WAITOMO DISTRICT COUNCIL COASTAL HAZARDS

FINAL

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Waitomo District Coastal Hazard Assessment

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EXECUTIVE SUMMARY

Background

The Waitomo District Council ("the Council") is currently reviewing and updating the Waitomo District Plan ("the Plan"). The Plan contains objectives, policies and rules that relate to the management of land vulnerable to coastal hazards. The Council therefore needs to understand coastal hazards and coastal hazard risks, particularly at urban coastal settlements.

This study was therefore commissioned by the Waitomo District Council to investigate coastal hazards and define areas potentially affected by coastal hazards (excluding tsunami), including high risk coastal hazard areas, and to provide management recommendations, with a focus on Mokau, Awakino, Marokopa and Te Waitere (including Kinohaku). To achieve this, we have worked with local communities, landowners, and Iwi to identify areas potentially at risk with existing sea level and those areas that could be affected with projected future sea level rise. We also considered local values and challenges and present draft adaptive management approaches to managing potential future risk in these areas.

Coastal Hazards in the Waitomo District

The Waitomo District is extensive and diverse and large areas of the District remain remote and essentially untouched. The developed areas of shoreline are characterised by open coast sandy beaches, estuarine intertidal sand flats and estuarine beaches, cliff shorelines, and low-lying estuarine margins. Existing residential development and some areas of public reserve are vulnerable to coastal erosion and/or coastal flooding at many settlements. The extent and nature of the hazard varies depending on the physical characteristics of the local environment.

The coastal hazard assessment included a review of all relevant literature and available data on the coastal environment of the District, including physical coastal features and processes and how they relate to coastal hazards. Two rounds of community meetings were held at key sites to both inform affected residents and gather any available local knowledge and unpublished information. Consultation was also undertaken with applicants under the Marine and Coastal Area (Takutai Moana) Act 2011. This information was incorporated into the study. Community consultation formed an important part of the information gathering and helped to guide the management recommendations.

Two coastal erosion hazard zones were identified from the available data:

- The Coastal Erosion Hazard Zone 1 (CEHZ 1): the area likely to be affected by coastal erosion within the next 50 years with existing sea level and coastal processes and/or with continuation of existing coastal trends.
- Coastal Erosion Hazard Zone 2 (CEHZ 2): the area likely to be affected by coastal erosion over the next 100 years with continuation of existing coastal trends and the likely impact of projected sea level rise of 1.0 m.

Two coastal flood hazard areas were identified:

- Coastal Flood Hazard Zone 1 (CFHZ 1): the extent of land likely to be vulnerable in a rare extreme storm surge event with current sea level and processes.
- Coastal Flood Hazard Zone 2 (CFHZ 2): the extent of land likely to be vulnerable in a rare extreme storm surge event, including the effect of projected sea level rise (1.0 m to 2120).

Coastal erosion and flooding hazard reduce with distance inland and elevation (respectively). As we project coastal hazard beyond the short term, the uncertainty increases very considerably. The Coastal Erosion Zone 2 therefore identifies the areas of land that are potentially vulnerable to coastal hazards in the long term, including the effects of sea level rise over the next 100 years. A high level of uncertainty is inevitable in identifying these areas. As discussed further below, we recommend that Council provide for site specific hazard studies that may refine the hazard within these areas.

Coastal Hazard Management Recommendations

This report recommends a range of measures for sustainable management of coastal erosion and flood risk in the Waitomo District. These recommendations are founded on a broad "hierarchy" of management approaches, implicit in national and regional coastal policy and developed to reflect the nature of the coastal environment, the likely responses of that environment to future climate change and the implications of different coastal hazard responses. This hierarchy is used to provide a basis for coastal management in the Waitomo District, with emphasis on risk avoidance and reduction, through to the use of soft and hard engineering works to protect development in known hazard areas where necessary and appropriate.

Risk avoidance is recommended as the preferred approach wherever practicable in identified coastal hazard zones when:

- establishing major new infrastructure,
- undertaking major upgrades to existing infrastructure,
- considering applications for Greenfield development or any other significant intensification of land use
- when considering applications for subdivision

In areas of existing development, it is recommended that Council develop appropriate policies and rules to both avoid increasing and, where reasonably practicable to reduce the risk of adverse effects from coastal hazards within the coastal hazard zones, with a particular focus on Coastal Erosion Hazard Zone 1 and the Coastal Flood Hazard Zone 1.

Relevant risk reduction approaches include:

- avoiding any development in Coastal Erosion Hazard Zone 1.
- avoiding subdivision in identified coastal erosion hazard zones without detailed investigation of future hazards, considering all sea level rise scenarios.

- requiring adaptive planning and design for development within Coastal Erosion Hazard Zone 2.
- requiring a site-specific geotechnical report in identified coastal erosion areas on cliff shorelines to ensure future development is not at risk from slope failure.

The Waitomo District council should retain existing rules within the District Plan that facilitate relocation of dwellings and structures within sites identified to be vulnerable to coastal erosion hazard. Council should require adaptive design (i.e. readily relocatable buildings) where there is a potential for the hazard to impact within the lifetime of the activity. Development within coastal flood hazard zones should have floor levels above defined levels or be of adaptable design (i.e. on piles so can be raised).

In all cases where development or activities are restricted by these identified hazard zones, we recommend that the Council provides for the consideration of further, more detailed information including site specific coastal hazard studies, data on sub-surface geology, land stability investigations or detailed surveying of land levels etc, as relevant to the potential hazard. Such data may provide for a better understanding of coastal hazard risk at a site-specific scale.

The adverse effects and long-term implications of hard engineering works have been increasingly recognised, and as such National Policy now emphasises the use of alternative approaches. Notwithstanding this, there are cases where “hard” coastal engineering works are the only practicable option.

We therefore recommend the District Plan broadly discourages the use of “hard” coastal protection structures. There will be circumstances where hard engineering works are an appropriate solution, particularly where there is significant coastal hazard risk under current conditions or within short time frames, and where adverse effects of the works can either be mitigated or avoided, or are outweighed by the benefits (considering both public and private values). It is very unlikely that hard protection works will be a viable long-term approach to coastal erosion management on the open coast of the Waitomo District due to the adverse effects and the huge engineering cost.

Where hard engineering is the only practicable option, it should be designed and located to avoid or minimise adverse effects on the coastline, by minimising encroachment and the length of structures and prioritising environmental considerations over cost. In many cases appropriate planning action and the implementation of other measures can reduce the need for the structure over time.

There are also many areas of the District where coastal restoration and/or environmentally soft approaches can usefully contribute to effective coastal hazard management. We recommend that the Plan include measures to actively encourage such approaches.

Adaptive Management Approach

Management of coastal hazards is extremely complex. While national and regional coastal policy constrain what options may be acceptable, there are a wide range of stakeholders on the coastal margin, with sometimes conflicting interests. Considerable uncertainties about the nature and scale of future coastal change further complicates decision making and planning. Activities or management options that might be quite adequate and acceptable in the short-term could be quite inappropriate and even have serious adverse effects and costs in the longer term. In this complex and uncertain setting, Council is required to consider a planning timeframe of at least 100 years.

We therefore recommend that Council work with relevant communities and stakeholders to develop agreed adaptive management strategies, particularly in areas where there is significant existing development within the Coastal Erosion Hazard Zones (e.g. Mokau and Marokopa).

The advantage of an adaptive management approach is that it enables Councils, community stakeholders and relevant experts to work together to:

- develop the most appropriate management responses/strategies for existing coastal hazards and for various future scenarios
- agree triggers or thresholds to adjust existing strategies (or adopt new strategies) as coastal hazards and goals change.

This adaptive approach enables councils and communities to adopt the most appropriate and cost-effective strategies presently relevant, while also identifying how these strategies will be adjusted or changed if coastal change triggers are reached. This provides a high level of transparency and certainty for stakeholders as well as ensuring the resilience of coastal values in the face of future change.

The role of relevant experts in adaptive management is not a decision-making role but rather to empower the Council and community stakeholders by providing a good understanding of the pros and cons of different options and how the costs and benefits of these options may alter with coastal change over time. To assist the Council and community stakeholders in the development of these adaptive management strategies, we have discussed the range of potential measures for sustainable management of coastal erosion and flood risk in the Waitomo District, identifying those that are most likely to be applicable. This commentary is founded on a broad “hierarchy” of management approaches, implicit in national and regional coastal policy and developed to reflect the nature of the particular coastal environment, the likely responses of that environment to future climate change and the implications of different management responses. Adaptive management strategies for each location must be developed with relevant community stakeholders and our commentary is simply to assist in that process.

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1 INTRODUCTION

The Waitomo District Council ("the Council") is currently reviewing and updating the Waitomo District Plan ("the Plan"). The Plan contains objectives, policies and rules that relate to the management of land vulnerable to coastal hazards in the Waitomo District (Figure 1). The Council therefore needs to understand coastal hazards and coastal hazard risks, particularly at urban coastal settlements.

As a new matter of national importance set out in section 6(h) of the Resource Management Act 1991 (RMA), territorial authorities are now required to recognise and provide for the management of significant risk from natural hazards, while section 7(i) RMA requires territorial authorities to have regard to the effects of climate change. The District Plan must also give effect to policies within the NZ Coastal Policy Statement 2010 and the Waikato Regional Policy Statement 2016, including identifying areas of coastal hazard risk and regulating land use and development within identified areas to avoid or reduce the risk of adverse effects associated with coastal hazards and hazard responses.

This study was therefore commissioned by the Waitomo District Council to investigate coastal hazards and define areas potentially affected by coastal hazards (excluding tsunami), including current and future coastal hazard areas, and to provide management recommendations, with a focus on Mokau, Awakino, Marokopa and Te Waitere (including Kinohaku). To achieve this, we have worked with local communities, landowners, and Iwi to identify areas potentially at risk with existing sea level and those areas that could be affected with projected future sea level rise. We also established local values and challenges and present draft adaptive management approaches to managing potential future risk in these areas.

This study also draws on the recently published national guidance document "Coastal Hazards and Climate Change – Guidance for Local Government" (MfE, 2017), including recommended sea level rise values and policy direction.

1.1 Purpose and Scope of the Study

Focus Resource Management Group was engaged to assess coastal hazards and provide management recommendations for the townships of Mokau, Awakino, Marokopa, Te Waitere and Kinohaku. This work included two rounds of community workshops, analysis of all available data and discussions with the Waikato Regional Council to:

Identify the areas of coastal margin potentially vulnerable to coastal erosion and/or coastal flooding over the next 100 years, including:

- areas potentially impacted with current sea level
- additional areas that could be affected over the next 100 years due to projected sea level rise.

- develop broad recommendations for management of these areas, including management of both existing and future land use and development, and provision for use of the precautionary approach and the adaptive management approach

The complex land occupation/ownership and coastal hazard issues at Te Maika are currently being worked through as part of a separate process between Council and all affected parties so is not included in this study.

This report provides a summary of the hazard assessment and the detailed work undertaken at each of the sites. The report identifies current and future potential hazard areas and provides recommendations for coastal hazard management approaches to guide the Waitomo District Council in the District Plan review process.

1.2 Report Layout

Section 2 outlines the approach to the project including the information considered and the consultation undertaken.

Section 3 summarises the national and regional policy setting, and national guidance for planning for coastal hazards and climate change in New Zealand.

Section 4 outlines the methodology used to assess the areas potentially susceptible to coastal erosion and inundation hazard, including the approach to calculating hazards with future projected sea level rise. ‘

Section 5 outlines the coastal hazard areas that have been identified in this study.

In Section 6, the policy background from Section 4 is translated into a broad hierarchy of preferred coastal hazard management approaches and associated recommendations for the management of new and existing development within identified coastal hazard areas.

Section 7 introduces the concept of adaptive management plans.

Section 8 provides recommendations for rules and methods in the proposed District Plan for each of the identified coastal hazard areas.

Sections 9 to 12 summarise the site-specific hazard assessments and recommended management approaches for each of the study sites.

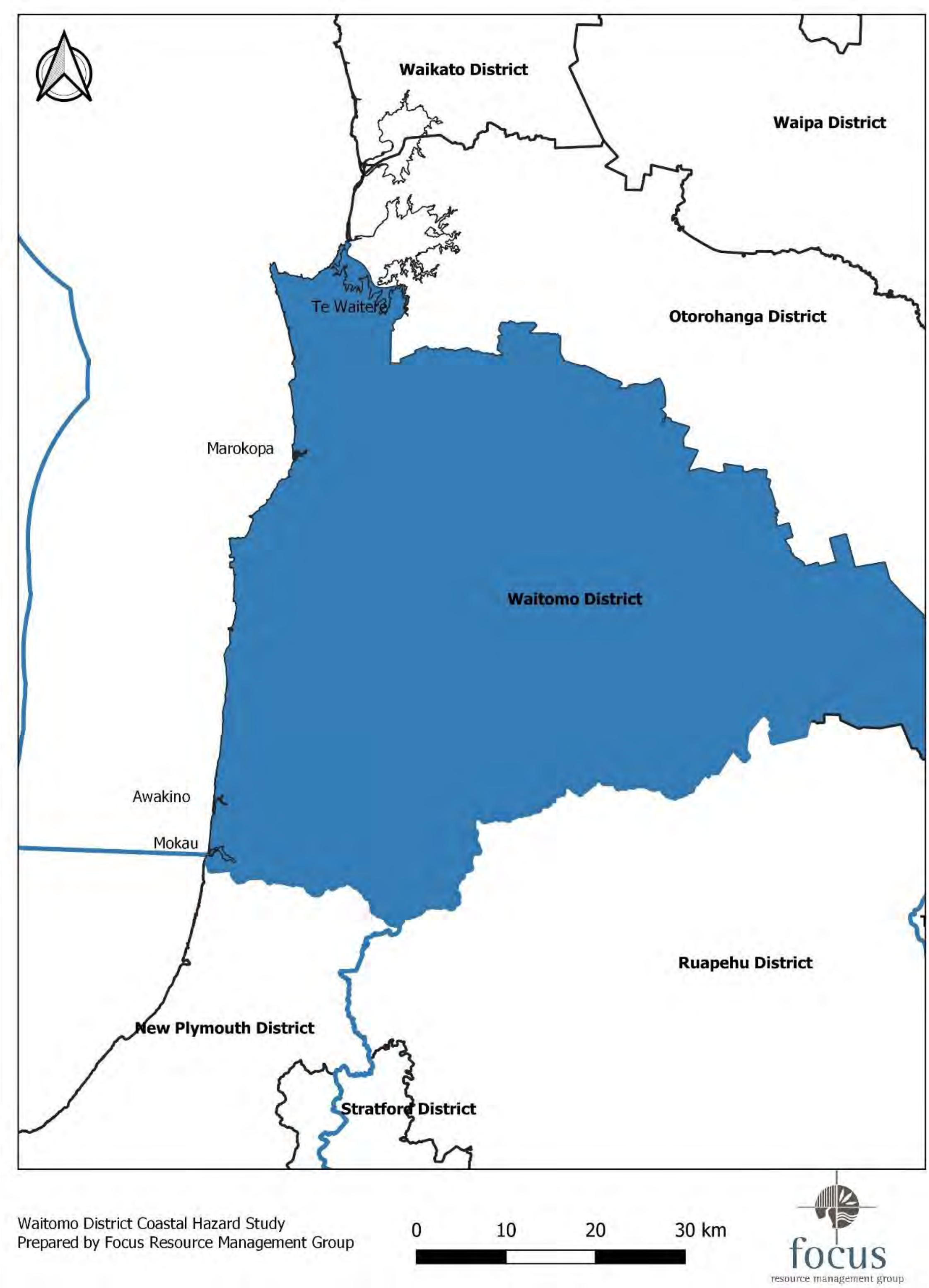

Figure 1: Extent of the Waitomo District coastline.

2 PROJECT APPROACH

Detailed hazard assessment and management recommendations are required to support structure planning at Mokau and rezoning at Marokopa. Less comprehensive studies are required at the remaining sites, while still identifying areas potentially at risk over the next one hundred years. The coastal hazard study at each of these sites included:

- collation and review of all existing information
- Regional Council and community discussions
- community/landowner discussions
- detailed analysis of shoreline change data.

2.1 Information Used

The coastal hazard assessment included a review of relevant literature on the coastal environment of the District, including physical coastal features and processes and how they relate to coastal hazards. Sources included but were not limited to:

- community and iwi observations and information
- vertical aerial photography dating from the 1940s to the present (including that available via Retrolens, Google Earth and both the WRC and WDC web sites)
- mapping of historic shorelines from ortho-rectified aerial photography undertaken by the Waikato Regional Council for much of the coast of the District using photos dating from 1942 to 2017
- a wide range of historic photographs and surveys obtained from the National Library, historic survey databases, community members and other sources (some sites dating from the late 1800s and early 1900s)
- early descriptions and maps of the area available from the National Library, community sources, survey databases, local history books and other sources
- available topographic (LiDAR) data and bathymetric information
- geological maps
- existing reports on coastal erosion and other relevant published resources (e.g. local history books and a range of technical reports and studies)
- storm surge modelling and sea level reports as well as tide gauge and coastal flooding data (including reports from historic events)
- physical and geomorphic characteristics of the coast
- central government guidelines in respect to potential sea level rise (e.g. MfE, 2017)
- appropriate conceptual geomorphic models (e.g. to assess the potential future impact of projected sea level rise - see Section 4.3 for more detail).

2.2 Community and Stakeholder Consultation

The west coast of the North Island is relatively sparsely populated and there is a limited amount of existing scientific data on which to base detailed coastal hazard assessments. Key coastal communities were contacted early in the coastal hazard investigation and meetings were held at each of the key sites to inform affected residents and gather any available local knowledge and unpublished information. This information was incorporated into the study.

The first round of meetings was held in December 2017 at Te Waitere (covered Kinohaku), Marokopa and Mokau (including Awakino residents). Letters were sent out inviting all property owners from areas thought to be potentially affected. Residents were given information about the purpose of the study and asked for local insight into past erosion and flooding events and to provide any historical knowledge or photographs that may be of use. The first round of community meetings provided great value to the study in terms of local insight and many historical photographs and plans.

A proposed management approach was drafted and presented in a second round of community meetings in August 2018. This second round of meetings provided an opportunity for a discussion with affected parties and to obtain feedback on the proposed management approach. Feedback received during this second round of meetings has been incorporated into the preparation of the final report.

Separate meetings were held with local iwi at Hangatiki, Te Kuiti and Mokau in April and May 2018.

Presentations were also given to Waitomo District Council staff and councillors, to provide an opportunity for feedback and discussion prior to draft management recommendations being taken to the community.

2.3 Analysis and Reporting

The information from the community and other sources was analysed and synthesised to assess the areas potentially vulnerable to coastal hazards and associated management issues. Various management options were then considered, and recommendations developed, guided by existing national and regional policy and by community and Council feedback from the initial consultation. Useful feedback was also obtained from review of initial drafts of this report by Council staff and consultants.

The hazard analysis indicates that the Waitomo District coastline is complex and there are significant uncertainties in some locations with respect to both existing and potential future hazards. Where this uncertainty coincides with historic coastal development within existing and potential future coastal hazard areas, there are significant management challenges. As discussed later in the report, these complex management issues cannot be fully addressed through the proposed District Plan alone and additional measures will be required.

In particular, the complexities of the existing and potential future management issues at Mokau and Marokopa are likely to require site specific adaptive management strategies, developed in active partnership with affected stakeholders and the wider community. We have attempted where possible to provide some useful discussion of the possible content of such strategies but emphasise that considerable further work with the stakeholders and wider community will be required to develop agreed strategies. It is also likely that management of these complex issues will require incremental change over a long period of time and the use of triggers.

In the absence of agreed adaptive management strategies, a precautionary approach will be required to management in many areas of existing development. These interim measures will in some cases present significant challenges for Council and affected stakeholders (see detailed discussion in Chapters 8-11).

These interim management recommendations will however need to be further discussed with relevant landowners and other stakeholders.

3 POLICY SETTING

3.1 National Policy

The New Zealand Coastal Policy Statement (NZCPS) 2010 directs Councils in New Zealand to manage coastal hazards by identifying hazard areas and implementing management approaches that mitigate future coastal hazard risk. This statement contains a number of objectives and policies directed at coastal hazard management.

Objective 5 of the NZCPS provides a foundation to coastal hazard risk management by outlining the key aspects of sustainable coastal hazard management:

"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."

Objective 5 is implemented through a number of policies within the NZCPS, most specifically through Policies 24-27, which are summarised below.

Policy 24 requires Councils to identify the areas potentially at risk from coastal hazards (erosion, flooding and tsunami) over at least the next 100 years, prioritising areas of high risk. To do this, the Council must examine the physical processes and drivers, the geomorphic characteristics of the coast, the short- and long-term natural fluctuations, the human impacts, and the likely impact of climate change.

Policy 25 addresses the management of these hazard areas and directs Councils to avoid redevelopment or land use change that increases the risk of adverse effects from coastal hazards, and to encourage management decisions that reduce the risk of adverse effects over time (e.g. managed retreat or relocatable buildings). This policy discourages the use of hard protection structures.

Policy 26 highlights the importance of natural defences such as beaches, estuaries, coastal vegetation and dunes in providing protection from coastal hazards.

Policy 27 addresses the most challenging aspect of coastal hazard management, where there is significant existing development in areas at risk from coastal hazards. This policy provides guidance for working through the range of potential management options. The focus is on long term sustainable risk reduction approaches, which may include the removal or relocation of development or structures.

Historically the approach to coastal erosion management has been dominated by the use of hard engineering structures to "hold the line" and prevent the erosion of both private and public land and assets. The adverse environmental, social and economic impacts of these approaches are now well recognised globally. "Hard" coastal protection structures interfere with natural coastal processes, can impact severely on the public values of shorelines and often tie communities into a perpetual cycle of ever-increasing financial investment.

National policy therefore now directs Councils to work with communities to manage coastal hazards in a way that over time decreases risk and increases the long-term resilience of coastal environments and communities. This is more important than ever as we face the likely impacts of projected sea level rise in coming decades. To achieve this, Councils are now required to emphasise risk avoidance and reduction and discourage the use of engineering works that control natural processes.

Specifically, Policy 27.2. directs that when evaluating options for reducing coastal hazard risk, "focus on approaches to risk management that reduce the need for hard protection structures and similar engineering interventions;"

The NZCPS does recognise that in some cases, hard protection structures may be the only practical option for protecting infrastructure of national or regional importance, but that the social and environmental costs of such an approach must be acknowledged and that planning should identify transition mechanisms for moving to a more sustainable approach in the longer term. Policy 27 (4) states that hard protection structures designed to protect private property should not be located on public land unless there is a significant public benefit.

Where hard engineering works are constructed to protect private assets, the social and environmental costs need to be acknowledged and they should not be located on public land unless there is significant benefit from doing so.

3.2 Waikato Regional Policy

The Waikato Regional Policy Statement (RPS) must give effect to the NZCPS. The RPS contains policies relating to the coastal environment, and specifically to natural hazards, and highlights the need to increase community resilience by mitigating the risk from natural hazards (including coastal hazards) over time.

Policy 6.2 of the RPS sets the framework for managing development in the coastal environment. Among other things, this policy requires that development is sufficiently set back and designed in such as a way as to provide for the full range of environmental and public values and allow for future sea level rise effects including landward migration of habitats. This policy also reflects the NZCPS and requires that development avoids increasing coastal hazard risk and maintains and enhances public access.

Policy 12.3.2 directs Councils to ensure that the amenity values of the coastal environment are maintained or enhanced. As part of this relates to providing suitable development setbacks along the coastal edge and "avoiding forms and location of development that effectively privatise the coastal edge and which discourage or prevent public access to and use of the coast…" and encouraging structure and development design that enhances amenity and maximises public benefits.

Policy 12.3.3 directs District Councils to incorporate the enhancement of public values in the coastal environment in public works and in plans and other planning documents.

Policy 13.1 requires that natural hazard risks are managed using an integrated and holistic approach that limits the risk from natural hazards while enhancing community resilience and recognises and prefers the use of natural features over man-made structures for defences against natural hazards.

There are a range of implementation methods relating to Policy 13.1, including 13.1.1, which states that Regional and District Plans shall incorporate a risk-based approach into the management of subdivision, use and development in relation to natural hazards.

Method 13.1.3 also states that the "Waikato Regional Council will collaborate with territorial authorities, tāngata whenua and other agencies to undertake assessments of coastal and other communities at risk or potentially at risk from natural hazards, and develop long-term strategies for these communities…"

These strategies will identify areas at risk, may include recommendations for hazard zones and will identify and evaluate options for reducing the risk to communities while preserving public access, amenity values and natural character where possible.

3.3 National Guidance on Planning for Sea Level Rise

In the longer term, projected sea level rise associated with global warming is expected to exacerbate both erosion and flooding hazard along much of the New Zealand coast. There are many ways that future climate change may influence coastal hazards, including:

- an increase in sea level and direct impact on coastal flood levels[1]
- potential shoreline retreat in response to a rise in mean sea level and increased wave effects
- an increase in nearshore tidal currents due to an increase in tidal prism [2]
- a possible increase in the frequency and/or duration of storm events
- potential loss of sediment to flood and ebb tide deltas due to these features increasing in volume with increasing tidal prism[2].

National guidance recommends that coastal hazard planning must consider the likely impact of projected sea level rise over the next 100 years and beyond. In the future, accelerated sea level rise is anticipated in response to global warming and so it is not appropriate to simply extrapolate past trends to predict the future. Unfortunately, the impact of these factors and other uncertainties accompanying climate change are difficult to predict. While scientists believe that sea level rise is inevitable, there is great uncertainty about how long it will take for this to happen. It is not possible to simply extrapolate past trends to predict the future, or to predict one “most likely” future.

MfE (2017) therefore recommends that Councils consider the likely impacts of a number of plausible scenarios (using lower, intermediate and higher sea level rise projections), and from these develop adaptive management plans that can respond to sea level rise as it occurs (see discussion of adaptive management in Section 6.8). The recommended projections are based on future global emission scenarios developed by the Intergovernmental Panel for Climate Change (IPCC, 2013 & 2014). The establishment of dynamic adaptive plans for at risk settlements will take time. The MfE (2017) document also provides recommendations for the application of “minimum transitional sea level rise allowances” for coastal hazard planning where an adaptive plan is not yet in place (summarised in Table 1).

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[1] As well as increasing the level of rare and severe events, just a small amount sea level rise will greatly increase the frequency of what are now rare events.

[2] The tidal prism is the volume of water in an estuary or inlet between mean high tide and mean low tide, or the volume of water leaving an estuary at ebb tide.

Table 1: Summary of sea level rise scenarios for coastal management in New Zealand (MfE national guidance note 2017).

Scenario	2070	2120	Transitional Application in Coastal Planning
Low (RCP 2.6) Lower bound "surprise"	0.32 m	0.55 m	
Intermediate (RCP 4.5)	0.36 m	0.67 m	Low-risk non-habitable works and activities, particularly those with a functional need to be near the coast.
Transitional		1.00 m	Recommended sea level rise value for planning in areas of existing development until a dynamic adaptive planning process has been completed.
High+ (RCP8.5) (85th percentile)	0.61 m	1.36 m	Greenfields development and major new infrastructure.

In terms of planning for intensification of land use (including subdivision in areas of existing development), there is no transitional sea level rise value recommended, but MfE (2017) advises that a full dynamic adaptive pathways planning approach is required using the four sea level rise scenarios (at the scale appropriate to the scale of the intensification).

Our recommendations for coastal hazard management in Sections 6-8 and our approach to the identification of coastal areas (Sections 9-12) reflect this national guidance, the principles of the NZCPS and RPS and the knowledge gathered during this study.

WAIKATO REGIONAL POLICY

The Regional Policy Statement (RPS) contains policies that must be consistent with the NZCPS. The RPS contains policies relating to the coastal environment, and specifically to natural hazards, and highlights the need to increase community resilience by reducing the risk from natural hazards (including coastal hazard) over time.

Policy 6.2 of the RPS sets the framework for managing development in the coastal environment. Among other things, this policy requires that development is sufficiently set back and designed in such as a way as to provide for the full range of environmental and public values and allow for future sea level rise effects including landward migration of habitats. This policy also reflects the NZCPS and requires that development avoids increasing coastal hazard risk and maintains and enhances public access.

Policy 12.3.2 directs Councils to ensure that the amenity values of the coastal environment are maintained or enhanced. As part of this relates to providing suitable development setbacks along the coastal edge and “avoiding forms and location of development that effectively privatise the coastal edge and which discourage or prevent public access to and use of the coast…” and encouraging structure and development design that enhances amenity and maximises public benefits.

Policy 12.3.3 directs District Councils to incorporate the enhancement of public values in the coastal environment in public works and in plans and other planning documents.

Policy 13.1 requires that natural hazard risks are managed using an integrated and holistic approach that limits the risk from natural hazards while enhancing community resilience and recognises and prefers the use of natural features over man-made structures for defences against natural hazards.

There are a range of implementation methods relating to Policy 13.1, including 13.1.1, which states that Regional and district plans shall incorporate a risk-based approach into the management of subdivision, use and development in relation to natural hazards.

Method 13.1.3 also states that the “Waikato Regional Council will collaborate with territorial authorities, tāngata whenua and other agencies to undertake assessments of coastal and other communities at risk or potentially at risk from natural hazards, and develop long-term strategies for these communities…”

These strategies will identify areas as risk, may include recommendations for hazard zones and will identify and evaluate options for reducing the risk to communities while preserving public access, amenity value sand natural character where possible.

4 IDENTIFYING COASTAL HAZARD AREAS

4.1 Coastal Erosion

4.1.1 Beaches

Beaches are typically the most heavily utilised areas in terms of human impacts and values and are also the most vulnerable to coastal erosion and are the most likely to be severely affected by the impacts associated with hard coastal protection works, particularly on retreating shorelines. Beaches are also highly susceptible to impact from future sea level rise. For these reasons, sandy beaches are often the most difficult and complex areas to manage.

To identify hazard areas, it is necessary to determine the extent of natural shoreline fluctuations ("dynamic envelope"), as well as the presence of any long-term trend for erosion or accretion. For assessing these changes in the Waitomo District, we have complemented shoreline mapping data provided by the Waikato Regional Council with field investigations and information provided by the community to gain an understanding of the coastline and past changes. From this information we can identify areas likely to be at risk from coastal erosion over planning timeframes.

There is much uncertainty in predicting future shoreline change, particularly the responses to future sea level rise. Ongoing data collection and review will be essential to successful management of the coast in the future. A detailed explanation of methodology is given in the site-specific assessments outlined in Sections 8-11.

There are a number of components to be considered when estimating the width of coastal erosion hazard zones for any planning period ("t") in a beach setting, including:

- any long-term trends for permanent erosion or accretion ("LT")
- maximum likely dynamic shoreline fluctuations over the planning period ("ST")
- slope instability associated with collapse of over steepened erosion scarps ("S")
- potential effect of climate change over the planning period, particularly sea level rise ("X")

Typically, these components are summed to provide a total width of hazard area (Coastal Hazard Erosion Zone or "CEHZ"):

$$CEHZ = (LT \times t) + ST + S + X$$

In areas where sea walls constrain erosion, an allowance must be included to provide for the erosion that would occur if the sea wall were not present, including any fill that may have been added immediately landward of the seawall. Where seawalls have been confirmed as the long-term management approach, some reduction of coastal erosion hazard areas will likely be appropriate, provided ongoing repair and maintenance of the sea wall is suitably guaranteed. However, coastal erosion hazard areas will still need to allow for possible short-term erosion associated with failure of the structure, so some setback from the landward edge of the structure is important.

We have estimated these components for each site where necessary using the available information discussed in Section 2, with particular emphasis on field observations and geomorphology, historic aerial photographs and surveys, and community information. The following sections briefly outline the methods used to assess each component. The derivation of the erosion hazard zones at each site are also discussed in more detail in Sections 8-11.

Long Term Trends for Shoreline Change

Long term trends for permanent shoreline advance or erosion were assessed using aerial and other photography, historic surveys, field observations, geomorphology and community information. Large dynamic shoreline changes occur on this coast over many decades, and it is difficult to separate these from "long-term" trends with certainty. The determination of long term trends for the purposes of hazard mapping was based on site specific assessment as discussed in Sections 8-11.

Dynamic Shoreline Fluctuations

Sandy beaches are naturally dynamic and respond rapidly to changes in local coastal processes. Natural functioning of sandy beaches relies on the presence of an intact sand dune, which is part of the natural beach system, and is critical to processes of natural erosion and recovery.

Sand dunes are formed when wind blows sand inland from the beach, where it is "caught" by sand trapping grasses and accumulates. This sand is stored in the dune until there is a storm event that erodes the beach and the face of the dune. During storms, sand eroded from the beach and dune is moved offshore to form offshore bars (Figure 2). In calmer conditions, sand from these nearshore bars is worked back onto the beach and beach levels recover over time (Figure 3). Natural dune recovery is slower and depends on suitable sand trapping vegetation on the dune (e.g. spinifex and pingao).

Sandy beaches can also experience dynamic shoreline fluctuations with extended periods of erosion and accretion due to causes such as climate cycles that alter weather patterns (e.g. affect the frequency of storms). The maximum scale of the dynamic shoreline fluctuations (often referred to as the "dynamic envelope") is typically only evident over long periods of time (generally many decades). Care and long-term records are therefore required to adequately assess the maximum likely dynamic shoreline fluctuations and to distinguish any contribution of permanent long-term trends for erosion or accretion. These changes can be particularly dramatic near the mouths of rivers and estuaries. Part of the settlement at Mokau is located on a sandy beach and dune system adjacent to a major river mouth. Awakino and Marokopa Townships are also located close to river entrances.

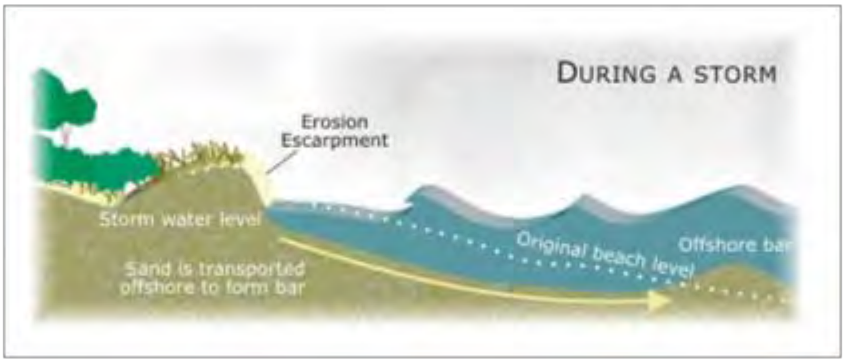


Figure 2: During storms, sand is eroded from the dune and forms bars offshore that absorb wave energy.

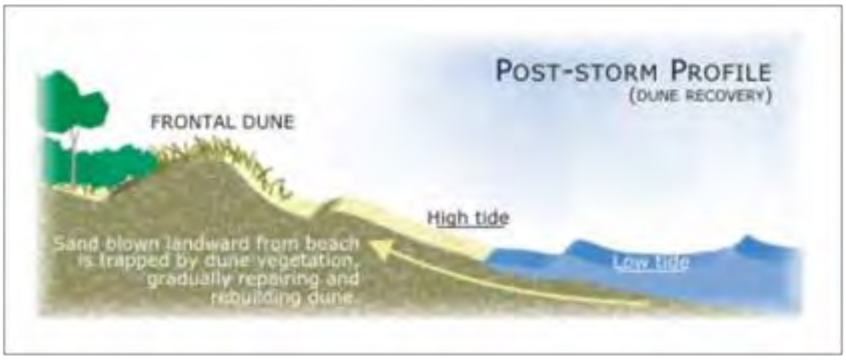


Figure 3: During calmer wave conditions, sand from the offshore bars makes its way to the beach and over time the dunes rebuild (source: Waikato Regional Council, 2011).

Collapse of Erosion Scarps

Following severe storms, dune erosion and beach lowering typically form near vertical erosion scarps. These scarps can then collapse to a more stable slope over time. The stable slope is generally in the order of 26 degrees in unconsolidated sands. In identifying erosion hazard zones, it has been assumed that the dune face will collapse to this stable slope. In practice, the value of this parameter is generally close to the height of the dune above the dune toe, as material collapsing from the top of the dune face will form a slope at the base of the scarp, stabilizing the slope.

4.1.2 Cliffs

Coastal erosion of cliffs typically occurs slowly and unlike beaches is essentially a one-way process. Cliff erosion mechanisms relate to coastal erosion at the toe, and/or by slope instability processes higher up. Coastal processes work to erode the base of the slope, until over steepening causes slope failure (Figure 4). Cliff erosion rates depend greatly on local geology and can be exacerbated by poor land management. While toe erosion is gradual and generally very slow, slope failure is episodic and can be significant.

There are cliff shorelines at Te Waitere, Awakino Heads and around some stretches of the river margin at Mokau. The mechanisms of slope failure and potential for erosion vary depending on cliff geology, height, and physical setting.

The key factors that need to be considered in erosion hazard assessment for cliff sites are:

- historic long term (i.e. time-averaged) rate of toe erosion
- slope instability arising from the toe erosion (typically assuming failure to a stable slope)
- the potential effect of sea level rise on the above factors (i.e. particularly toe erosion)

These factors have been assessed by considering:

- geological, geomorphic and field observations to estimate very long-term erosion rates (e.g. shore platform width) and likely stable slope.
- historical aerial and other photography
- historic shoreline surveys
- empirical techniques to estimate the potential impact of projected sea level rise (discussed further in Section 4.3).

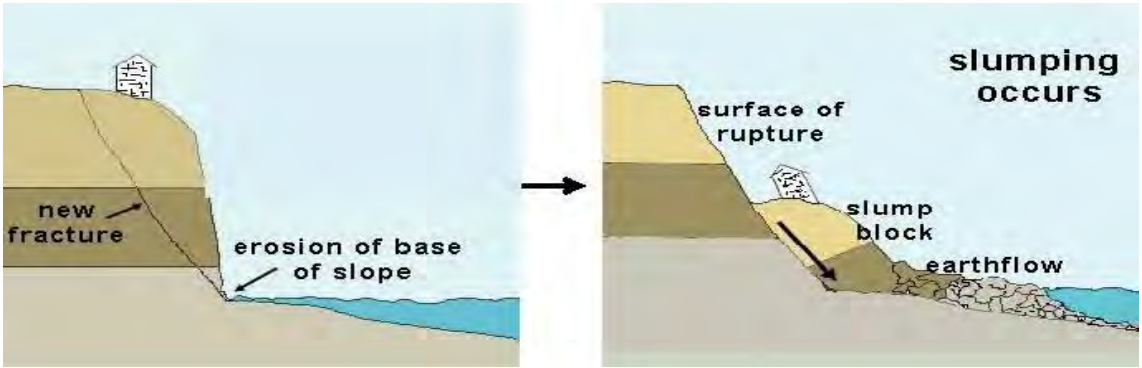


Figure 4: Processes of cliff erosion.

4.1.3 Estuaries and River Mouths

Estuaries and river mouths are commonly the focus of development on the West Coast as they provide sheltered coastal environment on an otherwise high energy coastline. Mokau, Marokopa and Awakino Townships are all located at river mouth settings. Close to river and estuary mouths, coastal and river processes combine to make complex patterns of shoreline change.

We have utilised a range of data (see Section 2) to determine the extent of natural shoreline fluctuations ("dynamic envelope"), as well as the presence of any long-term trend for erosion or accretion. Shoreline mapping data provided by the Waikato Regional Council has been a key data source, and this has been complemented with field investigations and information provided by the community to gain an understanding of the coastline and past changes. From this information we can identify areas likely to be at risk from coastal erosion over planning timeframes.

There is much uncertainty in mapping future coastal shoreline change at estuary entrances, particularly in response to potential sea level rise. Ongoing data collection and review will be essential to successful management of the coast in the future. A detailed explanation of methodology is given in the site-specific assessments outlined in Section 8-11.

As climate change induced sea level rise occurs, intertidal habitats will migrate inland. Where this landward migration is halted by either geography or by coastal engineering works, the habitat will be "squeezed" out. This is discussed further in Section 6 and Section 7.

4.2 Coastal Flooding

The key components contributing to coastal storm inundation over the next 100 years comprise:

- astronomical tides
- storm surge (elevation of sea level by barometric and wind effects)
- wave effects, including wave set-up and wave run-up
- rise in relative sea level due to climatic and tectonic changes

These various components are illustrated in Figure 5 and discussed further below.

The Waikato Regional Council has maintained a tide gauge at Kawhia since 2008. A study was commissioned by the Regional Council in 2014 to analyse tide gauge data from the Waikato Region (including Kawhia) to better understand the components that contribute to storm surges and to estimate storm tide levels and associated probabilities (Stephens et al., 2015). This data analysis provides the best data currently available on which to evaluate areas likely to be at risk from coastal inundation on Waitomo's coastal margin.

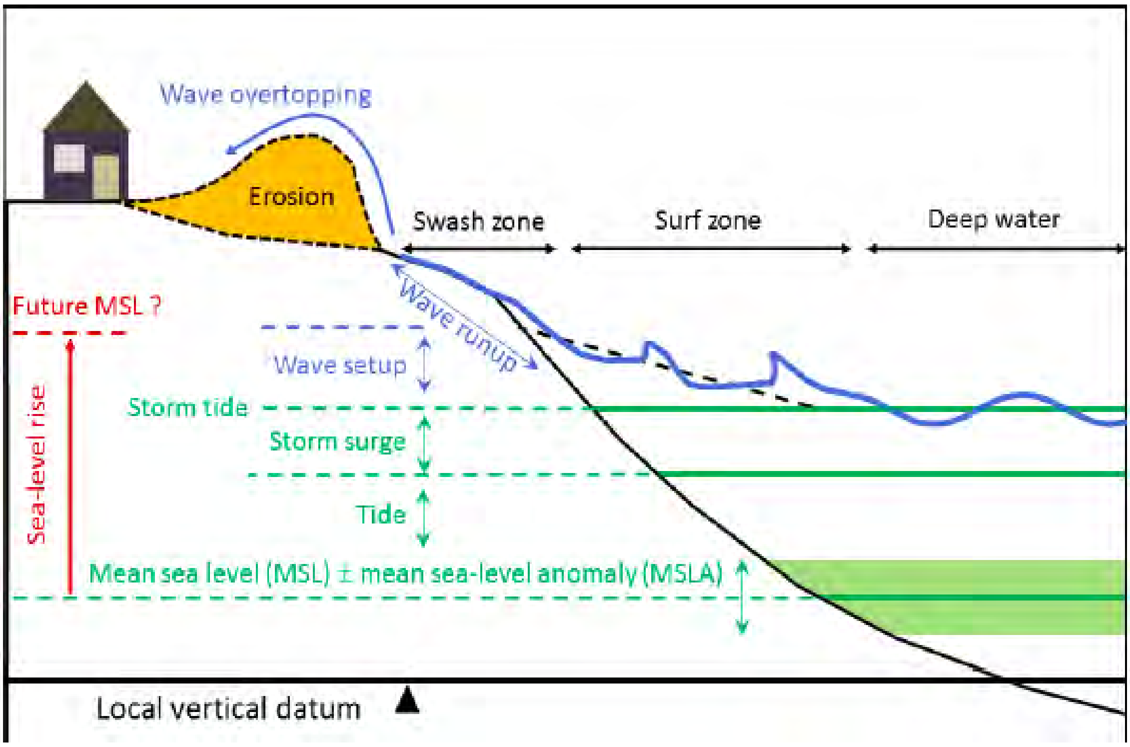


Figure 5: Summary diagram showing the various components that contribute to coastal storm inundation (source: Figure 30 from MfE, 2017)

4.2.1 Tides

The total storm tide height during an event is influenced greatly by the state of tide at the peak of the storm surge. Even a very large storm surge may not cause flooding if it peaks during low tide. The relatively large tidal range on the West Coast of the north Island means that the tidal component of any storm water level tends to dominate over other factors. Mean high water spring and maximum tide levels are given in Table 2.

Table 2: Elevation of Mean High Water Spring (MHWS) at Marokopa and Mokau (from Stephens et al. 2015 and Waikato Regional Council http://coastalinundation.waikatoregion.govt.nz/).

	MHWS (MSL)	Max High Water (MSL)	MHWS (MVD)	MHWS (NZVD,2016)
Marokopa	1.63 m	1.97 m	1.76 m	1.43 m
Mokau/Awakino	1.69 m	2.04 m	1.82 m	1.49 m

4.2.2 Storm Surge and Storm Tide

Storm surge is the combination of barometric set-up and wind set-up which elevate water level above the predicted tide. The barometric set-up effect occurs when low atmospheric pressure over the ocean drives an increase in water level. A 1 hPa fall in atmospheric pressure drives an increase in water level of 10 mm. The inverse barometric effect driven by low pressure systems typically contributes 100-150 mm of the observed storm surge on the West Coast of the Waikato Region.

Wave breaking processes generate an increase in the average elevation of sea level (wave set-up) during storm events due to the release of wave energy in the surf zone as waves break. When offshore waves are large, wave set-up can raise the water level at the beach substantially. Most weather systems approach the Waikato Region from the west of New Zealand and therefore propagate towards the west coast, generating wind waves and swells that affect the area. The wave effects are therefore generated by the same events that drive barometric and wind set-up.

During storms, onshore wind and waves can drive water up against the shore, increasing water levels. The tide data analysis undertaken by Stephens et al. (2015) revealed that the sea level at Kawhia seems to be highly influenced by wind. It is thought this is most likely due to wind-set up against the coast further influenced by Coriolis forces. The study revealed that storm surges at Kawhia were dominated by the effects of wind stress associated with persistently strong north-westerly winds from weather fronts blowing over several hours to days.

These conditions drive surges at Kawhia almost twice that experienced on the eastern Coromandel Peninsula. This effect is likely to be still somewhat relevant at Mokau and Marokopa, but it is difficult to ascertain whether the magnitude of effect will be as significant.

The sea-level ‘anomaly’ describes the longer-term variation of the sea level that does not relate to tides. The sea level variations occur at time periods over a year (seasonal changes), several years (El Niño and La Nina Climate Cycles) and over decades (Pacific Decadal Oscillation). Therefore, while tide levels can be accurately predicted, the actual sea level at any given location is likely to differ from the predicted tide. The range of this sea level anomaly is generally up to +/- 0.2 m (Stephens et al., 2015) and is included in the storm tide predictions.

The report by Stephens et al. (2015) examined the components that made up the largest observed storm tides in the tide gauge record at Kawhia. In all cases, the dominant component of storm surge was tide. The overall storm surge height is heavily dependent therefore on the stage of tide (high/low and spring/neap) when the storm is at its peak. Extreme storm-tide (total sea-level) analysis was undertaken to determine the storm tide frequency–magnitude distribution using the Monte Carlo joint-probability technique, which factors in the likelihood that extreme spring high tide levels will coincide with a peak in storm surge.

Table 3 presents elevations for the median storm surge at Kawhia, based on the joint-probability analysis of sea level data at Kawhia Harbour (Stephens et al. 2015). The storm tide elevations presented are given relative to a zero MSL and to Moturiki Vertical Datum 1953

(“MVD ’53). The data record at Kawhia is relatively short (six years at the time of the analysis) and Stephens et al. (2015) acknowledged that of the largest recorded storm surge events, none occurred due to a coincidence of high storm surge and a high spring tide. This means even larger storm surge events could occur in the future, though it is difficult to accurately determine their probability.

More extreme sea-level components are therefore likely to be measured as the record lengths increase. For example, three surges greater than 0.7 m were observed during the very short Kawhia record. Stephens et al. (2015) comment that it appears that Kawhia Harbour (and likely other west-coast estuaries) are subject to large wind-driven storm surges that could conceivably reach well over 1.0 m in magnitude.

Table 3: Storm tide elevations for Kawhia Harbour (Stephens et al. 2015).

AEP (%)	ARI (years)	Median (MSL)	Median (MVD ‘53)
10	10	2.33 m	2.46 m
5	20	2.42 m	2.55 m
2	50	2.54 m	2.57 m
1	100	2.63 m	2.76 m
0.5	200	2.73 m	2.86 m

In light of this uncertainty, Stephens et al. (2015) also calculated the maximum tide, maximum storm surge and maximum sea-level anomaly, during the sea-level measurement period (Table 4). Within the record, these maxima occurred at different times so there has not been a storm surge measured to this elevation. The summed maxima approach gives the maximum sea-level elevation expected if a very high tide combined with a very large storm surge and a very high sea-level anomaly, all at the same time. The probability of occurrence of the summed sea-level components is unknown but is likely to have an exceedance probability of less than 0.5% AEP (Stephens et al. 2015).

As noted above, the 1% AEP level calculated by Stephens et al. (2015) was based on just six years of data and the authors acknowledged the limitations of such a short data record and the likelihood that larger surges would be recorded in a longer record. We believe it is more prudent to estimate the maximum storm tide by summing the various maximum storm surge components.

Table 4: Maximum measured storm surge components at Kawhia.

Storm Surge Component (Maximum) Relative to MSL	Level (MSL)	Level (MVD '53)
Maximum Tide Level	1.94 m	2.07 m
Storm Surge	0.90 m	0.90 m
Sea Level Anomaly	0.16 m	0.16 m
TOTAL:	3.00 m	3.13 m

The maximum storm tide elevations for Marokopa and Mokau/Awakino were therefore estimated by combining the maximum tide at each location with the maximum storm surge components measured at Kawhia as shown in Table 5 and Table 6. As noted above, there is likely to be some conservatism in this estimate, it represents the best available information.

Table 5: Maximum storm tide values for Marokopa and Mokau/Awakino (Moturiki Vertical Datum 1953).

	Max Tide MVD '53	Max Storm Surge	Max SL Anomaly	Max Storm Tide
Marokopa	2.10 m	0.90 m	0.16m	3.16 m
Mokau/Awakino	2.17 m	0.90 m	0.16 m	3.23 m

Table 6: Maximum storm tide values for Mokau and Mokau/Awakino (corrected to New Zealand Vertical Datum (NZVD) 2016).

	Max Storm Tide (MVD)	MVD – NZVD Correction	Max storm (NZVD)
Marokopa	3.16 m	0.33 m	2.83 m
Mokau/Awakino	3.23 m	0.33 m	2.90 m

4.2.3 Wave Run-up

"Wave run-up" is the maximum vertical extent of wave "up-rush" on a beach or structure above the still water level (that would occur without waves), and is therefore only a short-term fluctuation in water level relative to wave set-up, tidal and storm-surge time scales. Swash can reach to considerably higher levels than the average water level and can cause ponding if sufficient to overtop dunes or seawalls to reach lower lying areas inland. The magnitude of wave run-up depends on the angle of the shore to the approaching waves, the nearshore water depth, wave height and period, beach slope and the nature of the shoreline (beach, dunes, vertical or sloping seawalls etc.). Wave run-up is therefore more significant on exposed open coasts and less so on sheltered estuarine shorelines. Wave run-up is not part of the calculations made by Stephens et al. (2015) as it is only a short-term fluctuation in water level and is not measured by tide gauges.

Wave run-up during storms can reach considerably higher levels than the storm surge water level and can aggravate inundation and cause physical damage to structures in areas closest to the shoreline. While we have not included an allowance for these wave effects in the above figures, we recommend that the Council include a "freeboard" in minimum floor levels, particularly close to the coast.

4.3 Sea Level Rise

4.3.1 Effect of Sea Level Rise on Coastal Erosion

Beaches

Observations of historic surveys and photographs indicate that the open coast and estuarine beaches of Waitomo District are generally in dynamic equilibrium or slowly eroding. On such beach systems, sea level rise is expected to drive an overall trend for shoreline retreat; with the beach profile adjusting landwards and upwards in response to the higher water level.

Shand et al. (2013) present a useful summary of the methods commonly used to provide indicative estimates of the erosion likely to arise from any given sea level rise. As they note, the most used method for sandy beaches are simple geometric models which simply consider two-dimensional (cross-shore) changes, such as the standard Bruun Rule (Bruun, 1962 & 1988) used on sandy beaches.

On sandy beaches, the standard Bruun Rule assumes that the equilibrium cross-shore profile of the beach (out to the seaward edge, known as the closure depth) is moved upward and landward conserving mass and original shape. This change results in the upper areas of the beach being eroded with this volume balanced by equivalent deposition offshore (Figure 6). With this simple model, indicative estimates of erosion can be obtained using the following basic relationship:

Erosion = (SLR x L*)/h

Where:

SLR = sea-level rise (m) (labelled B in Figure 6)

L* = distance between the landward and seaward edges of the beach system

h = elevation difference between seaward and landward edges of the active beach system (being the sum of B + h* in Figure 6)

In simple terms, the model simple calculates the average gradient over the entire beach system and extrapolates this slope landward by the amount of sea-level rise to estimate erosion.

The model is simple and indicative only and there are numerous complications. For example, strictly speaking, the interconnected beaches of the open west coast and lower estuarine regions within Waitomo District do not meet the conditions for the Bruun Rule; being complicated by longshore sand inputs and outputs. Wave climate changes could also change shoreline alignment giving rise to quite complex patterns of shoreline response including severe erosion in places and possibly accretion in others. Loss of sediment to ebb and flood tide deltas could be a further complication.

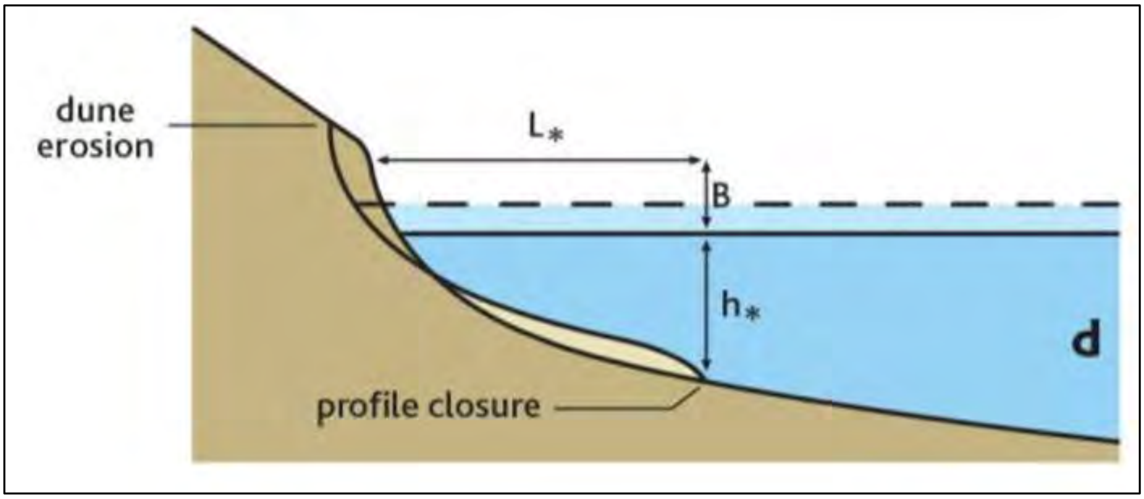


Figure 6: Schematic diagrams showing the standard Bruun Rule (top) and the generalised Bruun Rule (bottom) (Modified from Figure 1 in Shand et al. 2013).

Application of the Bruun Rule on the open coast is also complicated by lack of information on the seaward edge of the beach system (i.e. depth of closure) and variation in average cross-shore slope and dune height. In near entrance areas, ebb tide deltas also complicate offshore bathymetry. However, using available bathymetric and topographic data for the open coast of the Waitomo Region in areas removed from harbour entrances and adopting a closure depth of 6-8 m below Chart Datum suggests that erosion of approximately 75 m might occur for every 1.0 m of sea level rise. If the seaward edge of the beach system lies further offshore (e.g. about 10 m below Chart Datum) the erosion associated with 1.0 m sea-level rise would be higher (about 120 m). For this first pass assessment, a value of 75 m has been adopted but there is considerable uncertainty and the estimate is indicative only.

The full extent of this erosion will only occur if there is a sufficient width of sand backing the shoreline. If erosion extends back to a cliff constructed of harder geology (for example), the Bruun Rule will no longer apply, and the rate of erosion will change.

At more sheltered sand beaches (i.e. Marokopa and Awakino and the river shoreline of Mokau), the Bruun Rule is unlikely to be a realistic model as the offshore topography is complicated by various factors. These systems are also part of an integrated sediment system which includes the flood- and ebb-tide delta systems of significant river mouths. There are significant uncertainties in estimating the likely response of these beaches to sea level rise as there is potential for sediment to be lost not only to cross-shore adjustment of the beach profile (as per the Bruun Rule assumptions) but also to growth of the flood- and ebb-tide delta systems with sea level rise and other changes driven by river processes. We have used a typical upper beach slope of 1V:15H-1V:20H in erosion calculations in these areas. In our view, this method is likely to provide lower order estimates in some areas, and this will need to be considered in the development of adaptive management strategies for these sites.

These simple two-dimensional geometric models assume that neither the cross-shore shape of the beach profile nor the plan shape of the beach system are otherwise significantly modified; as might occur if climate change affects other key drivers additional (e.g. wave climate; sediment supply/budget). Obviously, this is an area of considerable uncertainty, one of many relating to potential climate change effects. It is our view that any such changes on the Waitomo coast are more likely to aggravate rather than offset or mitigate erosion. We therefore believe that the use of these simple geometric models to provide indicative estimates of erosion is not likely to significantly overestimate future erosional response. It is important to appreciate that (regardless of the assessment model used), estimates of shoreline response to sea level rise are always indicative rather than being accurate predictions. Future monitoring and the use of adaptable management approaches are therefore critical to successful long-term management on all coastlines.

Cliffs

Projected future sea level rise is also likely to increase the rate of erosion of cliffs and banks; particularly in areas where wave action influences existing toe erosion rates. As sea level rises, the frequency and severity of wave attack increases at the toe of the banks/cliffs.

The influence of sea level rise on bank and cliff erosion rates is still an active area of research and while various methods have been proposed to estimate these effects the methods have significant challenges. Ideally, as Le Cozannet et al. (2014) argue, it is necessary to rely on local observations and models applicable in the local geomorphological context.

At this point in time, there are no models developed in the local context that can be used to predict the potential influence of future sea level rise on bank/cliff erosion. However, Ashton et al. (2011) propose the following generic cliff retreat framework/equation for the response of a wide range of cliffed shores to sea level rise:

$$R2 = R1(S2/S1)m$$

Where R2 is the future rate of toe erosion, R1 is the historic (and presumed present) rate, S2 is the projected future rate of sea level rise and S1 is the historic rate of sea level rise. The constant m ranges from -0.5 (inverse feedback – damped erosion), through 0 (no effect) to 1 (instant response). This model is the best available approach for estimating the effect of sea level rise on future cliff erosion rates where wave erosion is the principal mechanism acting on the cliff face. However, the difficulty lies in choosing an appropriate value of the power function m.

On open coast sites with high rates of bank or cliff recession, the SCAPE (Soft Cliff and Platform Erosion) predictive model (m = 0.5) has provided reasonable estimates when tested against the known record of sea level rise and cliff retreat for various open coast soft cliffs in the UK; including The Naze, Essex (Walkden and Hall, 2005), NE Norfolk (Dickson et al., 2007) and the Suffolk Coast (Brooks and Spencer, 2010). However, a value of m=0.5 is probably too high for the Waitomo coast where rates of cliff recession are slow on both open and estuarine coasts. Accordingly, a value of m = 0.4 has been adopted for this study.

Given an effective sea level rise of 1.0 m to 2120 and an historic rate of sea level rise of 0.2 m over the last century, this yields a multiplier of approximately 2 – suggesting that existing erosion rates could be doubled. In identifying the coastal erosion sensitivity areas, we have therefore assumed that the existing toe erosion rates will double in response to 1.0 m sea level rise. This may only occur in areas with relatively soft and erodible banks, but nonetheless with the limited available data we feel it is prudent to acknowledge this possible increase in erosion rates on all cliffs and banks.

In defining the slope stability component of cliff erosion, we have adjusted the elevation of the toe of the bank by the relevant sea level rise. For instance, in estuarine areas the existing toe of bank is typically about RL 2.0 m and therefore in areas where 1.0 m of sea level rise has been considered, the stable slope has been calculated from RL 3.0 m.

4.3.2 Effect of Sea Level Rise on Coastal Flooding

Sea level rise is expected to greatly exacerbate the frequency and severity of coastal flooding over the next 50-100 years. Severe coastal inundation events that are currently very rare will become common with even relatively small sea level rise. The extent and severity of flooding during rare storm events will also be much greater in areas where coastal land is low lying; with areas not presently subject to coastal inundation likely to be affected.

5 COASTAL EROSION AND FLOODING HAZARD AREAS

5.1 Coastal Erosion Hazard Zones

For the purposes of coastal erosion hazard management, we have identified two coastal erosion zones at each of the main settlements:

> Coastal Erosion Hazard Zone 1 (“CEHZ1”): the width of coastal margin potentially vulnerable to coastal erosion over the next 50 years (less at Mokau as discussed below) with current sea level.
>
> Coastal Erosion Hazard Zone 2 (“CEHZ2”): the width of coastal margin likely to be vulnerable to coastal erosion over the next 100 years with projected sea level rise of 1.0 m.

Coastal Erosion Hazards Zone 1 identifies the area at highest risk for coastal hazard management. We have adopted 50 years rather than the 100 years adopted elsewhere (e.g. Dahm and Gibberd, 2009) because erosion calculations at some sites includes long term erosion trends. Extrapolating these trends for 100 years would unreasonably constrain use of existing properties at some sites.

It is important to clarify here that Coastal Erosion Hazard Zone 1 does not represent a “worst-case” potential coastal erosion area over the next 50 years. For instance, it does not include any aggravation of erosion by the projected sea-level rise that is likely to occur during that period. This fact will need to be incorporated in the management of development (e.g. relocatability requirements).

At Mokau Spit, there is a remarkably high level of uncertainty in predicting future shoreline change due to complicated coastal processes and dynamics. The definition of Coastal Erosion Hazard Zone 1 varies here from other sites; assuming a timeframe of 20 years with erosion rates consistent with those observed over the last 20 years. It is not possible to reliably predict future erosion rates at this site for a greater timeframe with any certainty as it is not clear if this erosion trend is permanent. The considerable uncertainties at this site mean it is a high priority site for an adaptive management strategy.

Coastal Erosion Hazard Zone 2 reflects an area with some uncertainty regarding future coastal hazard vulnerability. It is important to note that this zone is not a confirmed coastal hazard zone, and that there this little hazard risk in the short term and with current sea level. This area is identified due to the potential for vulnerability to coastal erosion in the long term with projected sea level rise. Further detailed investigation of coastal hazard is recommended prior to any future intensification of land use.

We have calculated erosion hazard zones (unless otherwise stated) as if coastal protection works such as seawalls were not present. This approach acknowledges the residual risk landward of the structure. In the development of adaptive management plans, the management of these hazard areas may reflect the presence of structures, but until such a plan is agreed, we cannot assume that the existing structures provide long term protection.

5.2 Coastal Flood Hazard Areas

We have identified two coastal flood hazard areas in developed areas:

- Coastal Flood Hazard Zone 1 (CEHZ1): the extent of land likely to be vulnerable in a rare extreme storm surge event with current sea level and processes.
- Coastal Flood Hazard Zone 2 (CEHZ2): the extent of land likely to be vulnerable in a rare extreme storm surge event, including the effect of projected sea level rise (1.0 m to 2120).

CFHZ 1 is therefore defined by the maximum storm surge at each location as defined by Stephens et al. (2015) (Table 5 & Table 6). CFHZ 2 includes an allowance for 1.0 m of sea level rise. Site specific storm surge levels are also discussed in each relevant section (Sections 9-12) and are summarised in Appendix D.

6 MANAGEMENT OPTIONS AND BROAD MANAGEMENT RECOMMENDATIONS

This section discusses a range of measures for management of coastal erosion and flood hazard risk. These represent a broad "hierarchy" of management approaches, implicit in national and regional coastal policy that should be applied in a way that reflects the nature of the coastal environment the likely responses of that environment to future climate change and the implications of different coastal hazard responses. The chosen approach will be greatly influenced by existing use and values in each area.

Coastal management is broadly presented here with an initial focus on hazard avoidance and acceptance. These approaches are particularly relevant when new development is considered, or where existing coastal hazard risk (being the combination of likelihood and consequence) is low to moderate. These measures can all form part of an adaptive management plan as discussed in Section 6.8.

6.1 Risk Avoidance

Risk avoidance is an "ideal" approach to coastal hazard management to ensure long term sustainability and resilience. This approach is generally most relevant to the management of proposed new development.

In areas of existing development, there are still opportunities in some cases to relocate infrastructure outside of hazard areas, particularly where land parcels are large and/or where the existing hazard is not severe.

In the context of the Waitomo District, a risk avoidance approach should be applied as the preferred approach wherever practical when:

- establishing major new infrastructure,
- undertaking major upgrades to existing infrastructure,
- considering applications for Greenfield development or any other significant intensification of land use
- when considering applications for subdivision

In the case of major new infrastructure or Greenfield development within the identified coastal erosion and flooding zones, Council should ensure that any such proposal considers the impacts of coastal hazards over at least the next 100 years, including consideration of the 1.36 m of sea level rise, to ensure that there will be no increase in the risk of adverse effects associated with coastal hazards in the foreseeable future.

Intensification of existing development should generally be avoided in identified flooding and erosion zones. Intensification should ideally only occur where a site specific coastal hazard study demonstrates that there will be no increase in coastal hazard risk, and/or effective and sustainable management of the risk is provided for in an agreed adaptive management strategy (that considers the full range of future sea level rise scenarios).

6.2 Living with hazards

In some cases where complete avoidance of coastal hazard areas is not practicable, it may be acceptable to live with a coastal erosion or flooding hazard. This approach is potentially viable where coastal hazards only affect the area periodically and do not prevent ongoing use of the area. For example, in some cases land may be affected but not dwellings or infrastructure, or the coastal erosion hazard is associated with dynamic fluctuations rather than permanent retreat.

Where the impact of engineered protection measures is unacceptable due to particularly high environmental, social, cultural and/or economic values of the local coastal environment, the most practicable solution may be to tolerate the hazard. This may be relevant for example where there is a regionally or nationally significant beach or ecologically significant wetland and the threatened land is in public ownership.

Living with hazards is often the most appropriate approach in rural or other undeveloped sites, or where other development is of low intensity and/or is resilient to the hazard.

6.3 Enhancing natural buffers

Natural coastal systems such as beaches, dunes and wetlands provide considerable protection against coastal hazards. National Policy promotes the protection and enhancement of these buffers to aid in the management of long-term coastal hazards.

Maintaining, restoring and/or enhancing natural coastal features and buffers can be a valuable tool to preserve the natural and amenity values of the shoreline over time and to mitigate the impacts of coastal hazards and climate change. These natural features/buffers can include:

- naturally vegetated riparian margins
- naturally vegetated dunes
- storm ridges on gravel shorelines
- beaches or cheniers
- saltmarsh and other coastal wetlands
- combinations of the above

Enhancing natural buffers such as beaches, dunes and wetlands can be viable and bring significant benefits where:

- natural buffers are already present or have been previously degraded (i.e. they used to exist)
- coastal erosion is dynamic and therefore natural dunes are required for shoreline recovery
- wetlands can provide protection from wave action and flooding on estuarine shorelines.

It is important to recognize that natural buffers are natural coastal systems and are only sustainable in an environment that is geomorphologically suited. That is, there is little value in constructing a buffer such as a wetland or dune in a setting where the coastal processes are not compatible with that feature (i.e. where that buffer would not naturally exist). While naturally functioning dunes provide a buffer for erosion and are critical to dune recovery between periods of erosion, they will not prevent erosion from occurring.

Council should manage future development in low-lying areas provide for restoration of coastal wetlands where these features have been lost historically and for landward expansion and migration of wetland habitats in response to sea level rise of at least 1.36 m (i.e. RCP8.5+). These habitats provide critical ecosystem services including protection against coastal flooding and erosion.

We recommend therefore that, outside of existing settlements and rural residential sections, infilling be strongly discouraged within the coastal flooding sensitivity areas. However, it is also important that controls do not impact on existing farming activities, which are often very reliant of existing measures such as drains, bunding and flap-gated culverts. The adverse effects of these measures can be relatively readily reversed when and if opportunity for wetland restoration occurs. A co-operative approach is strongly recommended in working with farmers to avoid future wetland loss and, where practical, encourage wetland restoration. It is also recommended that policy development examine potential incentive mechanisms to encourage appropriate wetland restoration within these areas.

In many places on this shoreline, adaptions to road management could have benefits to coastal resilience. Road cuttings expose highly fractured sand/siltstone, which erodes into potentially useful gravel material for beach nourishment in some locations (Figure 7). Prior to the construction of the road, any eroded material from the adjacent slopes would have arrived in the coastal marine area to supply the local shoreline. In suitable locations, slip material could be placed across the road or to a shoreline nearby to maintain sediment supply to the coast.

Figure 7: Road cuttings supply potentially useful material that should be supplying adjacent beaches.

6.4 Risk reduction

Risk reduction generally occurs as an outcome of actions that may be implemented from throughout the hierarchy of management approaches. However, there are particular approaches to the management of land use and development in high risk areas that reduce the risk from coastal hazards and the adverse effects of human responses to coastal hazard management. Priority should be giving to areas known to be vulnerable with current sea level.

6.5 Development Controls

In areas of existing development, we recommend that the Council implement policies and rules to reduce existing and future coastal hazard risk over time within the identified coastal erosion and coastal flood hazard areas and to manage future hazard risk and associated effects in the future and potential coastal hazard areas. Relevant risk reduction approaches include:

- encouraging dwellings and infrastructure to move landward away from high risk coastal erosion areas (e.g. avoiding development in identified Coastal Erosion Hazard Zone 1)
- designing buildings to be moved landward or raised over time in response to changing hazard risk (i.e. requiring adaptive design on soft (i.e. beach) shorelines and in flood hazard areas)
- requiring a site-specific geotechnical report in identified coastal erosion areas on cliff shorelines to ensure future development is not at risk from slope failure
- implementing minimum floor level requirements that reflect coastal flood hazard.

We recommend that the Council provides for the consideration of further, more detailed information in all cases where development or activities are restricted by these identified hazard areas. This information could include site specific coastal hazard studies, data on sub-surface geology, land stability investigations or detailed surveying of land levels etc., as relevant to the potential hazard. Such data may provide for a better understanding of coastal hazard risk at a site-specific scale.

In areas where existing development is located within the high-risk coastal erosion area, and there is insufficient space to relocate assets landward of these areas, a detailed site-specific adaptive management plan is likely to be necessary to determine the most appropriate course of action.

National Policy and Guidance directs Councils to avoid increasing the risk of adverse effects associated with natural hazards. While there is considerable uncertainty in predicting the rate and severity of future climate change effects, it would not be responsible to increase the amount of development within areas that may be vulnerable in the long term. Notwithstanding this, some new parcels may be appropriate in areas where only a portion of the parcel is vulnerable to hazards, and safe building sites are located within the property but outside of potential hazard areas.

6.6 Adaptation and Managed Retreat

Adaptability of development will be an important part of future coastal management in identified coastal hazard areas, particularly in areas where there is much uncertainty about future hazard impacts. We recommend that Council work with appropriate local professionals (e.g. architects, civil or structural engineers) to help develop and promote guidelines to encourage increased use of more adaptable design.

The Waitomo District council should retain existing rules within the District Plan that facilitate relocation of dwellings and structures within sites identified to be vulnerable to coastal erosion hazard. Council should require adaptive design (i.e. readily relocatable buildings) where there is a potential for the hazard to impact within the lifetime of the activity.

It is relevant to note here that in terms of implementing minimum floor levels, where design provides for the house to be readily and practicably lifted at some future date, a lesser standard (than 100 years with sea level rise) may be acceptable. Triggers tied to future sea level rise should be included in consent conditions and appropriately recorded (e.g. on LIM/PIM data for the property) to ensure the dwelling will be further lifted if required in the future. Minimum floor levels should be sufficiently elevated above predicted flood levels to provide for water level fluctuations and wave effects ("freeboard"). This freeboard would vary depending on the setting but would not be less than 0.25 m.

Ground levels will very likely need to be raised in some coastal inundation hazard areas over time; in response to both significantly increased frequency and severity of flooding as sea level rises and complications from potential groundwater level changes (which are often strongly influenced by sea level in coastal settings). However, this a very complex consideration as ad hoc raising of ground levels can also aggravate existing and future flood hazard for adjacent areas. Appropriate guidelines can therefore only be devised as detailed adaptive management strategies are developed and will need to consider coastal flooding, stream/river flooding (including overland flow paths) and stormwater flooding.

Managed retreat is still a relatively "new" approach to coastal management in New Zealand and there are many challenges to overcome before it can be successfully implemented where private properties will become unusable.

6.7 Engineered Approaches to Managing Coastal Hazards

6.7.1 Soft engineering

Soft engineering approaches work with nature and aim to provide protection from coastal hazards while avoiding the adverse effects associated with hard engineering works. Soft engineering approaches generally work by constructing or enhancing beaches and dunes through the addition of imported sediments ("beach nourishment") but can also include the creation of other natural coastal buffers such as wetland features. In many cases, soft engineering approaches will provide amenity and/or ecological benefits as well as hazard protection.

Soft engineering approaches are most likely to be a viable approach where:

- the local wave environment is low to moderate (i.e. estuarine or sheltered coastal setting)
- the coastal setting is part of a relatively discrete, enclosed sediment transport system (for beach nourishment)
- there are important land-based assets that require protection (that cannot be relocated), but the shoreline is also highly valued for recreation/amenity/ecology

Soft engineering approaches in high energy open coast environments can be applicable if the value of assets to be protected are sufficiently high but are often prohibitively expensive and performance can be uncertain. Approaches such as beach scraping and beach nourishment require ongoing maintenance and can only be applied in suitable circumstances.

Soft engineering approaches in sheltered environments can be cost effective and generate positive outcomes. It is critical that soft engineering approaches are designed and implemented based on principles of coastal geomorphology and hydrodynamics and a clear understanding of the local coastal system. In some cases, it may be appropriate to combine soft engineering with "hard" approaches such as sand retention structures.

6.7.2 Hard engineering structures

"Hard engineering" refers to structures that act as barriers to natural processes to prevent erosion or flooding of the land. These approaches have historically been the first line of action, particularly in response to coastal erosion risk. These approaches include sea walls, rock revetments, breakwaters, groynes and offshore reefs.

The most applied hard engineering structures are seawalls such as vertical walls or sloping rock revetments. Unfortunately, seawalls have severe adverse effects on eroding beaches (Pilkey & Wright, 1988; Wright & Pilkey, 1989). By way of example, Figure 8 and the associated text illustrates the impact of a seawall placed on an eroding beach.

Over time, the adverse effects and long-term implications of hard engineering works have been increasingly recognised, and as such National Policy now emphasises the use of alternative approaches. This shift in emphasis in coastal planning and management is occurring globally. The current national policy broadly discourages the use of hard engineering structures for coastal erosion management due to the now well understood adverse effects that these structures can have on wider coastal values and the potential for these adverse effects to be increased significantly with future sea-level rise.

We therefore recommend the District Plan broadly discourages the use of "hard" coastal protection structures. There will, however be circumstances where hard engineering works will be an appropriate solution in the short-medium term, particularly where there is significant immediate coastal hazard risk to dwellings or key infrastructure , and where adverse effects of the works can either be mitigated or avoided, or are outweighed by the benefits (considering both public and private values)

These structures may be appropriate as a temporary or permanent part of a chosen management approach in the Waitomo District where they are part of an adaptive management plan that has been developed with the community. Such a plan would need to ensure long term sustainability and that an appropriate balance is achieved between private and public values.

Where hard engineering is judged to be the best practicable option, measures to avoid risk/damage should include:

- locating the structure as far landward as reasonably practicable

- using vertical structures where appropriate in preference to sloping structures to minimise seaward encroachment
- designing hard structures to resemble natural shorelines (e.g. in cliff settings) where possible to reduce natural character impacts
- minimising the length of the structure required
- ensuring environmental impacts are given sufficient weighting in location and design of the structure
- planning appropriately and using other measures to reduce the need for the structure over time.

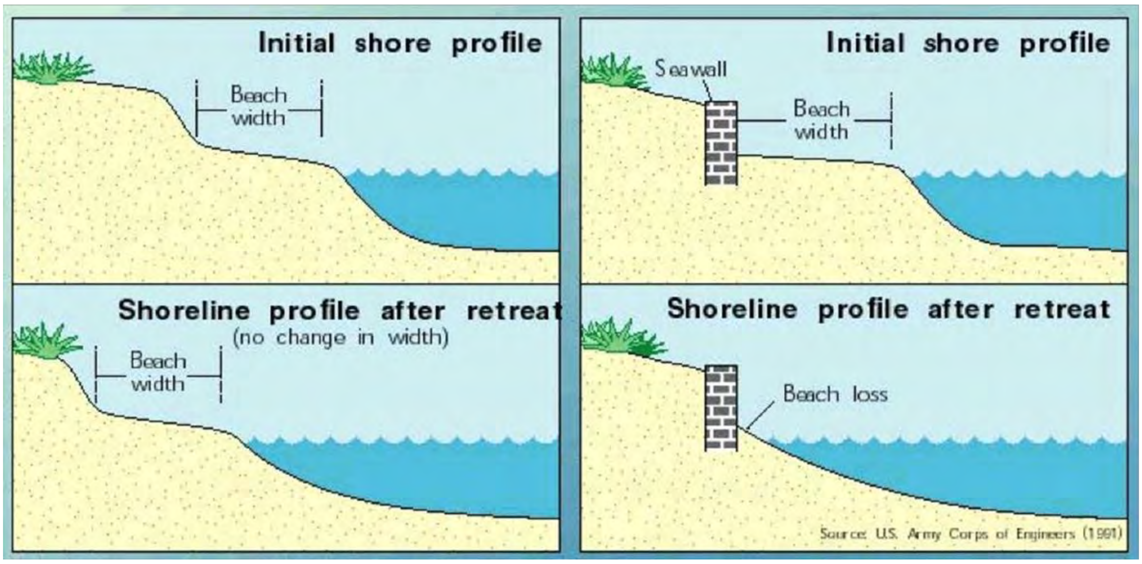
It is very unlikely that hard protection works will be a viable approach to coastal erosion management on the open coast beaches of the Waitomo District due to such adverse effects and the significant engineering cost. They are also unlikely to be appropriate on estuarine beaches within the district unless the adverse effects can be avoided or mitigated (e.g. by beach nourishment).

Impact of Seawalls on Beaches

On a natural beach, the shoreline adjusts in response to a phase of erosion. The dune and high tide beach re-establish to landward and the recreational and ecological and amenity values of the beach and dunes are unchanged. Where the erosion is part of a natural cycle, over time the dune and beach will build slowly seaward and the erosion will be reversed.

If a seawall is constructed to protect the land from erosion, the seawall does not change the natural coastal processes driving the erosion. The seawall simply prevents landward movement of the dune. The erosion of the beach will continue, and with the profile unable to move landward, useable beach is lost.

A seawall separates the beach from the dune and interrupts the natural processes of beach recovery. Without a functioning dune, it is more difficult for the shoreline to recover from short term erosion. Loss of beach impacts on the recreational value of the beach as well as on natural character and ecological values. This loss of beach width is clear at many sites, including Marokopa and Mokau in the Waitomo District.



As the beach level drops in front of the seawall, wave and tidal impacts on the seawall also increase. Larger waves can impact the structure, requiring more robust engineering to avoid wall failure. Beach lowering can also expose seawall foundations, or cause slumping of sloping rock structures. Seawalls often also cause increased “end effect” erosion of unprotected shorelines nearby.

Sea level rise will continue to exacerbate these effects in the medium to long term and “hard” engineering works that protect assets from coastal erosion and/or flooding will become increasingly difficult and expensive to maintain and will have more severe impacts on public and ecological values.

Figure 8: The effect of placing a seawall on an eroding beach.

6.8 Adaptive Management Plans

At many settlements, existing coastal development is already at risk from coastal hazards and/or coastal flooding. There is also much uncertainty about the long-term hazard, particularly regarding the future effects of sea level rise.

The issues are complex and difficult, and it is not possible to simply avoid all coastal hazard risk in the short to medium term. Reducing this risk over time requires difficult decisions to be made about the long-term sustainability of development and structures in the risk zones. In the past there has been a tendency to plan for either the “worst-case” or “most likely” scenario. While this approach is intuitively sensible, the huge uncertainties and long timeframes involved mean it can place unduly severe restrictions on current use of coastal properties and assets.

Reducing risk over time requires difficult decisions to be made about the long-term sustainability of development and structures in the risk zones and to establish a balance between public and private benefits and costs. In this context, the District Plan cannot alone provide all necessary outcomes, and coastal hazards are best managed using an adaptive management approach. Adaptive management is a flexible approach to managing development, which can adjust in response to changes over time.

The aim of adaptive management is to transition over time to a more sustainable management approach while allowing for ongoing use in areas of existing development as the transition occurs. The intention is to develop a plan of actions that can respond to events as they occur (e.g. rates of sea level rise) without requiring unnecessarily drastic changes in the short term based on the worst-case scenario.

Adaptive management aims to be sensitive to the community and its aspirations, and local variations in aspirations and sensitivities to increasing risk. It also helps to cope with uncertainty by establishing trigger or decision points with the community and developing a plan to implement these in both the short and long term.

There are five key stages to adaptive management:

- building a shared understanding (processes, hazards, community resilience)
- exploring the future and how communities are affected and identifying objectives
- building adaptive pathways
- implementing the strategy in practice
- monitoring the strategy using early signals and triggers (decision points) for adjusting between pathways.

Dynamic adaptive plans for coastal settlements in the Waitomo District would ideally include:

- agreement on preferred management responses and long-term outcomes that balance private and public values.

- identification of key effects and drivers
- thresholds and triggers (e.g. beach state, sea level rise value) for each phase of the adaptation plan (e.g. relocation of assets as required)
- provisions for ongoing use of the area (e.g. to provide for reasonable use of the properties while practicable), without incurring liability for the wider community.

Establishing an adaptive management strategy at sites such as Mokau and Marokopa involves conflict between the preservation of public and private assets. Such a process requires the community and stakeholders to agree on long term outcomes and to identify appropriate signals and triggers to initiate the staged implementation of the plan. This process will be challenging and will take time and requires patience and open dialogue.

It is also critical to maintain ongoing commitment to keeping the strategy alive and relevant over the planning timeframe.

7 DISTRICT PLAN RECOMMENDATIONS

This section proposes activity statuses for coastal development within the identified coastal hazard areas. These recommendations can be developed into rules by Council staff as appropriate.

Regarding coastal hazards (both erosion and coastal flooding), we recommend a management approach based on living with hazards and avoiding and reducing the use of sea walls to the extent reasonably practicable, including:

- avoiding coastal hazards where reasonably practicable with development controls within identified coastal hazard zones to ensure appropriate design and location of new development
- where avoid is not practical, reducing risk with development controls to ensure appropriate design and location of new development
- accepting and living with coastal erosion and coastal flooding through development controls in identified hazard areas (e.g. minimum floor levels, relocatable requirements)
- strict conditions on sea walls to ensure they are only used where appropriate and that adverse effects are appropriately avoided or mitigated to the extent reasonably practicable.

Where it is not practicable to accept and live with coastal hazards, we are advocating:

- use of natural buffers to manage erosion
- use of soft engineering to manage coastal hazards

It is recognised that the proposed management regime will not be appropriate in all situations and there will be cases where hard protection may be the best practicable option. We recommend that Council provide for this by providing for the use of sea walls, but only where proposed structures are able to pass strict tests to ensure the structure is the best practicable option, that adverse effects are appropriately avoided or mitigated and the measures are part of an agreed adaptive management strategy for the site.

In line with national and regional policy (which the District Plan must give effect to) we recommend that the activity status be more permissive for structures that are required to protect infrastructure of regional or national significance, than for less significant infrastructure or for private benefit structures. This is described in more detail in Section 7.5.

7.1 Coastal Erosion Hazard Zone 1 (CEHZ 1)

The Coastal Erosion Hazard Zone 1 ("CEHZ 1") is identified as the area likely to be affected by coastal erosion within the next 50 years with existing sea level and coastal processes and/or with continuation of existing coastal trends. There is a relatively high level of certainty in identifying this area as vulnerable to coastal erosion in comparison to projections that include longer timeframes and/or the effects of sea level rise. Any development within this zone is at risk in the short to medium and as such, we recommend the Plan include provisions to prevent any further development in this zone.

There will be some properties that will have insufficient space landward of the CEHZ 1 to provide for reasonable use. In these cases, it is recommended that The Plan provide for site specific investigations and/or an adaptive management plan to be developed to provide for ongoing use while managing future hazard risk and adverse effects.

Given the strict nature of the controls proposed for CEHZ 1, it is also recommended that the Plan provide for site-specific review and revision of this hazard zone by an appropriately qualified and experienced coastal scientist or coastal engineer.

We recommend the following activity statuses within the CEHZ 1:

- Any new building within CEHZ 1 should be prohibited
- Where there is no option within a property to place a dwelling and/or associated infrastructure (e.g. septic tanks) outside CEHZ 1, provision may be made for a relocatable dwelling (discretionary) provided it is consistent with the provisions of an agreed adaptive management plan for the site, including triggers for relocation. In cliff environments, development should be avoided in the CEHZ 1 unless there is a site-specific engineering report by a suitably qualified and experienced professional (generally a geotechnical engineer or an engineering geologist) that confirms that the development is not vulnerable to slope instability and/or that the risk can be satisfactorily managed (e.g. appropriately engineered retaining walls).
- Subdivision within the CEHZ 1 where each lot has a building platform landward of the CEHZ 2 should be discretionary.

- Subdivision within the CEHZ 1 where each lot does not a building platform landward of the CEHZ 2 should be prohibited.
- Any major public facility (e.g. a wharf, jetty, car park, cycleways or toilet facility) in the CEHZ 1 be discretionary if accompanied by a site-specific adaptive management strategy which indicates how existing and future erosion hazard risk will be managed, with emphasis on avoiding hard structures and mitigating adverse effects where practicable.
- Minor public facilities (including picnic tables, seating, rubbish/recycling bins and other readily relocatable structures) could be a Permitted Activity within CEHZ 1 provided clear triggers are defined for landward relocation and the facility does not depend on construction of a hard protection structure.
- Landward relocation of a dwelling or other infrastructure from a CEHZ 1 zone should be a permitted activity.

7.2 Coastal Erosion Hazard Zone 2 (CEHZ 2)

Coastal Erosion Hazard Zone 2 (CEHZ 2) identifies the area likely to be affected by coastal erosion over the next 100 years with continuation of existing coastal trends and the likely impact of projected sea level rise of 1.0 m. There is a level of uncertainty in defining this erosion risk area, particularly around the rate and scale of sea level rise over the next 100 years and the effects of such sea level rise on erosion.

The erosion hazard risk in these areas is currently low, but given the potential for long term risk, relocatable and adaptable design should be favoured while ongoing use is provided for.

We recommend the following provisions for management of activity within the CEHZ 2 zone:

- Any dwelling within the CEHZ 2 that is consistent with the provisions of an agreed adaptive management plan should be a restricted discretionary activity
- In the absence of an agreed adaptive management plan, any dwelling within the CEHZ 2 should be a discretionary activity. Matters of discretion to relate to ability of the activity to adapt to future hazard and the level of hazard at the location of the proposed dwelling.
- Any non-relocatable dwelling within CEHZ 2 should be non-complying.
- Subdivision within the CEHZ 2 where each lot has a building platform landward of the CEHZ 2 hazard zone should be discretionary.
- Any subdivision within CEHZ 2 that does not have a building platform landward of the CEHZ 2 should be a prohibited activity.

National Policy and Guidance directs Councils to avoid increasing the risk of adverse effects associated with natural hazards. While there is considerable uncertainty in predicting the rate and severity of future climate change effects, it would not be responsible to increase the amount of development within areas that may be vulnerable in the long term.

Notwithstanding this, some new parcels may be appropriate in areas where only a portion of the parcel is vulnerable to hazards, and safe building sites are located within the property but outside of potential hazard areas.

Where subdivision does occur, needs to be plan for adaptation and recognition of the portion of the property that is in the hazard area to prevent action being taken to stop the hazard. Any subdivision in the identified coastal hazard areas should require a site specific investigation of coastal hazards that considers all sea level rise scenarios (as described in Section 3.3).

7.3 Coastal Flood Hazard Zones

The Coastal Flood Hazard Zone 1 (CFHZ 1) identifies those areas vulnerable to coastal inundation during a rare and extreme storm event with current sea level. The Coastal Flood Hazard Zone 2 (CFHZ 2) identifies the additional area that would be vulnerable during the same extreme event after 1.0 m of sea level rise.

We recommend the following activity statuses within coastal flood hazard zones:

- Subdivision within CFHZ 1 and/or CHFZ 2 zone be a prohibited activity unless all lots proposed to be created have building platforms outside of these zones.
- Subdivision within CFHZ 1 and/or CHFZ 2 zone is a non-complying activity if all lots proposed to be created have building platforms outside of these zones but some raising of land levels within the zones is required.
- Subdivision within CFHZ 1 and/or CHFZ 2 zone is a restricted discretionary activity if all lots proposed to be created have building platforms outside of these zones and it is proposed to covenant at least 80% of the areas within the hazard zones for future wetland recovery or expansion.

New habitable dwellings or significant renovation of existing habitable dwellings within coastal flood hazard zones should adopt minimum floor levels that will provide protection from flooding during an extreme coastal inundation event, including 1.0 m of sea level rise and a freeboard suitable to the setting. Council may allow for a lesser standard of protection to be adopted if the new dwelling is able to readily lifted and suitable triggers for future lifting are clearly identified. However, this lesser standard is at the discretion of Council and should ideally provide a minimum standard of protection of 1%AEP and 0.3 m sea level rise, together with freeboard appropriate to the site

Minimum floor levels for all non-habitable buildings within coastal flood hazard zones would provide protection from flooding during a 1%AEP coastal storm inundation event, including 0.3 m of sea level rise and a freeboard suitable to the setting. Council may allow for a lesser standard of protection to be adopted if either:

- the new building can readily lifted and suitable triggers for future lifting are clearly identified

- Council accepts that lesser standard is appropriate for the uses and design life of the proposed building and other conditions at the discretion of Council

7.4 Other Coastal Areas

This project has only addressed the main coastal settlements of the district and has not involved any investigation of coastal processes and hazards in other areas on either the open or estuarine coasts of the district. The shoreline is predominantly backed by sloping land and cliffs, with the occasional stream mouth and dune shoreline.

The existing 50 m hazard area which applies to the open coast is in our view unlikely to be adequately conservative in all areas of the coast; particularly those areas where the shoreline is backed by wide coastal dunes or high, steep cliffs or slopes.

In the absence of any detailed information for other areas of the open coast, we recommend that a site-specific assessment of coastal hazards be required for development on the open coast outside of the main settlements. We recommend that a site-specific coastal hazard assessment be required if the proposed building site lies within the area defined by the greater of:

- a distance of 200 m from the coast, or
- a distance defined by the intercept of a 1V:2H slope with the land surface, as measured from the current seaward toe of bank or the seaward edge of vegetation, or
- for any slopes steeper than 1V:2H, a setback from the top landward edge equal to half the height of the top of the slope.

On estuarine or river margins outside of the main settlements, the existing 25 m coastal hazard setback (measured from the seaward toe of bank) will likely be adequate for coastal erosion in most areas. There may be some areas, however, where the shore is backed by high steep banks or dynamic areas close to river of estuarine entrances where this coastal setback may not be adequate. Without a detailed analysis, it is not possible to be sure that the 25 m is adequate in all areas.

Accordingly, in the absence of any detailed study of the estuarine and river coasts, we recommend that a site-specific assessment of coastal erosion hazards be required for any development on estuarine coasts if the proposed building site lies within the area defined by the greater of:

- a distance of 50 m from the coast (as measured from the existing seaward toe of bank), or
- a distance defined by the intercept of a 1V:2H slope with the land surface, as measured from the current seaward toe of bank or the seaward edge of vegetation, or
- for any slopes steeper than 1V:2H, a setback from the top landward edge equal to half the height of the top of the slope.

In terms of coastal inundation, the defined coastal flood hazard areas will identify potentially hazardous areas on the margins of rivers and estuaries in the District.

7.5 Sea Walls

It is recognised that the proposed management regime will not be practicable in all situations and there will be situations where hard protection may be the best practicable option. We recommend the following policy directions in developing rules for hard protection structures (e.g. seawalls, rock revetments, riprap):

- Seawalls that are necessary to protect public infrastructure of regional and/or national significance should be a restricted discretionary activity.
- Sea walls required to protect public infrastructure of local and/or district significance should be a discretionary activity. Matters of discretion for seawall applications:
    - clear evidence of public benefit
    - proper assessment of the measure as the best practicable option at that site
    - requirement for design, location and/or mitigation to avoid adverse effects to the extent reasonably practicable; particularly where such structures reduce beach width, adversely impact on public beach amenity and/or adversely impact on public access to and along the coast
- Seawalls designed to protect private property that are located on public land and preclude the formation of a high tide dry beach or are likely to do so within the design life of the structure should be a prohibited activity.
- Seawalls that are designed to protect private property and are required for protection of a dwelling and associated services should be a discretionary activity if:
    - the dwelling and associated services are:
        - existing and cannot be reasonably relocated further landward to avoid the need for the structure, OR
        - are located as far landward as reasonably practical and are appropriate in scale to the defined coastal hazard areas
    - the proposed structure is entirely on private land, and
        - is designed and located to avoid adverse effects on any beach to seaward during the design life of the structure, including any narrowing of the beach through passive erosion or encroachment losses, AND
        - the structure is designed and located to avoid adverse effects on public access to and along the coast during the design life of the structure

Seawalls designed to protect private property which are otherwise a non-complying activity.

7.6 Other Methods

7.6.1 Earthworks and Disturbances

Earthworks, disturbance and/or sediment placement within a CEHZ 1 or CFHZ 1 associated with restoration of coastal ecosystems or soft engineering should be a Permitted Activity provided:

- the works are designed and supervised by an appropriately qualified and experienced coastal scientist or coastal engineer
- the works involve one or more of the following:
  - restoration of native-vegetated ecosystems appropriate to the site, including riparian margins, dunes, coastal (estuarine or freshwater) wetlands, chenier ridges and/or beaches.
  - sediment push-ups (on beaches).

Earthworks to raise land levels within a CFHZ 1 or CFHZ 2 zone should be a permitted activity if:

- conducted for the purposes of creating a raised building platform for a dwelling and/or associated services on an existing residential property, and
- the area of land to be raised is limited to that necessary to achieve flood protection and limited in area (e.g. less than 1000 m^2).

Raising of land levels within a CFHZ 1 or CFHZ 2 zone should otherwise be a non-complying activity.

The Council should work closely with Waikato Regional Council to ensure consistency between District and Regional Plan controls as natural buffers and soft engineering works tend to straddle the jurisdictional boundary.

The Waitomo District council should retain existing rules within the District Plan that facilitate relocation of dwellings and structures within sites identified to be vulnerable to coastal erosion hazard.

We also recommend that the Council submits to the WRC Plan process to ensure that provisions provide for appropriate sediment taken from slips on the landward side of coastal roads to be placed on the adjacent shoreline. In many locations on the Kawhia Harbour margin, eroded cliff sediments have historically formed useful beaches around the margin of the harbour. However, in recent decades, beach suitable materials which have fallen onto the road have more typically been removed and placed outside of the CMA. We believe there is very considerable potential to use such materials for environmentally appropriate shoreline protection and for shoreline restoration; provided the materials are placed in suitable locations (which will vary with the nature of the materials and the local receiving environment).

Council may wish to further explore this option and to seek resource consent for appropriate in-harbour uses, as well as working with the Regional Council in the development of the Regional Coastal Plan to provide for such approaches. A partnership with the Regional Council on such matters is sensible given that relevant regional plans place considerable emphasis on giving preference to environmentally soft approaches and to restoration of harbour margin environments. This will reflect the intention of the existing provisions of the Regional Coastal Plan that encourage the preservation of sediment within the CMA. However, the wording of the current rules does not provide for the use of material that is sourced from outside the CMA, even though it would have naturally supplied the local beaches in the absence of a road. Criteria will be required for appropriate sediments and these criteria may vary with placement site. Similarly, it is important that suitable placement areas be identified, and sensitive receiving environments excluded or appropriately protected.

While land in the coastal flood hazard zones could potentially be raised in the longer term, this is not likely to be desirable from an environmental perspective; as with future sea level rise these low-lying areas will be critical for expansion and preservation of saltmarsh and other estuarine margin habitats. Raising of such low-lying harbour margin areas has the potential to be a very significant hazard threat to coastal margin ecosystems; and to further (and often quite considerably) exacerbate the extensive historic losses of these critical ecosystems. Accordingly, we recommend that Council consider measures to prevent raising and infilling of such areas to the extent practicable.

7.7 Existing Use Rights

It is recognised here that under existing use rights, existing buildings within these identified hazard zones may be able to be replaced by buildings of similar scale and within the existing footprint. This is beyond the jurisdiction of the District Council to influence. We recommend that the District Council work with Waikato Regional Council to consider a primary hazard zone where there is existing development within coastal hazard zones (particularly CEHZ1 and CFHZ1) with view to managing existing use rights in this area. In the interim, it is important that any owners who do exercise existing use rights bear in mind that this is a hazard risk area and that re-building in this area may result in impact by erosion or flooding and could also affect insurability and/or insurance premiums

Notwithstanding existing use rights, S71-73 of the Building Act apply to any application for building consent within areas at risk from coastal hazards. The Waitomo District Council therefore will need to consider the requirements of the Building Act when assessing building sent applications within the identified coastal hazard zones. Council should also ensure that the hazard risk is appropriately noted on titles for any development within this zone, and that Council is indemnified against any liability for loss or damage.

8 MOKAU

Mokau Township is built at the mouth of the Mokau River. A large proportion of the development (the original Town extent) is well elevated and landward of the ancient sea cliffs and is not at risk from coastal erosion or flooding (Figure 9). However, areas of development close to the banks of the river and on the Holocene sand spit at the river entrance are potentially vulnerable to coastal erosion and/or flooding.

Figure 9: Mokau river mouth and township in 1974. Mokau, Waitomo District. Ref: WA-72267-G. Alexander Turnbull Library, Wellington, New Zealand. /records/23075939. Photo Attribution 4.0 International (CC BY 4.0)

For the purposes of the coastal hazard assessment and the development of management recommendations, we have divided the Mokau surrounds into several compartments to reflect differences in geomorphology, coastal processes and exposure to hazards, as outlined below.

8.1 Current (Operative) District Plan

The operative Waitomo District Plan contains a number of provisions relating to identified coastal hazard areas.

The current district plan identifies the Mokau Spit as an area of high coastal hazard risk with three identified coastal hazard areas (Figure 10 & Figure 11); the Prohibited Activity Area, Coastal Hazard Area A and Coastal Hazard Area B. In other areas, a single coastal hazard area (Coastal Hazard Area A) applies; extending 25 metres of an estuary or within 50 metres of the open coast.

Figure 10: Prohibited Activity Area (left) and Coastal Hazard Area A at Mokau Spit (Waitomo District Plan, 2009).

Figure 11: Coastal Hazard Area B at Mokau Spit (Waitomo District Plan, 2009).

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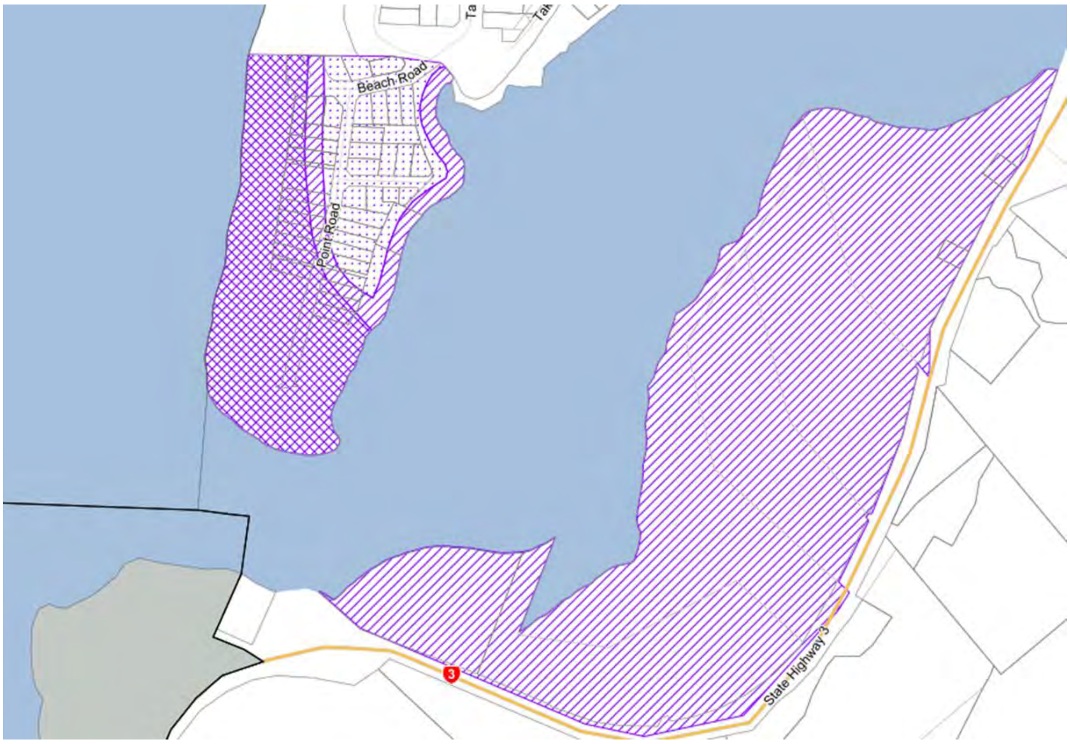


Figure 12: Coastal Hazard Areas at Mokau, including Coastal Hazard Area A south of the Mokau River entrance (Waitomo District Plan, 2009).

The Tainui Wetere Domain and Rugby Grounds are located immediately inside the Mokau River mouth, on the south bank of the Mokau River. This area has been identified as potentially vulnerable to coastal erosion and as such is identified in the current District Plan as "Coastal Hazard Area A" (Figure 12).

Under the current provisions, any building within the Prohibited Activity Area is a prohibited activity. While there is no allowance for consent in this area, buildings can be replaced within the existing footprint due to existing use rights.

Any building proposed within Coastal Hazard Area A is a non-complying activity indicating a high threshold test to pass for consent to be granted. Public infrastructure such as wharves, jetties, car parts and utility buildings are a discretionary activity in this area. If a dwelling is relocatable (i.e. can be moved in the future if required), it is a discretionary activity. The combined effect of these measures is to ensure that new dwellings are avoided in coastal hazard areas unless the dwellings can be moved if required.

Lawfully established buildings within the Prohibited Activity Area or Coastal Hazard Area A can be relocated landward within the same property without resource consent.

Within Coastal Hazard Area B, all proposed buildings are a discretionary activity.

The anticipated environmental outcome of the implementation of these rules is:

27.6.1 An environment where:

(a) The effects of natural hazards are lessened through greater public awareness and the use of mitigation/remedy measures, where appropriate.

(b) The threats posed by existing natural hazards are not increased through continued development of areas prone to natural hazards.

8.2 Mokau Spit

8.2.1 Coastal Erosion Hazard

For the purposes of this assessment, the shoreline at Mokau was considered in sections that reflected the broad geomorphic types and hazard considerations. Coastal flooding processes and the extent of current and future coastal hazard was assessed within the same compartments.

Existing information was reviewed for each location, including:

- physical setting (e.g. beach, estuary, cliff) and mechanisms of erosion/flooding
- presence of development close to the coast or in low lying areas
- local values and expectations
- historic shoreline change
- history of development and use, including human impacts
- records of coastal hazard events
- existing coastal hazard protection works
- tide gauge and coastal flooding data
- field observations

The sand spit on the southern side of the Mokau River entrance is composed of loose Holocene sands and the geomorphology of the river entrance indicates that the entire area of Holocene sediments seaward of the state highway is very dynamic over periods of century and millennia.

This was further reinforced by drilling and dating of the spit conducted by Waikato Regional Council in the 1990s. The drilling indicated loose erodible Holocene sands extend well below existing tide levels; the Holocene dune and beach sands underlain (typically >10 m depth) by coarser deposits with gravels, most likely river sediments, indicating the river has discharged through this area in the past. Carbon dating of shell taken from beach and river sediments underlying the spit indicate that the present spit feature began to form just over 2000 years ago, with the oldest sediments on the landward side of Point Road and north of Tokapapa Street and the youngest (typically deposited 1100-1200 years ago) towards the seaward end of Point and Beach roads.

The spit is also the location of the Te Naunau Urupa, and is an area is highly significant to local iwi.

The spit was subdivided by central government (Department of Lands and Survey) in the 1950s and has experienced serious issues with coastal erosion hazard since that time. The first period of severe erosion occurred in the late 1950s and early 1960s shortly after initial subdivision, causing total loss of some sections and serious damage to a number of others; with the Crown re-purchasing some properties and paying owners out. Eleven sections and an additional strip of reserve were revested in the Council.

A further period of severe erosion occurred again in the 1990s, and again in the period since 2004 (Figure 14); with a number of houses having to be relocated over this time. There was only very minor shoreline recovery between these recent erosion phases, and the overall trend has been for narrowing and shortening of the spit since the 1940s (Figure 15). The open coast shoreline at Point Road has eroded by approximately 65 m since 1946. Unauthorised rock seawall structures constructed by affected landowners have limited erosion since 2011 in some areas, though there is considerable uncertainty around the resilience and sustainability of these structures.

Large scale shoreline changes are common near the mouth of rivers and estuaries; driven by a wide range of complex processes associated with the river entrance and ebb tide delta dynamics, inner-harbour changes, sediment bypassing, variations in sediment supply along the wider coastline and other factors.

The causes of the erosion at Mokau are not certain but appear to relate to at least three factors:

- Northwards rotation of discharging river flows have coincided with significant accretion and changes in the alignment of the southern bank of the Mokau River (Figure 15 & Figure 16). This appears to have been a major factor in the early period of erosion (1950s and 60s) which truncated the southern end of the spit and Point Road; as there was very little erosion north of Point Road.
- Changes in offshore channels and banks have been associated with sediment bypassing of the river entrance. Field observations suggest that as sediments bypass the river entrance, the marginal flood channel which runs close to the shoreline is pushed landward aggravating erosion; followed by periods of accretion as a bar or pulse of sediment passes over the channel and attaches to the shoreline. This appears to have been a factor in the brief period of beach recovery in the late 1990s and early 2000s.
- Natural shoreline dynamics associate with decadal periods of erosion or accretion. Various studies suggest that beaches along the west coast can experience sustained periods of erosion or accretion which can last for many years or decades, sometimes (more rarely and localised) even centuries. The causes of these periods of erosion or accretion are not well understood but may relate to pulses in sediment supply and/or

movement, climatic variations (e.g. IPO, ENSO), and/or other factors. The sustained erosion observed along the coast between Mokau and Awakino in recent decades likely relates to one of these periods.

It is probable that the observed shoreline erosion is largely dynamic and, as such, may reverse at some stage in the future. However, there is no way to determine with any certainty when this might occur and how much further erosion may occur in the interim.

In addition, there is potential for projected future sea level rise to severely aggravate the situation. While it is not presently possible to predict the effects of sea level rise with any certainty, it is most likely to further exacerbate erosion and probably quite significantly. For instance, available crude predictive models based largely on beach gradient suggest sandy shorelines in this area could experience erosion in the order of 75 m per 1.0 m of sea level rise.

Figure 13: Private seawall fronting Point Road properties, Mokau.

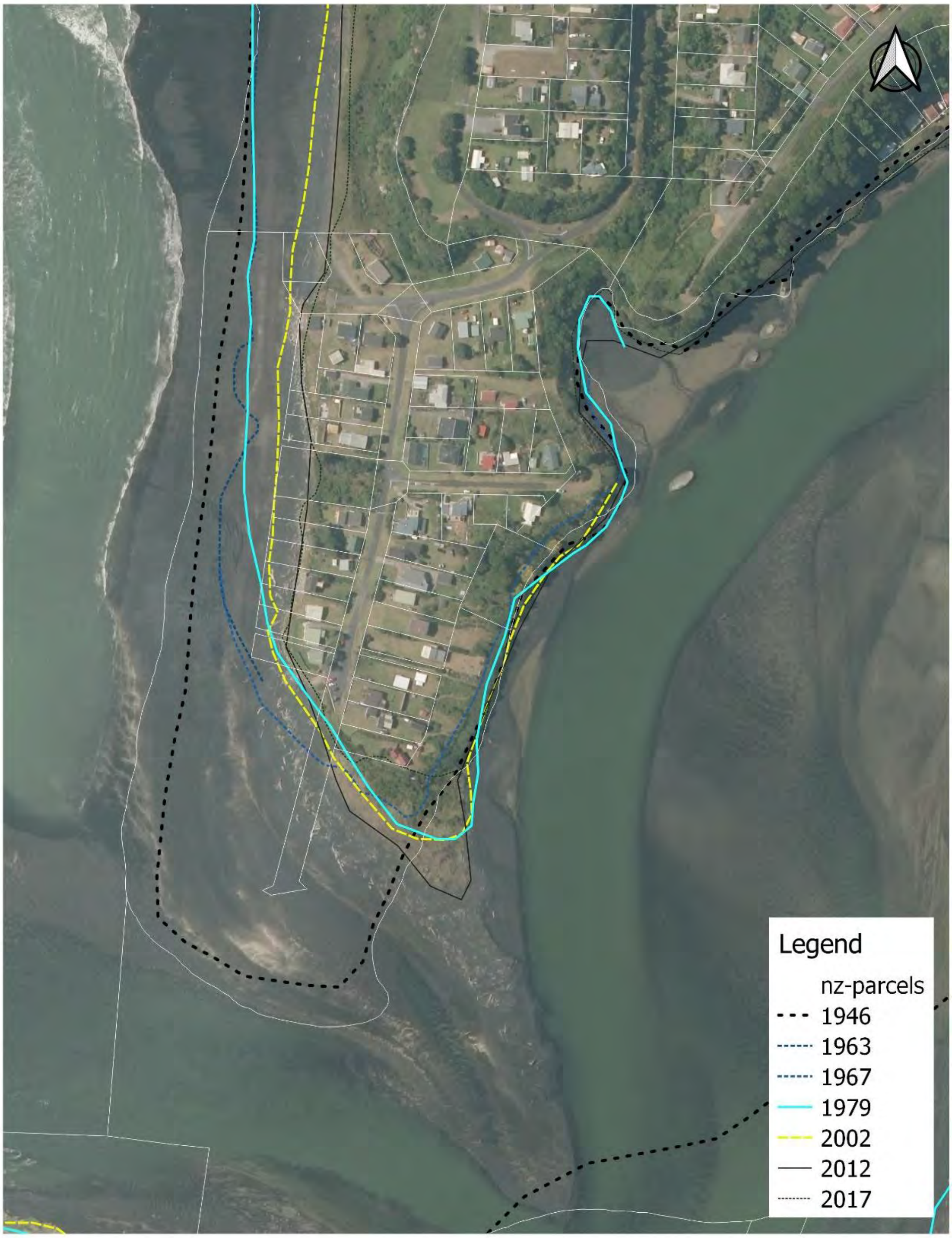
There is therefore considerable uncertainty around future erosion trends and the potential for further severe erosion at Mokau spit.

We have identified two coastal erosion hazard zones for the spit.

The Coastal Erosion Hazard Zone 1 (CEHZ 1) defines the area at highest risk from erosion. Along the ocean shoreline, this hazard zone has been defined on the basis of a time-averaged erosion rate of 1.5 m/yr over the next 20 years (consistent with the observed average rate over the last 40 years on unprotected stretches of this coast); except near the southern end of the spit where higher rates have occurred and an average erosion rate of 2.0 m/yr has been adopted (Table 7). The defined hazard zone also includes an allowance for collapse of near-vertical erosion scarps to a more stable slope. The definition of this hazard zone ignores the effect of the sea wall because of the uncertainties around the future of this structure.

On the landward (or river) shoreline of the Mokau spit, erosion rates have been slow and are difficult to discern from aerial photography. Field observations suggest that there is some long-term slow erosion and best estimates suggest an approximate long-term rate of 0.15 m per year since records began in the 1940s. The relatively narrow CEHZ 1 reflects these slow rates in this area and an allowance for a stable dune slope.

Coastal Erosion Hazard Zone 2 (CEHZ 2) covers the remainder of the spit. This area is not at immediate risk from erosion but could potentially become exposed to erosion in the longer-term future; if existing rates of erosion continue or accelerate, and/or erosion is exacerbated by future sea level rise. It is very important to emphasise that this is not a prediction that the entire spit is likely to be eroded, but simply an indication of the high level of uncertainty over the required 100-year planning period.



Waitomo District Coastal Hazard Study
Prepared by Focus Resource Management Group

0 50 100 150 m

focus resource management group

Figure 14: Historical Shorelines at Mokau Spit.

Waitomo District Coastal Hazard Study
Prepared by Focus Resource Management Group

0 250 500 m

Figure 15: Shoreline change since 1946 at Mokau River entrance. Parcel boundaries provide insight into the original length of Point Road.

Figure 16: Aerial photograph of Mokau Township and spit in the 1940s. The black line illustrates the position of the shoreline in 2017.

Table 7: Coastal erosion hazard areas at Mokau Spit.

Location		Sea Level Scenario	Timeframe	Future erosion	Slope stability3	Total Coastal Erosion Zone
Ocean Beach	CEHZ 1	0.0 m	20 yrs	30 m	8 m	38 m
Point of Spit	CEHZ 1	0.0 m	20 yrs	40 m	8 m	48 m
Ocean Beach	CEHZ 2	1.0 m	100 yrs			Entire sand spit
Landward Spit	CEHZ 1	0.0 m	50 yrs	7.5 m	11 m	18.5 m
Landward Spit	CEHZ 2	1.0 m	100 yrs			Entire spit

8.2.2 Coastal Flood Hazard

Elevations on Mokau spit vary from 8 m to 16 m above mean sea level. There is no foreseeable risk from coastal inundation.

3 These figures are estimates of slope factor based on Lidar data. There may be potential to refine these further at a property scale.

8.3 Management Options and Recommendations

The CEHZ 1 identified in this study affects a similar area to that covered by the existing "Prohibited Activity Area" and "Coastal Hazard Area A". The identification of this zone confirms that there are several private properties at high risk from coastal erosion if the existing erosion trend continues.

The CEHZ 2 area is consistent with the Coastal Hazard Area B identified in the operative District Plan, and essentially highlights the potential for the entire spit to be vulnerable to coastal erosion in the long term.

The level of existing risk and the potential large scale of long-term vulnerability means it is not practicable to simply live with natural processes, particularly seaward of Point Road. The community must therefore either "hold the line" with some form of engineering or develop a strategy to adapt away from the area at risk over time.

As part of the District Plan review, community meetings at Mokau were well attended, by both beachfront residents and the wider community. There were several key messages taken from the discussions about Mokau Spit, including:

- beachfront residents acknowledge the long-term risk but wish to continue to use properties as long as possible
- there is a desire to continue to maintain and repair the current private structures to maximise lifespan and ensure safety for beach users
- many landowners accept that Point Road properties may not be viable in the long-term future (and have paid purchase prices that reflect that reality)

At present erosion risk to beachfront properties is managed by setbacks and development controls outlined earlier in Section 8.1, based around a broad policy of managed retreat.

Beachfront property owners have also constructed a rock seawall as a measure to prevent ongoing erosion of their properties and loss of dwellings. The current seawall (Figure 13) was constructed in 2011, and has successfully prevented erosion since this time, though some maintenance is now required. However, the existing structure does not have a resource consent; nor landowner consent for portion of the wall on public land. The engineering standard and resilience of the wall is unknown.

In addition, the structure has quite severe adverse environmental effects; particularly during periods of erosion when it results in loss of a high tide dry beach to seaward, impacting on public access and amenity at higher stages of the tide. End effects of this wall have made it necessary for the Waitomo District Council to construct an interim rock revetment (built in in 2013). Council advises that the wall was built as an interim measure to secure physical access to affected properties at the southern end of Point Road, to allow for managed retreat when required (the existing Council position being that managed retreat is likely to be required if the erosion persists).

The beach loss and associated adverse environmental effects of sea walls on a retreating beach are unavoidable and these adverse effects will be considerably aggravated if the present erosion phase continues and/or are exacerbated by future sea level rise. Lowering of the beach and increased wave forces with ongoing erosion will also eventually undermine the existing structure. During consultation, some iwi also expressed strong opposition to the structure and concern that management agencies had failed to act to remove the structure despite serious adverse effects on beach users.

The long-term cost (financial and environmental) of maintaining a seawall along this frontage is not likely to be environmentally or economically sustainable if erosion is exacerbated by continuation of the erosion trend of recent decades and/or by future sea level rise. Accordingly, the sea wall is not likely to be consented as a long-term solution to the erosion.

"Holding the line" long term using other approaches is also unlikely to be practical to as the costs of these engineered protection schemes would be disproportionate to the value of the assets to be protected and the ability of the local community and/or Council to support. For example:

- Beach nourishment would require vast volumes of sediment on a high drift coast such as Mokau. There would be huge capital cost, great uncertainty and ongoing maintenance costs.
- Groynes placed to retain sediment would need to be very long and very robustly engineered, at enormous cost.
- Offshore reef technology is to date unproven and expensive.

For these various reasons, adaptation is likely to be only viable option if erosion trends continue and/or erosion is exacerbated by future sea level rise. Under these circumstances, it is likely that existing houses will have to be retreated and, ultimately, the properties will have to be abandoned. With continuation of existing trends, maintenance of properties in CEHZ 1 is likely to become unsustainable within 10-20 years, though this period will extend if the present erosion trends reverse and are followed by a period of beach recovery. Significant beach recovery has been observed over the past year (2019) but it is not known if this recovery signals the end of the earlier erosion phase or whether it is simply a short-term recovery similar to that observed in the early 2000s.

Given the high level of risk, particularly for properties seaward of Point Road, it is strongly recommended that an adaptive management strategy be developed to agree details (including triggers) for relocation and retreat.

As managed retreat has been clearly signalled by WDC and WRC since the mid-1990s, many present owners have purchased at prices reflecting that reality. Nonetheless, retreat is unlikely to be favoured by affected landowners, particularly in the near future, and so it is important to have a strategy that minimises retreat costs and which enables owners to use their properties for as long as is reasonably practicable.

Managed retreat runs counter to many landowner expectations and raises complicated issues on private land. To date, there is no effective model for managed retreat on private land and the option has been strongly resisted by landowners elsewhere in New Zealand; even at difficult sites (e.g. Haumoana). The difficulties are likely to be exacerbated if abandonment proves to be required (i.e. reasonable use proves to be no longer practical) in a limited timeframe and/or is driven largely by public good considerations (e.g. environmental effects).

In our opinion, the development of an effective and implementable site-specific adaptive management strategy will likely require management agencies (including relevant Crown agencies), affected landowners and other relevant stakeholders (e.g. iwi) working together.

Until an agreed adaptive management strategy is developed, Waitomo District Council will need to continue to provide for appropriate management of use and development on the Spit through provisions in the District Plan as described in Section 7.

8.4 Upstream – Takarei Terrace to Te Kauri Road

8.4.1 Coastal Erosion Hazard

This area incorporates the northern shoreline of the Mokau River from the inland edge of the spit through to the Mokau River bridge.

This shoreline includes:

- high, steeply sloping (typically 1:1 - 1:1.5) banks rising to elevations of 25-30 m above mean sea level, and
- two areas of narrow coastal flats with private sections; one fronting Takarei Terrace and the second immediately upstream of the SH 3 bridge (Te Kauri Road), in the vicinity of the wharf and boat ramp (Figure 17 and Figure 18).

The narrow coastal flats are fronted by sea walls in places and occupied by residential dwellings and (at Te Kauri Road), public infrastructure. We were advised during public consultation that some of these areas (particularly the flats near the wharf and boat ramp) had been reclaimed seaward in the past. In the present absence of data that indicates otherwise, it is best to consider that the entire flats are vulnerable to erosion unless protected by adequate (consented) coastal structures. Accordingly, the CEHZ 1 in these areas incorporates the entire width of the coastal flats; though we recommend that the Plan provide for management of the hazard area as justified by suitable future site-specific investigations conducted by an appropriately qualified and experienced scientist or engineer. The area potentially affected by erosion is not likely to be significantly increased by sea level rise of up to 1.0 m and so we have not defined a CEHZ 2 in this area.

Where the steeply sloping banks intercept the river shoreline (between Takarei Terrace and Te Kauri Road), the CEHZ1 represents the potential slope instability hazard. The existing slopes in this area are very steep (approximately 1V:1H). The erosion hazard in this area relates to potential slow undermining of the bank and episodic slope failure. Historical aerial photography indicates that erosion of this shoreline is slow, with no measurable change in the shoreline since 1946 (detectable given the accuracy of the data). In the absence of any detailed information about the underlying geology, we recommend that a hazard zone (CEHZ1) be identified as defined by a 1V:1.5H slope from the toe of the bank. Site specific geotechnical investigation may provide evidence that the width of the hazard zone can be reduced.

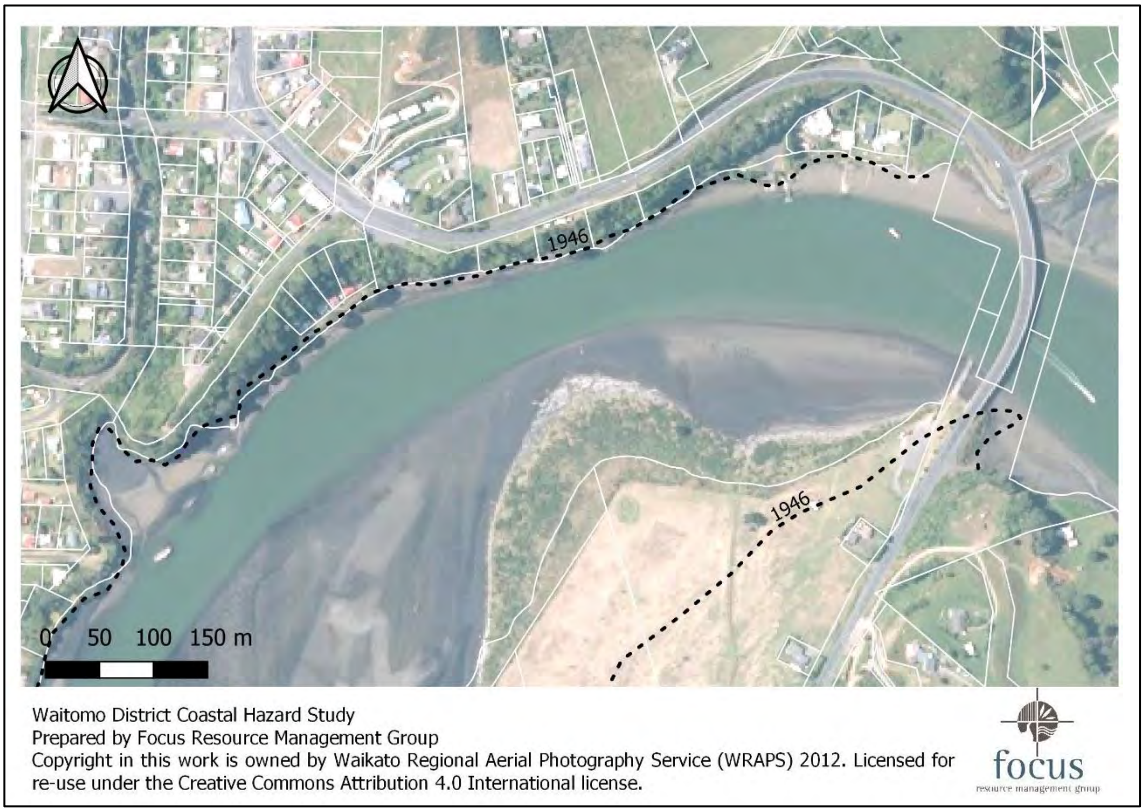


Figure 17: Shoreline between Mokau township and Mokau River bridge. There has been very little shoreline change on the northern shoreline of the River over the available record.

Figure 18: View of low-lying flats on northern margin of the river just downstream of the SH 3 bridge

8.4.2 Coastal Flood Hazard

The Wharf and boat ramp area (immediately west of the Mokau River bridge) is relatively low lying (3-4 m above mean sea level) and some areas of the boat ramp car park and the more seaward sections of some properties are potentially vulnerable to inundation during extreme storm events with existing sea level (Figure 19). Any future sea level rise will greatly increase the frequency that this area is impacted as well as threatening buildings. In less than 50 years, the car park and boat ramp could be completely inundated during extreme events.

The private properties on the river side of Takarei Terrace are located on a narrow area of relatively low-lying land close to the outer bend of the Mokau River. The properties are sufficiently elevated to be above storm surge levels with current sea level (Figure 19) and with 1.0 m of sea level rise (Figure 20).

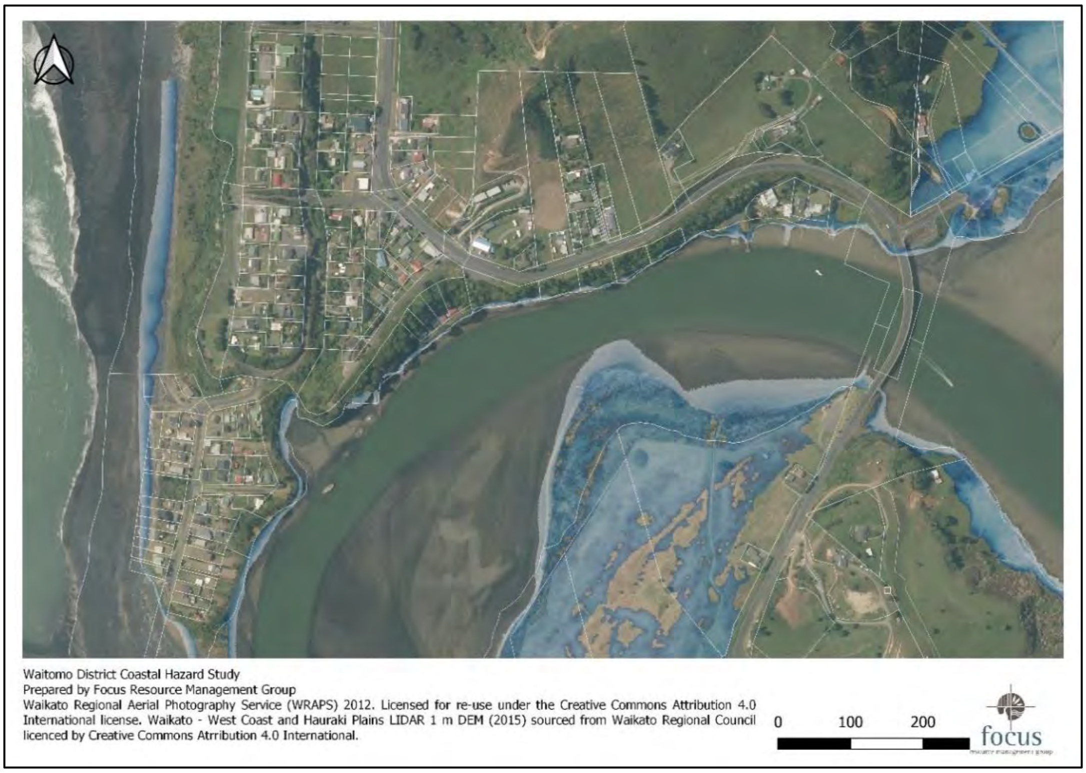


Figure 19: Shoreline between the Mokau township and Mokau River bridge. Blue indicates areas of land below the elevation of a severe storm surge.

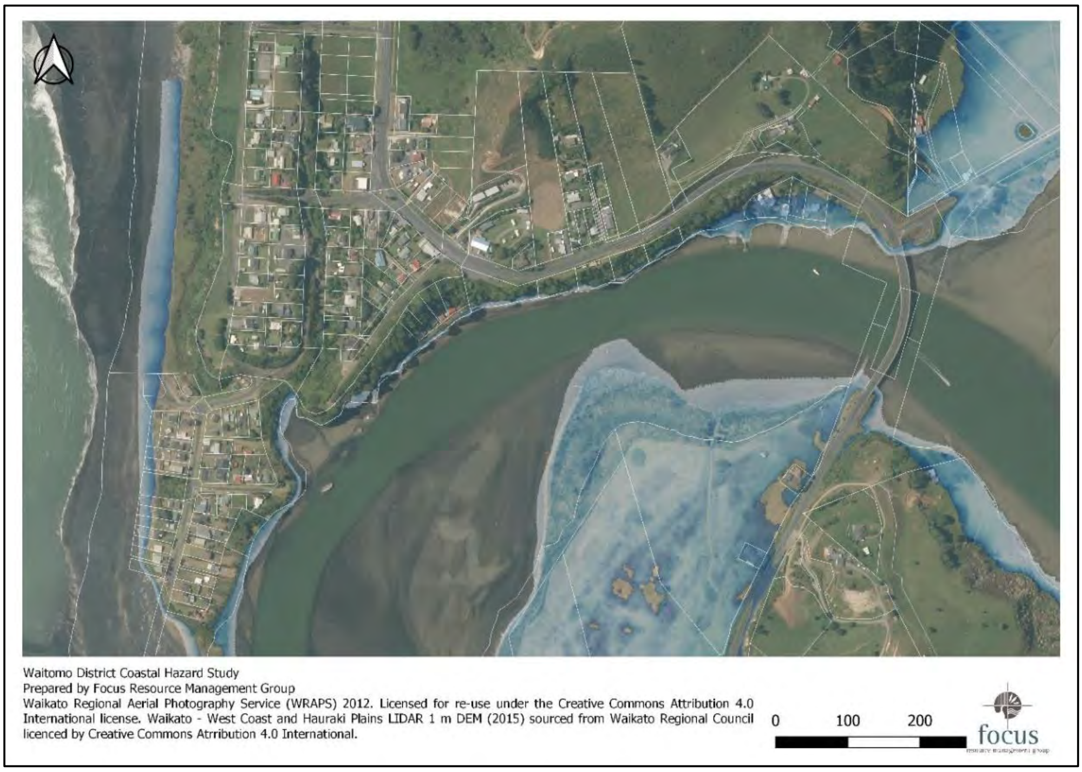


Figure 20: Shoreline between the Mokau township and Mokau River bridge. Blue indicates areas of land below the elevation of a severe storm surge with 1.0 m sea level rise.

8.4.3 Management Options and Recommendations

Coastal development in this area can be managed as described in Section 6 & 7 to reduce risk to dwellings over time, including through implementation of minimum floor levels to avoid coastal inundation.

There are some properties that lie partially or completely within the defined CEHZ 1. Replacement of these dwellings or any new development will require an adaptive management strategy that either provides for long term adaptation as required or for protection of the area using soft or hard engineering. The Council may wish to work with residents on Te Kauri Road to determine a management plan that protects private and public values given the important public facilities.

While there are existing hard protection structures fronting some properties, the consent status and engineering resilience of these structures is not known. These matters will need to be addressed if future consents are sought contingent on the protection provided by the structures; together with responsibility for maintenance of the structures. It also appears that some of the structures are located on public land and so provision for public access and amenity is likely to be required if consent is sought for the structures as private benefit protection. Any future adaptation strategies relying on hard engineering will also need to address current and potential future impacts on public access and amenity as discussed in Section 7.5.

Minimum floor levels implemented through the District Plan are likely to impact these dwellings as they are upgraded or replaced. Some areas of Te Kauri Road are low lying, particularly where the road passes underneath the Mokau River bridge. This section of road is potentially vulnerable in extreme events and will become more frequently impacted with sea level rise.

8.5 Te Mahoe Road

Te Mahoe Road runs adjacent to the northern bank of the Mokau River, upstream from the main road bridge (Figure 21). This area is sparsely developed, with rural and low-density residential development. The area is generally low lying and there is no significant development on the river side of the road.

Figure 21: View of Te Mahoe Road and adjacent low-lying lands (viewed from near the intersection of Te Mahoe Road and SH 3).

8.5.1 Coastal Erosion hazard

Analysis of historical shoreline data indicates little change in the position of the shoreline since the 1940s. The only area of notable erosion is directly upstream from the northern side of the bridge, on Te Mahoe Road. Up to 40 m of low-lying DoC reserve has been lost since the 1940s, but this appears to simply be associated with natural changes in the mouth of the adjacent stream. Erosion is unlikely to threaten the existing development landward of the road in this area.

While we have not undertaken a detailed coastal erosion investigation for this area, historical data and field investigations suggest that existing development is unlikely to be threatened by coastal erosion. The existing rural zone 25 m potential coastal erosion zone provides adequately for likely coastal erosion hazard in this area, provided it is measured from the toe of the bank and not from tidal datums (e.g. MHWS) located further seaward.

8.5.2 Coastal Flood Hazard

Significant areas on both sides of Te Mahoe Road (and the road itself), and adjacent lifestyle blocks are low-lying, including large areas of drained freshwater and estuarine wetland. These low-lying areas are already very vulnerable to coastal inundation during storm events with current sea level (Figure 22). The areal extent of the flooding will increase slightly with 1.0 m sea level rise (Figure 23), but the frequency and severity of this flooding will increase markedly; with many areas likely to flood during normal tides.

Figure 22: Te Mahoe Road, Mokau. Blue indicates areas of land below the elevation of a severe storm surge with current sea level.

Figure 23: Te Mahoe Road, Mokau. Blue indicates areas of land below the elevation of a severe storm surge with 1.0 m sea level rise.

8.5.3 Management Options and Recommendations

Coastal land in this area is currently zoned for rural land use. This provides for low density housing and farming activities. Given the severity of coastal and river inundation with future sea level rise, further subdivision and/or intensification of these low-lying areas should be avoided, as discussed in our recommendations for District-wide coastal flood management (Section 7.3). There is considerable potential for recovery of estuarine and freshwater wetlands, so Council could consider use of development incentives once this area transitions out of farming and into development; granting increased development rights on high land above flood levels in return for return of low-lying areas to wetlands.

Minimum floor levels are required for replacement dwellings associated with existing development. It may also become necessary to raise building platforms in the longer term. The road in this area will be flooded with increasing frequency and severity and may also need to be raised in the longer term.

8.6 Tainui Wetere Domain – Rugby Grounds

The Tainui Wetere Domain and Rugby Grounds are located immediately inside the Mokau River mouth, on the south bank of the Mokau River. Much of this land is zoned for Conservation, including the Rugby Grounds.

8.6.1 Coastal Erosion hazard

The shoreline in this area has changed dramatically since the 1940s (see Figure 24) due to changes in the course of the Mokau River channel and spit. The geomorphology of the area also clearly indicates that the entire area seaward of SH 3 is very dynamic over timescales of centuries and longer. Accordingly, land in this area is best considered as somewhat "temporary".

The dynamic changes in the river estuary in recent decades have severely eroded the reserve frontage in southern areas, with a (broadly equivalent) area of accretion in more northern areas on the inside of the river bend (Figure 24). These changes have occurred at the same time as extensive erosion of the spit on the northern side of the river mouth and the changes are probably related as discussed earlier in Section 8.2.

The broad pattern of change reflects erosion on the outside of the river bend (southern end of the reserve) and accretion on the inside (northern area of reserve). It is difficult to reliably predict future shoreline changes in this area due to the highly dynamic nature of the setting; the maximum erosion and the maximum accretion since 1946 both exceeding 100 m. The most recent aerial photography suggests that the broad pattern of shoreline change observed over recent decades may be continuing, although slowly. Notwithstanding this, the very dynamic nature of the area means that the pattern of change over the next 100 years may vary. The effect of future sea level rise is also very uncertain, but it is more likely to generate a trend for erosion than accretion; as well as translating the shoreline further landward due to higher tide levels.

While shoreline change over the next 20-30 years will probably reflect the broad pattern since 1946, it is exceedingly difficult to be definitive for the next 100 years. We recommend that the entire area of land seaward of the State Highway continues to be recognised as vulnerable to erosion and is designated as a Coastal Erosion Hazard Area 2. This does not mean that the whole area will necessarily be impacted by erosion over this timeline, but simply reflects the high level of uncertainty associated with this very dynamic area and with future sea level rise. No CEHZ 1 is recommended for this area but guidelines for future use are discussed in Section 6 and Section 7.

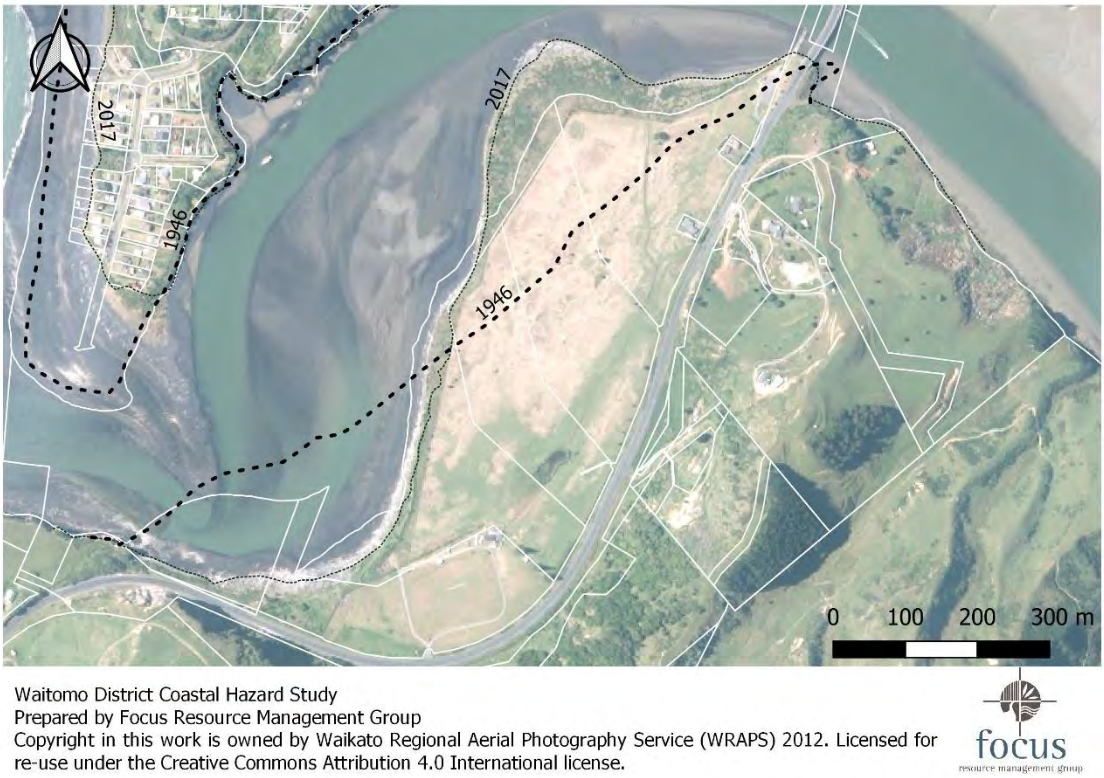


Figure 24: Overall shoreline change since 1946 at the Tainui Wetere Domain and reserve.

8.6.2 Coastal Flood Hazard

Many parts of the reserve, including the area that has accreted since the 1940s are low lying, at an elevation of approximately 2-3 m above sea level and as such is vulnerable to occasional flooding during extreme events with current sea level (Figure 25); as also reinforced by community information. With as little as 0.5 m of sea level rise, this low area could be flooded during “normal” high spring tides. Much of this area would be underwater with every spring high tide following 1.0 m of sea level rise.

The Rugby grounds are unlikely to be impacted by coastal flooding with current sea level (Figure 26), but as little as 0.5 m of sea level rise would make the rugby grounds vulnerable during occasional extreme events. With 1.0 m sea level rise, virtually the entire area of the reserve would be vulnerable to flooding with extreme events (Figure 27).

Figure 25: Flooding of low-lying areas adjacent to the rugby grounds at the Tainui Wetere Domain in June 2015 (ref Waitomo District Council).

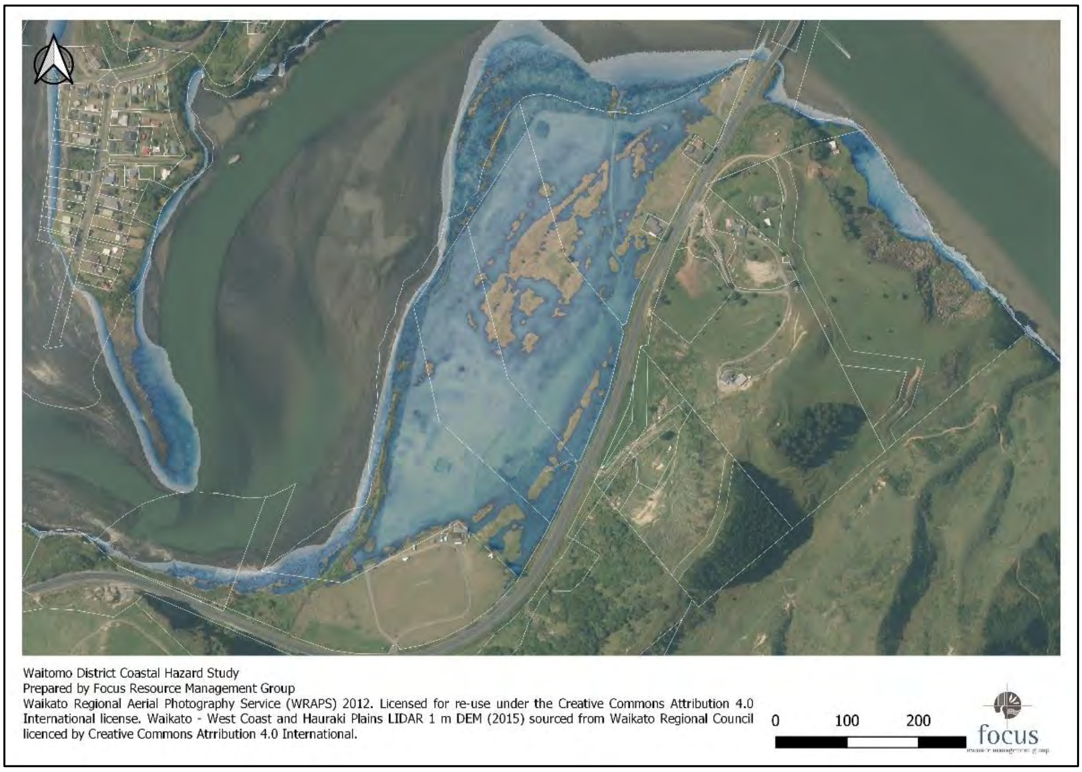


Figure 26: Potential coastal flooding at the Tainui Wetere Domain. Blue indicates areas of land below the elevation of a severe storm surge.

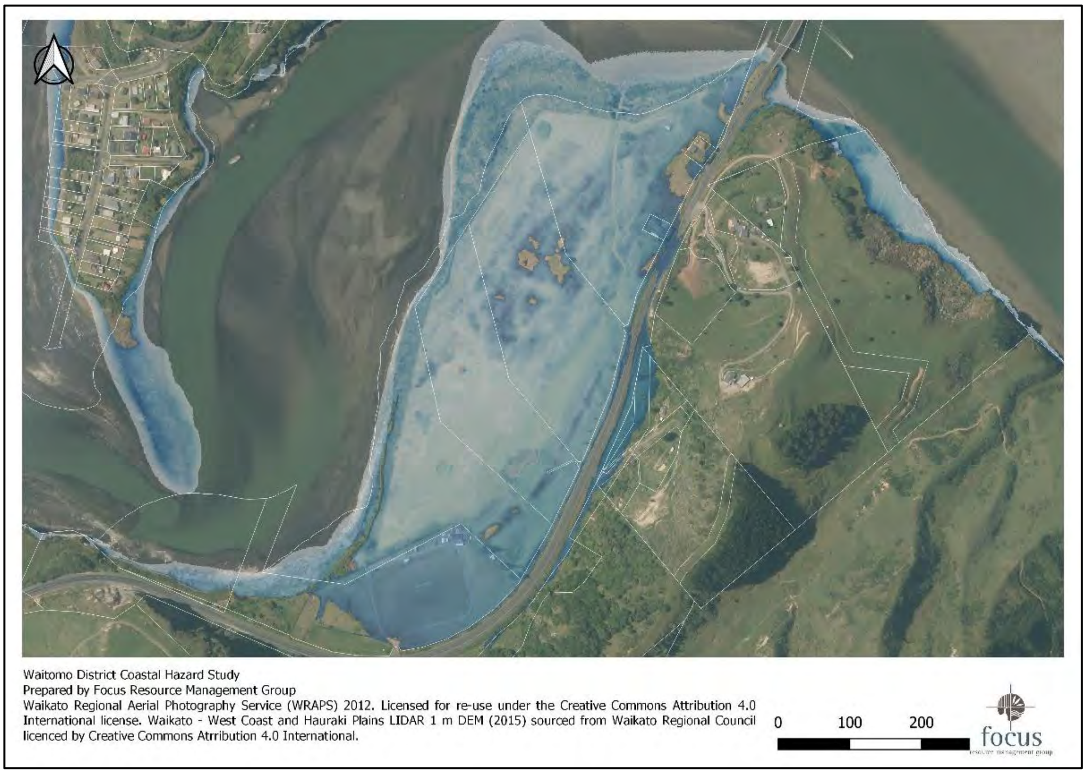


Figure 27: Potential coastal flooding at the Tainui Wetere Domain. Blue indicates areas of land below the elevation of a severe storm surge with 1.0 m sea level rise.

8.6.3 Management Options and Recommendations

As described above, this area is recognised as potentially vulnerable to coastal erosion, and large areas are subject to coastal flooding during storm events with current sea level. Most of the area will also become very vulnerable to coastal flooding with projected sea level rise over the next 100 years. The vulnerability of the land to coastal inundation and erosion means that it is not well suited for subdivision and more suited to land uses that can readily adapt to changes over time, such as existing reserve uses.

Ideally, an adaptive management plan should be developed for the reserve in consultation with the wider community, iwi and key stakeholder groups (e.g. rugby club, recreational users). In addition to provision for recreational and amenity uses, there is also considerable opportunity to enhance natural values along both the shoreline and in the lowest areas. For instance, there is considerable potential for the most low-lying areas to be restored as estuarine ecosystems by relatively simple works.

In terms of coastal erosion, it is recommended that the management plan for this area should be to “live with nature” and adapt use and development, as necessary. Given that some areas of the shoreline have eroded by more than 100 m since the 1940s, use of hard erosion protection would be very expensive and very damaging to natural coastal values. Ideally, a wide naturally vegetated buffer zone could be maintained around the shoreline.

At present, the rugby grounds are located adjacent to the area where the most severe erosion has been experienced over at least the last 80 years. The placement of the rugby grounds reflects historic decisions made many decades ago when the shoreline was further seaward. Erosion in recent decades and ongoing trends have made this area is increasingly vulnerable to erosion. Any future sea level rise will make the area more vulnerable to coastal inundation. It would be useful to plan to move the fields and associated assets further north on the reserve that are less vulnerable to erosion. If required, the fill used to raise the grounds to existing elevations could also be moved and the low-lying areas so created could readily be integrated with wetland restoration. A trigger for such relocation of these assets could be agreed as part of any adaptive management strategy developed for the area.

Given the dynamic nature of the shoreline, it is also important that any buildings or similar assets are located well back from the shoreline, particularly in southern areas where erosion has been concentrated since at least the 1940s. Any buildings should also be readily relocatable and adopt appropriate minimum floor levels. These issues will be best managed through District-wide minimum floor levels and development controls.

If low flood embankments are required (such as that constructed along the coastal margin seaward of the rugby grounds), these should be well set back from the coast. Otherwise they are likely to be affected by erosion on this very dynamic shoreline, requiring ongoing maintenance and protection and degrading the natural character of the coast.

Community members advise that the shoreline in southern areas of the reserve was once a popular beach and a significant public use area. It is important to note that a beach can be retained in this area even with future erosion, as long as no hard protection is built along the margin. The past degradation of the shoreline has been degraded more by the embankment and by ad hoc works than by erosion. As noted above, embankments and hard protection are simply not appropriate in areas like this that are retreating and will require constant ongoing maintenance and cost as well as degrading public use and natural values.

9 AWAKINO

Awakino is a small township north of Mokau, located at the entrance of the Awakino River. The Township is located on the inner bend of the river and is sheltered from the open coast wave energy by a long narrow sand spit (Figure 28).

9.1 Current (Operative) District Plan

The operative Waitomo District Plan contains several provisions relating to identified coastal hazard areas. Coastal Hazard Area A is identified throughout the district as the area within 25 m of a river mouth or estuary margin, and within 50 m of the open coast. Most coastal development at Awakino is landward of this coastal hazard area, except for one or two existing houses at Awakino Heads.

Any building proposed within Coastal Hazard Area A is a non-complying activity indicating a high threshold test to pass for consent to be granted. Public infrastructure such as wharves, jetties, car parts and utility buildings are a discretionary activity in this area. If a dwelling is relocatable (i.e. can be moved in the future if required), it is a discretionary activity. The combined effect of these measures is to ensure that new dwellings are avoided in coastal hazard areas unless the dwellings can be moved if required.

9.2 Coastal Erosion Hazard

9.2.1 Awakino Township

Analysis of aerial photographs shows that the shoreline of the Township itself has remained relatively stable over the available record (Figure 28). In contrast, the coastal spit has narrowed markedly and relatively consistently since the 1940s and is now breached in two locations (Figure 29). Over the historical record, the seaward side of the spit has retreated by 0.7-1.0 m per year. Given the observed trend for spit erosion and the existing minor breaches in the spit, it is very possible that the main entrance location may change in the medium-long term.

There is currently some wave penetration through the existing entrance, and this will occur through any future entrance. Full spit breach further north could increase erosion of the mainland shoreline due to increased wave exposure, but much of this shoreline is relatively resilient so erosion rates are expected to remain low. Developed areas of the Township are well upstream from the entrance and will not be directly impacted by wave action. However, relocation of the main river entrance to the north may increase the ability of waves to propagate upstream.

There is no evidence of significant shoreline change since the 1940s on the river shoreline adjacent to Iredale Quay. With current sea level it is unlikely that the shoreline will fluctuate by more than 5 m over the next 50 years. We recommend a Coastal Erosion Hazard Zone 1 (CEHZ 1) of 5.0 m from the current toe of bank be identified along this river shoreline.

The northern shoreline of the township is more exposed and has experienced greater fluctuations in the past. This area could experience further change if the current breach in the coastal spit increases in width and/or becomes the new entrance. Historically, this area has accreted overall, reflecting the location on the inside of a bend in the river, but there has been little measurable ongoing accretion since 1976. We therefore recommend increasing the width of the CEHZ 1 to 10 m at the northern end of the Township. This distance should be measured from the most landward measured shoreline in this area.

In the longer term, there is considerable great uncertainty over future shoreline trends with:

- the potential for major breaches to form in the coastal sand spit, including possibly a permanent new entrance near the township, with increased potential for wave penetration
- projected future sea level rise which will translate the shoreline further landward and which is likely to also aggravate erosion through various processes.

It is therefore possible that there could be greater erosion than provided for by the CEHZ 1. However, it is very difficult to provide any reliable erosion hazard assessment for this longer period and any aggravated erosion may also be partially or wholly offset by continued accretion on the inside of the bend at the more vulnerable northern end of the township. Moreover, the greater hazard vulnerability relates to coastal inundation due to the low-lying nature of the area (see Section 9.3 below). Nevertheless, to provide caution we recommend a simple doubling the proposed CEHZ 1 for the proposed CEHZ 2.

9.2.2 Awakino Heads

Most of the properties and dwellings at Awakino Heads are located on “hard” geology (Tertiary sandstones and siltstones), though most of the southern properties seaward of the road appear to be at least partly located on more erodible Pleistocene and/or Holocene sediments (Edbrooke, 2005).

The estuarine shoreline fronting the Awakino Heads settlement is likely to be periodically exposed to waves penetrating into the estuary through the main river mouth (Figure 30). No information was received on this property during the community consultation, but evidence provided at Marokopa does indicate that significant wave energy can sometimes penetrate the shallow river entrances on this coast (see Section 10.2).

Awakino Heads Road is also located close to the top seaward edge of steeply sloping banks and therefore may also be vulnerable to periodic slope instability arising from slow toe erosion. While shoreline mapping suggests that the toe erosion rates are slow, the toe in this area lies on the outside of a bend and will therefore be subject to strong currents during floods as well as waves penetrating through the entrance. Existing bank slopes are relatively steep and historic aerial photos suggest slope failure is very infrequent.

Field inspections and shoreline mapping suggests that the cliffed areas fronting the higher properties on Tertiary sedimentary rocks erode only very slowly (probably time-averaged cliff erosion rates of <1-2 m/century). Given the slow observed erosion, we recommend a CEHZ 1 that reflects an allowance for a stable slope (1V:1.5H).

The cliff erosion rate may increase with sea level rise and the shoreline will also be translated slightly seaward simply by the higher tide levels and so we have allowed a total of 5 m for these effects, plus an allowance for slope instability (1V:1.5H) effects.

The southernmost residential property on the seaward side of Awakino Heads Road (No. 5) appears to be at least partly composed of more erodible sands could experience slightly more erosion. Analysis of historical aerial photographs indicates that shoreline changes in this area have been minor (<5-7 m), the exact scale of change within the uncertainties and errors of the mapping. We recommend a 15 m wide CEHZ 1 in this area to provide for erosion and associated slope instability. We believe an allowance of 15 m for SLR and associated effects will be adequate in this setting, giving a total CEHZ 2 setback of 30 m.

Given the uncertainties noted above and other factors (e.g. variations in cliff height and therefore in the slope stability factor) the plan should allow for modification of the recommended setbacks based on appropriate site-specific investigations by a suitably trained and experienced professional.

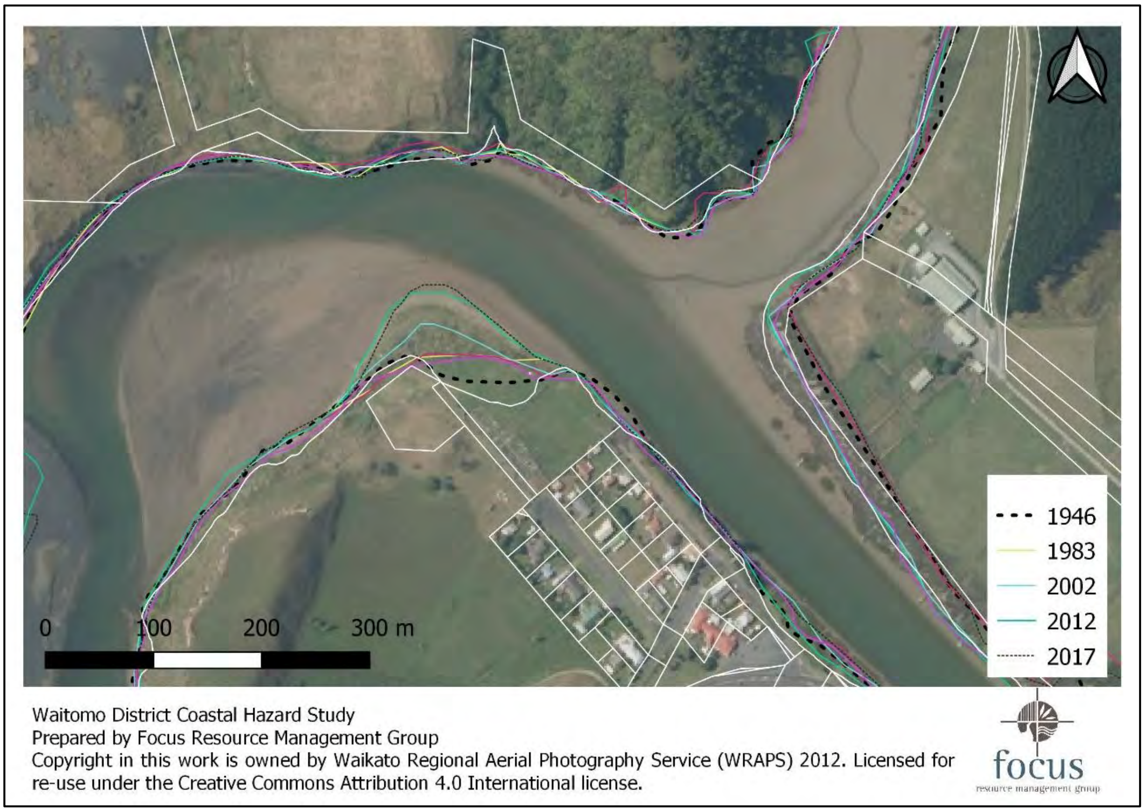


Figure 28: Historical shorelines at Awakino Township.

Figure 29: Shoreline change at Awakino river mouth.

Figure 30: Existing development at Awakino Heads.

9.3 Coastal Flood Hazard

9.3.1 Awakino Township

While the risk from erosion is relatively minor, much of the Awakino Township is potentially at risk from storm surge (Figure 31). The State Highway at Awakino is elevated above current coastal storm surge levels, while portions of Iredale Quay are vulnerable to flooding during rare and extreme events.

The frequency and severity of inundation will be greatly increased with any future sea level rise, with all of the township likely to become vulnerable with 1.0 m sea level rise (Figure 32). The state highway is sufficiently elevated at Awakino to be above the level of expected inundation due to coastal processes, even following 1.0 m of sea level rise.

Some areas of the Township will be vulnerable to inundation during high spring tides with as little as 0.5 m of sea level rise.

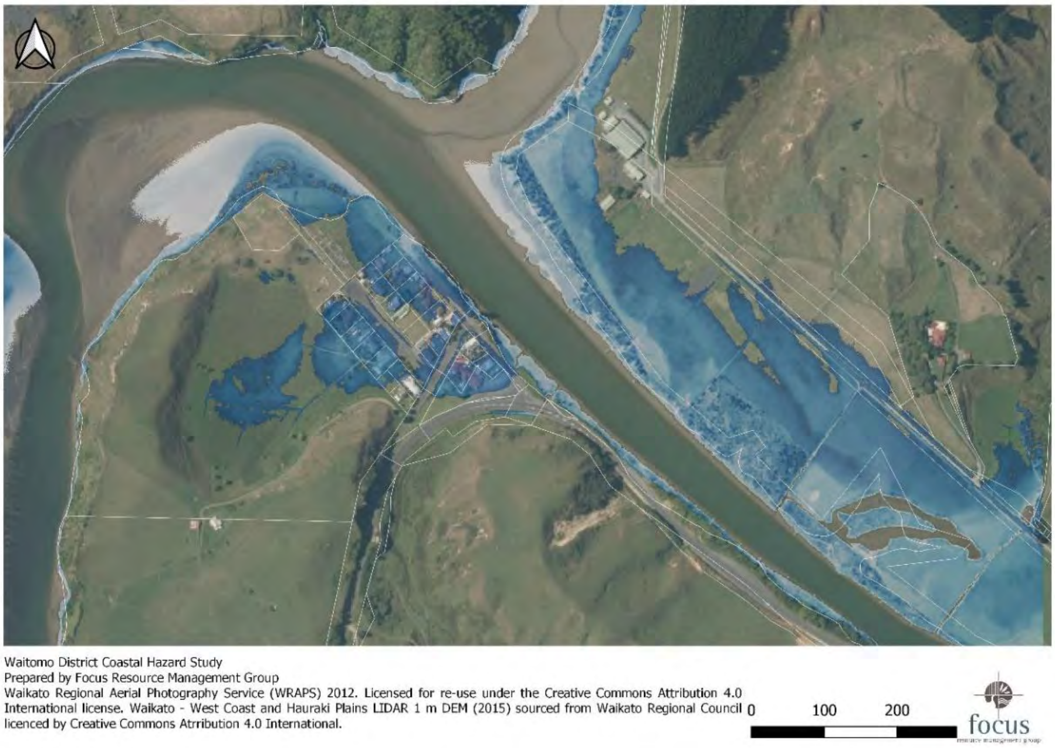


Figure 31: Potential coastal inundation hazard at Awakino Township. Blue indicates areas vulnerable to coastal inundation during an extreme storm event with current sea level.

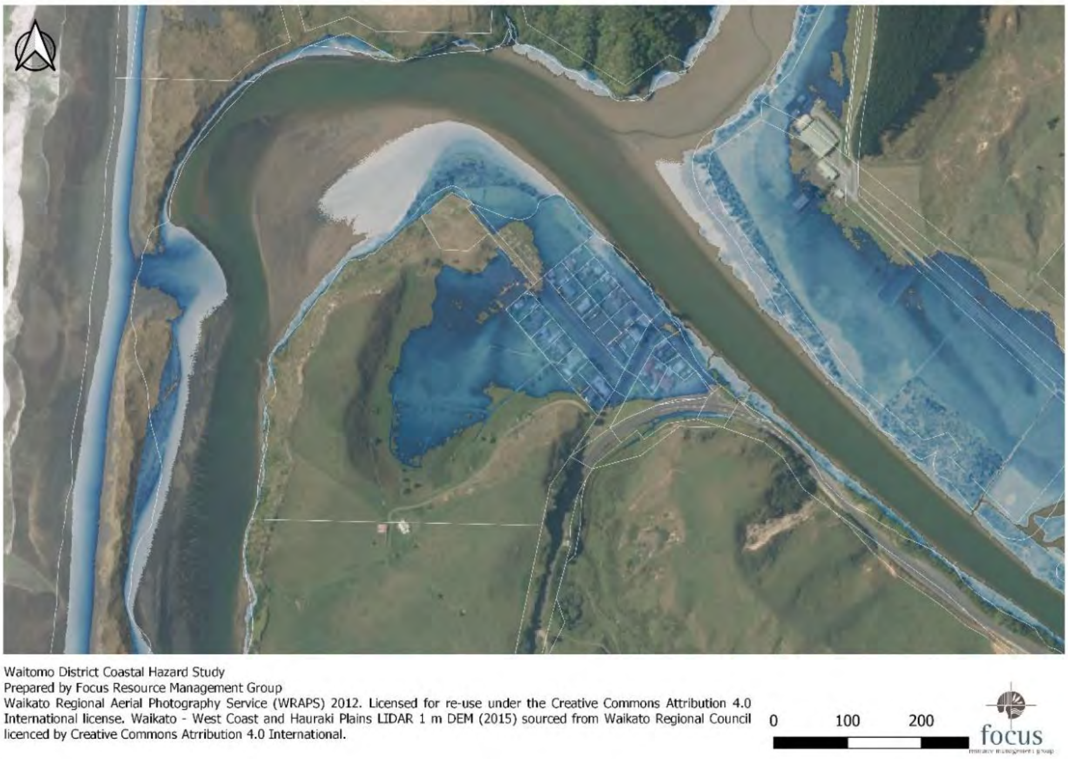


Figure 32: Illustration of the areas likely to be inundated (blue) in a severe storm surge with 1.0 m of sea level rise.

9.3.2 Awakino Heads

Properties at Awakino Heads are sufficiently elevated (>5 m RL) to be at low risk from coastal inundation.

9.4 Management Options and Recommendations

As discussed above, Awakino Township is very vulnerable to coastal inundation and is likely to be frequently and severely impacted with future sea level rise. Much of the land adjacent to the current township is also potentially vulnerable to coastal hazards, particularly coastal flooding and is therefore not well suited for intensive development in the future. Accordingly, we recommend that no further subdivision or intensification occur in low-lying areas unless the existing and potential future risk can be adequately and appropriately managed by an agreed adaptive management strategy.

As discussed in Section 6 and Section 7, minimum floor levels and adaptable design can be used to reduce the risk to existing development as houses are upgraded or replaced. However, in the longer term it is likely that existing properties and roads will also need to be raised.

Erosion risk is generally low in both Awakino and Awakino Heads and can be appropriately managed using the recommended setbacks and the various development controls recommended Section 6 and Section 7.

10 MAROKOPA

Marokopa is a small township, located at the entrance of the Marokopa River, on the west coast south of Kawhia. The Township is located on the inside of a large bend in the river, much of the town sandwiched between the upstream and downstream river channels (Figure 33 and Figure 34). A large sand spit shelters the township from open coast waves, though storm swell does periodically penetrate the estuarine reaches adjacent to the township.

10.1 Current (Operative) District Plan

The operative Waitomo District Plan identifies a Coastal Hazard Area A within 25 m of a river mouth or estuary margin, and within 50 m of the open coast. Coastal Hazard Area A and associated provisions presently guide the management of coastal hazards at Marokopa (Figure 33).

Figure 33: Coastal Hazard Area A at Marokopa (Operative Waitomo District Plan).

Any building proposed within Coastal Hazard Area A is a non-complying activity indicating a high threshold test to pass for consent to be granted. Public infrastructure such as wharves, jetties, car parts and utility buildings are a discretionary activity in this area. If a dwelling is relocatable (i.e. can be moved in the future if required), it is a discretionary activity. The combined effect of these measures is to ensure that new dwellings are avoided in coastal hazard areas unless the dwellings can be moved if required.

Lawfully established buildings within Coastal Hazard Area A can be relocated landward within the same property without resource consent.

The anticipated environmental outcome of the implementation of these rules is:

27.6.1 An environment where:

> *(a) The effects of natural hazards are lessened through greater public awareness and the use of mitigation/remedy measures, where appropriate.*
>
> *(b) The threats posed by existing natural hazards are not increased through continued development of areas prone to natural hazards.*

10.2 Coastal Erosion Hazard

Analysis of aerial photographs and plans shows that there has been a small amount of accretion on the inside of the river bend, and some erosion on the outside of the bends, most notably fronting the private residential development between Marokopa Road and Moana Quay (Figure 34). There has also been some accretion on the inside of the river bend.

There has also been significant erosion of the landward shoreline of the spit itself; reflecting the fact that it is composed of loose erodible sands and lies on the outside of a large bend in the river (an area subject to strong currents and scour). The seaward shoreline of the spit has been relatively stable since records began.

The most significant erosion along the township foreshore occurs along the frontage of Rauparaha Street at the southwestern end of the township (Figure 34 & Figure 35). Exposed stretches of the eroding bank indicate it is composed of iron-cemented sands (known as “coffee rock”) at the toe of the bank (Figure 35), which slow erosion but do not prevent it. The eroding bank lies on the outside of a bend in the river, but wave action appears to be the main process causing the erosion. Community information indicates that the shoreline is also subject to occasional, significant storm swell; penetrating the river entrance and propagating along the shoreline (Figure 36). The effect of the wave action also extends further up the estuary and can lead to overtopping of Marokopa Road on the eastern side of the township; but is most significant along the Rauparaha Street frontage.

The erosion fronting Rauparaha Street is associated with slow downstream movement of the meander bend and is balanced by accretion along the upstream opposite bank (Figure 34); this accretion extending from about 23 Tangaroa Road to about 19 Carley Reeves Drive.

The earliest available aerial photography from the 1940s shows an erosion scarp north and south of Marokopa Road, indicate that erosion in some areas was already occurring. This is consistent with the surveyed reserve boundary being located some 15-20 m to seaward of the shoreline even at this time.

The natural time-averaged rate of erosion is difficult to assess with accuracy as there have been various structures placed over the years in an attempt to stop or at least slow erosion. However, the properties in this area were surveyed in 1913 (DP8725) and the seaward edge of the reserve as fixed at that time now typically lies variously 25-35 metres further landward in unprotected areas; which suggests a time-averaged rate in the order of 0.25-0.35 m/yr. The seaward edge of the reserve is noted on the original plan as being “ordinary HWM” (i.e. ordinary high-water mark), which datum was probably seaward of the bank; so actual bank erosion may have been slightly less. However, given the various ad hoc structures placed over the years which have slowed erosion, the average rate might also be slightly higher.

By 1966, there were many houses along the foreshore and some armouring works. The shoreline between Marokopa Road and Moana Quay was in a very similar location to the present alignment. Exposed stretches of the eroding bank fronting the township is cemented by iron (Figure 35), and the presence of this older material confirms a long-term trend for erosion. However, the presence of shoreline protection structures interferes with past erosion rates and in turn, makes prediction of potential future erosion rates difficult. The cemented material erodes moderately slowly, and analysis of historical aerial photography and survey data suggests that long term average rates of erosion in areas that were not protected by seawalls have been in the order of 0.2 m per year since the 1940s.

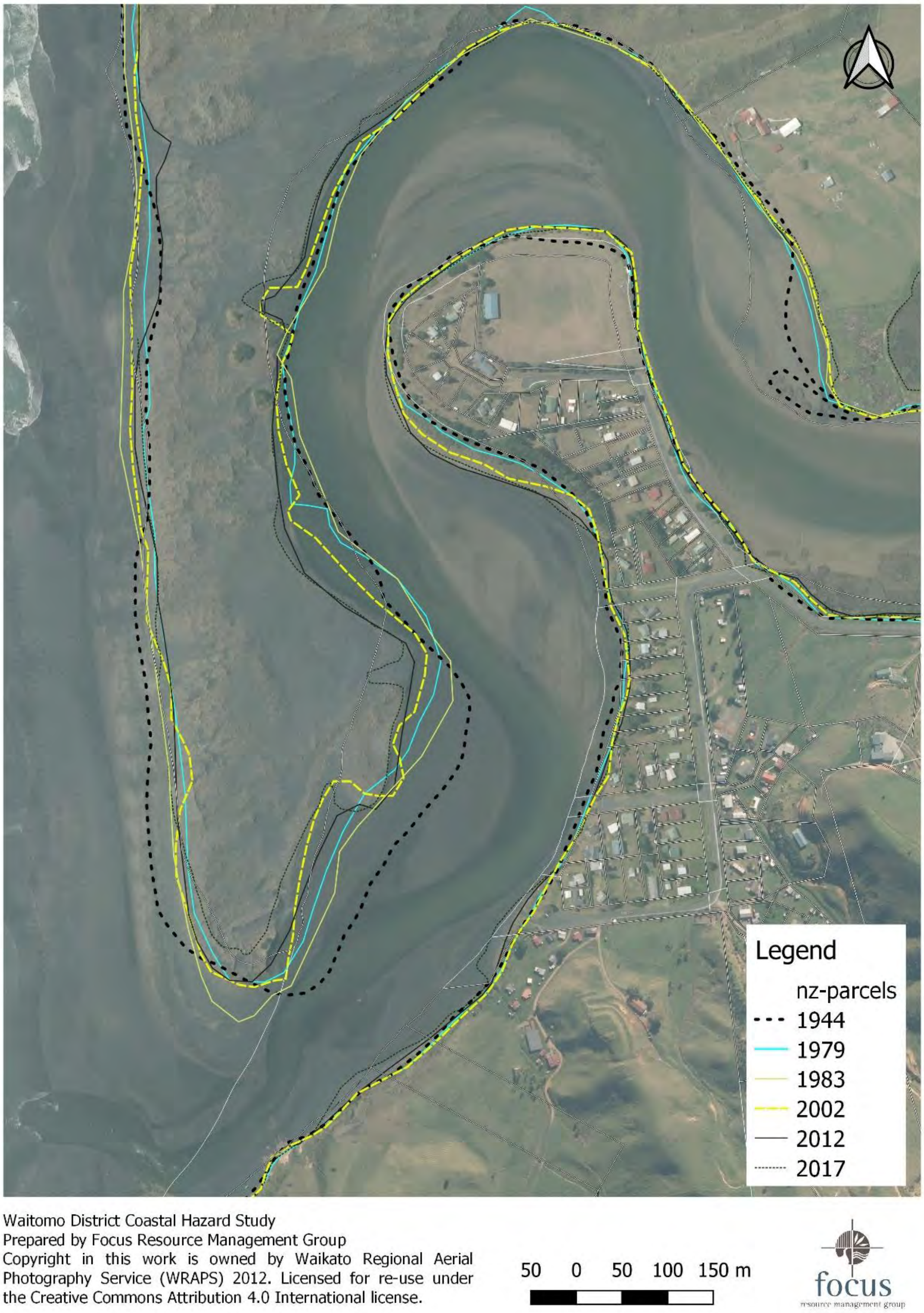


Figure 34: Shoreline change at Marokopa (data from Waikato Regional Council).

The accretion on the shoreline immediately north is similar. For instance, in the area immediately north of Marokopa Road the seaward toe of the dune in 2017 typically lay a maximum of 30 m seaward of the 1913 shoreline. However, as the 1913 shoreline was "ordinary HWM" the toe of bank at that time would have lay further landward and so the actual accretion is probably in the order of 35 m, consistent with the typical upper level estimate of erosion.

For the purposes of hazard planning, the time-averaged rate of erosion of 0.35 m/yr has been adopted for the purposes of calculating erosion hazard. It is important to bear in mind that the erosion occurs episodically and so there may be up to 1-2 m of erosion in localised areas during a particularly severe event and then little erosion for some time. However, it is the time-averaged rate of erosion which provides the best estimate of erosion for management purposes.

Community observations confirm the impact of occasional storm swell waves entering the river mouth and propagating along the shoreline. Reflection off the vertical structures can be significant during storms and would further exacerbate erosion in these areas.

There is probably a downstream limit to the extent of the meander migration and so the existing rate of erosion may not continue indefinitely. For instance, there is some evidence that the rate of accretion on the upstream shoreline is decreasing. In addition, shoreline mapping indicates that the average rate of erosion along unprotected areas of Rauparaha Street has averaged only about 0.2 m/yr since the 1940s. However, it is clear from the 1913 plan that the accretion and erosion trends were already evident at that time and so are quite long-term trends. Accordingly, for the present time, we believe it is wise to assume that the higher average rate since 1913 will continue; though this can be altered in the future if ongoing monitoring indicates rates are slowing.

Figure 35: Cemented sands eroding at Marokopa Township.

Figure 36: Storm swell propagating along the shoreline of Marokopa Township towards the northern end of Rauparaha Street.

Historic aerial photographs indicate that various ad hoc erosion protection works started to appear in the 1960s, the time that a number of houses were built in the area (with only isolated dwellings evident in earlier photos). It is clear from field inspections that where sea walls have been built, the sandy beach fronting the shoreline has been significantly narrowed and lowered. This reflects the passive erosion effects which occur with sea walls on retreating coastlines (see Figure 8 and associated discussion). This narrowing and lowering of the beach impacts adversely on public access and use at higher stages of the tide and these adverse effects are already significant in places. Wave interaction with these structures also exacerbates beach loss and lowering. The ad hoc structures also have a significant adverse effect on the natural character of the coastline. The continuing erosion trend and the likely exacerbation of the erosion by future serious level rise will eventually eliminate the narrow beach seaward of any effective sea wall. Due to these effects, hard coastal structures may not be an appropriate long-term solution to the erosion.

Given the historic trend for slow erosion along the shoreline seaward of Rauparaha Street (including Marokopa Road and Moana Quay), and the physical setting on the outside of a river meander, it is reasonable to expect that in the absence of coastal protection works, the slow erosion would continue, at least in the short to medium term. We therefore recommend the that the CEHZ 1 be defined by an average erosion rate reflective of past rates (0.35 m/yr) and a small allowance for a stable slope (Table 8).

Sea level rise is likely to further accelerate this retreat in the long term. Sea level rise will most likely increase the rate of coastal erosion, particularly where the shoreline is either stable or eroding with present sea level. While there is considerable uncertainty associated with predicting the response of shorelines in river entrance areas, it is reasonable to assume that this shoreline may erode by approximately 15 m per 1.0 m of future sea level rise due to local beach slope. This additional allowance for sea level rise effects is included in CEHZ 2, which provides for the possible long-term erosion driven by 1.0 m of sea level rise and 100 years of slow erosion (Table 8). This longer term CEHZ 2 estimate has a high level of uncertainty; due to the uncertainties around sea level rise and its effects and due to the fact that it assumes that the high historic rates will continue (which may not be the case as noted above).

Table 8: Coastal erosion hazard and sensitivity areas at Marokopa (Marokopa Road, Moerua Street and Moana Quay).

Zone	Sea level rise scenario	Timeframe	Future erosion	Slope stability	Total Coastal Erosion Zone
CEHZ 1	0.0 m	50	17.5 m	2.5 m	20 m
CEHZ 2	1.0 m	100	50 m	2.0 m	52 m

These coastal erosion hazard areas in this area will be measured from a site-specific baseline and that provides for local sea wall effects and includes the length of shoreline backed by properties on Raupara Street and (both sides of) Marokopa Road and Moana Quay.

The remaining areas of shoreline northwards right around to the north-eastern end of the rugby fields include an area of ongoing accretion (discussed above) but appear otherwise to be simply fluctuating over time; with any permanent trends (for either erosion or accretion) very slow. In some places, fluctuations of up to 5-10 m have been observed. We recommend a single CEHZ 1 erosion hazard zone of 15 m width for this area. The effect of sea level rise is difficult to predict but, as noted above, it is reasonable to assume that 1.0 m sea level rise could give rise to at least 15 m permanent erosion due to local beach slopes; giving a CEHZ 2 width of 30 m (Table 9).

Table 9: Coastal erosion hazard areas at Marokopa (Carley Reeve Drive and Rugby Grounds).

Sea Level Scenario	Timeframe	Dynamic Changes & Slope	SLR	Total Coastal Erosion Zone
0 m	100	15.0 m	0.0 m	15.0 m
1.0 m	100	15.0 m	15.0 m	30.0 m

Shoreline mapping from aerial photographs indicate there has been no measurable change in the position of the river shoreline east of the rugby grounds and along the Esplanade, despite this area lying on the outside of a bend in the river. However, field inspection does indicate some areas of erosion (Figure 37). There is also evidence that the sand bank in this area has been extended seaward in the past by human activity – with the erosion occurring primarily in these areas where there is typically only an intertidal beach (i.e. no high tide dry beach) seaward of the bank.

Figure 37: Bank erosion fronting the Esplanade. The erosion occurs primarily where the bank does not have a high tide dry beach to seaward. Locals advise that the erosion was primarily caused by waves.

Community advice indicates that wave effects do extend as far upstream as this and can contribute to overtopping of the road and flooding of the camping ground; but are much less severe than further downstream. This is also supported by the presence of a narrow beach composed of black sands derived from the coast (Figure 37). While limited, the wave effects are clearly adequate to cause erosion, particularly where the bank is fronted by only an intertidal beach. However, overall, we believe that a CEHZ 1 of 5 m width is adequate for this area; even in the areas where active erosion is occurring.

The effect of sea level rise in this more sheltered area is difficult to predict. However, given the presence of some wave effects and a narrow sand beach along most of the shoreline, it is reasonable to assume that there will be some additional erosion. While this erosion might be as high as the 15 m estimate adopted for other areas in this estuary, we believe a figure of 10 m is more appropriate; given the lesser wave effects and the limited erosion observed since at least the 1940s. This gives a CEHZ 2 of 15 m (Table 10). However, as with the earlier CEHZ 2 estimates, it is important to note that there is considerable uncertainty around sea level rise and its likely effects in this area.

Table 10: Coastal erosion hazard areas at Marokopa (river shoreline).

Sea Level Scenario	Timeframe	Future erosion	SLR	Total Coastal Erosion Zone
0 m	100	5.0 m	0.0 m	5.0 m
1.0 m	100	5.0 m	10.0 m	15.0 m

10.3 Coastal Flood Hazard

There are some areas in and around the Township that are currently vulnerable to coastal inundation during extreme events with current sea level. These areas are shown in Figure 38 and include:

- rugby grounds
- southern township (including Marokopa Road and adjacent areas)
- marae land on northern bank of the river
- extensive areas of farmland and road upstream

With sea level rise of 1.0 m, these same areas will be subject to more regular and severe flooding and additional areas will also be impacted (Figure 39). A particularly significant consequence of sea level rise is that areas that are presently only infrequently inundated will be much more regularly impacted. For example, with 1.0 m of sea level rise, large areas of farmland, the rugby grounds and some other areas in the township would be inundated during even spring tides during an extreme storm surge event with current sea level, water will almost cross the base of the internal spit through Moerua Street; with most of this path below 3.0 m RL. Even a small amount of sea level rise would see this inundation occurring much more frequently.

Historical aerial photography (e.g. 1946, Figure 40) show large areas of land upstream from the township were originally saltmarsh and freshwater wetlands. These low-lying areas are currently protected from flooding in some areas by stop banks. However, these areas will be difficult to protect with future sea level rise and are not suitable for development. However, they have considerable potential for wetland restoration and Council could consider incentivising such work in return for increased development rights in more suitable areas.

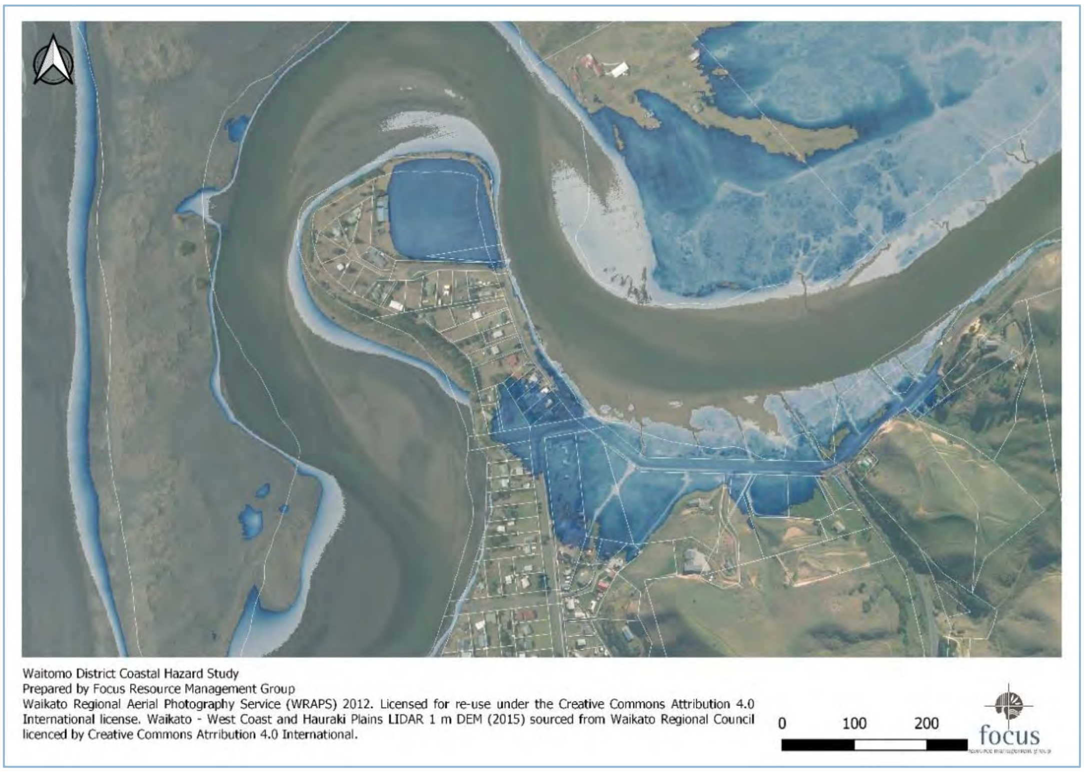


Figure 38: Areas of land below the elevation of coastal inundation in an extreme storm surge event (3.16 m MVD ‘53). For Discussion of levels see Section 4.2.

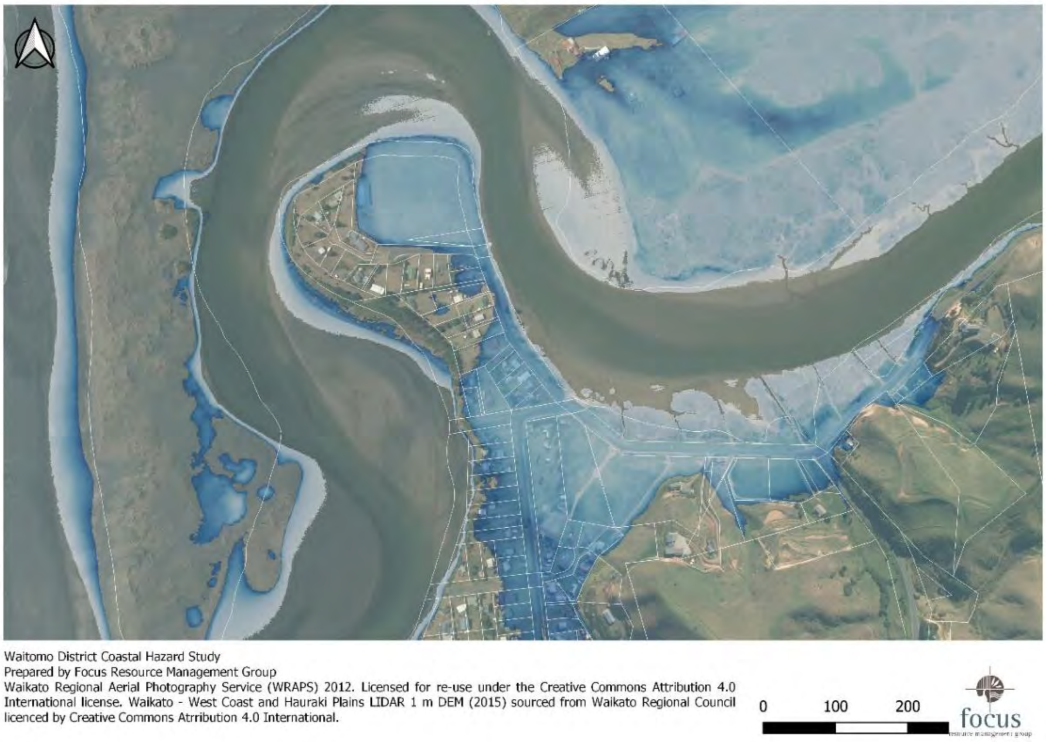


Figure 39: Areas of land below the elevation of coastal inundation in an extreme storm surge event after 1.0 m of sea level rise (4.16 m MVD ‘53). For Discussion of levels see Section 4.2.

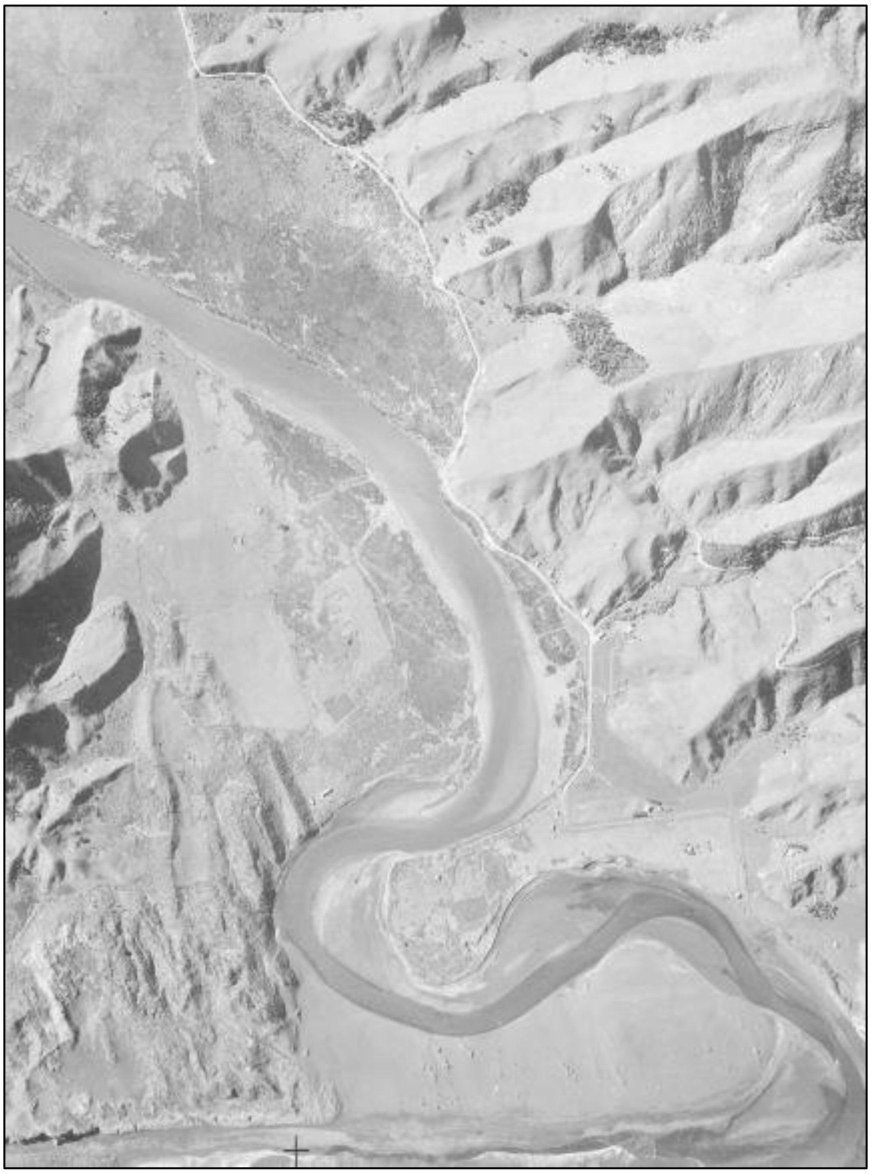


Figure 40: Marokopa Township and surrounding area in 1944. Large areas of salt marsh still existed at this time upstream from the Township. ©Sourced from http://retrolens.nz and licensed by LINZ CC-BY 3.0.

10.4 Management Options and Recommendations

As outlined above, the most immediate coastal hazard issues at Marokopa relate to coastal inundation in south-western areas of the township and coastal erosion along the foreshore of Rauparaha Street. In the longer term with projected sea level rise, coastal inundation will become an increasingly serious issue for a significant area of the township.

The coastal erosion hazard along Rauparaha Street foreshore reflects a long-term trend for permanent shoreline retreat in this area as outlined in Section 10.2. The existing properties were created in 1913 over 106 years ago and the high-water mark has retreated by 25-35 m since that time, eliminating the original reserve and extending into private properties. If historic average rates of erosion continue, the shoreline is likely erode by a further 15-20 m over the next 50 years and with sea level rise of 1.0 m by up to 50 m over the next 100 years (see Table 8). There is some evidence that the average erosion rates may be slowing but this is not conclusive.

The erosion of the properties has led to various ad hoc protection works (largely sea walls) being constructed in recent decades as owners attempt to prevent further erosion. However, the sea walls are having significant adverse effects; narrowing and lowering the sandy beach immediately seaward and adversely impact public access and amenity, as well as the natural character of the coast. These adverse effects will be considerably exacerbated by ongoing erosion and consequently the sea walls are unlikely to provide an acceptable long-term solution to the erosion.

Most of the properties are sufficiently deep that reasonable use (including a safely located dwelling) will continue to be practicable for at least the next 50 years (i.e. the area defined by CEHZ 1) even without intervention. However, preliminary consultation indicates this approach is generally not favoured by landowners. Moreover, living with erosion over the next 50 years might preclude reasonable use of some properties; including 4 Marokopa Road, 8 and 9 Moerua Street (the latter a cross-lease property with two separate dwellings), and 14 Moana Quay (created by subdivision of an original 1913 lot in the early 1970s – DPS 16016). Some existing dwellings would also need to be relocated within the next 50 years.

While such managed retreat is implicit in existing national and regional policy directions, there is presently no national guidance on how to balance the conflicting public and private interests involved.

Given these difficulties, we recommend an adaptive management strategy should be developed to manage the complicated aspects of coastal hazard management at Marokopa. In particular, this plan would need to provide for coastal erosion seaward of Rauparaha Street and the long-term implications of sea level rise on coastal flooding. The strategy will be based around adaptation and living with erosion in the long term, and is likely to include:

- development controls to gradually move dwellings away from the CEHZ 1 and to encourage adaptability in CEHZ 2.
- triggers for removal or relocation of structures over time (to be developed with the community).
- dune restoration in suitable areas.

All key stakeholders (including local iwi and the wider community) will need to be involved as there are a range of complex public and private interests involved. The adaptive management strategy will likely need to be built around living with erosion but with provisions to ensure reasonable use of all properties (e.g. suitable dwelling) for as long as practicable. In the longer term, it may prove to be cost-effective to hold the shoreline (or to at least mitigate erosion) using soft measures, such as (for instance) a combination of beach nourishment and groynes.

However, such measures can be quite expensive, and we suspect that living with erosion will be the more cost-effective approach for most properties for at least the short-medium term; but with triggers for appropriate intervention when required.

Until an agreed adaptive management strategy has been developed, we recommend that coastal erosion hazard be managed using the recommended setbacks and associated development controls (the latter outlined in Section 6 and Section 7) to prevent exacerbation of existing issues. However, the plan should allow for such measures to be superseded by an appropriate adaptive management strategy once the latter is developed and agreed.

There are areas of road that would potentially be inundated at every spring high tide with 1.0 m of sea level. This highlights the need for a long-term plan for the Township prior to any significant or land use change that would increase the hazard risk.

In terms of coastal inundation management, the Council will incorporate minimum floor levels in flood prone areas throughout the Marokopa area. Ground and road levels may need to be raised in the longer term as projected sea level rise eventuates.

11 TE WAITERE AND KINOHAKU

Te Waitere (Ahuahu) is a small township located on a peninsula in the southern Kawhia Harbour (Figure 41); the peninsula composed of Jurassic sandstones and siltstones. The settlement is largely elevated, with a varied, predominantly steep cliffed shoreline. The northern shoreline is fronted by high (15-30 m) steeply sloping vegetated cliffs (Figure 42). Dwellings exist very close to top of the cliff edge.

The south-facing coastline of the Township is fronted a narrow reclamation associated with the local Boat Club and, further southwards, by an eroding cliffed margin commonly 3-5 m high (Figure 43 & Figure 44). In general, private properties lie landward of the road along the eastern margin but there are some long narrow properties on the seaward side; remnants of larger blocks that were cut off when the road was formed in the early 1900s. Most of these foreshore sections are owned by the Te Waitere Boating Club but there is one private property (1120 Te Waitere Road) with an existing dwelling located close to the top edge of the eroding cliff.

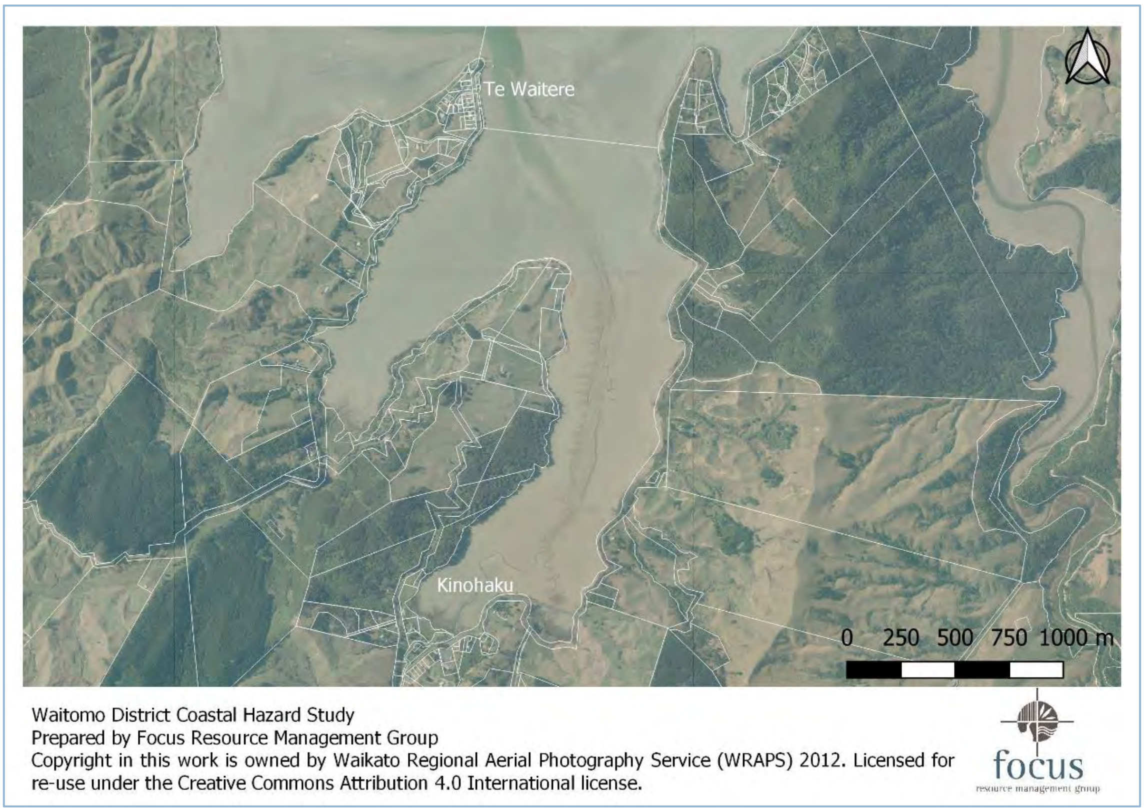


Figure 41: Te Waitere and Kinohaku settlements, in southern Kawhia Harbour.

Figure 42: North western Te Waitere shoreline showing steep vegetated cliffs.

Figure 43: Te Waitere Boat Club reclamation.

Figure 44: A historic view of the low eroding cliffs which naturally characterised the eastern margin and which still occur to the south of the reclamation at Te Waitere (Photo: Te Waitere Boating Club)

11.1 Current (Operative) District Plan

The operative Waitomo District Plan contains provisions relating to identified coastal hazard areas. Coastal Hazard Area A is identified throughout the District as the area within 25 m of a river mouth or estuary margin. There is some existing development within this coastal margin at Te Waitere and Kinohaku, including the Boating Club, one or two existing clifftop houses on Whiteley Place and several properties seaward of Te Waitere Road between Te Waitere and Kinohaku.

Any building proposed within Coastal Hazard Area A is a non-complying activity indicating a high threshold test to pass for consent to be granted. Public infrastructure such as wharves, jetties, car parts and utility buildings are a discretionary activity in this area. If a dwelling is relocatable (i.e. can be moved in the future if required), it is a discretionary activity. The combined effect of these measures is to ensure that new dwellings are avoided in coastal hazard areas unless the dwellings can be moved if required.

Lawfully established buildings within Coastal Hazard Area A can be relocated landward within the same property without resource consent.

The anticipated environmental outcome of the implementation of these rules is:

27.6.1 An environment where:

> *(a) The effects of natural hazards are lessened through greater public awareness and the use of mitigation/remedy measures, where appropriate.*
>
> *(b) The threats posed by existing natural hazards are not increased through continued development of areas prone to natural hazards.*

11.2 Coastal Erosion Hazard

The north western side of the Te Waitere Peninsula is characterised by high (15-20 m) cliffs with current slopes close to 1V:1H (45 degrees). While this shoreline is relatively exposed to waves from the north west, it is fronted by a wide intertidal flat (150-200 m) and is sheltered from wave action from other directions. A narrow beach along the base of the bank (essentially a veneer of sediment over a sloping shore platform) protects the bank from wave action except at or near spring high tides or higher sea levels.

Field inspection indicates that the toe of the bank is eroding but aerial photo records indicate that the rate of erosion is very slow and below levels able to be accurately measured (Figure 45). The slow rate of toe erosion likely reflects the relatively resistant geology (frittered Jurassic mudstone), limited wave energy and the low frequency of wave attack. While it is not possible to accurately assess the rate of toe erosion, the available evidence suggests it is less than 2-3 m per century.

Future sea level rise of up to 1.0 m may increase the time-averaged rate of erosion due to an increase in the frequency of wave attack. The beach slope at the toe of the cliff suggests such additional erosion might be in the order of 10 m for a readily erodible bank. However, given the relatively resistant geology, erosion is likely to be significantly less than this.

The steeply sloping banks are periodically subject to slope instability but available historic data indicates that major landslips extending to the top landward edge of the bank appear to be very rare; as also reflected in the occurrence of some moderate-sized trees on the seaward slope. Detailed geotechnical investigations would be required to assess an accurate stable slope. We understand that some geotechnical investigations were conducted during the 1990s but were not able to access this information. In the absence of available information, we recommend that a precautionary approach be adopted. Accordingly, while existing steep slopes are typically 1:1–1:1.5, we recommend that a stable slope of 1:2 be assumed until more detailed information is available.

Figure 45: Shoreline change at Te Waitere since 1944.

The steep nature of existing slopes suggests that the probability of failure to 1V:2H is low. However, given the consequences and the current lack of useful information on potential slope instability a precautionary approach is appropriate in this (essentially a "first pass") assessment. As at other sites, we recommend that Council provide for modification of this "first pass" assessment, based on a detailed site-specific investigation by an appropriately qualified and experienced geotechnical engineer or engineering geologist.

In this area we have defined a single coastal erosion hazard zone. The Coastal Erosion Hazard Zone 1 (CEHZ 1) on the north-facing cliffs at Te Waitere provides for 3 m of toe erosion, and a stable slope of 1:2 (26 degrees), to provide for potential episodic slope failure. The width of this area therefore increases with elevation. There are several houses located close to the cliff edge that may be partially within this hazard zone.

On the eastern shoreline, the reclamation in the vicinity of the boating club currently protects this area from erosion. The reclamation in the vicinity of the boat club is evident in the earliest (1944) aerial photo but appears to have been extended further southward alongshore between 1997 and 2001. The reclamation on which the boating club is located is protected in northern areas by an old concrete sea wall which seems to be performing well. However, further south the reclamation is protected by a wooden sea wall, which is beginning to fail in places (Figure 46).

The natural cliffed shoreline to the south of the reclamation is slowly eroding, with a near-vertical active erosion scarp commonly evident to the top edge of the bank, even though often obscured by overhanging trees. Historic surveys suggest the MHWM has retreated by up to about 5 m in places (though typically less) since originally surveyed in the early 1900s. Accordingly, we have adopted an average toe erosion rate of 5.0 m per century for existing sea level. However, the actual average rate may be less and is likely to vary with bank materials.

Sea level rise is likely to increase the average rate of toe erosion and we have estimated a doubling of existing bank erosion rates may occur with up to 1.0 m sea level rise as discussed in Section 4.3.1. In general, the natural eroding cliff is very steep, often near vertical in the lower (2-3 m high) bank areas immediately south of the boat club reclamation. Accordingly, we have adopted a relatively steep stable slope of 1:1 for this area.

Figure 46: Boat Club reclamation at Te Waitere.

The Coastal Erosion Hazard Zone 1 (CEHZ 1) for the eastern shoreline therefore provides for erosion of 2.5 m to 2070 and a stable slope of 1:1.5; yielding a CEHZ 1 of 10 m width. The reclamation area is an uncertainty and would likely erode back to the original natural shoreline within a relatively short period if the sea walls protecting the reclamation were to completely fail at some future date. We recognise that, given the high public amenity values of the boat club and reclamation, it is more likely that the community and/or Council will act to protect the reclamation and boat club if the existing sea walls fail. For these reasons we have not included any additional erosion of the cliff landward of the reclamation in calculating this hazard zone.

The Coastal Erosion Hazard Zone 2 (CEHZ 2) for the area immediately south of the Boat Club reclamation includes toe erosion rate of 10 m per century and a stable slope of 1:1.5, yielding a CEHZ 2 of 15 m.

At Kinohaku, the coastal erosion hazard zone for other (mostly rural) coastal areas (Section 7.4) will provide adequate protection from coastal erosion.

11.3 Coastal Flood Hazard

Te Waitere Township is well elevated above the level of extreme storm surge with current sea level and with foreseeable sea level rise in the next 100 years. There is a significant area of low-lying land at Kinohaku and stretches of road that are potentially vulnerable to coastal inundation during an extreme storm surge with current sea level (Figure 47). Flooding would become much more severe and frequent with even modest sea level rise. With 1.0 m sea level (Figure 48) rise, most of the area would flood every high tide.

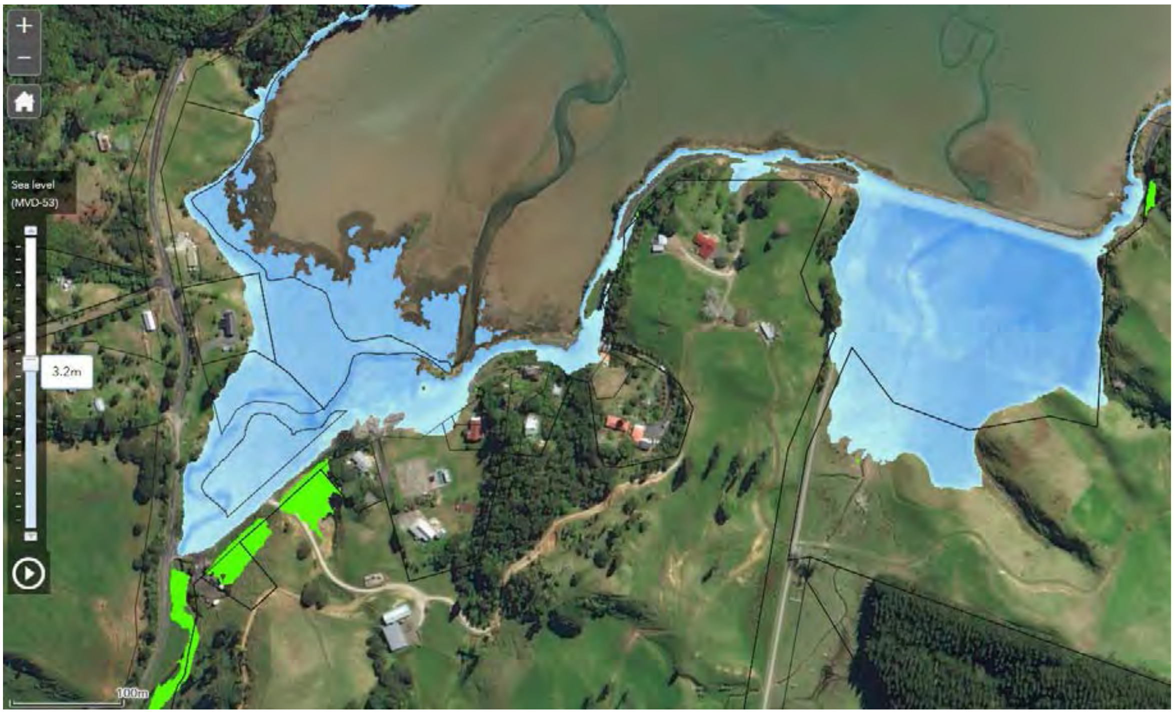


Figure 47: Areas of land (blue) at Kinohaku below the elevation of coastal inundation in an extreme storm surge event (3.16 m MVD '53). For Discussion of levels see Section 4.2. Green areas indicate land below the elevation of flooding, but with no clear hydraulic link to the coast. Waikato Regional Council Coastal Inundation Tool http://coastalinundation.waikatoregion.govt.nz/.

Figure 48: Areas of land (blue) at Kinohaku below the elevation of coastal inundation in an extreme storm surge event with 1.0 m of sea level rise (4.16 m MVD '53). For Discussion of levels see Section 4.2. Green areas indicate land below the elevation of flooding, but with no clear hydraulic link to the coast. Waikato Regional Council Coastal Inundation Tool http://coastalinundation.waikatoregion.govt.nz/.

11.4 Management Options and Recommendations

The defined erosion hazard zones indicate potential for erosion to impact a number of properties along the north western margin of Te Waitere Township, including some dwellings. Similarly, the erosion hazard zones along the eastern margin indicate for erosion to extend back to the road over the next 100 years and for the existing dwelling at 1120 Te Waitere Road to be impacted within the next 50 years, even with existing sea level.

We recommend that the erosion hazard be managed using development controls in the recommended hazard zones as outlined in Sections 6 and 8. If these provisions preclude reasonable use of any properties (which could be the case for 1120 Te Waitere Road) then we recommend that site-specific adaptive management strategies be developed for these properties.

Sea walls are unlikely to be consented as an appropriate long-term solution along the north western margin as the toe of the bank lies in public land the degradation of the public beach and associated impacts on natural character, public access and amenity are likely to rule these measures out. National policy precludes private benefit seawalls being placed in such locations unless there is public benefit, which would not be the case. In addition, the erosion rates on this coast are so slow that there is unlikely to be any significant erosion mitigation benefits from sea walls.

Well-engineered sea walls are likely however be a preferred and appropriate option fronting the boat club and reclamation; given the high level of public benefit associated with the boat club and reclamation and the relatively minor adverse environmental effects relative to existing baseline conditions) in this area.

Sea walls may also be an appropriate and practicable option where required to protect Te Waitere Road, though environmentally soft protection is also likely to be practicable in some areas. As discussed in Section 8.5, we note that bank and cliff erosion debris from the highly frittered sedimentary rocks in this area are now often removed during road maintenance works and no longer supply local beaches.

The hazard analysis also indicates considerable risk from coastal inundation in the Kinohaku area. We recommend that (as described in Section 7) no further subdivision or intensification of use be permitted in these hazard areas. We also recommend that Council work with local landowners at Kinohaku to develop an adaptive management strategy for the low-lying areas. One option which has the potential to balance landowner and environmental objectives would be to provide suitable incentives (e.g. increased development opportunities) in return for setting low-lying areas aside where this is practicable. This option has potential not just in the Kinohaku area but most estuarine margin areas within Waitomo.

Coastal inundation will also affect many low-lying roads around the harbour (including in the vicinity of Kinohaku). While there are currently only isolated areas affected by extreme water levels during storms, future sea level rise will cause widespread and more frequent inundation of the local roads; with sea level rise of 1.0 m very likely to result in extensive flooding even during normal tides. Council will need to consider triggers for adaptation of road levels over time as necessary in response to future sea level rise. Where practicable, alternative alignments could also be planned for the medium-longer term.

APPENDIX A: KEY NZCPS POLICIES

Policy 24: Identification of coastal hazards

(1) *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, over at least 100 years, are to be assessed having regard to:*

(a) *physical drivers and processes that cause coastal change including sea level rise;*

(b) *short-term and long-term natural dynamic fluctuations of erosion and accretion;*

(c) *geomorphological character;*

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

(e) *cumulative effects of sea level rise, storm surge and wave height under storm conditions;*

(f) *influences that humans have had or are having on the coast;*

(g) *the extent and permanence of built development; and*

(h) *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 of climate change on the region or district.

Policy 27: Strategies for protecting significant existing development from coastal hazard risk

(1) *In areas of significant existing development likely to be affected by coastal hazards, the range of options for reducing coastal hazard risk that should be assessed includes:*

(a) *promoting and identifying long-term sustainable risk reduction approaches including the relocation or removal of existing development or structures at risk;*

(b) *identifying the consequences of potential strategic options relative to the option of 'do-nothing';*

(c) *recognising that hard protection structures may be the only practical means to protect existing infrastructure of national or regional importance, to sustain the potential of built physical resources to meet the reasonably foreseeable needs of future generations;*

(d) *recognising and considering the environmental and social costs of permitting hard protection structures to protect private property; and*

(e) *identifying and planning for transition mechanisms and timeframes for moving to more sustainable approaches.*

(2) *In evaluating options under (1):*

(a) *focus on approaches to risk management that reduce the need for hard protection structures and similar engineering interventions;*

(b) *take into account the nature of the coastal hazard risk and how it might change over at least a 100-year timeframe, including the expected effects of climate change; and*

(c) *evaluate the likely costs and benefits of any proposed coastal hazard risk reduction options.*

(3) *Where hard protection structures are considered to be necessary, ensure that the form and location of any structures are designed to minimise adverse effects on the coastal environment.*

(4) *Hard protection structures, where considered necessary to protect private assets, should not be located on public land if there is no significant public or environmental benefit in doing so.*

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** of social, environmental and economic harm from coastal hazards;*

(b) *avoid redevelopment, or change in land use, that would increase the risk of adverse effects from coastal hazards;*

(c) *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 of existing structures or their abandonment in extreme circumstances, and designing for relocatability or recoverability from hazard events;*

(d) *encourage the location of infrastructure away from areas of hazard risk where practicable;*

(e) *discourage hard protection structures and promote the use of alternatives to them, including natural defences; and*

(f) *consider the potential effects of tsunami and how to avoid or mitigate them.*

[The NZCPS 2010 glossary states that 'Risk is often expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated likelihood of occurrence (AS/NZ ISO 31000:2009 Risk management—Principles and guidelines, November 2009)'.]

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.

APPENDIX B: REGIONAL POLICY STATEMENT KEY POLICIES

Policy 6.2 Planning for development in the coastal environment

Development of the built environment in the coastal environment occurs in a way that:

- ensures sufficient development setbacks to protect coastal natural character, public access, indigenous biodiversity, natural physical processes, amenity and natural hazard mitigation functions of the coast;
- protects hydrological processes and natural functions of back dune areas;
- avoids the adverse effects of activities on areas with outstanding natural character, and outstanding natural features and landscapes;
- ensures that in areas other than those identified in (c) above, activities are appropriate in relation to the level of natural character or natural feature and landscape;
- has regard to local coastal character;
- allows for the potential effects of sea level rise, including allowing for sufficient coastal habitat inland migration opportunities;
- protects the valued characteristics of remaining undeveloped, or largely undeveloped coastal environments;
- ensures adequate water, stormwater and wastewater services will be provided for the development;
- avoids increasing natural hazard risk associated with coastal erosion and inundation;
- has regard to the potential effects of a tsunami event, and takes appropriate steps to avoid, remedy or mitigate that risk;
- avoids ribbon development along coastal margins;
- does not compromise the function or operation of existing or planned coastal infrastructure;
- provides for safe and efficient connectivity between activities occurring in the coastal marine area and associated land-based infrastructure;
- manages adverse effects to maintain or enhance water quality; and
- maintains and enhances public access.

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Policy 12.3.2 Amenity value of the coastal environment

Regional and district plans shall ensure that the amenity values of the coastal environment are maintained or enhanced, including by:

- recognising the contribution that open space makes to amenity values and providing appropriate protection to areas of open space;
- maintaining or enhancing natural sites or areas of particular value for outdoor recreation;
- employing suitable development setbacks to avoid a sense of encroachment or domination of built form, particularly on areas of public open space and along the coastal edge;
- avoiding forms and location of development that effectively privatise the coastal edge and which discourage or prevent public access to and use of the coast;
- recognising that some areas derive their particular character and amenity value from a predominance of structures, modifications or activities, and providing for their appropriate management;
- ensuring the removal of derelict or unnecessary structures within the coastal marine area;
- encouraging appropriate design of new structures and other development to enhance existing amenity values;
- maximising the public benefits to be derived from developments;
- ensuring public access to public areas is enhanced where practicable; and
- recognising the role of esplanade reserves and strips in contributing to public open space needs.

Policy 12.3.3 Enhance public values in the coastal environment

Local authorities should seek to incorporate the enhancement of public amenity values, including when undertaking works and services or preparing or reviewing growth strategies, structure plans, or regional and district plans.

Policy 13.1 Natural hazard risk management approach

Natural hazard risks are managed using an integrated and holistic approach that:

- ensures the risk from natural hazards does not exceed an acceptable level;
- protects health and safety;

- avoids the creation of new intolerable risk;
- Reduces intolerable risk to tolerable or acceptable levels;
- enhances community resilience;
- is aligned with civil defence approaches;
- prefers the use of natural features over man-made structures as defences against natural hazards;
- recognises natural systems and takes a 'whole of system' approach; and
- seeks to use the best available information/best practice.

Policy 13.1.1 Risk management framework

Regional and district plans shall incorporate a risk-based approach into the management of subdivision, use and development in relation to natural hazards. This should be in accordance with relevant standards, strategies and plans, and ensure that:

- new development is managed so that natural hazard risks do not exceed acceptable levels;
- intolerable risk is reduced to tolerable or acceptable levels
- the creation of new intolerable risk is avoided;
- any intolerable risk as a result of existing use and development is as low as reasonably achievable; and
- where intolerable risk remains, the risks will be managed until an acceptable level is achieved.

Policy 13.1.3 Assess natural hazard risk to communities

Waikato Regional Council will collaborate with territorial authorities, tāngata whenua and other agencies to undertake assessments of coastal and other communities at risk or potentially at risk from natural hazards, and develop long-term strategies for these communities. The strategies will, as a minimum:

- include recommendations for any hazard zones that should be applied, including primary hazard zones;
- identify risks to the community and existing infrastructure from natural hazards; and
- identify options for reducing the risks to the community to an acceptable level and the relative benefits and costs of those options, including taking into account any effects on:

- public access;
- amenity values; or
- natural character (including natural physical processes, indigenous biodiversity, landscape and water quality).

APPENDIX C: REFERENCES

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APPENDIX D: SUMMARY OF COASTAL EROSION HAZARD ZONES

Location	Shoreline Type	CEHZ 1	CEHZ 2	Notes
Mokau Ocean Beach – Point Road	Open Coast Beach and River Entrance	38 m 48 m (point of spit)	Entire spit.	Reflects very large historic changes in spit and river entrance shorelines (Section 8.2). CEHZ 1 based on 1.5 m/yr for 20 years + slope. 2.0 m/yr near end of spit + slope. Slope = 1:1 to allow for dune collapse. CEHZ 2 provides for large dynamic fluctuations and future sea level rise. Reflects uncertainty. CEHZ measured from custom baseline that reflects seawall effects. Maps best produced using 2012 or 2017 shoreline as seaward boundary.
Mokau Spit River Shoreline	River Entrance, River shoreline	18.5 m	Entire spit.	CEHZ 1 based on 0.15 m/yr + slope (1:1 to allow for dune collapse) CEHZ 2 provides for dynamic shoreline fluctuations and future sea level rise. Measured from 2017 shoreline.
Takarei Terrace & Te Kauri Road	River shoreline, low lying coastal plain	Width of coastal plain	N/A	CEHZ 1: map base of slope. 6.0 m contour may provide useful landward boundary. Measured from 2017 shoreline.
North St/SH3 Between Takarei and Te Kauri Roads	River shoreline, cliff.	1:1.5 slope		1:1.5 slope from base of slope. Measured from 2.0 m contour.
Tainui Wetere Domain	Estuary/river shoreline	N/A	All low-lying area to road.	Road is landward boundary. Measured from 2017 shoreline.

Awakino Heads	Estuary/river shoreline	18 m	22 m	CEHZ 1 based on 1:1.5 slope. CEHZ 2 based on 5 m erosion + 1:1.5 slope. Measured from 2.0 m contour (3.0 m for CEHZ 2) or 2017 shoreline.
5 Awakino Heads Rd	Estuary/river shoreline	15 m	30 m	Measured from 2017 shoreline.
Awakino Township	River shoreline (Iredale Quay) Shoreline north of Iredale Quay	5 m 10 m	5 m 20 m	Measured from most landward measured shoreline.
Marokopa Rauparaha St	River/estuary shoreline	20 m	52 m	Includes shoreline seaward of Rauparaha Street (including Marokopa Road and Moana Quay). Measured from baseline adjusted for seawall effects.
Marokopa Rugby Grounds	River/estuary shoreline	15 m	30 m	Includes area north of Marokopa Road to Rugby Grounds. Allowance for 15 m shoreline fluctuations, and 15 m for sea level rise of 1.0 m. Measured from 2017 shoreline.
Marokopa Esplanade	River/estuary shoreline	5 m	15 m	Area on river shoreline upstream from Rugby grounds and fronting the Esplanade. Measured from 2017 shoreline baseline.

Te Waitere North	Estuary Cliffs	3 m + 1:2		CEHZ 1: 3.0 m toe erosion + stable slope (1V:2H). Measured from 2.0 m contour (MVD '53).
Te Waitere Boat Club Reclamation	Estuary bank, reclamation, sea walls.	Width of reclamation	N/A	CEHZ 1: provides for residual risk with reclamation. Map base of bank slope. Measured from 2017 shoreline baseline.
Te Waitere South	Estuary bank shoreline.	10 m	15 m	CEHZ 1: 5 m erosion + 1:1.5 slope CEHZ 2: 10 m erosion + 1:1.5 m slope. CEHZ 1 measured from 2.0 m RL baseline (MVD '53) CEHZ 2 measured from 3.0 m contour (MVD '53).