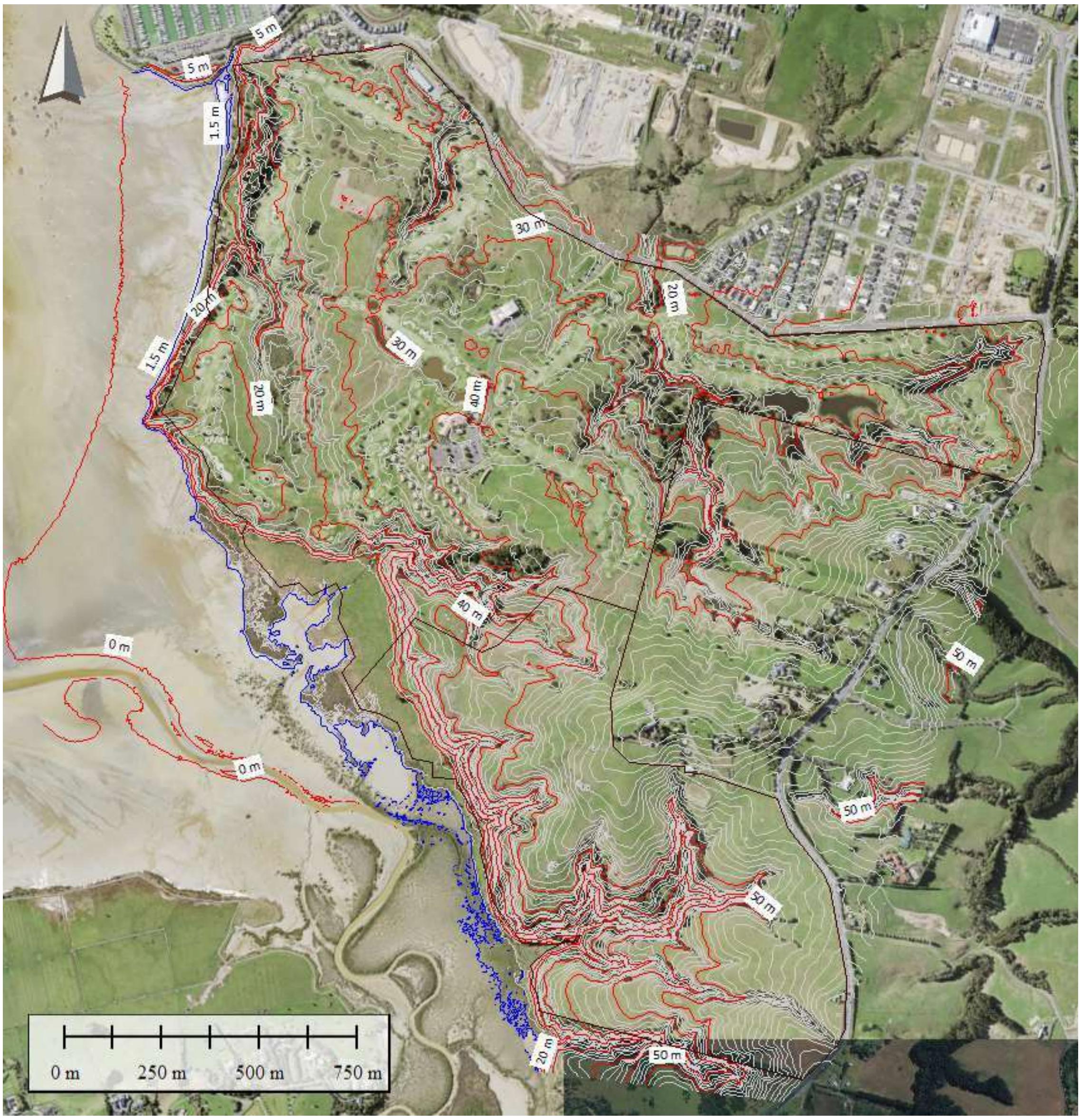


Figure 3-8: Site contours based off 2016 AC LiDAR data. Minor contours in grey, major contours in red,indicative MHWS level (m RL) in blue.

3.5 Hydraulic environment

3.5.1 Water levels

The tide and nearshore seabed levels controls the amount of time coastal processes interact with the shoreline. With the beach and cliff toe at around 0.6 to 1.4 m RL, erosion from coastal processes is limited to higher tide levels and is exacerbated by storm surge that combine with high tide conditions. At spring high tides, the water depth at the toe of the beach/cliff shoreline is around 0.2 to 1.0 m.

3.5.1.1 Astronomical tide

The closest long-term tidal station to Beachlands is at the Port of Auckland located some 18 km northwest of the site (see Table 3.1 for tide levels at the Port). Typically, the tidal variation range is 2.88 m and 1.80 m for spring and neap tides, respectively. The perigean mean high water springs level (MHWPS) is 1.67 m RL. This is the high tide level that will only be exceeded by 6% of all high tides over the next 100 years, excluding the effects of sea level rise. Numerical modelling has been carried out to identify MHWPS levels around the coastline (Ramsay et al., 2008). The predicted level at Beachlands is 1.75 m.

Table 3.1: Predicted tide levels at Port of Auckland[1] and Beachlands

Nominal level	Water level CD (m)	Water level RL[2] (m)
Highest Astronomical Tide (HAT)	3.72	1.98
Mean High Water Perigean Springs (MHWPS)	3.49	1.75 m at Beachlands[3]
Mean High Water Springs (MHWS)	3.36	1.62
Mean High Water Neaps (MHWN)	2.83	1.09
Mean Sea Level (MSL)	1.91	0.17
Mean Low Water Neaps (MLWN)	1.03	-0.71
Mean Low Water Springs (MLWS)	0.48	-1.26
Lowest Astronomical Tide (LAT)	0.06	-1.68

1 New Zealand Nautical Almanac (LINZ, 2020)
2 Levels in Auckland Vertical Datum 1946, which is 1.74 m lower than Chart Datum (CD)
3 Ramsay et al. (2008)

3.5.1.2 Storm surge

Storm surge results from the combination of barometric setup from low atmospheric pressure and wind stress from winds blowing along or onshore. This process, described in Figure 3.9, elevates the water level above the predicted tide. The combined elevation of the predicted tide and storm surge is known as the storm tide.

In 2013, NIWA modelled coastal-storm inundation around the coastline of the Auckland region (Stephens et al., 2013). The predicted storm tide levels for a range of return periods for Beachlands at the open coast are presented in Table 3.2. These levels exclude local effects of wave set-up that are likely to be relatively minor in a shallow estuary environment.

Table 3.2: Storm tide levels for Beachlands (Stephens et al., 2013)

Annual Exceedance Probability(AEP)	39%	18%	10%	5%	2%	1%	0.5%
Average Recurrence Interval (ARI)	2 yr	5 yr	10 yr	20 yr	50 yr	100 yr	200 yr
Elevation RL[1] (m)	1.94	2.00	2.05	2.09	2.14	2.18	2.20

1 Elevations in Auckland Vertical Datum 1946

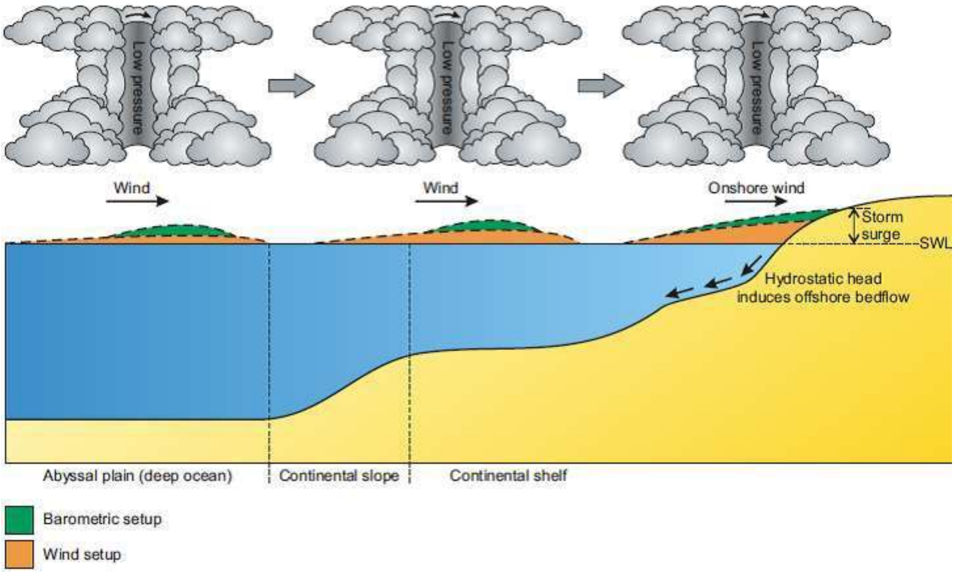


Figure 3-9: Storm surge processes (Shand et al., 2010)

3.5.2 Medium-term fluctuations

Natural fluctuations in New Zealand's (and the Pacific's) climate are influenced by two key natural cycles operating over timescales of years: the El Niño–Southern Oscillation (ENSO) and the longer Inter-decadal Pacific Oscillation (IPO). These natural phenomena operate over the entire Pacific Ocean and beyond, in response to changes in ocean temperature, prevailing trade winds and the strength of the subtropical high-pressure belt. El Niño and La Niña occur irregularly over about two-to-seven years, with each phase lasting from nine months to two years.

These natural fluctuations can change the mean level of the sea at a specific time. The combined effect of these is shown in Figure 3.10 and show a combined effect of up to ± 0.25 m.

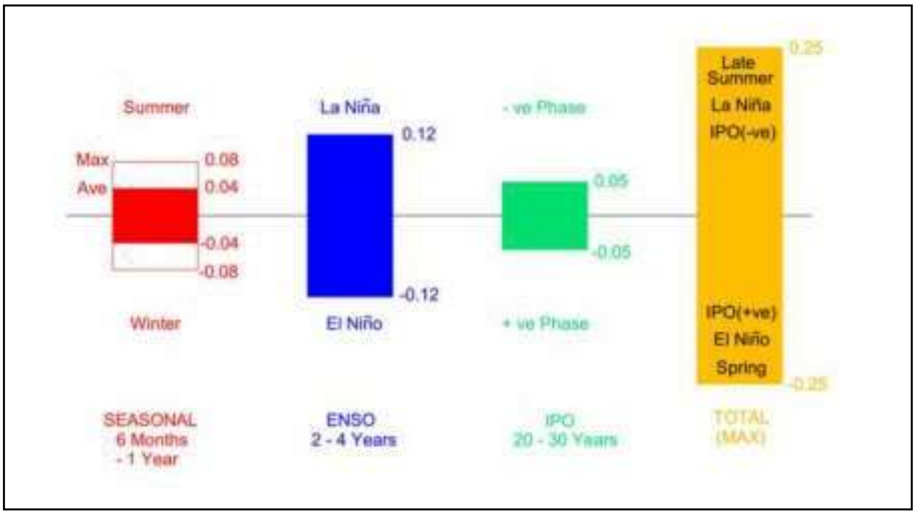


Figure 3-10: Factors influencing long-term sea level fluctuations (NIWA,2011)

3.5.3 Long-term changes

Historic sea level rise (SLR) in New Zealand has averaged 1.81 ± 0.05 mm/year to 2018, with rates at Auckland averaging 1 .67 ± 0.08 mm/year[2] (1899-2018) and climate change is predicted to accelerate this rate into the future.

The Ministry for the Environment (MfE, 2017) guidelines on climate change use four sea level rise scenarios based on the Intergovernmental national Panel on Climate Change (IPCC, 2015) projections of three Representative Concentration Pathway (RCP) emission scenarios. These are the median projections of the RCP 2.6, RCP 4.5 and RCP 8.5, and RCP 8.5+ the upper end of the 'likely range' (i.e., 83rd percentile) of the RCP 8.5 projection. The latter is primarily for the purposes of stress-testing adaptation plans where the risk tolerance is low and / or future adaptation options are limited, and for setting a SLR for greenfield development or major new infrastructure where the foreseeable risk is to be avoided (MfE, 2017). The projections of the potential future scenarios adjusted to the New Zealand regional scale shownin Table 3.3.

Table 3.3: Sea level rise projections from the 1986-2005 baseline (MfE, 2017) adjusted for historic sea level rise

	Emission Scenario			
Horizon	**RCP 2.6M**	**RCP 4.5M**	**RCP 8.5M**	**RCP 8.5+**
2060	0.27	0.30	0.36	0.48
2080	0.37	0.42	0.55	0.75
2100	0.46	0.55	0.79	1.05
2130	0.60	0.74	1.18	1.52

3.5.4 Wind climate

The Musick Point weather station provides the closest long-term wind dataset for the site. The station is located approximately 9 km to the northwest and is representative of the wind climate at the site. Continuous one hourly wind data was available for Musick Point from June 2000 to July 2015.

Figure 3-11 presents this data as a wind rose showing the direction and strength of where the wind iscoming from. The predominant wind direction at Musick Point to be from the west to southwest sector, occurring 47% of the time. Maximum wind speeds typically occur from the northeast to east during tropical storms and cyclones. The predominant sector for strong winds that would directly affect this coastline is from the north to easterly fetches.

[2] https://www.stats.govt.nz/indicators/coastal-sea-level-rise#:~:text=Our%20long%2Dterm%20records%20show,Wellington%2C%20Dunedin%2C%20and%20 Lyttelton.

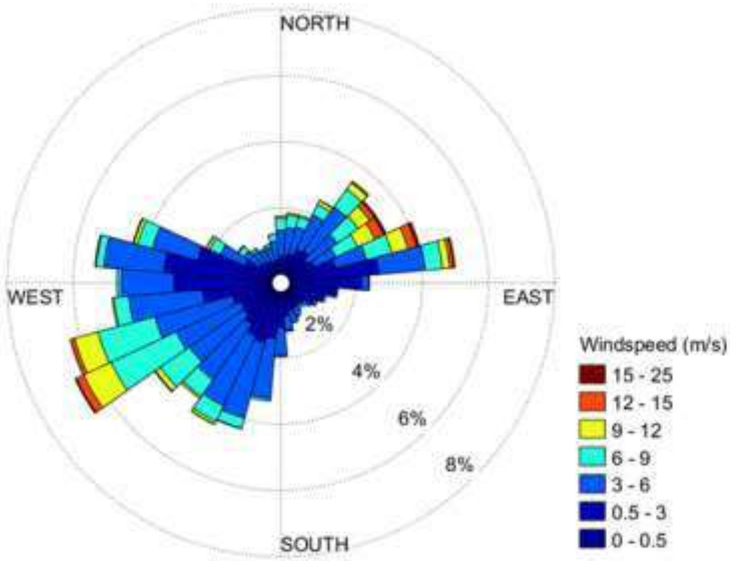


Figure 3-11: Wind rose of Musick point, 2000-2010 (source: NIWA Clifo)

3.5.5 Wave climate

Due to the sheltering from the westerly winds and the generally low wind speeds, wave heights are generally low apart from periods of strong winds from the north to east. In addition, the shoreline is only affected by waves during high tide levels. The construction of the marina has also provided shelter to parts of this coast from north-easterly waves

The local extreme wave heights were assessed using a shallow water SWAN (Simulating Waves Nearshore) wave model of the Tamaki Straight. The model comprises of two computational grids of varying resolution. Results have been extracted from the finest grid (50 m by 50 m).

Winds speeds inputted in SWAN to develop wave heights were derived from AS/NZS 1170.2 2011. Wind speed and subsequent wave height at the 2 m contour (CD) are shown in Table 3.4 below. These waves will further shoal and reduce in height towards the coast.

Table 3.4: Extreme wave heights from SWAN hindcast model

Wind direction	100-year wind speed (m/s)	Water depth (m) at 2m contour	Significant wave height, H_s (m)	Peak wave period, T_p (s)
N - 0°	24.5	5.93	1.52	4.46
NW - 315°	27.4	5.93	1.78	4.53

Boat-generated waves also have the potential to create additional wave energy reaching the site that could potentially affect sediment transport. The ferry terminal and marina at Pine Harbour is situated on the northern edge of the site, with frequent vessel movement occurring throughout the day. However, large vessel (ferry) movement is restricted to the thin channel extending north-west out from Pine Harbour and generally approach and leave the marina at low speeds. Therefore, it is unlikely for boat-generated waves from this movement to have a significant impact on sediment transport along the northwest section of the site and will have no effect on the southwest facing shoreline.

4 Coastal characterisation

4.1 Shoreline position

Historical aerial photographs have been obtained from Crown archives (via Retrolens) for the years 1939, 1955, 1972, 1980 and 1987. Present-day (captured in 2017) high resolution aerial photographs have also been obtained from LINZ. These photographs located in Appendix A.

The shoreline position has been mapped for the years 1955, 1972, 1987 and 2017 based on theaerial photographs, as seen in Appendix D.

4.1.1 Before marina construction

From 1939 through to 1980, much of the northern section of the shoreline fluctuates between the two stream outlets (Stream A & B). as the outlet of Stream A moves northward, the shoreline position in between the two stream moves landward, shown in Figure 4-1.

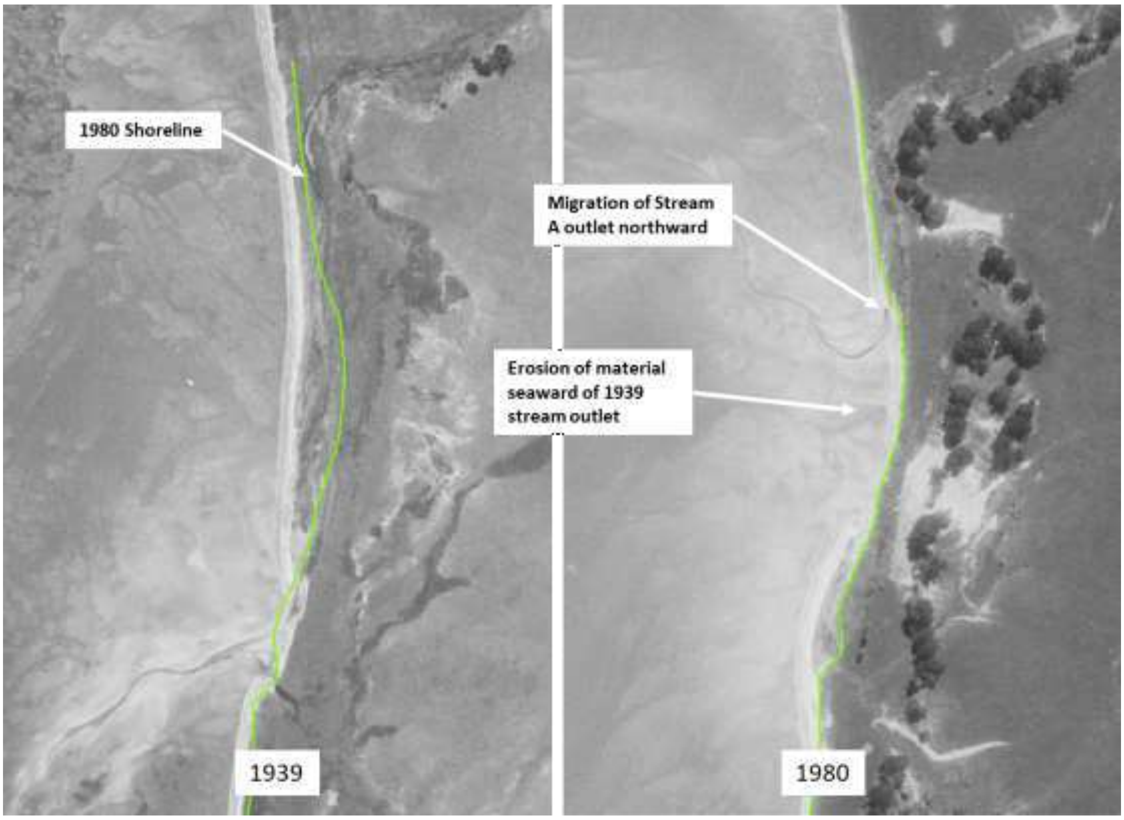


Figure 4-1: Comparison of 1939 and 1980 historic photographs showing movement of shoreline landward to 1939 stream bank

4.1.2 After marina construction

A major anthropogenic change occurred in the late 1980's with the construction of the Pine Harbour marina, subsequent reclamation of the shoreline north of the site, realignment of an unnamed stream outlet (Stream A) and possible fill material placement (unknown source) along parts of the northern shoreline of the site, shown in Figure 4-2.

After the construction of the marina, a chenier ridge started to form at the northern end of the site, shown in Figure 4-3, likely due to the sheltering effect of the marina. Directly south of the chenier ridge to an unnamed river outlet (Stream B) (approx. 130 m), there appears to be some erosion of the shoreline which has been occurring since 1987 at approximately -0.05 m/yr.

The southern beach section seems to be accreting since 1987 and looks to be straightening in between the headlands to the south and the river outlet to the north (Stream B). The cliff section around the headlands has experienced some erosion since 1955, atapproximately -0.05 m/yr. South of the headland, there is a section of salt marsh which has fluctuated in shape and size since1955, with the western section eroding and the eastern section accreting.

For the remainder of the site, the shoreline position appears relatively unchanged, indicating the shoreline here is less susceptible to erosion due to exposure, due to the south-west orientation with chenier ridge and dense mangrove growth seaward of the shoreline.

Figure 4-2: Comparison of 1980 and 1987 aerial photographs at the present location of Pine Harbour marina

Figure 4-3: Growth of the chenier ridge at the northern end of the site since 1987

4.2 Coastline delineation

The site was divided into 6 coastal cells based on shoreline behaviour which can influence the resultant hazard. Factors which may influence the behaviour of a cell include:

- Historical shoreline trend.
- Cell morphology and lithology.
- Profile geometry.
- Backshore elevation.

The coastal cell splits for each site are outlined in Appendix G.

5 Coastal erosion hazard

5.1 Coastal erosion mechanisms and assessments

5.1.1 Cliff shorelines

Consolidated shorelines, which include soil and rock cliffs and coastal terraces, are not able to rebuild following periods of erosion but rather are subject to a one-way process of degradation. Areas susceptible to coastal erosion and coastal land instability along cliff (consolidated) shorelines typically has two components:

- **Toe erosion**

  A gradual retreat of the cliff toe caused by weathering, marine and bio-erosion processes. Thisretreat will be affected by global process such as SLR and potentially increase soil moisture.

  Future cliff toe position based on historic erosion rates with a factor applied to allow for theeffect of future sea level rise.

- **Cliff instability**

  Episodic instability events are predominately due to the decrease in material properties of thecliff or yielding along a geological structure. Instability causes the cliff slope to flatten to an angle under which it is 'stable'. Cliff slope instabilities are influenced by processes that erode and destabilise the cliff toe, including marine processes, weathering and biological erosion or change the stress within the cliff slope. Instability events may range from small-scale instabilities (block or rock falls) or discontinuities, to cliff slope instability cause by large-scale and deep-seated mass movement.

These types of instability events cannot be predicted with certainty. They can only be monitored once signs of movement are observed. To generate a rate from episodic events the period needs to be long enough to enable the cliffs to undergo a full cycle of regression; toe erosion, oversteepening, instability, removal of failed material, toe erosion.

If erosion of the cliff toe is halted through either natural (i.e., establishment of a beach) or artificial (i.e., through rock protection) processes, then the above cliff will continue to retreat until a stable angle is reached. After which time vegetation often becomes established as there is no further removal of material.

The conceptual models for the toe erosion component and cliff instability component are as follows:

$$\textit{Cliff Instability} = (h_C/\tan\alpha) \qquad \text{(Equation 1)}$$

$$\textit{Cliff Toe Erosion} = (R \times T) \qquad \text{(Equation 2)}$$

Where:

h_C	=	Height (m) of cliff based on DEM
α	=	The characteristic composite slope angle (i.e., composite of lower rock and upper soilslope angle if applicable)
R	=	Future recession rate, see Equation 7
T	=	Timeframe over which erosion occurs.

These can then be combined into the models for consolidated shoreline for the present day ASCIE and future ASCIE. The present day ASCIE is a function of the cliff instability component only as regression of the cliff toe is a long-term process. The future ASCIE is a function of both cliff instability and cliff toe regression, with the latter likely being affected by increased SLR rate effects.

The models for consolidated shorelines are expressed in Equation 3 (current ASCIE) and Equation 4 (future ASCIE), where the ASCIE is established from the cumulative effect of the components (Figure 5-1):

$$\text{Current ASCIE} = (h_C/\tan\alpha) \quad \text{(Equation 3)}$$

$$\text{Future ASCIE} = (R \times T) + (h_C/\tan\alpha) \quad \text{(Equation 4)}$$

Note that coastal cliffs may be comprised of more than one geological type with different characteristics. If the cliff slope is comprised of two geotechnical domains, soil and rock, they will have different observed field angles. The height and slope for each domain are assessed separately and are combined to derive the ASCIE (see definition sketch Figure 5-1). For those cliffs where the cliff height (h_c) and the slope angle (α) are subdivided in an upper "soil" (h_{cs} and α_s) and lower "rock" (h_{cR} and α_R) section, the overall slope angle (OSA) is the composite angle α based on a combination of the upper and lower slope angles.

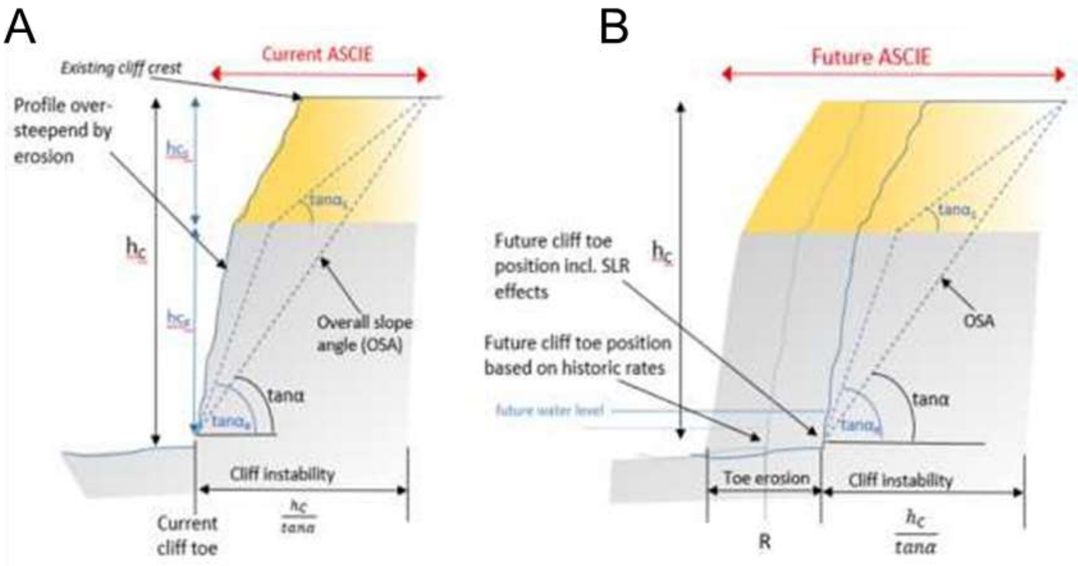


Figure 5-1: Definition sketch for Areas Susceptible to Coastal Instability and/or Erosion on consolidated (cliff) shoreline for current (a) and future (b) states

5.1.2 Beach shoreline

Conceptual models for coastal erosion differ slightly unconsolidated beaches compared to cliffs and estuarine shorelines. The model for unconsolidated beach shorelines is expressed in Equation 5 (Current ASCIE) and Equation 6 (Future ASCIE), where the ASCIE is established from the cumulative effect of six main components (Figure 5-2 & Figure 5-3).

D
R
A
F
T

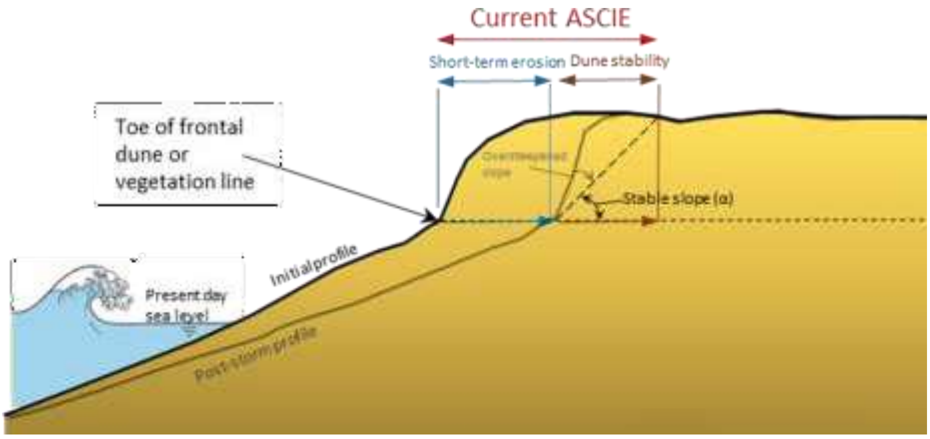


Figure 5-2: Definition sketch for current Areas Susceptible to Coastal Instability and/or Erosion on a beach shoreline

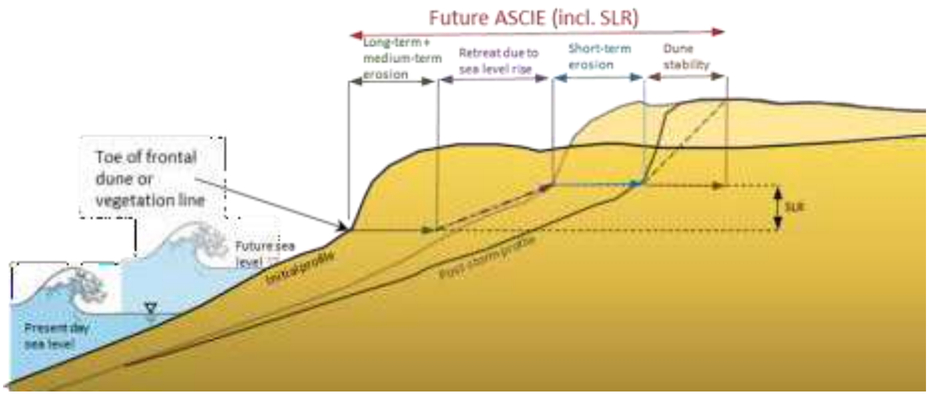


Figure 5-3: Definition sketch of future Areas Susceptible to Coastal Instability and/or erosion on a beach shoreline

$$Current\ ASCIE_{Beach} = ST + DS \qquad \text{(Equation 5)}$$

$$Future\ ASCIE_{Beach} = ((LT \times T) + SL + ST + DS) \times F \qquad \text{(Equation 6)}$$

Where:

ST	=	Short-term changes in horizontal shoreline position related to storm erosion due to singular or a cluster of storm events or fluctuations in sediment supply and demand,beach rotation and cyclical changes in wave climate (m).
DS	=	Dune stability allowance. This is the horizontal distance from the base of the erodeddune to the dune crest at a stable angle of repose (m).
LT	=	Long-term erosion rate of horizontal shoreline movement (m/year), excludingmedium-term fluctuations. For accretive shorelines LT is set to zero.
T	=	Timeframe (year).
SL	=	Horizontal shoreline retreat because of increased mean sea level m).

F = Factor of uncertainty, taken as 2.0 for this assessment.

5.2 Effects of sea level rise

5.2.1 Adopted SLR values

The SLR values included in MfE (2017) based on the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) have been adjusted from the 1986-2005 baseline to the present-day baseline, which is 2016 as the LiDAR DEM was captured between 2016 and 2018. For consolidated cliff and embankment shorelines these adjusted SLR values are used to assess the effect of SLR (refer to Section 5.1.1). For unconsolidated beach shorelines the average historic rate of sea level rise of 1.7 mm/year has been deducted from the projected sea level rise value to provide an 'effective' SLR for use in this assessment on the basis that the existing long-term trends and processes already incorporate the response to the historic situation (see Table 5.1). For this assessment, only the RCP 8.5+ SLR scenario to 2080 and 2130 were mapped.

Table 5.1: Adopted sea level rise values used in analysis (m)

Timeframe	SLR scenario	Projected SLR relative to 1985-2005 basline[1]	SLR from present day baseline[2,3]	'Effective' SLR from present day baseline[2,4,5]
2080	RCP8.5	0.55	0.47	0.36
	RCP8.5H+	0.75	0.65	0.55
2130	RCP8.5	1.18	1.10	0.91
	RCP8.5H+	1.52	1.42	1.23

[1] Source: Projected SLR from MfE (2017) referencing IPCC (2013) Assessment Report 5

[2]Correction applied to adjust from 1986-2005 (taken to be 1995) to 2016 (baseline derived from 2016 LiDAR DEM)[3]Utilised for consolidated cliff and embankment shorelines

[4]Subtracts assumed historic rate of 1.7 mm/year (Hannah & Bell, 2012) to avoid double-counting erosion response

[5]Used for unconsolidated beach shorelines

There is a new IPCC assessment report (AR6), released on 9 August 2021 which gives the latest summary of climate change and projected climate change. This report includes five emission scenarios with the 2.6, 4.5 and 8.5 scenarios that are similar, but not exactly the same, as the AR5 report. The modelling projects slightly more warming for a given pathway than AR5 scenarios. Downscaled data for this is not yet available for New Zealand from NIWA, and this is expected in 2022. However, based on available data from NASA, (Sea Level Projection Tool – NASA Sea Level Change Portal) that gives AR6 sea level rise information. Adjusting this information to the base baseline as the AR 6 assessment (see Figure 5-4) the AR6 projects are within the bounds of AR5 to 2080. Increases occur for the SSP8.5M and SSP8.5(83rd) scenarios at 2130 by around 0.07m and 0.2m respectively. Using existing MfE data from AR5 remains acceptable, and still provides a more conservative 100 year sea level rise condition than included in the current Unitary Plan (refer Section 2.3).

MfE (2017) recommends avoiding coastal hazard risk for new coastal new subdivisions using the RCP8.5+ for over 100 years. This means that building lots should be landward of the erosion hazard zone for the RCP8.5+ scenario at 2130.

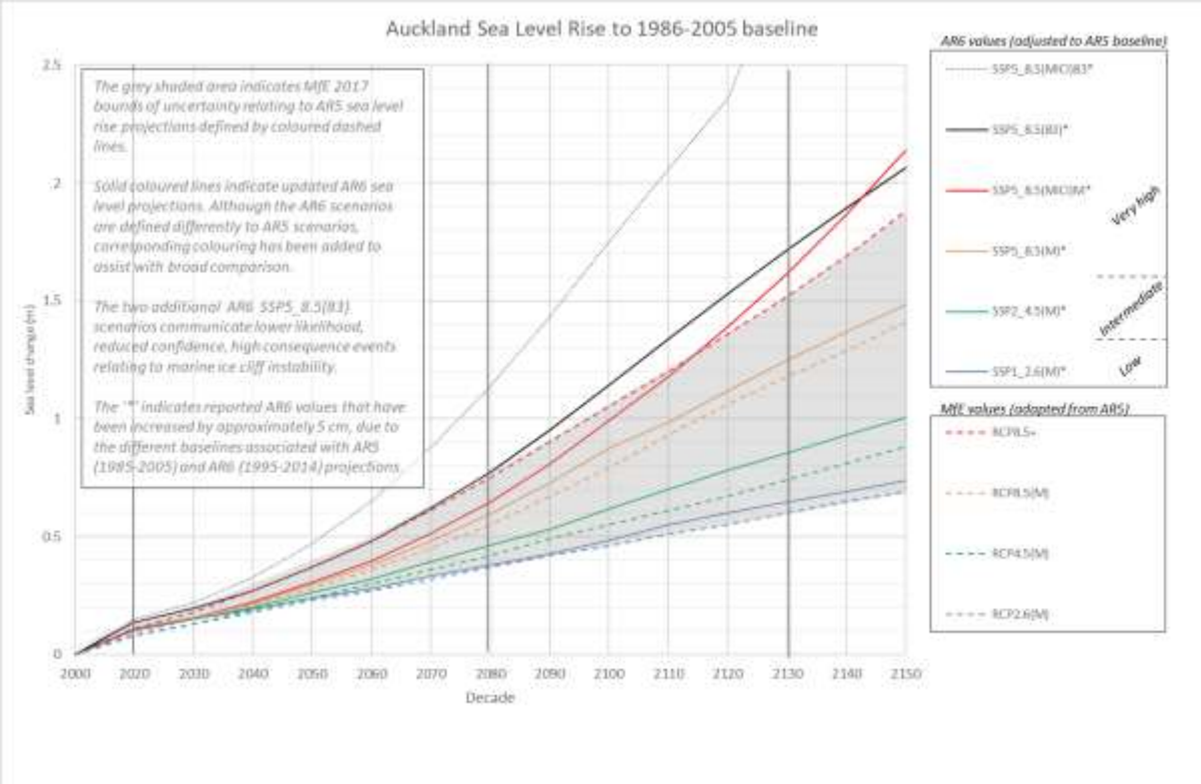


Figure 5-4: Comparison of AR5 and AR6 sea level rise levels

5.2.2 Cliff response to SLR

Erosion of a consolidated shoreline is a one-way process of material removal, which typically can be divided into components. Gradual recession caused by weathering and coastal processes and episodic failures due to cliff lithology and geologic structure and process triggers (e.g., extreme rainfall, leaking utilities).

This section describes the method for assessing gradual recession as a result of rising sea levels. This process is due to weathering and is a function of climatic conditions, exposure and cliff material.

Marine hydraulic processes affect cliffs either by wave action causing erosion at the toe, or by removing slope debris deposited at the toe following subsequent cliff-face collapse. Sea level rise increases the amount of wave energy able to propagate over a fronting platform or beach to reach a cliff toe, removing talus more effectively and increasing the potential for hydraulic processes to affect erosion and recession. However, in some locations, the existence of a talus will provide self-armouring, and may slow cliff recession due to waves.

Ashton et al. (2011) proposed a generalised expression for future recession rates of cliff shorelines shown in Equation 4.8 and Figure 5-4 where m is the coefficient, determined by the response system (sea level rise response factor). The future rate of SLR S_F is based on the adjusted SLR values as set out in Table 5.1 divided by the relevant timeframes. The historic rate of SLR S_H is based on Hannah and Bell (2012). LTH is the historic long-term retreat (regression rate), m/year. Measured from digitised historic shorelines.

$$R = LT_H \left(\frac{S_F}{S_H}\right)^m \quad \text{(Equation 7)}$$

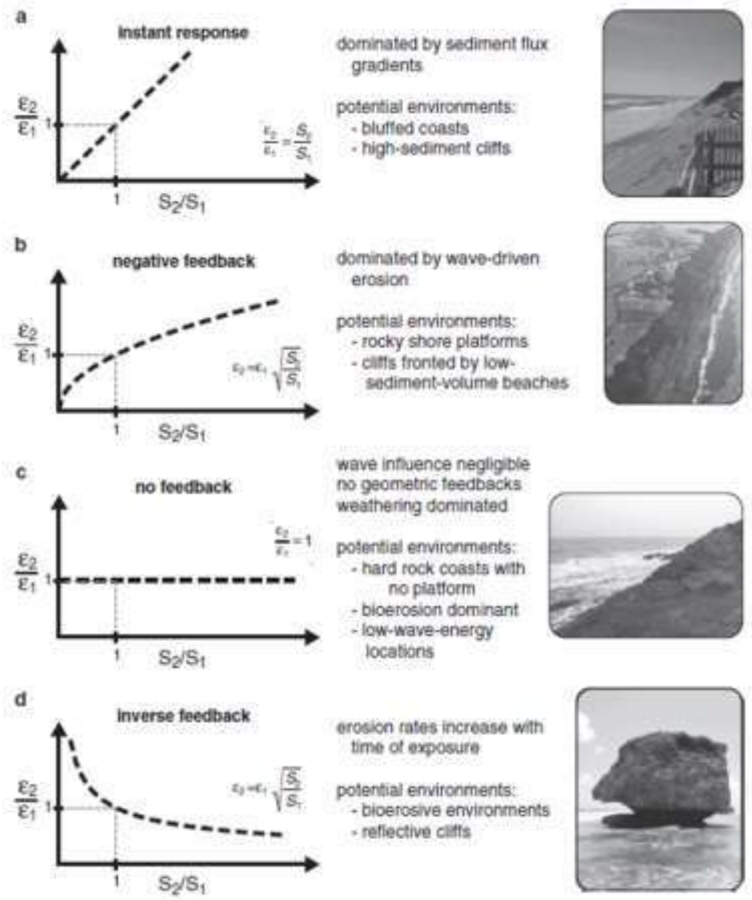


Figure 5-5: Possible modes of cliff response to SLR (adapted from Ashton et al., 2011)

An instantaneous response (m = 1) is where the rate of future recession is proportional to the increase in SLR. An instant response is typical of unconsolidated or weakly consolidated shorelines. No feedback (m = 0) indicates that wave influence is negligible, and weathering dominates. The most likely response of consolidated shorelines is a negative/damped feedback system (m = 0.5), where rates of recession are slowed by development of a shore platform (see Figure 5-4). Ashton et al. (2011) also suggests an additional case of inverse feedback when m < 0 indicating a reduction in recession with increasing sea levels. They suggest this could occur when erosion is controlled by bio-erosion which may reduce with additional submergence. The approach suggested by Ashton et al. (2011) is conceptually plausible and has the potential to predict recession rates on a wide variety of rock types with further analysis.

5.2.3 Beach response to SLR

Geometric response models propose that as sea level is raised, the equilibrium profile is moved upward and landward conserving mass and original shape (see Figure 5-5). The most well-known of these geometric response models is that of Bruun (1962, 1988) which proposes that with increased sea level, material is eroded from the upper beach and deposited offshore to a maximum depth, termed closure depth. The increase in seabed level is equivalent to the rise in sea level and results in landward recession of the shoreline. The model may be defined by the following equation:

$$SL = \frac{L_*}{B + d_*} S$$

(Equation 8)

Where SL is the landward retreat, d_* defines the maximum depth of sediment exchange, L_* is the horizontal distance from the shoreline to the offshore position of d_*, B is the height of the berm/dune crest within the eroded backshore and S is the sea level rise. Figure 5-5 shows the schematic diagrams of the Bruun models, with the Standard Bruun rule used for this assessment.

The inner parts of the profile exposed to higher wave energy are likely to respond more rapidly to changes in sea level. For example, Komar (1999) proposes that the beach face slope is used to predict coastal erosion due to individual storms. Deeper definitions of closure including extreme wave height-based definitions (Hallermeier, 1983), sediment characteristics and profile adjustment records (Nicholls et al., 1998) are only affected during infrequent large-wave events and therefore may exhibit response-lag.

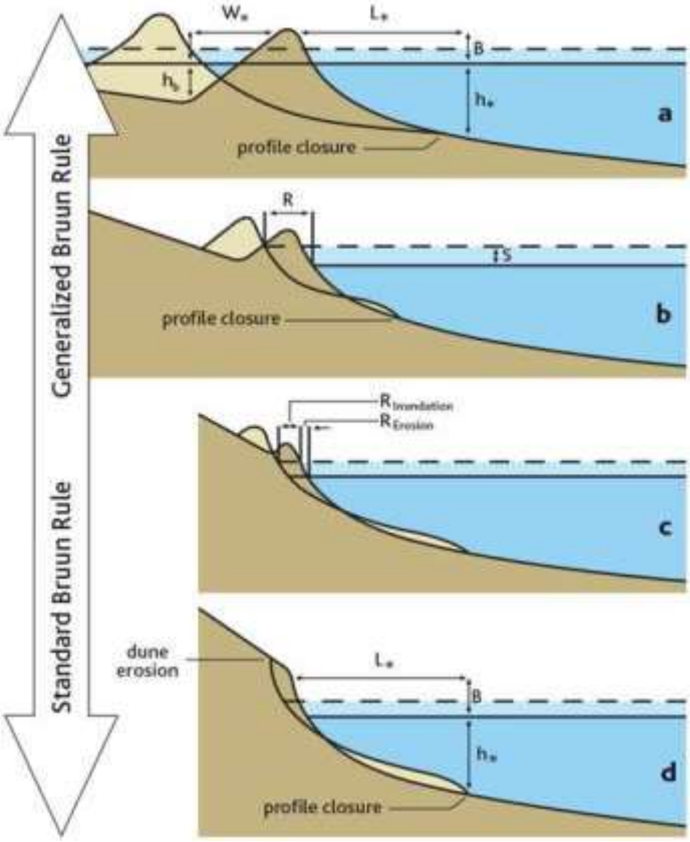


Figure 5-6: Schematic diagrams of the Bruun model modes of shoreline response (after Cowell and Kench, 2001)

5.3 Resulting Areas Susceptible to Coastal Instability and Erosion (ASCIE)

The resulting setback distances for ASCIE along the shoreline for the site are given in Table 5.2 and Figure 5-7. These areas have been mapped and are shown in Appendix G in more detail. Minimum values were adopted for cliff/terrace cells as -5 m, -10 m and -15 m for current, 2080 and 2130 ASCIE respectively.

Table 5.2: ASCIE for all cells

Cell	Current ASCIE (m)	2080 ASCIE (m)	2130 ASCIE (m)
A[1]	-9	-19	-32
B[2]	-5	-10	-15
C[1]	-9	-19	-32
D[2]	-27	-33	-38
E[2]	-52	-62	-72
F[2]	-52	-58	-64
G[2]	-5	-10	-15
H[2]	-5	-10	-15

1 calculated using the beach method, see Section 5.1.2.

2 calculated using the cliff method, see Section 5.1.1.

5.4 Assessment of impact of coastal instability and erosion on the proposed structure plan and plan change

The coastal erosion susceptibility extents have been overlain on the live-zone plan to assess the potential impact of coastal erosion susceptibility on the proposed development (see Figure 5-7). This shows that all property parcels, key assets and infrastructure are located landward of the 2130 area susceptible to coastal instability and erosion. The AUP framework for addressing natural hazards and climate change will be sufficient for addressing coastal instability and erosion and no specific mitigation is required.

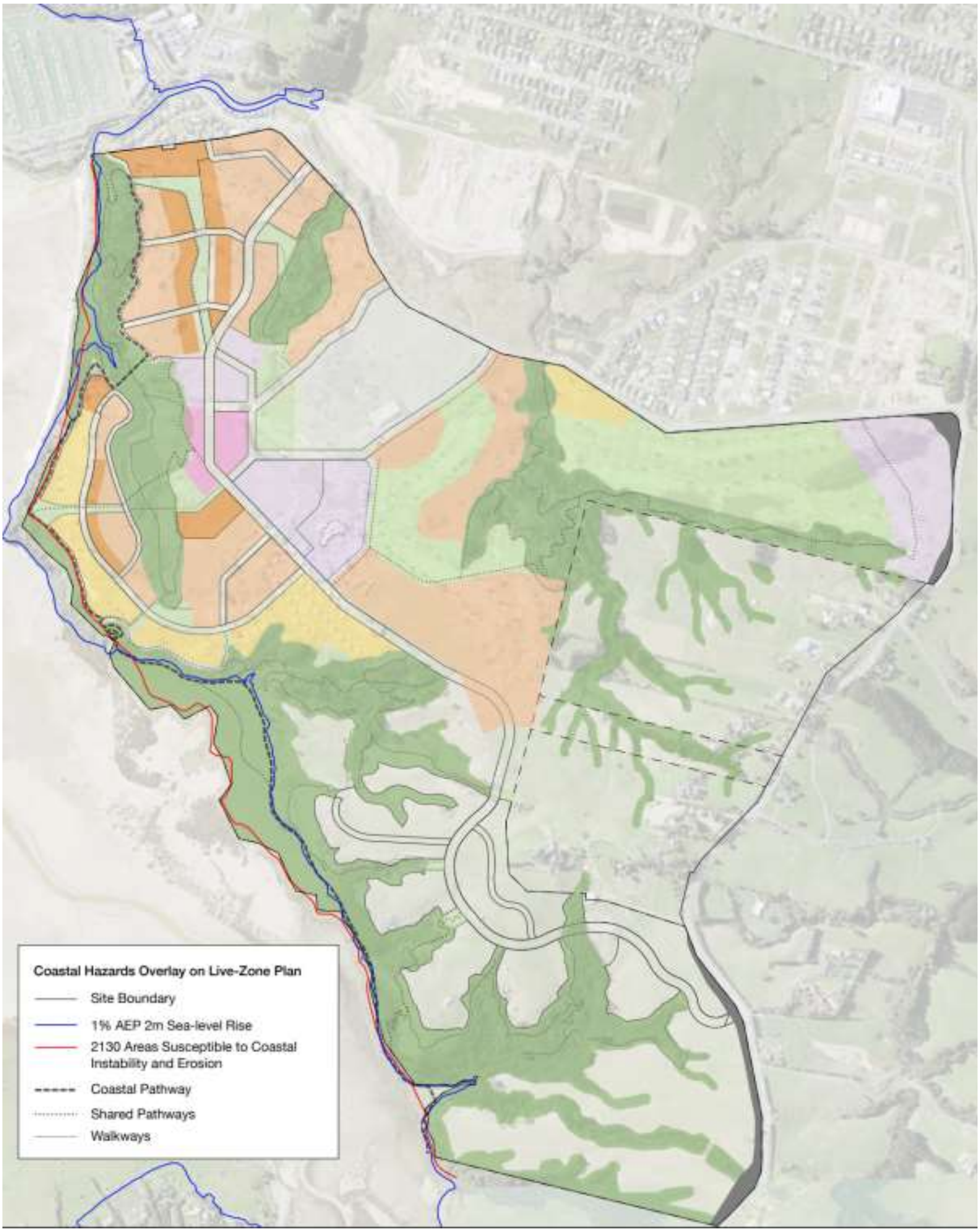


Figure 5-7: Overlay of coastal hazards on the Live-Zone plan

6 Coastal inundation hazard

6.1 Coastal inundation extents

Coastal storm inundation is an acute natural event arising from extreme weather events in which normally dry but low-lying coastal land is flooded. This occurs when high tides combine with storm surge, wave setup and run-up, and the higher than average monthly mean sea level due to climate cycles and variability.

The likelihood and magnitude of coastal inundation during storms is highly dependent on the timing of spring high tides, storm surge and wave conditions. The area and depth of inundation depends on the physical characteristics of the shoreline and hinterland topography. If sea levels rise as predicted, then coastal inundation will be exacerbated.

Several coastal inundation scenarios have been mapped by Auckland Council based on the storm surge modelling carried out by Stephens et al. (2016). Published maps of the coastal inundation extents for 1% Annual Exceedance Probability (AEP) event at present day and with 1 m and 2 m sea level rise have been obtained from Auckland Council and are presented in Appendix H. The 1%AEP storm surge with 1 m sea level rise is the current requirement for consideration within the Unitary Plan, but MfE guidance suggests considering the potential consequence of 2 m sea level rise for new subdivisions and development.

For the present-day scenario inundation rises over much of the low lying chenier ridge, shell beach and salt marsh cells and propagates some 250 m up Stream A to the north of the site, however much of the coastal terrace on the northwest side of the site remains above the 1% AEP storm surge level. With the future 1 m and 2 m SLR scenarios, the majority of the Jack Lachlan Esplanade Reserve seaward of the cliff toe becomes inundated and propagates some 450-500 m up Stream A. There is relatively little difference in flood extent between the 1 m and 2 m sea level rise scenario and this is due to inundation reaching the toe of the cliffs, so the main difference between 1 m and 2 m sea level rise is the depth of inundation during storm surges. While such water level is not expected to flood the site landward of the cliff sections, it would leave the much of the cliff toe previously protected by low-lying coastal terraces more vulnerable to wave action and subsequent coastal erosion. However, due to the relatively low water depth and the sheltered location of these cliffs, this is not anticipated to be an issue for the next 100 years.

6.2 Assessment of impact of coastal inundation on the proposed structure plan and plan change

The coastal inundation extents have been overlain on the live-zone plan to assess the potential impact of coastal inundation on the proposed development (see Figure 5-7) including an allowance for 2 m sea level rise. An area of low lying reserve will be periodically inundated, but no flooding will occur on residential or commercial land or road corridors. With the consideration of inundation impacts of up to 2 m sea level rise, the AUP framework for addressing hazards and climate change will be sufficient for addressing coastal inundation hazards and no specific mitigation is required. The coastal pathway through the wetland area is located within the area of inundation with a 1%AEP storm surge and sea level rise of between 1 and 2m sufficiently. It is sufficiently landward and elevated that it is unlikely to be at risk until sea level rise exceeds 1.5m, and it has the ability to be raised as required.

7 Tsunami

Tsunami are long-period water waves generated by undersea shallow-focus earthquakes or by undersea crustal displacements (subduction of tectonic plates), landslides, or volcanic activity. Tsunamis can travel great distances, undetected in deep water, but shoaling rapidly in coastal waters and producing a series of large waves capable of destroying harbour facilities, shore protection structures, and upland buildings (FEMA, 2008).

Tsunami may be broadly categorised as being either local (wave arriving within 1 hour of associated event), regional (wave arriving between 1 and 3 hours of associated event), or distant (wave arriving more than 3 hours after associated event). Along Auckland's east coast, the most significant local Tsunami source is from an earthquake along the Kermadec Arc, a subduction zone that extends northwards from East Cape to just south of Fiji (Gillibrand et al., 2010).

Tsunami wave characteristics at the coast can vary substantially, depending on several factors, including: the generating mechanism; the location, size and orientation of the initial source; source-to-locality distance; and local seabed and coastal margin bathymetry and topography. The timing and height of high tide with the tsunami peak waves are also important factors in determining the extent and magnitude of inundation. Sea-level rise will also exacerbate tsunami inundation and increase flow depths relative to present day for the same event.

The mapped tsunami evacuation zones included in the Auckland Council GIS maps are a conservative estimate of possible inundation threat (see Figure 7-1) for civil defence purposes (GNS, 2012, 2013). The red tsunami evacuation zone represents the highest risk zone and is the first area people should evacuate from in all types of tsunami warnings. This area includes all of Auckland's beaches and foreshore areas. The orange evacuation zone includes a range of tsunami scenarios, both distant and regional that could generate a 3 m high tsunami (return period in the order of 200 to 300 years) and a maximum amplitude (2,500 year return period at 84% – yellow evacuation zone) tsunami. They are mapped using first order attenuation approaches within shallow harbours and estuaries.

These levels suggest tsunami inundation extents for tsunami's with return periods of up to 200 years are likely to be within storm surge inundation levels at this location, although the potential of greater scour and erosion forces acting along the shoreline. Larger tsunamis may cause slightly greater inundation extents, but likely to still be within the inundation extents indicated by inundation maps inclusive of 2 m sea level rise.

All key infrastructure and developments are located landward of the tsunami inundation extents. The AUP framework for addressing hazards will be sufficient for addressing tsunami hazards and no specific mitigation is required.

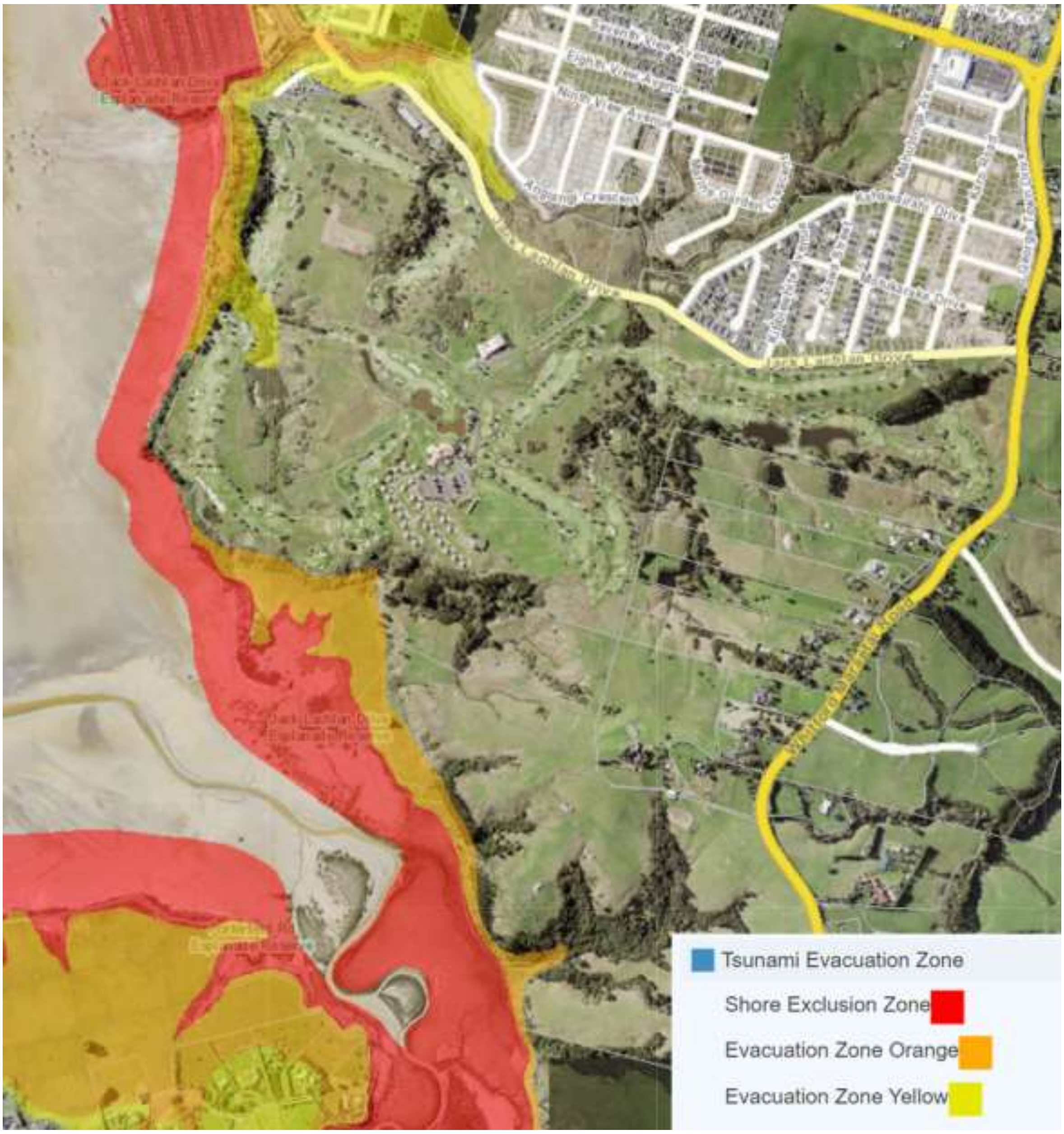


Figure 7-1: Tsunami evacuation zone (Source: Auckland Council GeoMaps)

8 Conclusion

The intention of this assessment is to provide Beachlands South Limited Partnership information on potential coastal hazard issues to inform the structure planning process and private plan change for rezoning of the land for future urban development. This study includes a local scale assessment of Areas Susceptible to Coastal Instability and Erosion (ASCIE) of both consolidated (cliff/ terrace) and unconsolidated (beach) shorelines, and an assessment of the inundation hazard of the site based on scenarios supplied by Auckland Council.

This assessment meets the objectives and policies in the RPS (Chapter B of the AUP) that set strong directives to manage the risk of coastal hazards (Chapters B8 and B10) by considering natural hazards and the effects of climate change on natural hazards for at least 100 years.

All property parcels, key assets and infrastructure are located landward of the 2130 area susceptible to coastal instability and erosion. No coastal inundation or tsunami hazard will occur on property parcels, key assets and infrastructure, even with a consideration of 2 m sea level rise. The AUP framework for addressing natural hazards and climate change will be sufficient for addressing coastal instability and erosion and no specific mitigation is required.

The AUP currently requires a 30 m coastal yard for buildings measured from MHWS under the AUP framework. This yard is for a range of purposes and is considered to be adequate for managing the development of buildings and structures adjacent to this coastal edge but there is no reason from a coastal hazard perspective to change this setback standard.

With the development situated to avoid coastal hazards the proposed development will not exacerbate or accelerate any of the existing hazards present. Any structures or development within the future inundation areas should be landward of the erosion susceptibility extent and designed to accommodate or be adaptable to coastal inundation hazards complying with the rules in Chapter E36 of the AUP. This should reduce and manage the coastal inundation hazard risk to the proposed development.

9 Summary and recommendation

This study includes a local scale assessment of Areas Susceptible to Coastal Instability and Erosion (ASCIE) of both consolidated (cliff/ terrace) and unconsolidated (beach) shorelines, and an assessment of the inundation hazard and tsunami hazard based on scenarios supplied by Auckland Council.

The present day ASCIE and two future ASCIE (2080 and 2130) were evaluated. Present day ASCIE is based on the current stability of the shoreline and potential erosion to occurafter large storm events, and future ASCIE is based on present day values, plus a future long-termregression rate, including a sea level rise component (using the RCP 8.5+ scenario). The resulting setback distances have been determined for ASCIE along the shoreline for the site. These areas have been mapped and are shown in Appendix G and overlain on the live-zone plan (Figure 5-7). Inundation extents including 1%AEP storm surge and 1 m and 2 m sea level rise have been considered and these are included in Appendix H and Figure 5-7.

All property parcels, key assets and infrastructure are located landward of the 2130 area susceptible to coastal instability and erosion. No coastal inundation or tsunami hazard will occur on property parcels, key assets and infrastructure, even with a consideration of 2 m sea level rise. The AUP framework for addressing natural hazards and climate change will be sufficient for addressing coastal instability and erosion and no specific mitigation is required.

Only beach and salt-marsh areas are susceptible to coastal inundation and are also the most likely to be affected by tsunami. These low-lying areas around the coastal edge have only been considered for recreational amenity and no habitable buildings should be located on these areas. The walkway is situated sufficiently landward and is of an elevation that reduces the risk of inundation to negligible for sea level rise of up to 1.5m. Adaptation responses can be considered to raise or relocate in the long term.

Any structures or development within the future inundation areas should be landward of the erosion susceptibility extent and designed to accommodate or be adaptable to coastal inundation hazards. This should reduce the coastal hazard risk to any the proposed development within these areas.

The assessment meets the requirement of Policy 24 of the NZCPS and the proposed structure plan meets both Objective 5 of the NZCPS ensuring that coastal hazard risks, taking into account of climate change are managed by locating new development away from areas prone to such risks, and Policy 25 by avoiding any increased risk of adverse effects from coastal hazards. By avoiding providing the setback areas along the coastal edge, the proposal recognises and protects the existing natural defences of vegetated slopes and wetlands, meeting requirements of Policy 26 of the NZCPS.

We note that the AUP currently requires a 30 m coastal yard for buildings measured from MHWS under the AUP framework. This yard is for a range of purposes and is considered to be adequate for managing the development of buildings and structures adjacent to this coastal edge but there is no reason from a coastal hazard perspective to change this setback standard.

10 Applicability

This report has been prepared for the exclusive use of our client Beachlands South Limited Partnership, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Report prepared by:

....	....
Benjamin Westgate	Richard Reinen-Hamill
Senior Engineering Geologist	Technical Director Coastal Engineering

Authorised for Tonkin & Taylor Ltd by:

....

Peter Millar

Project Director

p:\1014358\1014358.6000\workingmaterial\20211202.rrh.pjm.coastal_hazards_report.v4.docx

11 References

Ashton, A.D., Walkden, M.J. and Dickson, M.E. (2011). Equilibrium responses of cliffed coasts tochanges in the rate of SLR. Marine Geology. 284 (2011) 217-229.

Bruun P (1962). Sea-level rise as a cause of shore erosion. J. Waterways Harbors Div 88:117–130.

Bruun, P., (1988). The Bruun Rule of erosion by sea level rise: a discussion on large-scale two- andthree-dimensional usages. JCR, 4, 627–648.Cai, M.,

FEMA (2008). Guidelines for Design of Structures for Vertical Evacuation from Tsunamis. FEMA P- 646A, prepared by the Applied Technology Council for the Federal Emergency Management Agency,Washington, D.C.

Gillibrand, P. W. Power, E. Lane, X. Wang, J. Sykes, H. Brackley, J. Arnold (2010) Probabilistic hazard analysis and modelling of tsunami inundation for the Auckland Region from Regional Source Tsunami, NIWA Report CHC2010-102, GNS Report 2010fe/200 for Auckland Regional Council, August2010.

GNS (2012) An initial GIS-based tsunami inundation area for a three-metre wave height in Auckland.GNS letter report 2012/208LR for Auckland Council, 30 July 2012.

GNS (2013) A GIS-Based tsunami inundation area for the maximum credible wave height inAuckland. GNS letter report 2013/240LR for Auckland Council, 20 November 2013

Hallermeier, R.J. (1983). Sand transport limits in coastal structure designs. Proc. of Conf. on Design,Construction, Maintenance and Performance of Coastal Structures. ASCE, Arlington, pp 703– 716.Hamill P.F. and Balance P.F. (1985). Heavy mineral rich beach sands of the Waitakere coast, Auckland, New Zealand, New Zealand Journal of Geology and Geophysics. 28:503-511.

Kermode, L.O. (1992). Geology of the Auckland urban area. Scale 1:50 000. Institute of Geological &Nuclear Sciences geological map 2. 1 sheet + 63 p. Institute of Geological & Nuclear Sciences Ltd., Lower Hutt, New Zealand.

Klinac, P. (2002) Sediment dynamics of the sheltered East Coast beaches of Auckland. Thesis,University of Waikato.

Komar, P.D., McDougal, W.G., Marra, J.J. and Ruggiero, P. (1999). The Rational Analysis of SetbackDistances: Application to the Oregon Coast. Shore and Beach Vol. 67 (1) 41-49.

LINZ (2012). Tidal levels for surveyors. http://www.linz.govt.nz/geodetic/datums-projections-heights/vertical-datums/tidal-level-information-for-surveyors.

MfE (2017). Coastal Hazards and Climate Change: Guidance for Local Government. Published by the Ministry for the Environment (MfE) December 2017. https://www.mfe.govt.nz/publications/climate-change/coastal-hazards-and-climate-change-guidance-local-government

Nicholls, RJ., Laron, M., Capobianco, M. and Birkemeier, W.A. (1998) Depth of Closure: ImprovingUnderstanding and Prediction. ICCE 1998.

Ramsay, D., Altenberger, A., Bell, R., Oldman, J., Stephens, S. (2008a) Review of rainfall intensity curves and sea levels in Manukau City. Part 2: Sea levels. Consulting Report to Manukau City Council,No. HAM2007-168: 74.

Reinen-Hamill, R., Hegan, B., Shand, T., et al. (2006). Regional Assessment of Areas Susceptible to Coastal Erosion (Technical Report Volume 1). Prepared for Auckland Regional Council by Tonkin &Taylor Ltd.

Inundation Hazard Study: Coastal Storms and Extreme Waves, WRL TR2010/16.

Stephens et al. (2016). Coastal Inundation by Storm-tides and Waves in the Auckland Region. Prepared by the National Institute for Water and Atmospheric Research, NIWA and DHI Ltd forAuckland Council. Auckland Council technical report, TR2016/017.

T+T (2020). Auckland Costal Erosion Study (Final Draft). Prepared for Auckland Council by Tonkin &Taylor Ltd. March 2020.

T+T (2021). Beachlands South Structure Plan Change: geotechnical report. Unpublished report for Bechlands South Limited Partnership, dated 1 December 2021.

Appendix A: Geotechnical supporting data

•

A1 Statistical method for slope angles

To create a statistical method for determining the Areas Susceptible to Coastal Instability (ASCI) slope angles a dataset was required to be created for the Beachlands area. Therefore, each lithological domain or sub domain was analysed at 15 to 25 m section spacing for different coastal environments. For each profile the cliff toe, crest of the rock layer and crest of the soil layer were derived to obtain the height and slope of both the rock and soil layers (see sketch in Figure Appendix A.1).

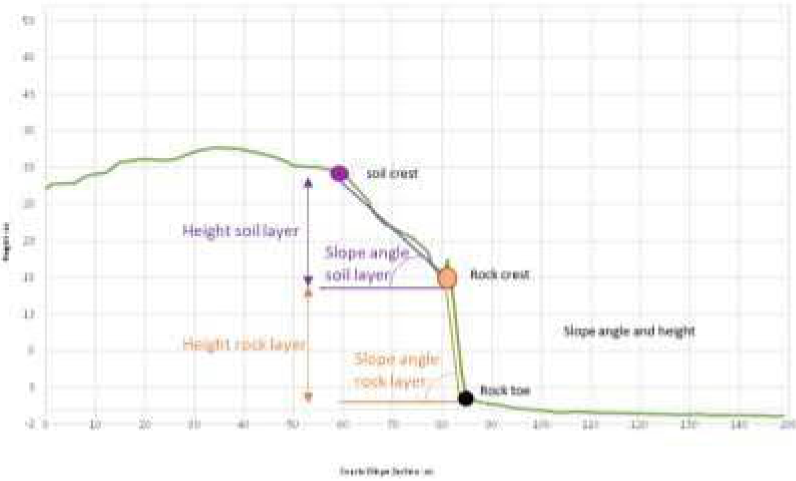


Figure Appendix A.1: Cliff profile sketch showing identified rock toe, rock crest and soil crest to derive angles and heights

The derived heights and angles from each profile were then analysed and combined to derive combined slope angles for each lithology. The combined slope angles were plotted as scatter plots (see Figure Appendix A.2) and slope angle statistics were derived. Figure Appendix A.3 shows the distribution of combined slope angles for the site including the medium, unlikely, and exceptionally unlikely likelihood slope angles. The definitions of the likelihood of occurrence adopted here have been taken from the Intergovernmental Panel on Climate Change (IPCC) methodology (using the lower three categories: Medium (33-66% - 50% Mean adopted), Unlikely (10-33% - 10% adopted) and Exceptionally Unlikely (1% adopted)).

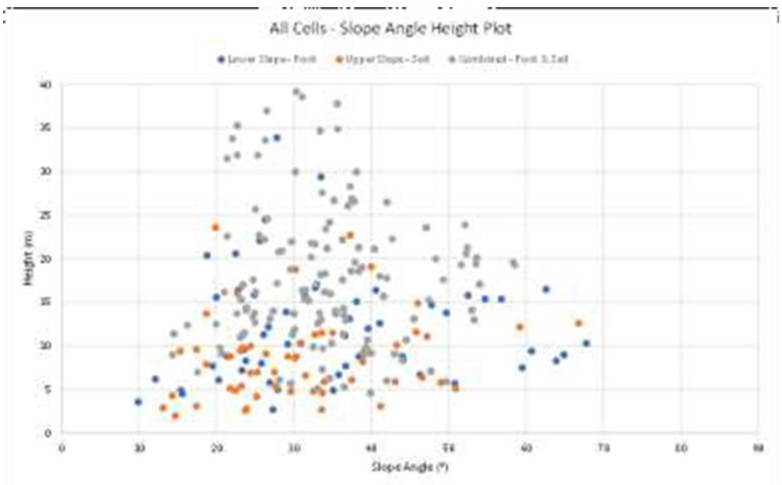


Figure Appendix A.2: Statistical evaluation of ASCI height and slope profiles for Beachlands

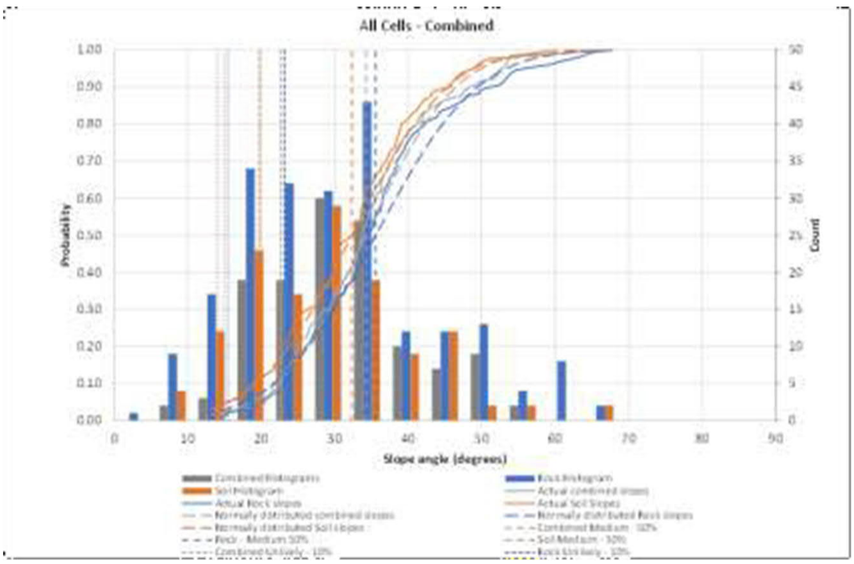


Figure Appendix A.3: Statistical evaluation of ASCI slope profiles for Beachlands

A2 Beachlands site specific ASCI slope angles

A detailed assessment was undertaken for Beachlands to define ASCI slope angles based on the digital elevation model (DEM) of the site. To refine DEM the coastline was divided into five (5) cells as shown below and on Figure Appendix A.4.

- Cliff Cell A – accretion beach with vegetated cliff slopes. This cell contains a man-made slope that has been excluded from the analysis.
- Cliff Cell B – rock outcrop in the toe, with exposed face.
- Cliff Cell C – sheltered shore platform with rock outcrop toe, including an unstable soil slope.
- Cliff Cell D – salt marsh toe zone, including an unstable soil slope.
- Cliff Cell E – estuarine zones with low vegetation coverage.
- Cliff Cell F – estuarine zones with pine woodland indicating potentially a deeper soil profile.

Each cell was divided into a series of cliff profiles at a spacing of 15-25 m. The spacing depended on the crest length of the cell to facilitative the statistical evaluation of the profiles. These were then graphed and the Medium (50%), Unlikely (10%) and Exceptionally Unlikely (1%) probabilities tabulated, as shown in Appendix A Table 1, Figure Appendix A.2 and Figure Appendix A.3.

On reviewing the statistics from the soil, rock and combined slope angles at the various probabilities are minimal. Therefore, for simplicity in approach the Unlikely composite slope angles of 23° (Table 3.2) should be used for the toe projection.

There were two areas where previous historical instability events have occurred, these are shown on Figure 3-2by X1 and X2. The slope angle for the unstable slopes are between 15 to 36°. Therefore, the lower ‘Unlikely’ slope angle of 23° should be applied.

Cliff Cell B was identified as having the steepest slope angle, this was identified in the site walk over as the most recently unstable with a series of rockfalls observed at the toe. The rock falls are high probably events with a low consequence for coastal instability due to the size of the blocks being released (0.03 to 0.15 m^3). Therefore, the cell has the potential to be over steepened and closer to equilibrium.

Appendix A Table 1: ASCI slope angles for Beachlands cells

Lithology	Rock (°)			Soil (°)			Composite (°)		
	50%	10%	1%	50%	10%	1%	50%	10%	1%
Beachlands Average	36	23	15	32	20	14	34	23	15
Cliff Cell A	35	24	24	23	13	13	35	24	24
Cliff Cell B	50	36	27	42	25	16	47	36	31
Cliff Cell C	41	21	20	32	22	18	38	25	22
Cliff Cell D	25	15	13	28	23	19	25	15	14
Cliff Cell E	34	25	19	34	27	24	34	28	21
Cliff Cell F	32	24	23	27	17	16	31	23	22

Figure Appendix A.4: Cliff cell locations

A3 Assessment for Auckland Council Code of Practice (2013)

A slope stability analysis was undertaken for one of the two slope instabilities recorded during the site walk. The site chosen was site X2 as shown in Figure Appendix A.5. The stability analysis was undertaken in Limit Equilibrium software SlopeW (Geostudio) to ensure that they conformed to the current ACCoP (2013) and that the statistical approach provides parity of results. The material parameters used in the analysis are shown below in Appendix A Table 2.

The morphology of the adjacent slope was modelled with a rise in groundwater to re-created the instability with a Factor of Safety (FoS) approximately 1.0 or slope equilibrium, with a slope angle of 36°. The model was then re-run to generate a FoS of 1.5 and compliance with ACCoP (2013).This resulted in a slope angle of (15°) and a toe to crest distance of 62 m.

To validate the slop stability model a ground investigation should be undertaken adjacent to the site to confirm material properties and groundwater conditions. The resulting data should be used in ground model validation and re-assessment of the slope stability.

Appendix A Table 2: Adopted ASCI cliff angles

Geotechnical domain	Unit weight	Cohesion	Friction Angle	GSI	UCS
	kN/m^3	kPa	°		kPa
Waitemata Group - Soil	19	4	28		
Waitemata Group - ECBF	20	25	35	35	1000

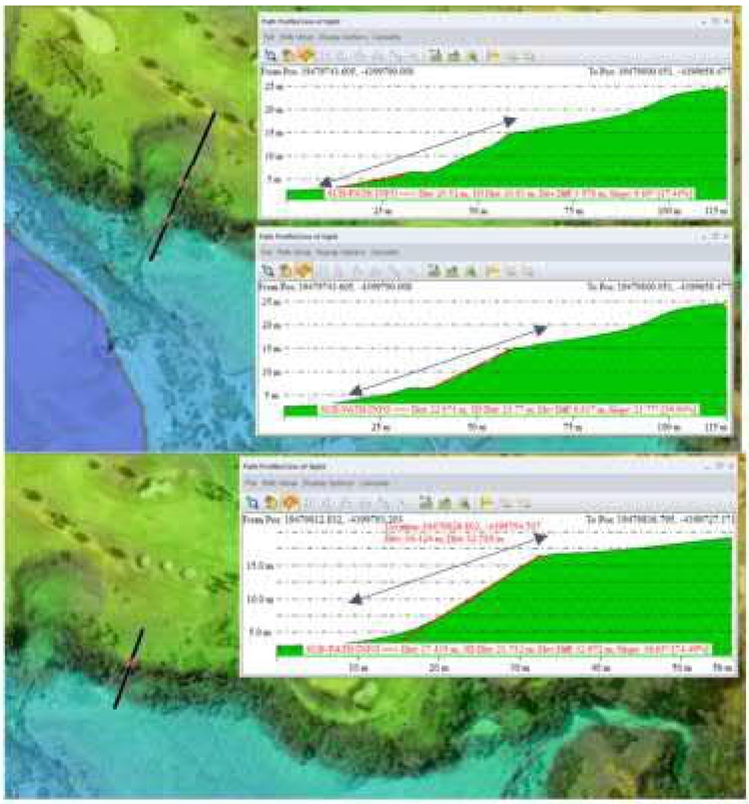


Figure Appendix A.5: Slope instability in the Beachlands coastal section

Appendix B: Aerial images

Figure Appendix B.1: Historic aerial photograph of the site dated 1939 (Source: Retrolens)

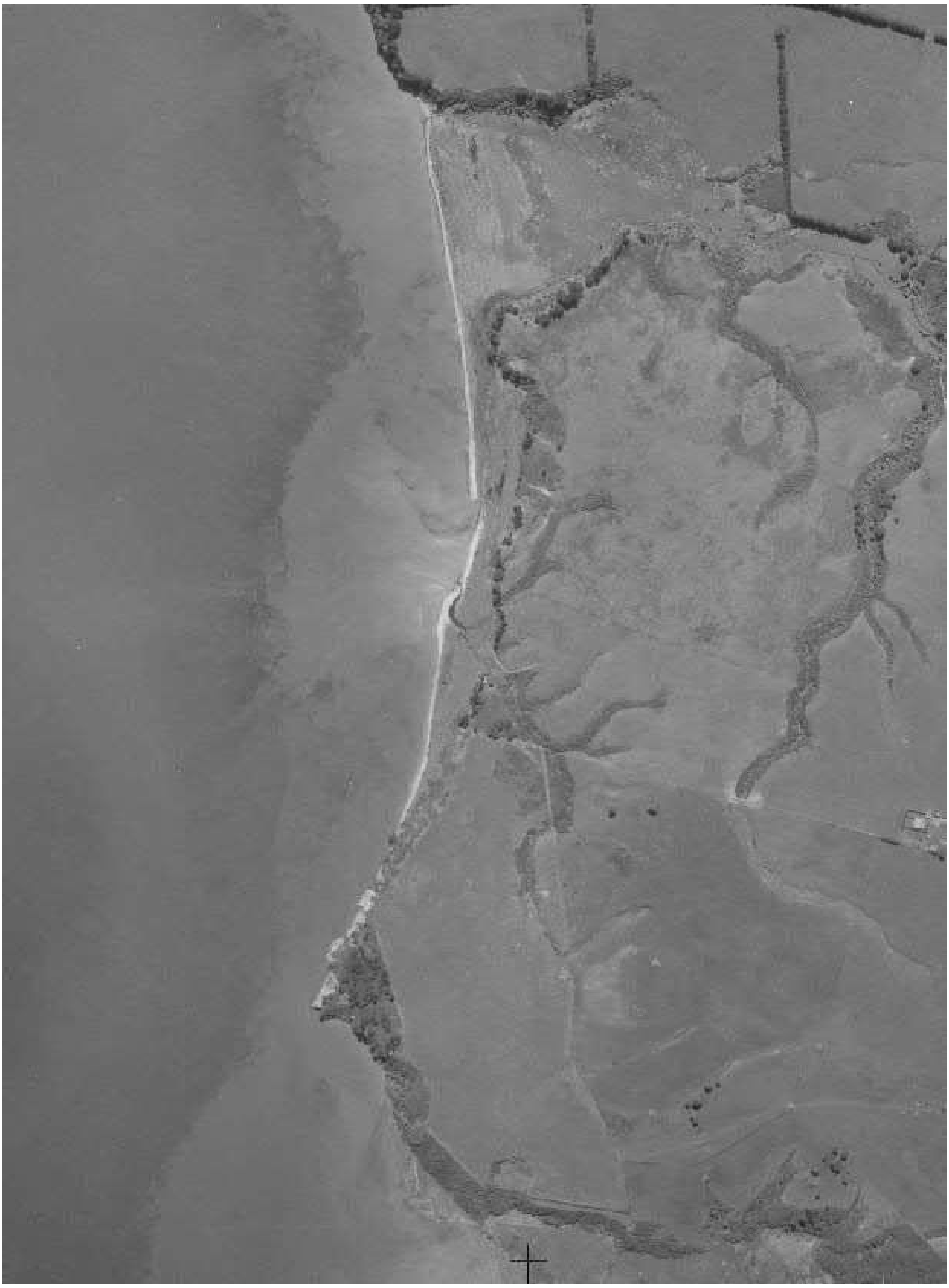


Figure Appendix B.2: Historical aerial photograph of the site dated 1955 (Source: Restrolens)

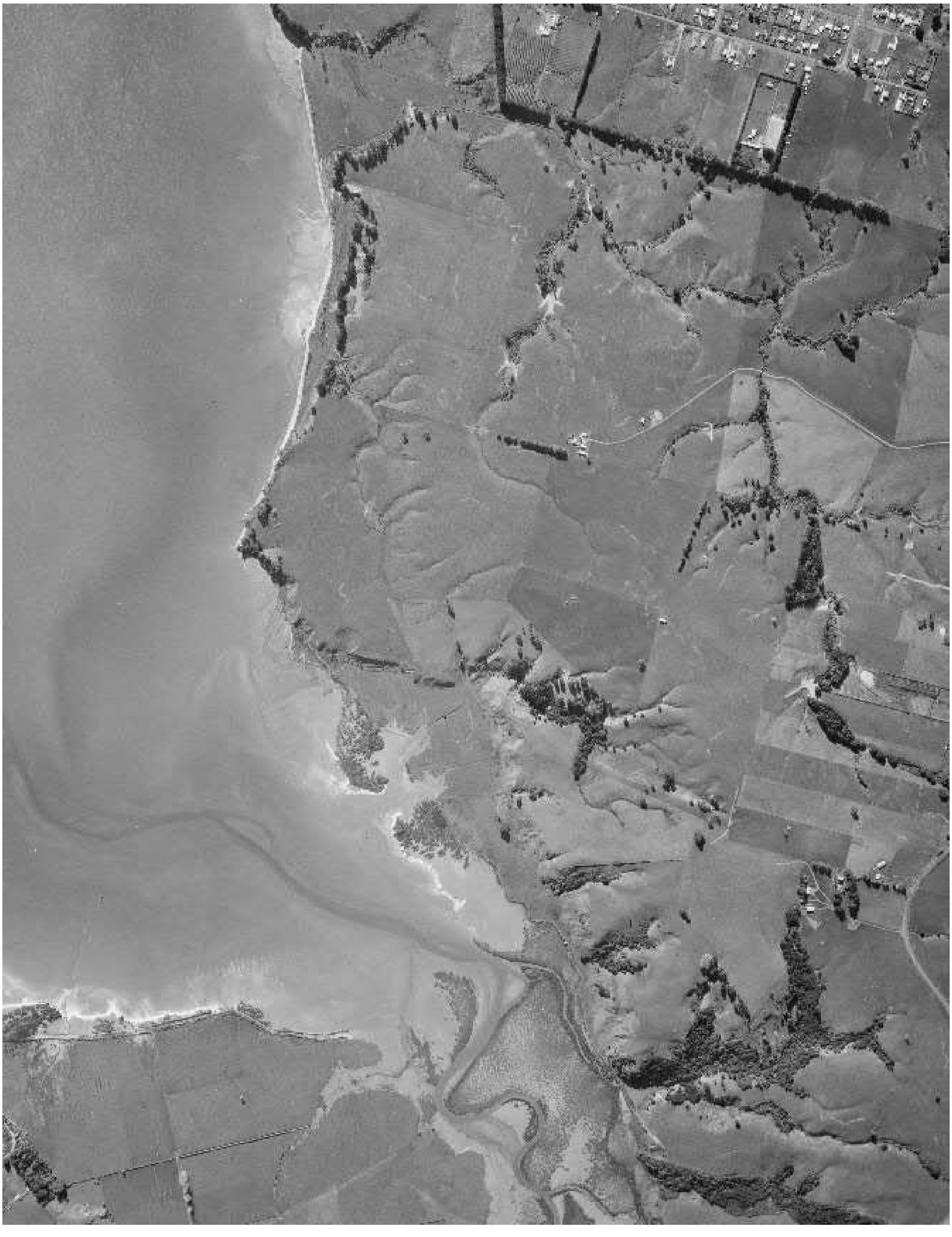


Figure Appendix B.3: Historic aerial photograph of the site dated 1972 (Source: Retrolens)

Figure Appendix B.4: Historic aerial photograph of the site dated 1980 (Source: Retrolens)

•

Figure Appendix B.5: Historic aerial photograph of the site dated 1987 (Source: Retrolens)

Figure Appendix B.6: Present day aerial photograph of the site dated 2017 (source: LINZ data service)

Appendix C: Site photographs

Figure Appendix C.1: View (looking south) of the chenier ridge building out on the left with stream outlet in front

Figure Appendix C.2: View (looking east) of eroding terrace, the loose rock seaward of terrace is an indication of erosion

Figure Appendix C.3: View (looking north) of 'Stream B'

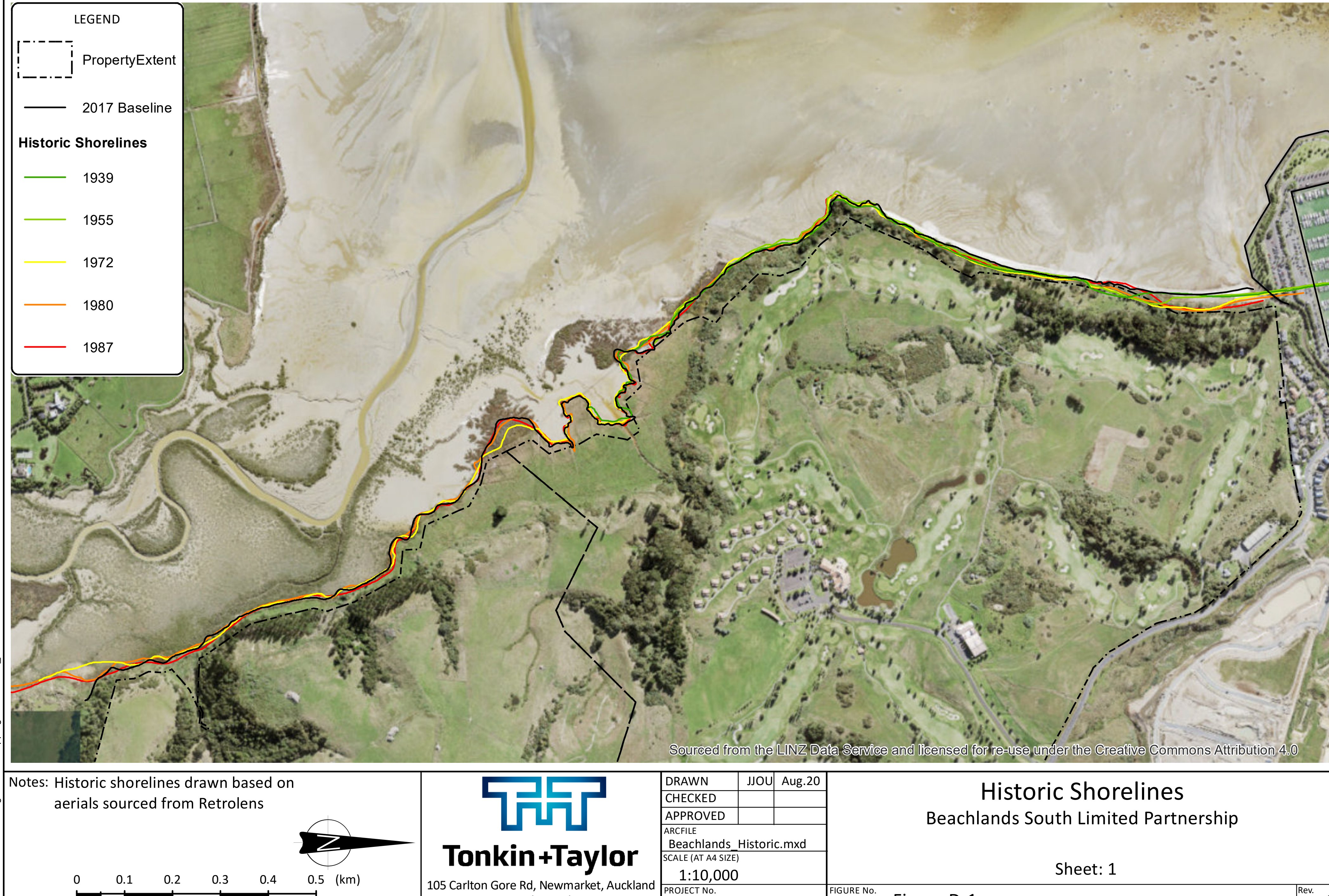
Figure Appendix C.4: View (looking south) of beach section with cliff headlands in the background

Figure Appendix C.5: View (looking southeast) of cliff headlands, with mudstone flats seaward

Figure Appendix C.6: View (looking east) of cliff section south of headlands showing signs of erosion

Figure Appendix C.7: View (looking west) of salt marsh and mangrove scattering

Appendix D: Historic shorelines



Path: P:\1014601\WorkingMaterial\Mapping\Beachlands_Historic.mxd Date: 11/08/2020 Time: 10:50:57 AM

Notes: Historic shorelines drawn based on aerials sourced from Retrolens

Tonkin+Taylor
105 Carlton Gore Rd, Newmarket, Auckland
www.tonkintaylor.co.nz

DRAWN	JJOU	Aug.20
CHECKED		
APPROVED		
ARCFILE Beachlands_Historic.mxd		
SCALE (AT A4 SIZE) 1:10,000		
PROJECT No. 1014601.0000		

Historic Shorelines

Beachlands South Limited Partnership

Sheet: 1

FIGURE No. Figure D.1

Rev. 0

Appendix E: Local bathymetry

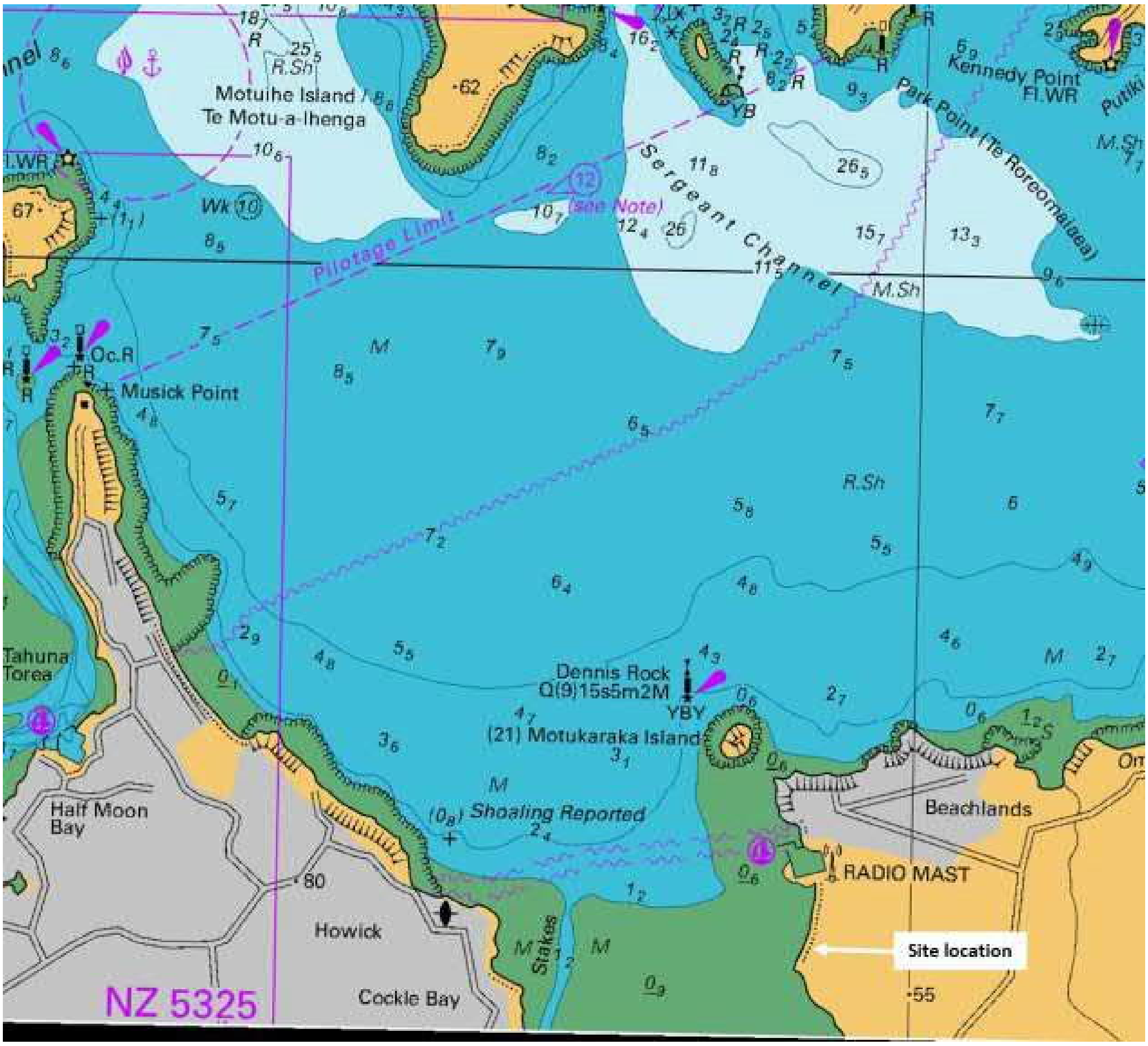


Figure Appendix E.1: Excerpt of hydrographic chart NZ 532 Approaches to Auckland (Source: LINZ data service). Note that levels are expressed in Chart Datum (CD) which is 1.743 m below AVD46 (RL)

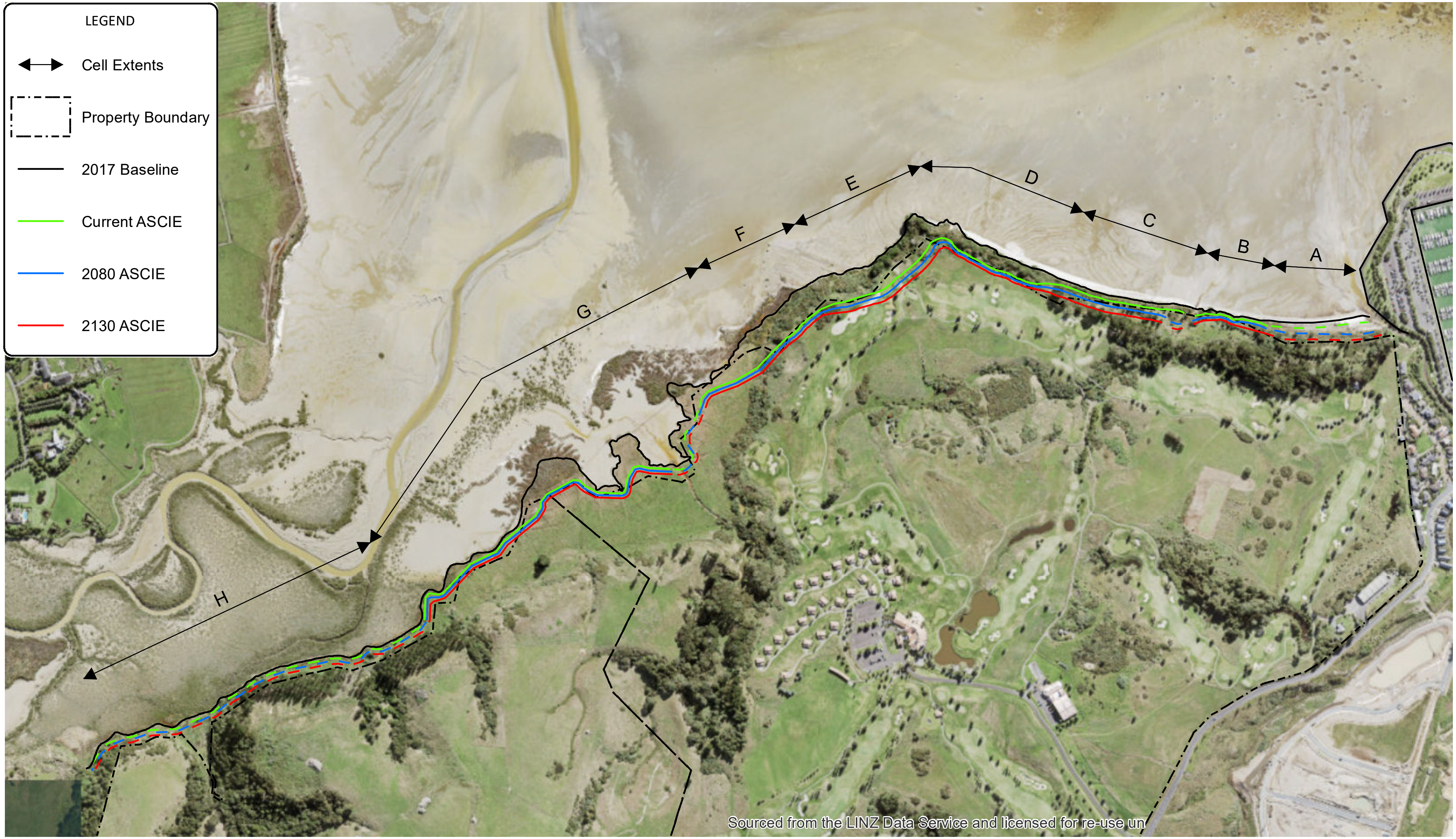
Appendix F: Erosion input values

Appendix F Table 1: Component values for erosion hazard assessment

Cell	A[1]	B	C[1]	D	E	F	G	H
Morphology	Sand/shell chenier ridge	Soft consolidated terrace+	Sand/shell beach	Exposed ECBF cliff	Vegetated ECBF cliff	Vegetated ECBF cliff with salt marsh at toe	Salt marsh with chenier ridge formations	Coastal terrace with dense mangroves seaward
Short-term (m)	3	0	3	0	0	0	0	0
Dune Stability (m)	1.7	0	1.7	0	0	0	0	0
Dune/Cliff elevation (m above toe or scarp)	0.7	0.9	0.9	20	22	18	1	1.5
Stable angle/ angle of repose (deg)	34	23	34	36	23	23	23	23
Long-term (m/yr) -ve erosion +ve accretion	*0*	-0.05	*0*	-0.05	-0.1	*-0.05*	0	0
Closure slope (beaches) / Cliff response factor	0.11	0.4	0.11	0.3	0.3	0.4	0.4	0.4

1: Calculated using the beach methodology, otherwise cliff methodology was used.

Appendix G: Mapped ASCIE



Path: P:\1014601\WorkingMaterial\Mapping\Beachlands_Setbacks.mxd Date: 11/08/2020 Time: 10:26:40 AM

Notes: Dashed ASCIE indicates greater uncertainty around stream mouths and backshore topography.

0 0.1 0.2 0.3 0.4 0.5 (km)

Tonkin+Taylor
105 Carlton Gore Rd, Newmarket, Auckland
www.tonkintaylor.co.nz

DRAWN	JJOU	Aug.20
CHECKED		
APPROVED		

ARCFILE Beachlands_Setbacks.mxd

SCALE (AT A4 SIZE) 1:10,000

PROJECT No. 1014601.0000

Coastal erosion hazard map

Beachlands South Limited Partnership

Areas Susceptible to Coastal Instability and Erosion (ASCIE)

Sheet: 1

FIGURE No. Figure G.1

Rev. 0

Appendix H: Mapped AC inundation layers

Notes: Inundation layers sourced from Auckland Council.

0 0.1 0.2 0.3 0.4 0.5 (km)

Tonkin+Taylor
105 Carlton Gore Rd, Newmarket, Auckland
www.tonkintaylor.co.nz

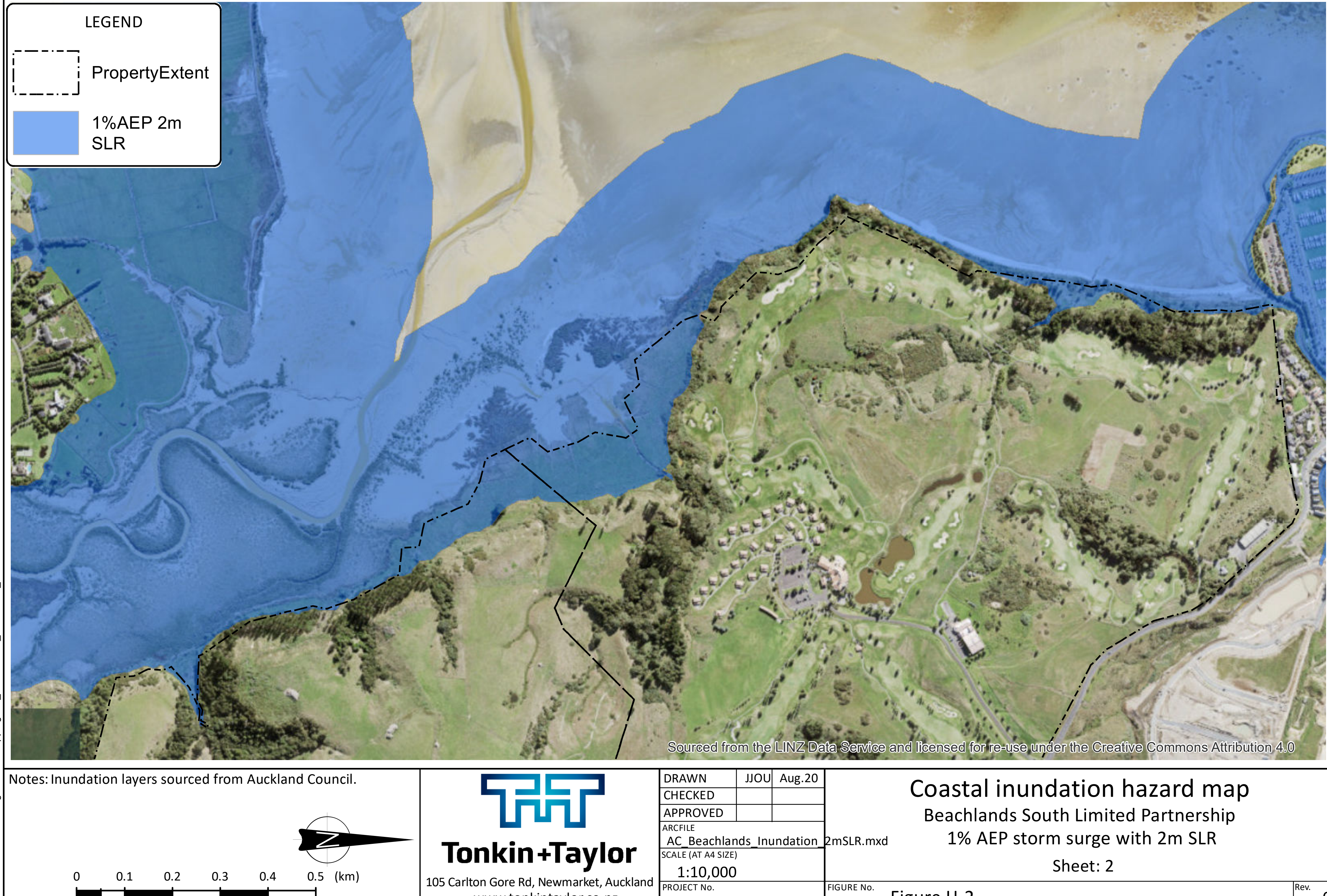
DRAWN	JJOU	Aug.20
CHECKED		
APPROVED		

ARCFILE: AC_Beachlands_Inundation.mxd
SCALE (AT A4 SIZE): 1:10,000
PROJECT No.: 1014601.0000

Coastal inundation hazard map
Beachlands South Limited Partnership
1% AEP storm surge with 0 m SLR & 1 m SLR cases
Sheet: 1

FIGURE No.: Figure H.1
Rev.: 0

Path: P:\1014601\WorkingMaterial\Mapping\AC_Beachlands_Inundation.mxd Date: 11/08/2020 Time: 11:01:39 AM



Notes: Inundation layers sourced from Auckland Council.

Tonkin+Taylor
105 Carlton Gore Rd, Newmarket, Auckland
www.tonkintaylor.co.nz

DRAWN	JJOU	Aug.20
CHECKED		
APPROVED		

ARCFILE
AC_Beachlands_Inundation_2mSLR.mxd

SCALE (AT A4 SIZE)
1:10,000

PROJECT No.
1014601.0000

Coastal inundation hazard map

Beachlands South Limited Partnership
1% AEP storm surge with 2m SLR
Sheet: 2

FIGURE No. Figure H.2

Rev. 0

Path: P:\1014601\WorkingMaterial\Mapping\AC_Beachlands_Inundation_2mSLR.mxd Date: 11/08/2020 Time: 10:57:57 AM

www.tonkintaylor.com